Using MS4 To Combat Harmful Algae Blooms and Other Water Quality Impairments

Stephen J. Souza, Ph.D.

Clean Waters Consulting, LLC
Ringoes, NJ 08551
SJSouza.CWC@gmail.com

CWC

Thanks For Joining In This Presentation

ANJEC

Local Environment Matters

Part 1 –
What is a Harmful Algae Bloom (HAB)?

Harmful Algae Blooms

- Cyanobacteria natural part of phytoplankton community.
- HAB defined by high density of cyanobacteria cells and elevated concentrations of cyanotoxins.
- HABs impact recreational use, ecology and water quality of lakes, streams and rivers.
- Cyanotoxins pose health risk to humans, pets and livestock.
- Nothing new…public / policy makers catching up to science… but HABs happening more often and seem to be more persistent.

The High Cost of Algae Blooms in U.S. Waters: More Than $1 Billion in 10 Years

By **Anne Schechinger**, Senior Analyst, Economics

WEDNESDAY, AUGUST 26, 2020

Communities across the United States have spent more than $1 billion since 2010 dealing with outbreaks of potentially toxic algae in lakes, rivers, bays and drinking water supplies, according to an analysis by the Environmental Working Group.

We identified 85 locations, mostly cities and towns, in 22 states that spent money to prevent or treat algae blooms in the past 10 years. The staggering price tag: about $1,158,245,000. This is a first attempt to calculate the cost to communities.

Source: https://www.ewg.org/research/high-cost-of-algae-blooms/

Tell Me More About Cyanobacteria

- In past referred to as “blue-green algae” (hence term harmful algae blooms).
- Cyanobacteria are prokaryotes, not eukaryotes (such as true algae), lack membrane encased organelles or mitochondria.
- However, they can photosynthesize.
- Thus, share properties of both bacteria and algae.

Cyanos Are Unique Critters!

- Many can assimilate atmospheric nitrogen… an unlimited source of critical nutrient.
- Biologically adept at assimilating organic phosphorus – common sources of organic P are decaying algae and aquatic plants, goose feces, fertilizer, pet waste.
- Can actively regulate positon in water column.
- Selectively rejected as food source by filter feeders and zooplankton.

Tell Me More About Cyanotoxins

- Released into environment by both living and dead cyanobacteria.
- Extremely stable in environment and decompose slowly.
- Impacts magnified upon "crash" of cyanobacteria bloom - large amounts released quickly from degraded cells.

Why Are HABs a Common Problem in NJ?

- Most of State's waterways drain developed suburban or urban watersheds.
- Most development occurred BEFORE SW regulations.
- Majority of State's waters are eutrophic… overly productive due to high influx of nutrients.
- Many lakes fairly small and shallow - heat up quickly.
- Many lakes have limited water exchange – slow flushing rate.
  - More time for cyanos to assimilate nutrients
  - More time for cyano cells to multiply (bloom)
  - More time for toxins to concentrate

Why Do HABs Occur?

Root cause:

- Too much phosphorus, the "limiting nutrient" in aquatic ecosystems
- More phosphorus leads to more productivity (algae growth)
- Excessive productivity leads to a HAB

Phosphorus Sources:

- Dissolved phosphorus - stormwater runoff, goose and pet feces, septic systems, internal loading due to stratification and anoxia
- Particulate phosphorus – Adhered and bound to sediment and silt transported with stormwater runoff

Improper/inadequate stormwater management is the leading cause HABs and other WQ impairments

The Phosphorus Connection

- Phosphorus mobilized and transported via stormwater runoff, especially during first flush.
- Stormwater conc. range from 0.275-0.50 mg/L… >0.03 mg/L can stimulate and sustain a HAB.
- Inadequate SW management = more phosphorus loading = more eutrophication = greater opportunity for development of HAB.
- Four geese produce as much phosphorus daily as a single septic system.

So… HAB prevention requires going on a phosphorus diet

Stormwater Management
Is a Big Part of the Phosphorus Diet Strategy

The Climate Change Link
Increased Occurrence, Severity and Persistence

- More intense storms result in more nutrient loading.
- Warmer summer water temperatures favor rapid cell growth.
- Droughts lessen flushing and water exchange… favors buildup cyanobacteria cells and development of blooms.
- Warmer winters mean longer "growing season" favoring earlier development of HABs.

How Does NJDEP Define a HAB?

Use combination of visual evidence, cyanobacteria cell counts and measurement of cyanotoxins.

- Cell counts ≥ 20,000, ≥ 40,000, ≥ 80,000 cells/ml.
- Toxin thresholds –
  - Microcystin > 2 µg/L
  - Cylindrospermopsin > 5 µg/L
  - Anatoxin > 15 µg/L

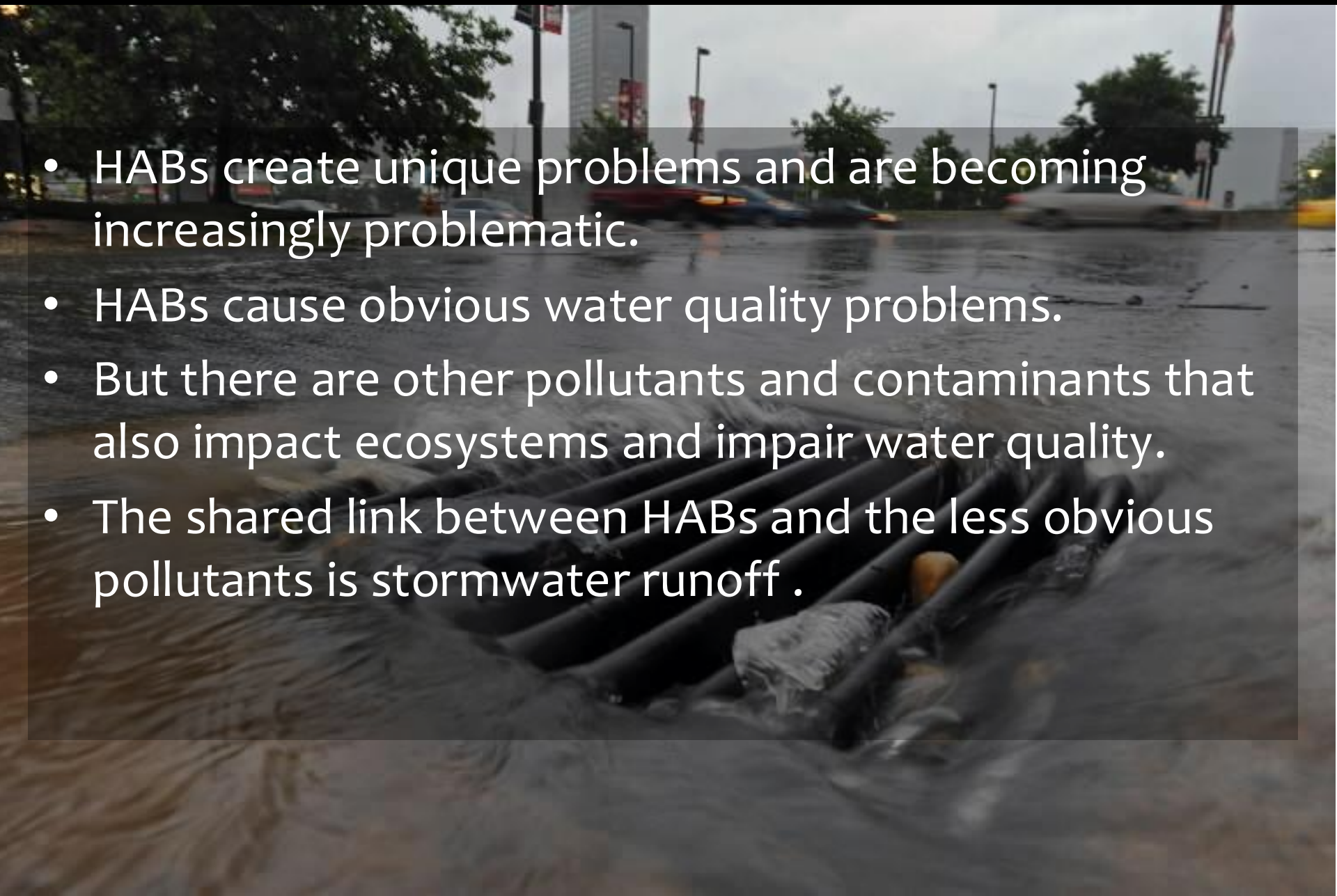
DEP stresses personal sensitivities vary, children maybe more sensitive, and even w/out toxins symptoms may be experienced

HAB Alert Level	Criteria	Recommendations
HAB Not Present	**HAB reported and investigated. No HAB present.**	**None**
WATCH *Suspected or confirmed HAB with potential for allergenic or irritative health effects*	Suspected HAB based on field survey **OR** Confirmed cell counts ≥20K - <80K cells/mL **AND** No known toxins above public health thresholds	**Public Bathing Beaches Open** Waterbody Accessible: Use caution during **primary contact (e.g. swimming) and secondary (e.g. non-contact boating)** activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with moderate risk of adverse health effects and increased potential for toxins above public health thresholds*	Lab testing for toxins Microcystins: ≥2 µg/L Cylindrospermopsin: ≥5 µg/L Anatoxin-a: ≥15 µg/L Saxitoxin: ≥0.6 µg/L **OR** Confirmed cell counts ≥80K cells/mL	**Public Bathing Beaches Closed** Waterbody Remains Accessible: Avoid primary contact recreation Use caution for secondary contact recreation Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with high risk of adverse health effects due to high toxin levels*	Toxin (microcystins) ≥20 - <2000 µg/L	**Public Bathing Beaches Closed** Cautions as above May recommend against secondary contact recreation.
DANGER *Confirmed HAB with very high risk of adverse health effects due to very high toxin levels*	Toxin (microcystins) ≥2000 µg/L	**Public Bathing Beaches Closed** Cautions as above. Possible closure of all or portions of waterbody and possible restrictions access to shoreline.

But HABs Aren't Just A "Lake Thing"

HAB Millstone River and Delaware Raritan Canal

HABs… Canary In The Coal Mine?



- HABs create unique problems and are becoming increasingly problematic.
- HABs cause obvious water quality problems.
- But there are other pollutants and contaminants that also impact ecosystems and impair water quality.
- The shared link between HABs and the less obvious pollutants is stormwater runoff .

Part 2 – Problems Caused By A "Little Bit" of Stormwater Runoff

Let’s Start With The Basics

Important Definitions

- Flow – refers to a rate – CFS, Gallons/minute, etc.
- Volume – refers to an amount – Gallons, M^3, Ft^3, etc.
- Concentration – amount/volume – mg/L, lbs/gallon
- Load – Derived from volume and concentration – lbs or lbs/yr, lbs/storm, etc.
  - Load = Conc (lbs/gallon) x Volume (gallons) = lbs
  - Annual Load = Conc (lbs/gallon) x Annual runoff (gallons/yr) = lbs/yr
- 1-year Event –100% chance of occurring annually = 2.8" rainfall over 24 hrs
- 100-year Event – 1% chance of occurring annually = 8.15" rainfall over 24-hrs

Non-Point Source Pollution

A Call to Action on Combating Nonpoint Source and Stormwater Pollution

"The United States will never achieve its goal of restoring and maintaining the chemical, physical, and biological integrity of its waters without implementing a comprehensive, aggressive program to reduce nonpoint source water pollution and polluted urban runoff".

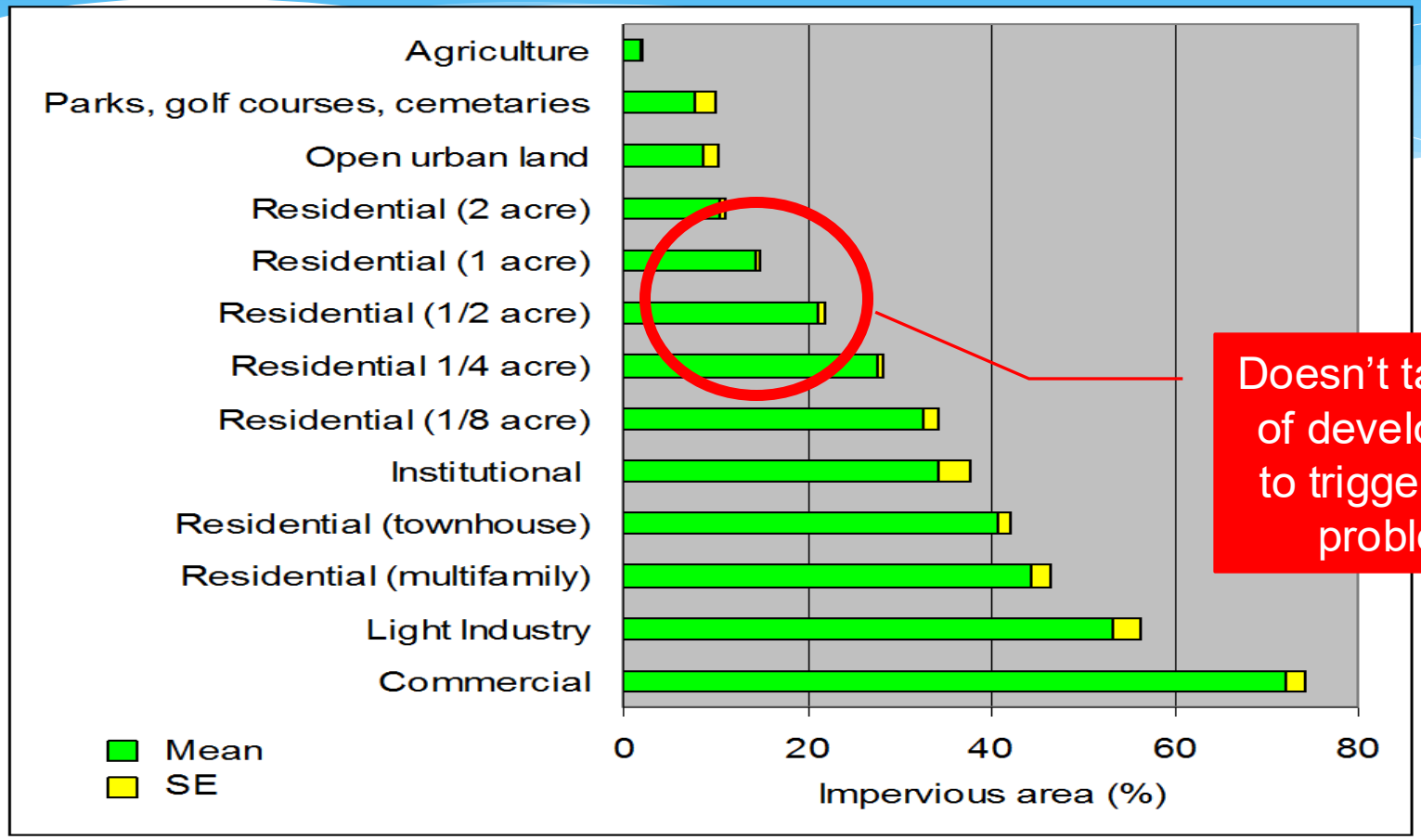
27 Oct 2020 -
https://www.americanprogress.org/

The "Cascading" Impact of Watershed Development

Development Leads To:

- Altered SW hydrology.
- Altered SW hydraulics.
- Increased nutrient, sediment and pollutant loading.
- Lost ecological services and functions.
- More money needed to restore impaired aquatic ecosystems.

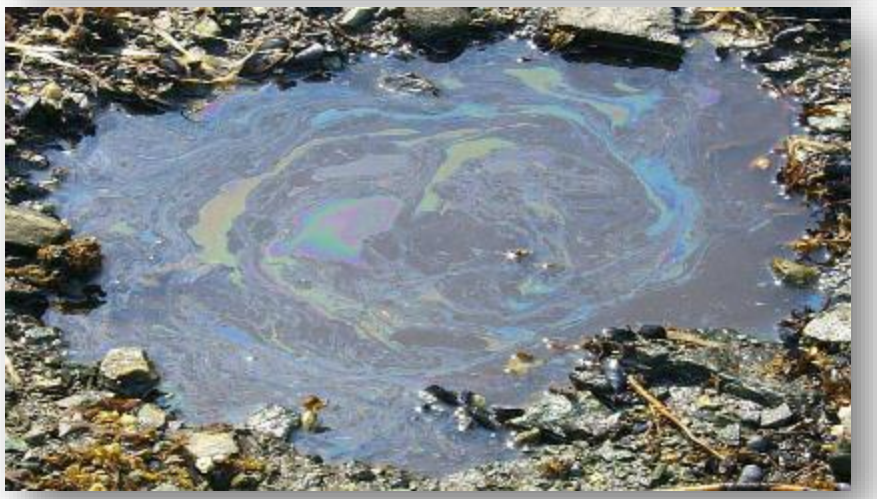
But Its Not Just A "Big City" Problem



As little as 15-20% impervious cover enough to cause WQ impairments … that's 1 house/acre.

And Its Not A "Big Storm" Problem

- "Mega-storms" and catastrophic floods raise public's attention…
- But the smaller more frequent events cause longer term, perpetuating, chronic ecological damage.



Its Really A "Small Storm" Problem

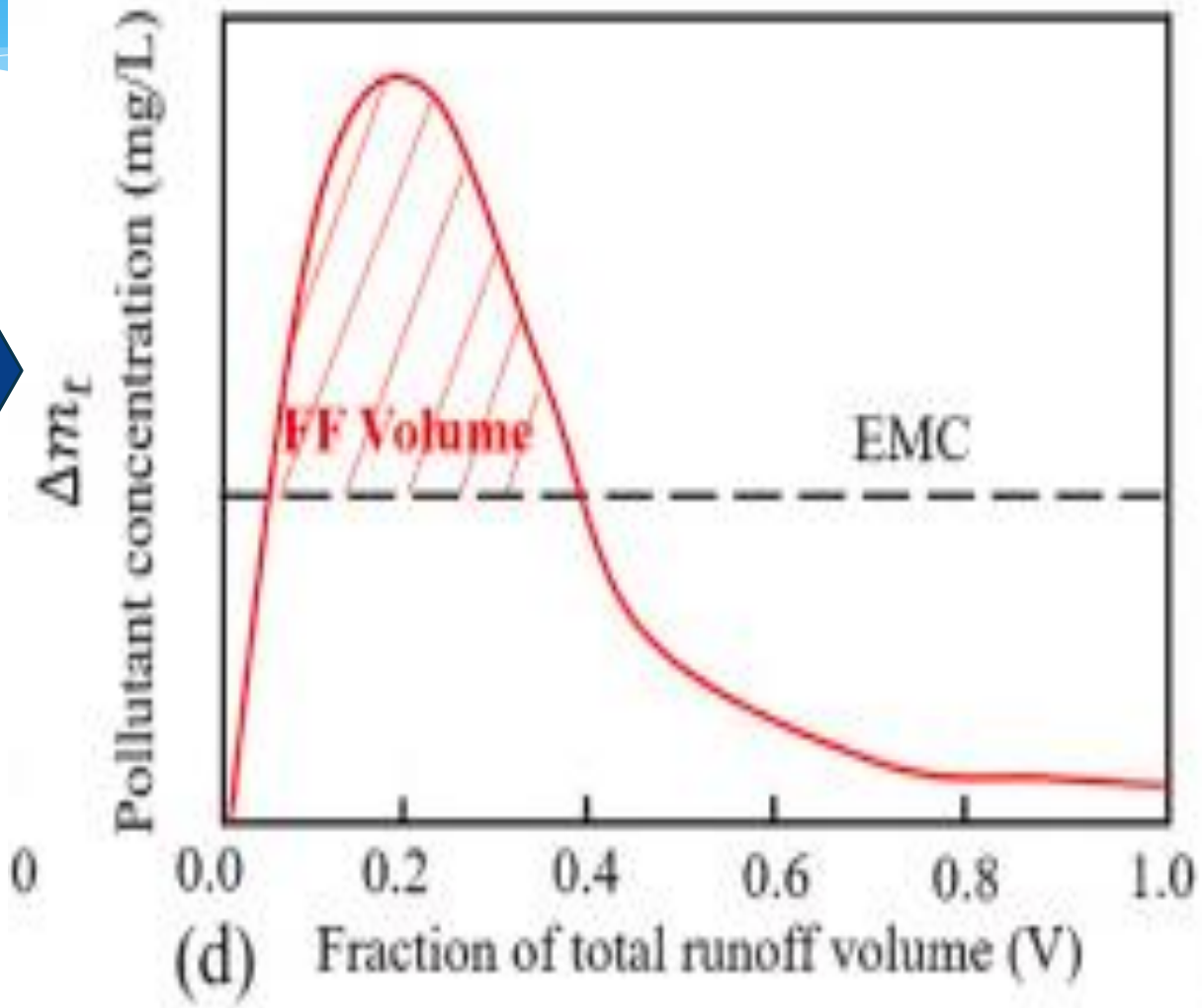
- Smaller frequent storms (0.5-yr, 1-yr and 2-yr events) responsible for :
  - Localized nuisance flooding.
  - Mobilization and transport of high concentrations of pollutants.
  - Result in frequently repeating ecological impacts.
  - Directly linked to lake eutrophication and HABs.

Data shows amount and intensity of rainfall resulting from "small" storms has significantly increased over the past 20 years

First Flush Effect

FF volume transports disproportional amt of pollutant load

Treating the "dirtiest" part of storm decreases chronic water quality and ecological impacts.



Gao et. al. 2023. Journal of Environmental Management Volume 340:1-12.

All of This Is Linked To MS4

Part 3 – NJ's Stormwater Rules and Municipal Separate Storm Sewer System (MS4) Requirements

History of Stormwater Management

- The Federal Clean Water Act ("CWA") of 1972 prohibited the un-permitted point-source discharge of any pollutant into the navigable waters of the United States.
- CWA amended in 1987 set schedule for the regulation of stormwater.
  - Industrial discharges,
  - MS4 (municipal separate storm sewer system), and
  - Other stormwater system discharges.
- EPA monitors performance but implementation delegated to state and local governments.

New Jersey's Stormwater Regulations

Stormwater for new and redevelopment regulated primarily under NJAC 7:8.

- However… SW management also addressed within:
  - NJAC 7:13 - Flood Hazard Rules
  - NJAC 7:14A -NJ Pollution Discharge Elimination System
  - NJAC 7:15 - WQ Management Planning
  - NJAC 7:9B - NJ Water Quality Standards
  - NJ Best Management Practices Manual
  - RSIS (Residential Site Improvement Stds)
  - Pinelands Comprehensive Plan

NJAC 7:14A
Pollution Discharge Elimination System

- NJPDES linked to Federal Clean Water Act; Sections 201, 208 and 303.
- Framework for water quality management policies, procedures and standards.
- Within 7:14A - Municipal separate storm sewer (MS4) defined as "a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains)."

Over Arching Goal of MS4

Swimmable, Fishable and Drinkable Waters

- Encourage/support sustainable development.
- Restore impaired (303d listed) waters and protect high quality waters from impairment by reducing NPS loading.
- Utilize green infrastructure BMPs to reduce NPS loading to the "maximum extent practicable" (MEP).
- Monitor / enforce compliance… role of local stormwater management compliance officer but can be aided by environmental commission.

New Jersey's MS4 Regulations

- NJDEP passed first MS4 requirements 2 February 2004
  - General permits authorizing SW discharges from **Municipalities (Tier A & B)**, Public Complexes, and Highway Agencies.
- MS4 requirements updated 1 January 2023
- Tier A & B communities combined; MS4 now applies to 557 communities statewide.
- MS4 updates also in part driven by recognized impacts of climate change on intensity and volume of SW runoff.

MS4 Municipal Requirements In Effect Since 2004

Municipalities required to develop stormwater management programs inclusive of the Six (6) Statewide Basic Requirements (SBRs):

1. Public involvement and participation including public notice.
2. Local public education and outreach.
3. Construction site stormwater runoff.
4. Post construction stormwater management for new development and redevelopment (ordinances supporting NJAC 7:8).
5. Pollution prevention/good housekeeping.
6. Mapping of MS4 stormwater system, illicit discharges and scouring detection and control.

Goals of 2023 MS4 Update

- Improve function, performance and maintenance of municipal stormwater infrastructure.
- Reduce MS4 contribution of pollutants to impaired waterbodies & TMDL waterbodies.
- Address stormwater flooding to protect human health and safety and environment.
- Develop and implement Watershed Implementation Plan (WIP) to achieve all of the above.

Key 2023 MS4 Updated Requirements

- Map all MS4 stormwater infrastructure (**not just stormwater outfalls**).
- Prepare Stormwater Pollution Prevention Plan (SPPP).
- Prepare Watershed Improvement Plan (WIP).
- Pass community-wide **tree removal replacement ordinance.**
- Improved roadside vegetation waste management and erosion control.

Stormwater Pollution Prevention Plan (SPPP)

Minimize pollution using source control strategies via community-wide ordinances and measures.

- Example ordinances – Pet waste mgmt., Yard waste mgmt., Tree removal/replacement, No waterfowl feeding
- Example measures –Pooper scooper stations, Road salt mgmt. (storage and application), Litter control, Stabilize/repair eroded roadside swales, Retrofit both public and private stormwater inlets.

Watershed Improvement Plans (WIP)

- Municipalities must develop a WIP that details how to:
  - Improve water quality of TMDL waterbodies
  - Improve water quality of impaired (303d List) waterbodies
  - Reduce or eliminate flooding… prioritizing those waterways that have high risk threat to human health/safety, **result in severe environmental impacts** (e.g. sedimentation, scour) and have history of flooding or high frequency / likelihood of occurrence.

WIP – 3 Step Process

Overarching Goal of WIP – improve water quality of impaired waters and help TMDL waters meet TMDL load reductions:

- Step 1 – Watershed Inventory Report – **Due Jan 2026**
- Step 2 – Watershed Assessment Report – **Due Jan 2027**
- Step 3 – Final Watershed Improvement Plan – **Due Dec 2027**

Public involvement in all three steps, starting NO LATER than 1 Jan 2026… Make sure your voice is heard.

Key Elements – Watershed Inventory Report

- Delineate/map watershed area of all impaired waters within or bordering the municipality.
- ID water quality classification of receiving waters.
- Map all MS4 stormwater inlets and outfalls (including drainage area) and receiving waterbodies.
- ID ownership, locate, and map all stormwater outfalls and SW basins, etc. not municipally owned/operated.

Due Jan 2026

MS4 Mapping Requirements

- Must locate and map -
  - MS4 collection and conveyance system
  - Storm drain inlets
  - MS4 manholes
  - MS4 storm outfalls (including name of receiving water)
  - Stormwater structures (basins, etc.) used to manage SW
- Program to detect, investigate, and control stream scouring due to municipal MS4 outfalls and illicit discharges.
- Submit to DEP Stream Scouring Investigation Recordkeeping Form and Illicit Connection Inspection Report

Key Elements – Watershed Assessment Report

- ID possible water quality improvement project(s) by sub-watershed and parameter including projected percent load reduction to TMDL/impaired waters
- Estimate cost and funding needs for each project
- List of funding sources
- Projected schedule of project implementation
- Summary of public feedback/input

Due Jan 2027

Key Elements – Final Watershed Improvement Plan

- Summarize public comments and edits to WIP based on public input
- ID location of proposed **public and private** water quality improvement projects
- Regulatory integration of projects (e.g., Flood protection; surface water quality protection; climate change/resiliency; CSO reductions, wetland and riparian buffer restoration)
- Projected cost by project and year… likely sources of funding
- Schedule of project implementation
- Schedule of WIP status public information sessions

Due Dec 2027

Part 4 – How Environmental Commissions Can Promote and Capitalize on MS4

How Can ECs Capitalize On MS4? Step 1 – Know Your Watershed

- Are your waterbodies located within a TMDL watershed?
- Are your waterbodies 303d listed (impaired water)?
- Are your waterbodies phosphorus impaired? NJAC 7:9B total phosphorus std for lakes ≤ 0.05 mg/L and ≤ 0.10 mg/L for streams
- Has your stormwater collection and conveyance system been fully mapped and catch basin inlets upgraded?
- Are your streams eroded?
- Have sediment deltas accreted at SW outfalls?

How Can ECs Capitalize On MS4? Step 2 – Play A Role in Compliance

1. Be actively involved in preparing land use and SW ordinances
2. Be involved in local development review process.
3. Take leadership role and support public participation in MS4 Public Education and Outreach programs (mandatory element of MS4).
4. Assist with monitoring, reporting and mapping of key outfalls…work closely with municipal stormwater compliance officer, DPW or township engineer.

How Can ECs Capitalize On MS4? Step 2 – Play A Role in Compliance

5. Be "eyes and ears" of municipal government; inspect key catch basins and report back to stormwater compliance officer, DPW or township engineer on catch basins and BMPs in need of maintenance.
6. Promote green infrastructure SW practices for new development, redevelopment and to "correct past sins".
7. Identify and assist in the preparation of grant applications or teaming opportunities to implement green infrastructure stormwater management.

How Can ECs Capitalize On MS4?
Step 3 – Promote Green Infrastructure SWM

Green Infrastructure Stormwater Management

- Foundation of NJDEP MS4 and Stormwater Management narrative.
- Addresses the "three headed" stormwater monster – rate, volume and pollutants.
- Can provide societal benefits that go beyond "just" managing stormwater runoff.
- Increase environmental resiliency and reverse environmental impacts (loss of ecosystem services and functions).

Promote Source Controls

- Stormwater Pollution Prevention Plan
- Public Education and Outreach
- Pollution prevention ordinances
  - Septic management
  - Fertilizer use
  - Yard waste management
  - Pet waste management
  - Waterfowl control

All part of MS4 Compliance Refer to SPPP and 6 Statewide Basic Requirements

Make use of ANJEC resources and experts

Promote Green Infrastructure Delivery Controls

- Applicable for new development, redevelopment and retrofit opportunities
- Wide array of products, technologies, and practices
- Focused on use of engineered systems that mimic natural processes by storing, soaking up and passively treating runoff.
- Rely on vegetation and soils working in concert to infiltrate, evaporate, and/or recycle stormwater runoff
- End result… less non-point source driven problems.

The Benefits of Green Infrastructure

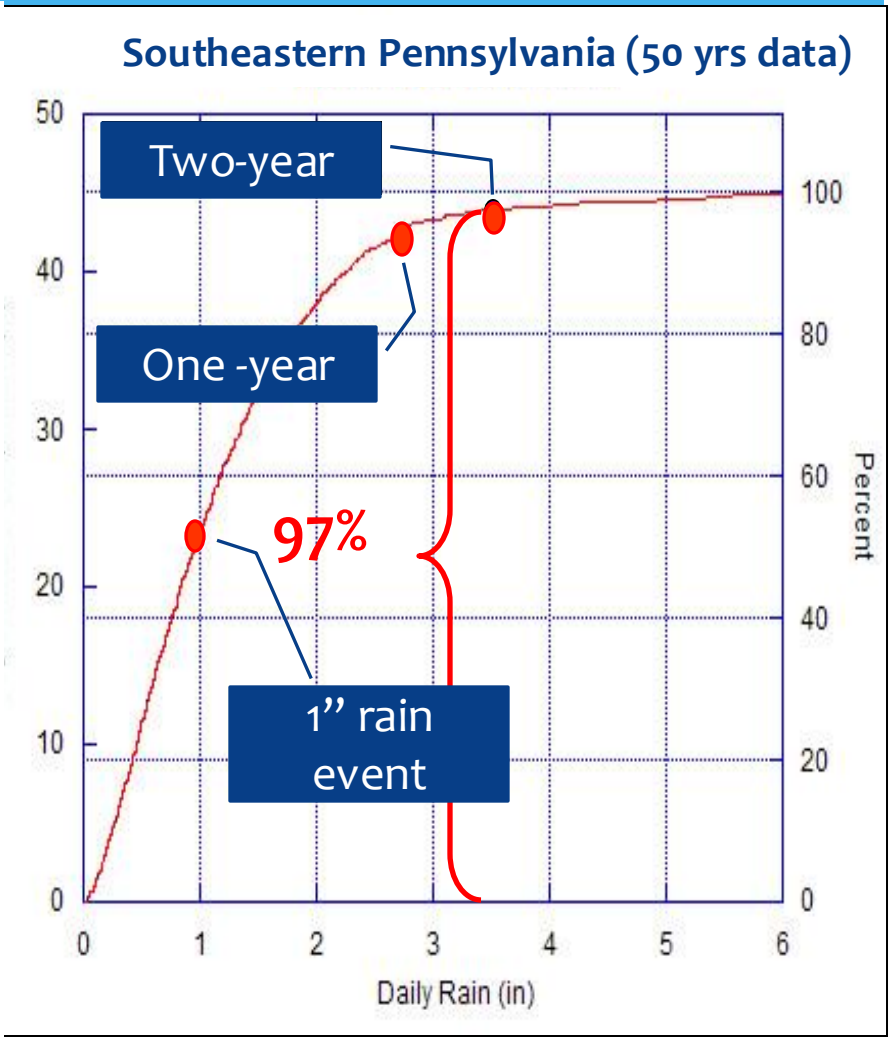
Turn Down The Volume!!!

- GI SWM strategies reduce the volume of runoff discharged to receiving systems by every storm event.
- Less volume and lower flow rates decrease stream scour and erosion.
- Less volume inherently results in less nutrient, sediment and pollutant loading.

Capable of managing/treating entire volume of smaller storms and first flush of large storms

Focus On Smaller Storms / First Flush

- Majority of annual rainfall result of small, frequent events.
- Capture and retain 1" rainfall will fully manage ~50% of total annual runoff volume.
- Capture and retain WQ event (1.25"-2 hrs.) fully manage 93% of total annual runoff volume.



“Think Small For Big Results”

- Catch Basin Retrofits
- Tree Boxes
- Manufactured treatment devices
- Rain storage / beneficial reuse systems (rain barrels)
- Rain gardens
- Conversion of conventional detention basins into bio-retention and bio-infiltration basins

All MS4 Type Projects

Catch Basin Retrofits – Eco-grates

Effective retrofit to limit litter, floatables, leaves, etc.

Frankford Township /Culver Lake Catch Basin Retrofits

Flex Storm Catch Basin Inserts

Stainless steel frame adaptable to various size catch basins…

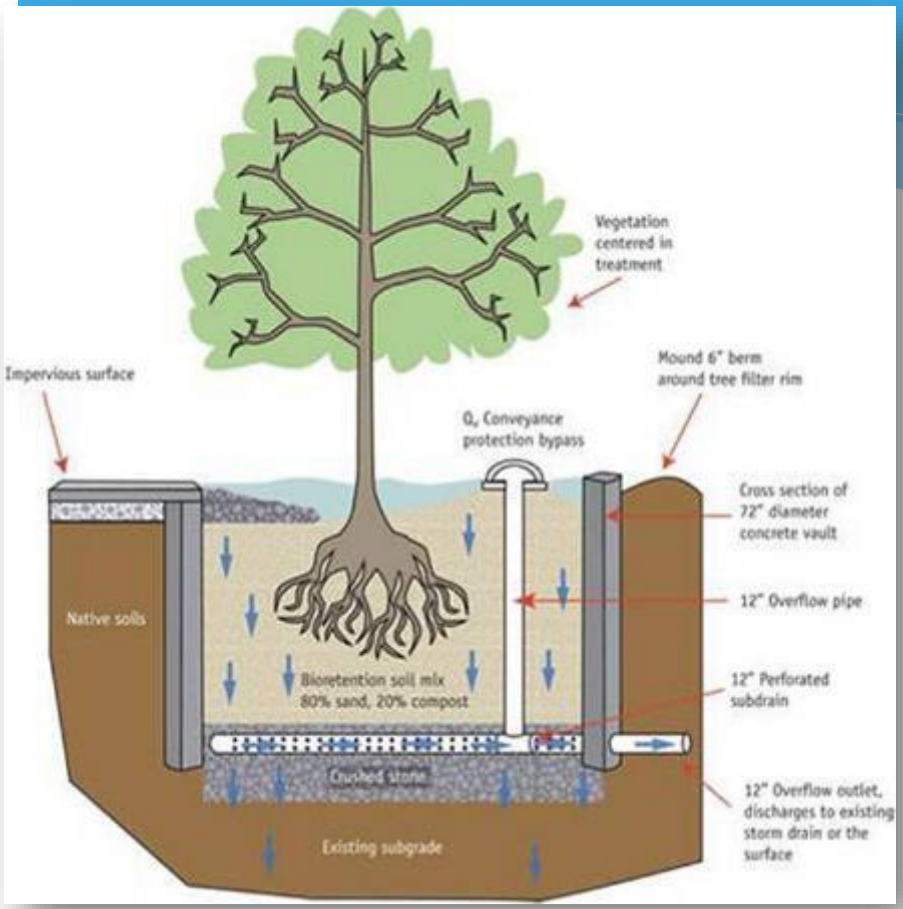
Filter removes sediment, leaf litter, and other particulates

Treats runoff generated by 1-yr event and 1st flush of larger storms

Capable of 99% TSS removal @ flow rate of 137 GPM/Ft^2

Filter bag capacity 5-6 Ft^3

Filterra Tree Boxes



Source: University of New Hampshire, Stormwater Center. 2009 Biannual Report

Toms River High School North

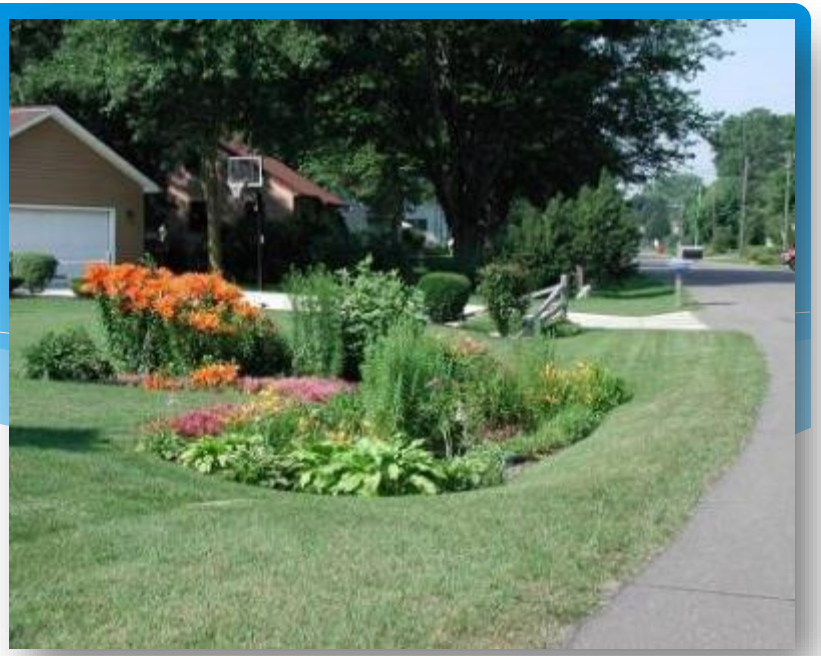
Asbury Park Small-Scale MTD

Rain Barrels

- Good kickoff project for community involvement.
- “Gateway drug” for bigger and better SW Mgmt. techniques.
- Scalable from 50 – 100,000 gal
- Beneficial reuse e.g. landscape irrigation, fire suppression

Photos Source – Rutgers Agricultural Extension Service

Rain Gardens



Scalable – From single home to regional basins

Sizing and Construction Guidance

http://water.rutgers.edu/Green_Infrastructure_Guidance_Manual/2015-03-31_Manual.compressed.pdf

There's An App for That!

UCONN Rain Garden App

- Everything you need in the "palm of your hand"
  - Soil drainage maps
  - RG size calculator
  - Installation guidance
  - Plant selection assistance
- Video tutorials
- Maintenance recommendations

Community Rain Garden – Asbury Park

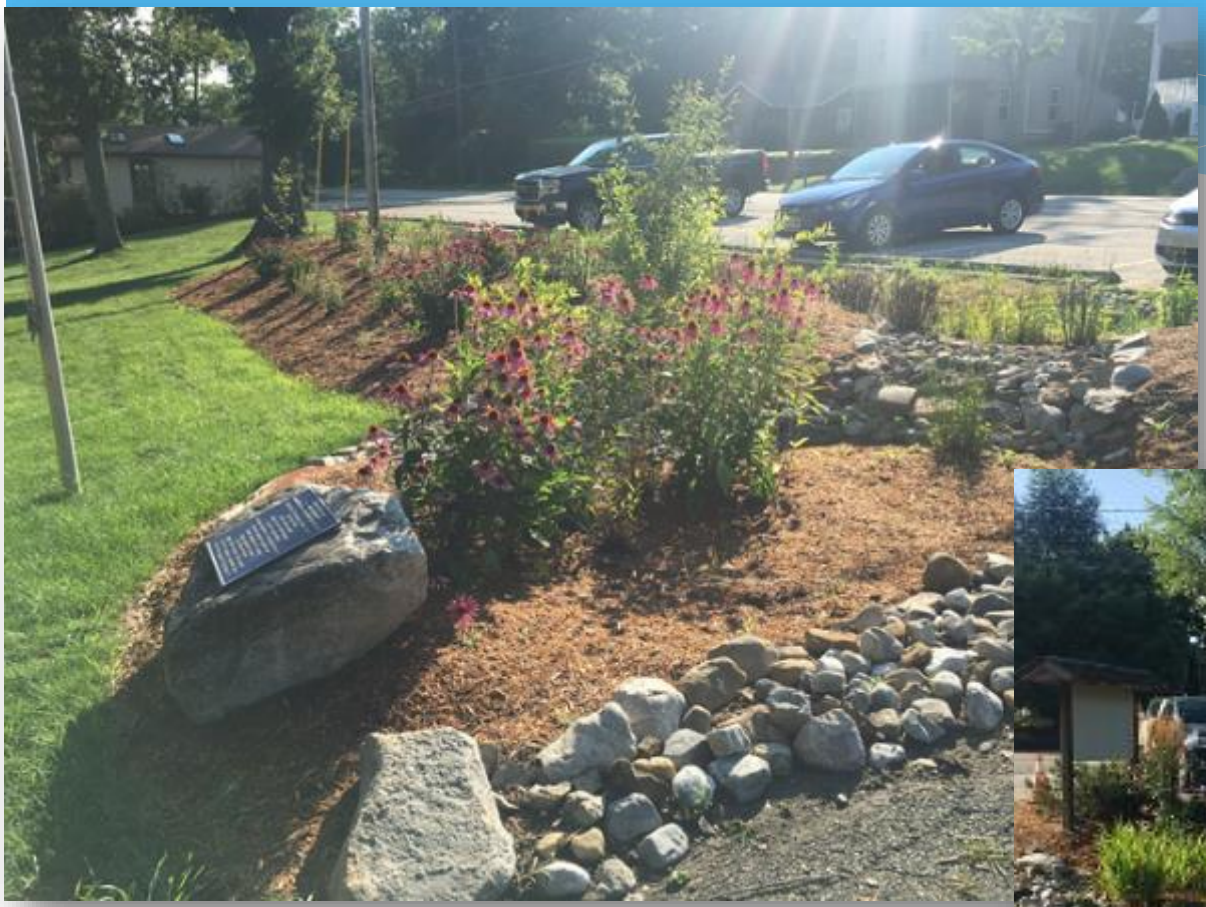
Asbury Park Bus Station

High Profile Location

Converted Conventional Detention Basin into Functioning Bioretention Basin

Culver Lake Community Rain Garden

Culver Lake Community Rain Garden



Ocean Township Curbside Rain Garden – DLC/DLWA Project

East Amwell - Retrofit Conventional Detention Basin Into Bioretention Basin

"Show Me The Money" Potential Sources of Funding

- NJDEP 2023 Municipal Stormwater Assistance Grants Program ($19 million total) for MS4 compliance ($25,000 for original Tier As and $75,000 for original Tier Bs.
- 319(h) grants – Funds various GI SW projects and WIP preparation
- NJ Water Bank - low interest loans for SW improvements: www.njib.gov/njeit
- Highlands Council Planning Grants
- Stormwater Utilities – https://dep.nj.gov/njpdes-stormwater/swu_stormwaterutility/ (legislation passed in 2019)
- FEMA grant opportunities: https://www.fema.gov/grants
- National Fish and Wildlife Foundation - www.nfwf.org/apply-grant
- ANJEC grants for open space stewardship projects

ANJEC Knows MS4

- Check out - Understanding the New MS4 Permit: A Primer for New Jersey Municipalities
- ANJEC brochures, fact sheets, etc. on municipal stormwater management initiatives including model stormwater ordinances and (coming soon) Homeowner's Stormwater Checklist.
- A MS4 permit requires updated tree removal/ replacement ordinance (adoption date 1 May 2024)… go to ANJEC for fact sheets and sample municipal ordnance.

ANJEC Knows MS4

- Information and resources on management of shade tree and establishment of urban forests:
  - Urban & Community Forestry Program
  - NJ Community Forestry Council
  - New Jersey Shade Tree and Urban Forestry Act
- ANJEC supports passage of NJDEP's REAL rules and other state-wide initiatives pertaining to MS4 compliance, stormwater permitting, flood protection/resiliency and proactive protection and improvement of the quality of all the State's waters.

Use MS4 To Take the Bite Out of Stormwater Runoff!

Thank You… Questions

Stephen J. Souza, Ph.D.

Clean Waters Consulting, LLC
Ringoes, NJ 08551
SJSouza.CWC@gmail.com

CWC