



**Providence
Stormwater
Innovation
Center**



**Audubon Society
of Rhode Island**





Thanks to our Funders

- City of Providence
- Restore America's Estuaries SNEP program
- Rhode Island Foundation
- Audubon Society of Rhode Island
- The Nature Conservancy
- SNEP Network



Water Quality Monitoring and Analysis



Training and Curriculum Development



Natural Infrastructure Design Innovation

Training and Curriculum Development

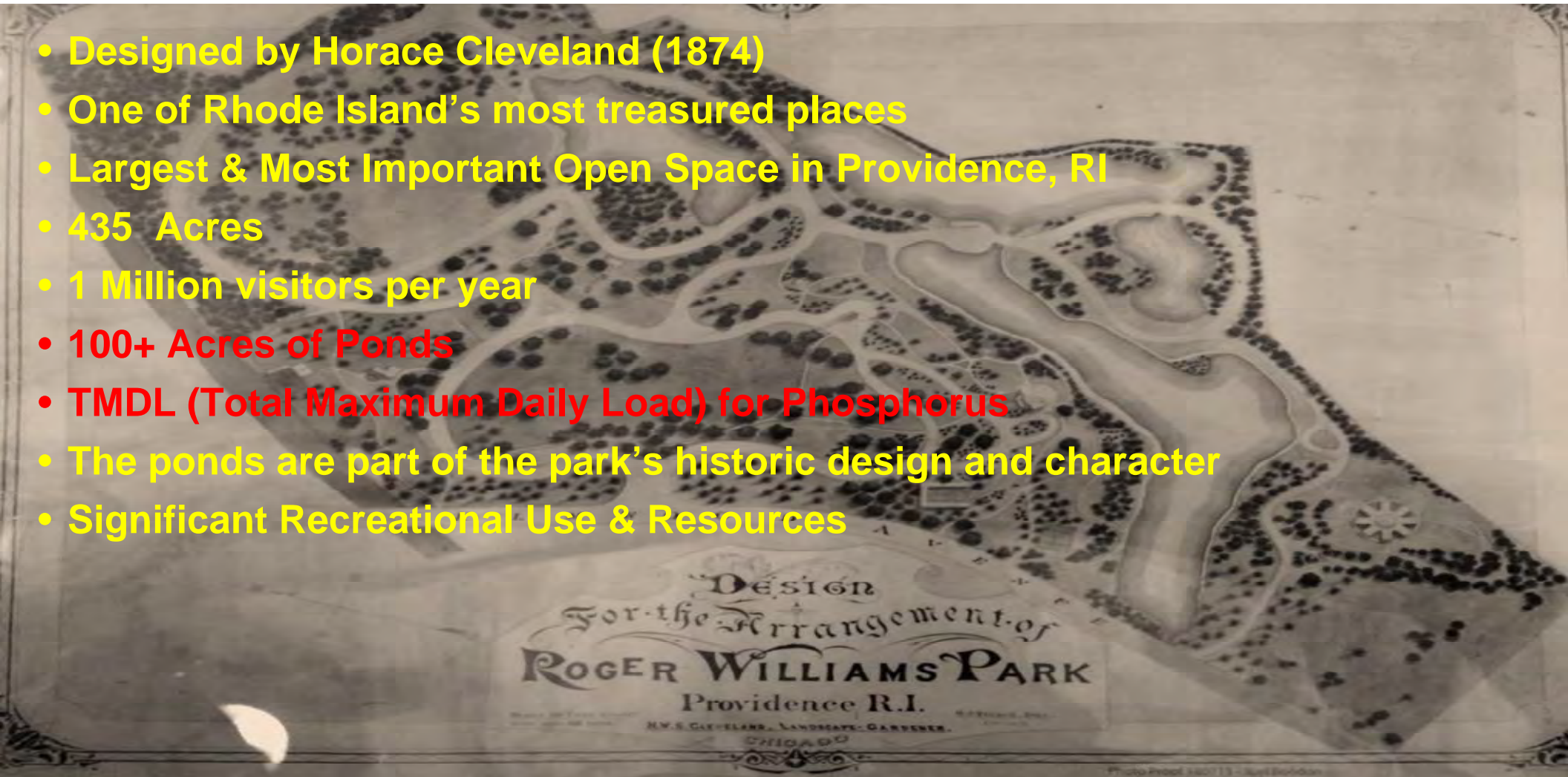


Natural Infrastructure Design Innovation



ROGER WILLIAMS PARK

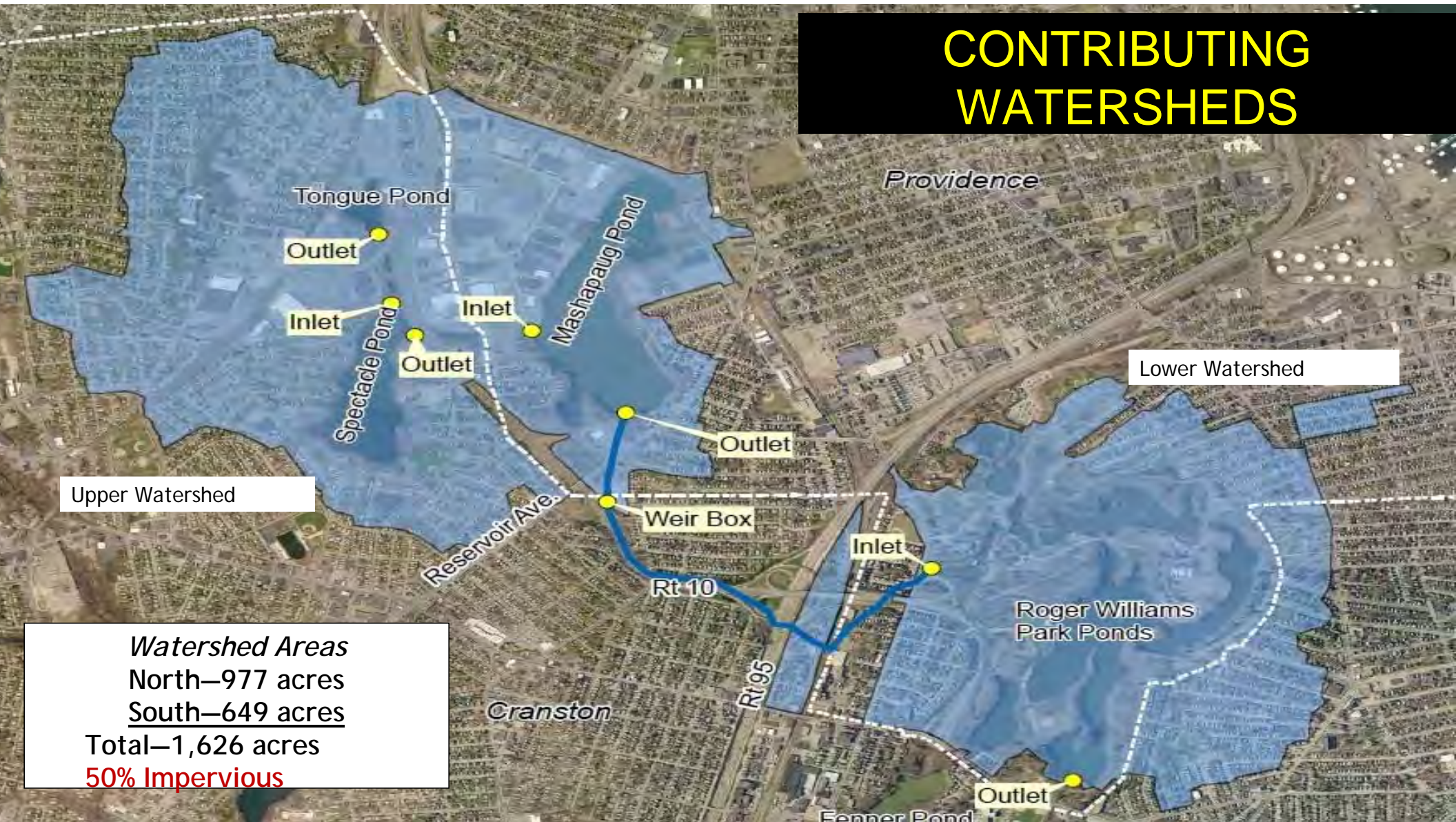
- Designed by Horace Cleveland (1874)
- One of Rhode Island's most treasured places
- Largest & Most Important Open Space in Providence, RI
- 435 Acres
- 1 Million visitors per year
- 100+ Acres of Ponds
- TMDL (Total Maximum Daily Load) for Phosphorus
- The ponds are part of the park's historic design and character
- Significant Recreational Use & Resources



Pawtuxet River watershed



CONTRIBUTING WATERSHEDS



Poor Water Quality - Cyanobacteria



City of Providence and RIDEM Execute Consent Agreement

Providence Forced to Invest in Stormwater System

March 09, 2017/ Jo Detz **By ecoRI News staff**

PROVIDENCE — *Mayor Jorge Elorza recently signed an agreement with the Rhode Island Department of Environmental Management (DEM) to bring the city's stormwater management system into compliance with its Municipal Separate Storm Sewer System permit.*

- ▶ Signed following a Notice of Violation issued by RIDEM with penalties of \$25,000 per day
- ▶ City has seven (7) years to come into compliance with the EPA's Clean Water Act
- ▶ Items included in the agreement
 - ▶ Mapping of all 12,000 catch basins and piping
 - ▶ Increased Efforts related to Stormwater Management
 - ▶ Increased Public Engagement Around Stormwater Prevention
 - ▶ Implementation of Green Infrastructure Projects in Roger Williams Park

Parks Department Capital Projects 2018-2019

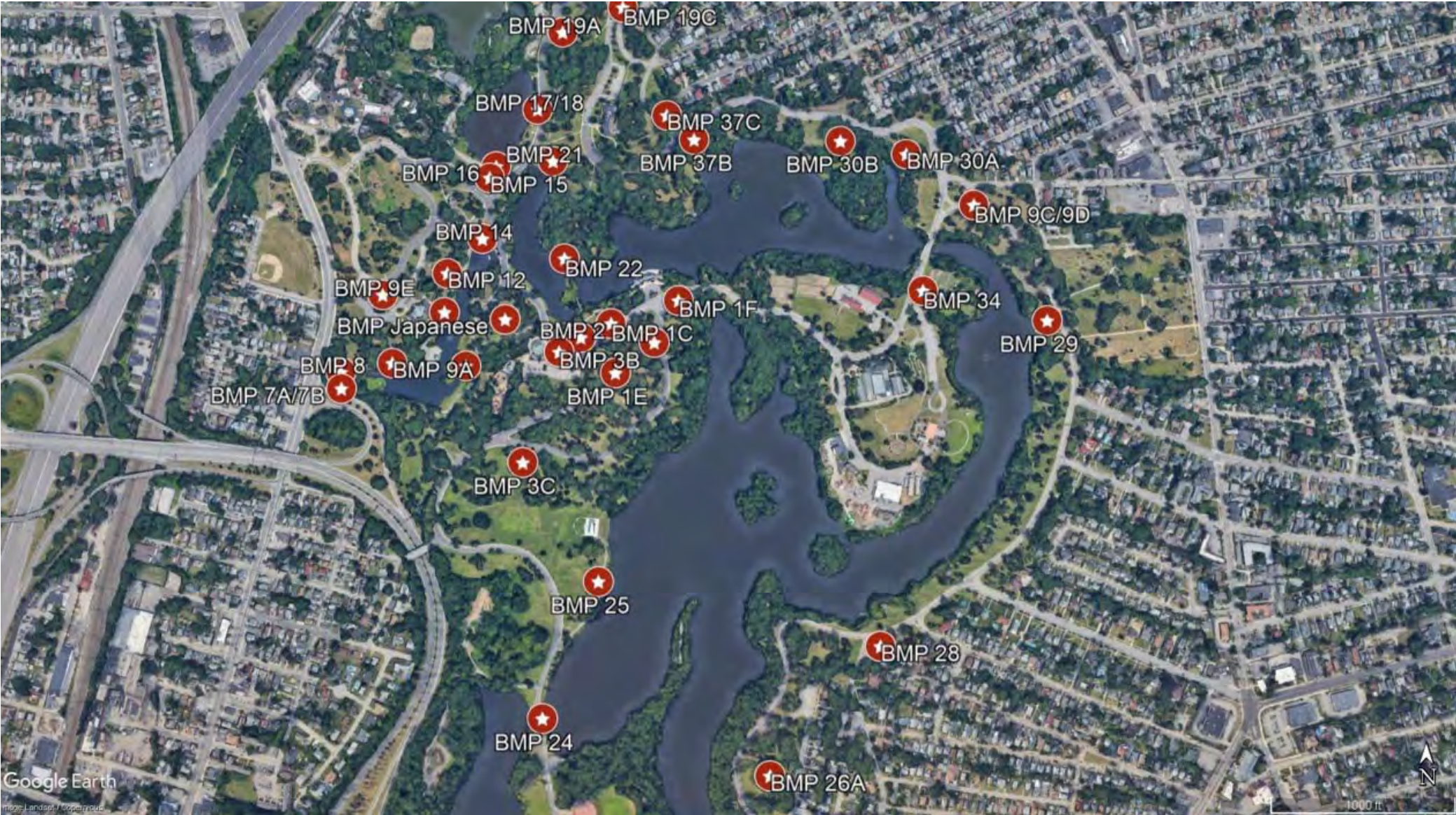
DEM Consent Agreement - 2016 - City of Providence - RIPDES RIR040005					
ATTACHMENT TO: CONSENT AGREEMENT; SECTION (C) AGREEMENT; ITEM (4); SUBSECTION (a); ITEM (III) 1					
Roger Williams Park Ponds, Water Quality Management Plan (Horsley Witten Group, June 2013)					
Proposed Projects in Roger Williams Park					
SITE I.D.	LOCATION	DESCRIPTION	Status / Schedule	Budget	Current
RWP-3B	Carousel Parking Lot	Construct bioretention at entrance of parking lot for half of the parking lot runoff; overflow into existing closed drainage system	Complete	\$18,000.00	\$18,000.00
RWP-17/18	F.C. Greene Memorial Blvd.	Create paved flume/inlet structure direct road runoff to wet swale modify box culvert to create diversion structure; runoff to bioretention swale	Complete	\$149,000.00	\$149,000.00
RWP-24	F.C. Greene Mem. Blvd. Between Cunliff and Deep Spring Lakes	Increase buffer vegetation and reduce road width/impervious surface; remove curb, add vegetated swale in buffer to catch water before it overfalls through existing spillway	Complete	\$162,000.00	\$162,000.00
RWP-28	Intersection of Edgewood, Beachmont and F.C. Greene Memorial Blvd.	Remove pavement and add sand filter; install paved flumes and forebays prior to main sand filter cell, design overflow structure to connect to existing pipe outfall into the lake	Complete	\$112,000.00	\$112,000.00
RWP-6	Roosevelt Lake Across from Monument	Pavement removal; rain gardens and buffer restoration	Complete	\$300,000.00	\$300,000.00
RWP- 1G	Shoreline Near Boathouse	Re-vegetate buffer area with low-growing grasses & shrubs	Complete	\$9,000.00	\$9,000.00
RWP-26	Ballfield Erosion	Fine grading, stabilization, erosion control and seeding; swale	Complete	\$9,500.00	\$9,500.00
RWP-10	Casino Hillside Erosion	Buffer Planting & Re-Seeding	Complete	\$3,300.00	\$3,300.00
RWP-4	F.C. Greene Mem. Blvd -East of Japanese Garden	Buffer Planting & Re-Seeding	Partially Complete 2018	\$5,000.00	\$5,000.00

Parks Department Capital Projects 2018-2019 (2)

RWP-23	F.C. Greene Memorial Blvd. by Temple of Music	Curb Removal only and areas of no-mow meadows	Curbing Complete Plantings Pending	\$19,500.00	\$19,500.00
RWP-12	Ornamental Bridge North of Casino	Diversions structure into a terraced bioretention under the bridge	Complete 2017	\$159,000.00	\$159,000.00
RWP-19A	Outfall at Polo Lake-Museum	Terraced Bioswale	FY2018	\$103,000.00	
RWP-2	Road by Carousel	Plant native material; augment soils and convert low area at yard drain to rain garden; shoreline buffer planting	FY2018	\$18,600.00	
RWP-8	Island @ Elmwood Entrance	Fine grading, stabilization, erosion control and seeding; rain garden	FY2018	\$21,000.00	
RWP-9A	Hillside Erosion South of Casino	Fine grading, stabilization, erosion control and seeding; pathway removal	FY2018	\$17,000.00	
RWP-22	Path Intersection by Willow & Pleasure Lakes	Fine grading, stabilization, erosion control and seeding; knotweed removal	FY2018	\$15,000.00	
RWP-1A	Pine Hill Ave	Bioretention Area	Complete	\$14,000.00	\$14,000.00
RWP-1B	Pine Hill & Maple	Bioretention Area	FY2018	\$16,000.00	
RWP-1E	Maple Ave	Dryswale	FY2018	\$21,500.00	
RWP-26A	F.C. Greene Mem. Blvd Ballfield	WVTS	Complete	\$6,500.00	\$6,500.00
RWP-26B	F.C. Greene Mem. Blvd Ballfield	WVTS	FY2018	\$9,500.00	
RWP-37A	History Museum Lot	Dry Swale	FY2018	\$7,000.00	
RWP-37B	History Museum Memorial Blvd.	Terraced Bioswale	FY2018	\$60,000.00	
RWP-37C	History Museum Babcock Street	Bioretention Area	FY2018	\$50,000.00	
RWP 16	Hillside Near Polo Lake	Plant with native, low growing grasses and shrubs to stabilize and	FY2019	\$19,000.00	

Parks Department Capital Projects 2018-2019 (3)

RWP-25	Temple of Music Access Rd	Bank clearing; fine grading; stabilization; erosion control; planting & re-seeding	FY 2019	\$87,000.00	
RWP-11	Hillside Erosion East of Casino	Fine grading, stabilization, erosion control and seeding; Buffer Planting	FY 2019	\$12,000.00	
RWP-21	Hillside Erosion Near Pleasure Lake	Fine grading, stabilization, erosion control and seeding; planting	FY 2019	\$25,000.00	
RWP-3C	Carousel Parking Lot	Bioretention Area	FY 2019	\$23,500.00	
RWP-9C/9D	Casino Parking Lot	Bioretention Area	FY 2019	\$22,500.00	
RWP-9E	Casino Entrance	Bioretention Area	FY 2019	\$9,000.00	
RWP-19B	Outfall at Polo Lake-Tennis	Dry Swale	Complete	\$92,000.00	\$92,000.00
RWP-34	Botanical Center/Stables	Bioretention Area	FY 2019	\$130,000.00	
RWP-22	Path Intersection by Willow & Pleasure Lakes	Re-vegetate erosion near stairs; replant area of recent storm damage / tree removal; remove area of Japanese knotweed	Duplicate	\$18,800.00	\$18,800.00
RWP-16	Hillside South of Polo Lake	Fine grading, stabilization, erosion control and seeding; buffer planting	Duplicate	\$19,000.00	\$19,000.00
RWP-1F	Cladrastris Ave Intersection	Bioretention Area	FY 2020	\$8,500.00	
RWP-7A	Rt 10 Off-Ramp	Infiltration Basin / Dry Swale	Ongoing - RIDOT	\$14,000.00	\$14,000.00
RWP-7B	Outfall at Roosevelt Lake	From Route 10 WVTS	Ongoing - RIDOT	\$11,000.00	\$11,000.00
RWP-19C	Miller Ave	Bioretention Area	FY 2020	\$115,000.00	
RWP-29	Oakland Cemetery and Wentworth Ave.	Terraced/Shallow Bioretention	FY 2020	\$85,000.00	
RWP-30A	Marion Ave & F.C. Greene	Terraced Bioswale	FY 2020	\$203,000.00	
RWP-1C	Cladrastris Ave - Boathouse	Dryswale	FY 2021	\$18,500.00	
RWP-20	Willow Lake - Near Bridge	Buffer Planting & Re-Seeding	Complete	\$3,900.00	\$3,900.00
RWP-14	North of Roosevelt Lake	Shallow Bioretention	FY 2021	\$17,700.00	
RWP-15	Polo Lake Near Rotary	Terraced Bioswale	FY 2021	\$67,500.00	
RWP-30B	Marion Ave & F.C. Greene	WVTS	FY 2021	\$215,000.00	
do not reflect actual project costs - construction costs will vary				Budget	Completed
be revisions and are working with consultants to formalize pricing				Totals:	\$2,818,400.00 \$1,121,400.00
of P-N from RWPP Report Page E-7; Table E.5				Balance to Complete:	\$1,697,000.00



SITE 3-BIORETENTION



Roger Williams Park Carousel infiltration area

- installed 2012



Roosevelt Lake road removal: 2013





2012

393 ft

Roosevelt Lake road removal: 2013





2017

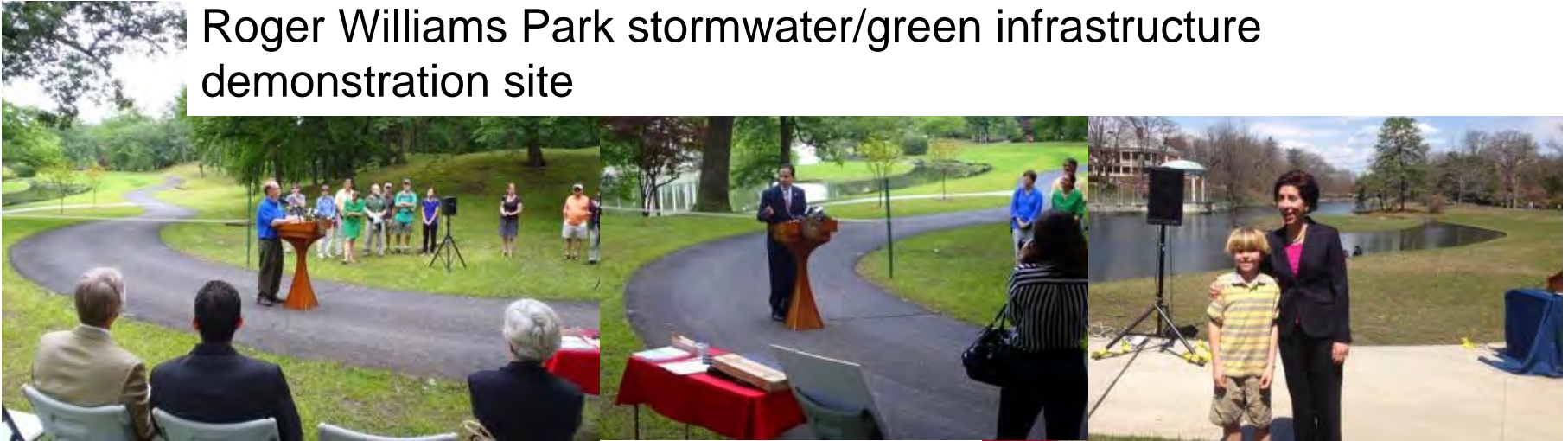
Roosevelt Lake buffer planting



Roosevelt Lake wet meadow



Roger Williams Park stormwater/green infrastructure demonstration site

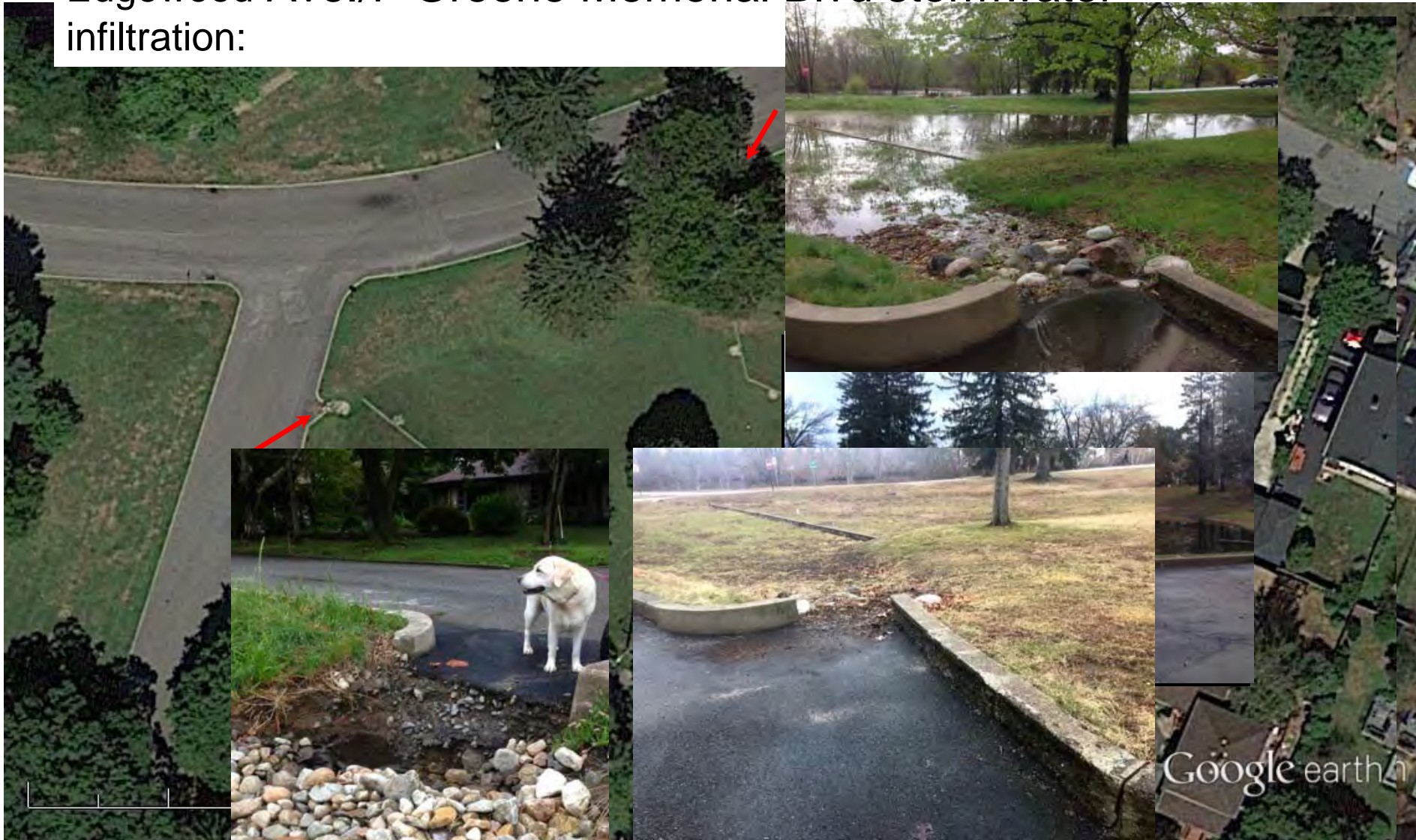


2013



2015

Edgewood Ave./F Greene Memorial Blvd stormwater infiltration:



SITE 17/18-WET SWALE

Stormwater
Pretreatment

Buffer Restoration



Polo Lake stormwater infiltration: 2013





Polo Lake wetland/buffer planting: 2013



August 2015



LESSONS LEARNED



LESSONS LEARNED



SITE 24

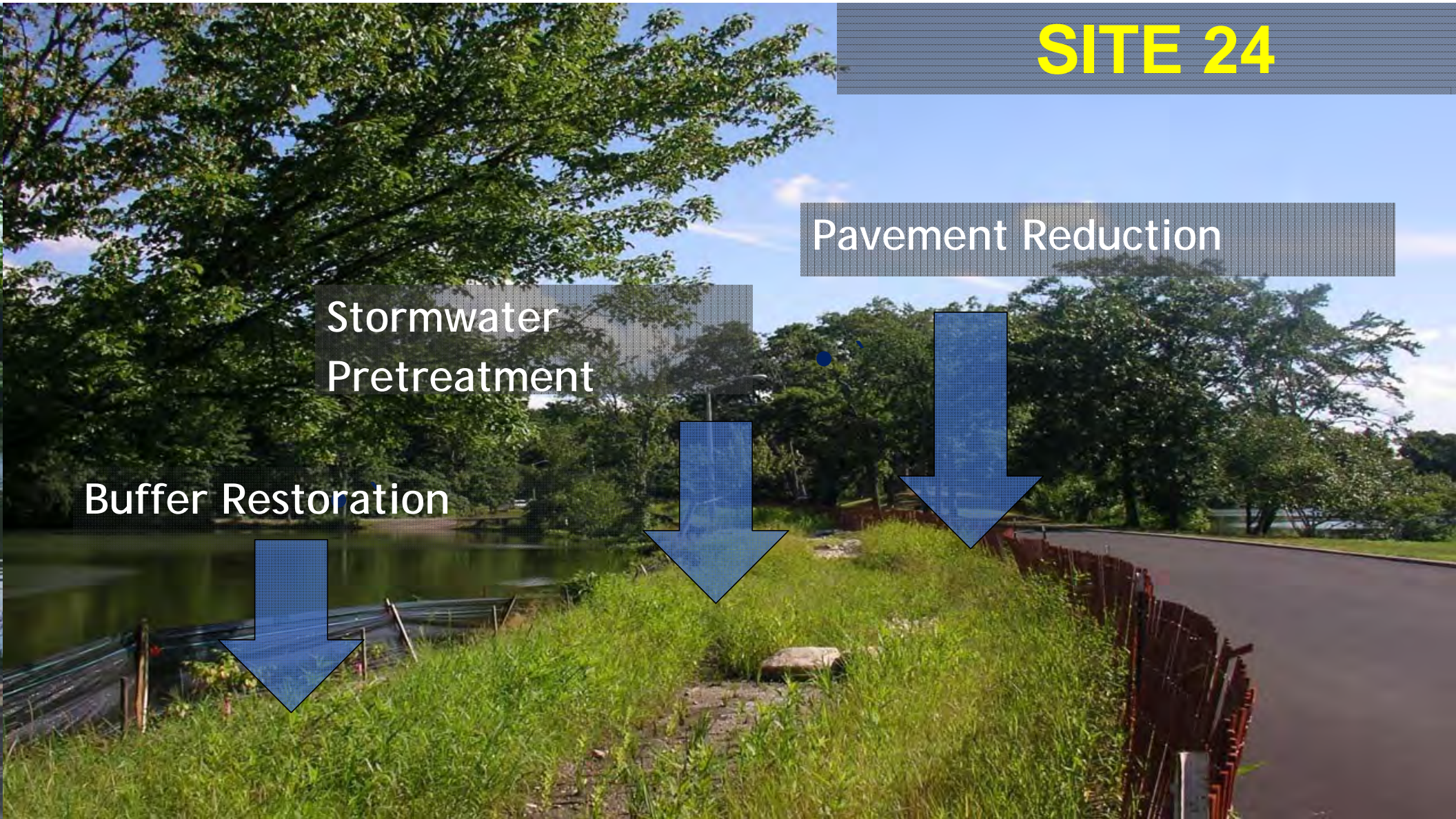


SITE 24

Pavement Reduction

Stormwater
Pretreatment

Buffer Restoration



LESSONS LEARNED



System Malfunction – Berm Elevation



Over Compaction

- Control Access
- Review Materials
- Repair
- Re-establish Proper Elevation for Water Direction

SITE 12

08.24.2016 10:07



SITE 12

08.24.2016 09:05



Breach in System Boulder Wall

Construction Practice

- Boulder Walls Need to be
Set Higher in Terrace
- Mortar or Fill Voids in Boulder
Walls
- Confirm Overflow is Lower
Than Boulder Wall



Additional Stormwater Elements

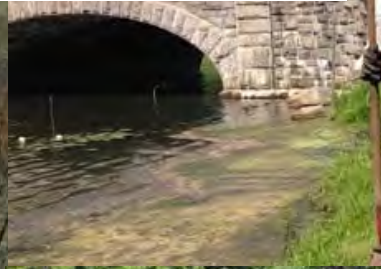
- Geese Control – Egg Addling – US Department of Agriculture
- Downspout Disconnection Program - Pavers
- Lawn Signs for ‘Stormwater Heroes’
- Rain Barrel Sale / Giveaway (DPW)
- Algae Water Treatments - \$18k Per Year
- Street Sweeping & Catch Basin Cleaning
- Street Scuppers on Roadway Projects



Roger Williams Park stormwater infiltration: green curbs



Willow Lake buffer planting/no mow area



Design Challenges at Roger Williams Park - Visitors

**Creating Places People Can Enjoy and
Still Make Room for Green
Infrastructure**

- Lessons Learned – Temple to Music
 - Impact of Installation on Events
 - Difficult to Control Behavior
 - Result – Element not Functioning
 - Victims of Our Own Success
 - Increased Activity Day and Night



Design Options - Economics

Re-Purposing Materials

- Element of Value Engineering
 - Creating Weir Structures
 - Used Granite or Pre-Cast Curbing
 - Base Materials
 - Recycled asphalt
 - Fire Wood (Forestry Operations)
 - Water Bars and Retaining Structures
 - Appalachian Mtn. Club Guide
 - Used Brick and Cobblestones
 - Swales
 - What is the Next Great Idea?
 - Tires, Trash or Mattresses



Perception and Impact on Activities

Element/Benefit

Shoreline Plantings

Discourages Geese

Selective Mowing on Hillsides

Filters Water & Prevents Erosion

Rain Gardens

Water Filtration

Aerating Fountains

Water Movement & Oxygen

Pavement Removal

Decreases Impermeable Area

Perception/Impact

Shoreline Plantings

Aggravates Fisherman

Selective Mowing on Hillsides

Not Doing Our Job – Golf Course Mentality

Rain Gardens

Love the Flowers – but Tics and Rodents

Aerating Fountains

Activates Park (Lit at Night) - Leak

Pavement Removal

Less Parking Spots

Maintenance Challenges

- **Funding**

- Staffing to Maintain (42) Stormwater Sites with Budgets Cuts Etc.
- Huge Task for the Parks Department
- Outsourcing Needs Commitment – Funding

- **Education**

- Schools
- Adult Education Classes
- Adult Job Training
- Apprenticeship Programs



Design With Maintenance In Mind

- Use native plants that will not only flourish but will be easily identified by maintenance personnel
- Cost effective designs.
- Landscape material that does not require yearly installation - mulch
- Forebays that are accessible and are easy to be clean out – ‘Drive By’
- Design GI systems based on what funding you will have for future maintenance.
- Always design the structure for who will be maintaining it.

Maintenance Issues - Accessibility

- Proximity to Roadway

- Sediment Removal
 - Large Basin
- Slopes
- Access To All Areas
- 'In Water' Access
- Equipment Capabilities
- Design for Staff and Machinery



Maintenance Issues - Training

- Experience of Crews

- Equipment Operation
 - Training
 - Plant Identification

- Experience of Management

- Landscape Architect
 - Botanical Center Manager
 - Training

- Willingness to Adapt



Maintenance Issues - Funding

- Much More Expensive Than Traditional Catch Basins
- Labor Intensive = More Staff
- Commitment from City to Make Clean Water a Priority
- Compliance with the MS4 Permit and the Clean Water Act



Maintenance – Training - Plans



Roger Williams Park - Providence, RI
Site 12 – Terraced Bioretention
Operation and Maintenance Checklist

Date:
Time:
Inspector:

Maintenance Item	Description	Maintenance Required? (Y/N)
1. Drainage Structures: Includes: Manholes/Diversion Structures/Water Quality Units and Outlets Inspect annually and after major storm events (2" of rain or greater)		
Debris	Remove all trash, leaf litter and debris.	
Manholes/Diversion Structures/Outlets	Check for sediment accumulation that impacts inflow. If sediment accumulation. <u>Schedule cleaning.</u> Check for leaf litter and inlet clogging and clear.	
ADS Water Quality Unit	<u>Per manufacturers recommendations.</u> See Appendix D of O&M manual.	
Drainage Network	Check contributing and associated catch basins, manholes and pipes for sedimentation/clogging	
2. Bioretention Inlet Inspect annually and after major storm events (2" of rain or greater)		
Debris	Remove all trash and debris from the swale and forebay.	
Sediment/Organic Debris Removal	Check for sediment accumulation. Remove sediment as necessary	
Vegetation Maintenance	Check to ensure vegetation is not blocking the inlet. Prune/thin vegetation as necessary. Remove undesirable woody vegetation and weeds.	
3. Bioretention System Inspect at least bi-annually and after major storm events the first year; then annually and after major storm events (2" of rain or greater)		
Debris	Remove all trash and debris from the surface of the bioretention system.	
Side Slopes	Check for signs of erosion gullies, animal burrowing, or slumping. Repair as necessary.	
Sediment	Check for sediment accumulation that impacts infiltration. <u>Remove</u> any sediment accumulation and properly dispose.	

1 of 2

Maintenance Item	Description	Maintenance Required? (Y/N)
Vegetation Maintenance / Replacement	Check for erosion and signs of scouring. Remove and replace ill-established, dead or severely diseased plants annually. Remove undesirable woody vegetation and weeds. See Sheet LA-1 of Construction Plans for appropriate species. Grasses should be cut back annually in the spring.	
Overflow Structure	Check for sediment accumulation that impacts inflow. If sediment accumulation. <u>Schedule cleaning.</u> Check for leaf litter and inlet clogging.	
Water Draining properly	If standing water is observed in the bioretention area 48 hours after a storm event: Check cleanouts for underdrain clogging. See plans Aerate/Rototill the bottom 6 inches to breakup any hard-packed sediment, and replenished with mulch	
4. Boulder Walls Inspect annually and after major storm events (2" rain or greater)		
Boulder Walls	Check for wall settlement, areas of erosion or water seepage. Repair as necessary.	
5. Emergency Spillways Inspect annually and after major storm events (2" rain or greater)		
Emergency Spillways	Check for settling gully, erosion damage or settling. Repair as necessary and return to design grades.	
Overflow	Look for areas of erosion in the overflow swale between bioretention areas. Repair as necessary.	
6. Routine Grounds Maintenance Inspect annually or as needed.		
Debris	Remove trash from perimeter areas.	
Pavement Sweeping	Sweep roads minimum once a year after spring thaw.	
Contributing drainage area	Check for erosion/sediment sources from the surrounding area	

*Sediment shall be disposed of offsite in a pre-approved location.
Comments:

Action to be Taken:

2 of 2

Plants to be removed

Trees/shrubs

Cottonwood

Populus sp.



Pussy willow

Salix discolor



Willow

Salix sp.



Plants to be removed

Tulip Tree

Liriodendron tulipifera



Maple

Acer sp.



Staghorn

Sumac

Rhus typhina



Plants to be removed

Grassy

Common Reed

Phragmites australis



Herbaceous

Eastern Daisy Fleabane

Erigeron annuus



Pokeweed

Phytolacca Americana



Plants to be removed

Smartweed

Polygonum persicaria



Mugwort

Artemisia vulgaris



Perennial sowthistle

Sanctus arvensis



Plants to be removed

Vines

Bittersweet

Nightshade

Solanum dulcamara



Oriental

Bittersweet

Celastrus orbiculatus



Japanese
beach rose

Rosa multiflora



Sources:

Photos for

Maintenance Documentation

Greencities – Work Force



Awareness



Education - Schools and Public



8

Nature is at work here!

We're creating a healthy community! This site uses nature to clean dirty stormwater and reduce flooding.

www.greeninfrastructureri.org

What's happening here?



Clean

Uses plants and soil to filter out pollution.



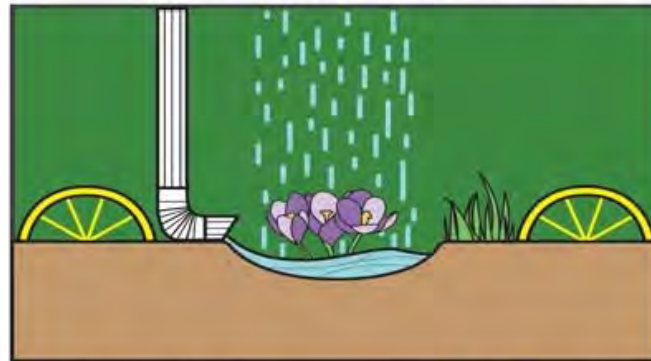
Protect

Absorbs rain and reduces flooding.



Economy

Reduces utility bills and creates local jobs.



Cool

Replaces hard surfaces that hold heat.



Wellness

Cleans our air and creates welcoming spaces.



Habitat

Attracts animals like butterflies, turtles and frogs.



William D'Abate Elementary Rain Garden

5th Graders here helped plant this rain garden to hold and clean rain water coming off of the school roof. Plants native to RI beautify the school while making food for butterflies. This garden will also help reduce flooding in the Woonasquatucket River at Riverside Park.



H

Signage in Areas People Visit or Pass By



'Park'nerships That Work



MAYOR JORGE O. ELORZA
CITY OF PROVIDENCE



Horsley Witten Group
Sustainable Environmental Solutions



GROUNDWORK
Rhode Island



100 RHODE ISLAND
FOUNDATION
— 1916 - 2016 —



RHODE ISLAND
GREEN INFRASTRUCTURE
COALITION



Monitoring Plan



Types of monitoring:

- Water Quality
- Water Quantity
- Picture Posts
- Cyanobacteria
- Visual Inspection of BMPs



Water Quality

URI Watershed Watch Volunteer Monitoring Program



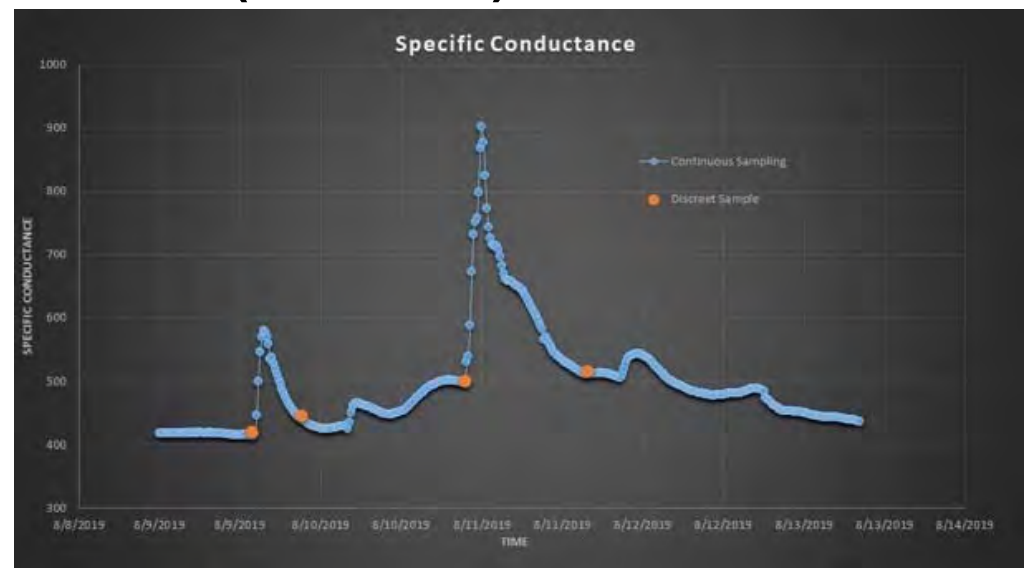
URI Watershed Watch Volunteer Monitoring Program

<u>PARAMETERS</u>	<u>FREQUENCY</u>
Dissolved Oxygen, Temperature	Weekly
Chlorophyll-a	Bi-Weekly
Nutrients, bacteria, alkalinity, pH	3 times per year



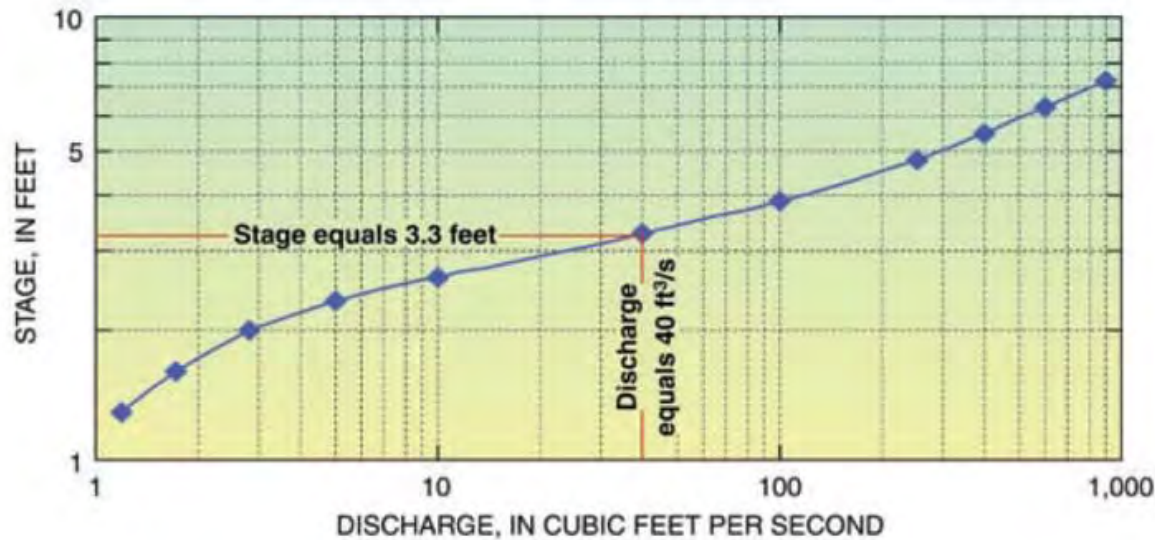
Continuous Water Quality Monitoring

- Data logged every 5 minutes (Inflow and Outflow)
- Nitrogen and Phosphorous (Spectro::Lyser)
- Temperature, Specific Conductance, pH, Dissolved Oxygen, Fluorescent dissolved organic matter (YSI-EXO2)



Water Quantity Monitoring

- Continuous Water Level and Streamflow monitoring (Inflow and Outflow)
- Precipitation Monitoring
- BMP Volume Monitoring



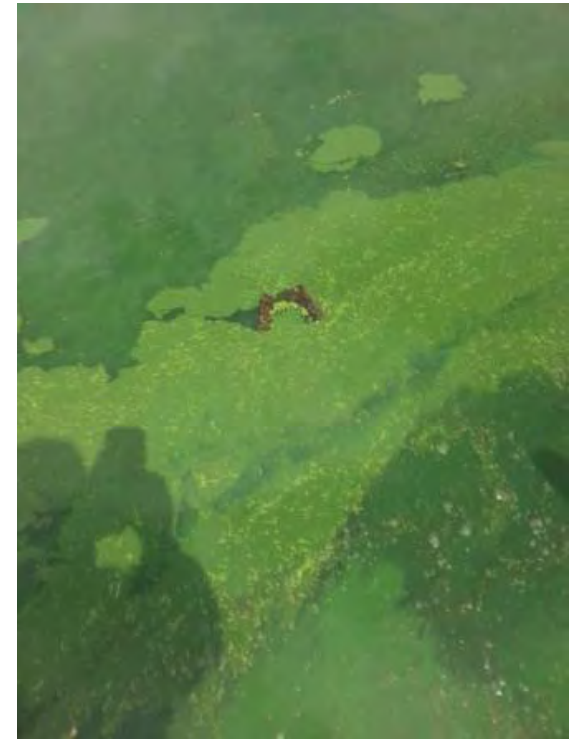
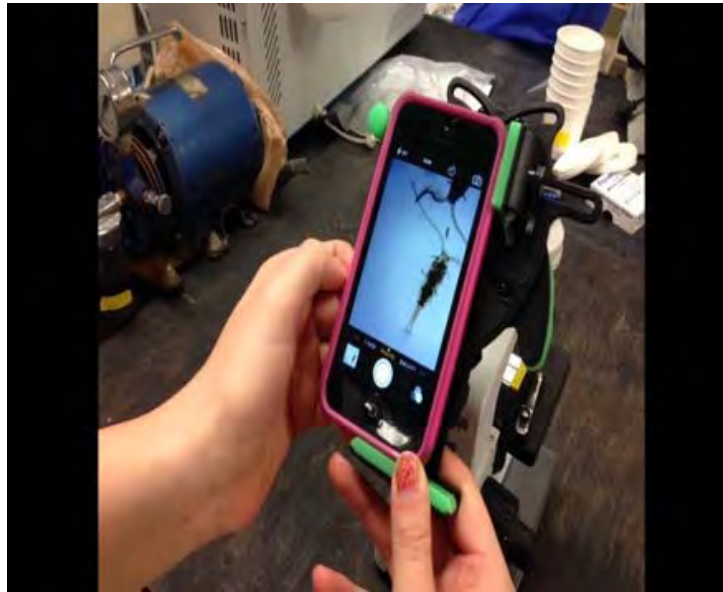
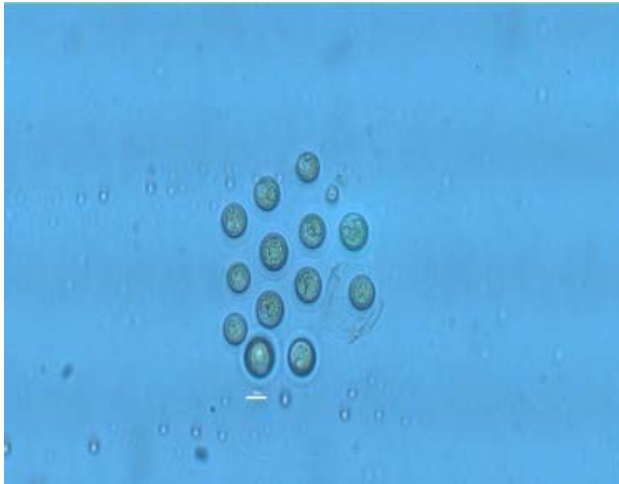
Picture Post Monitoring

- Community Involvement
- Document changes of BMPs over time
- Visually document timing of algal blooms



Cyanobacteria Monitoring

- Organize Volunteers to participate in Cyanobacteria Monitoring Collaborative
- Bloomwatch App
- Cyanoscope Training



Visual Inspections of BMPs

- Inlet and outlet are functioning
- Invasive plants
- Trash, debris, leaves
- Excessive sediment in forebay
- Water draining properly



DISCUSSION:

How could the Stormwater Innovation Center support your work?

[*www.stormwaterinnovation.org*](http://www.stormwaterinnovation.org)

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