A Nature-based Hybrid Green Infrastructure Solution For Reducing Phosphate Loads And Offsetting Microcystis Blooms In Prospect Park Lake, Brooklyn New York

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The City College of New York

QUEENS COLLEGE

CUNY ADVANCED SCIENCE RESEARCH CENTER

NOAA-CESSRST

CENTER FOR EARTH SYSTEM SCIENCES AND REMOTE SENSING TECHNOLOGIES

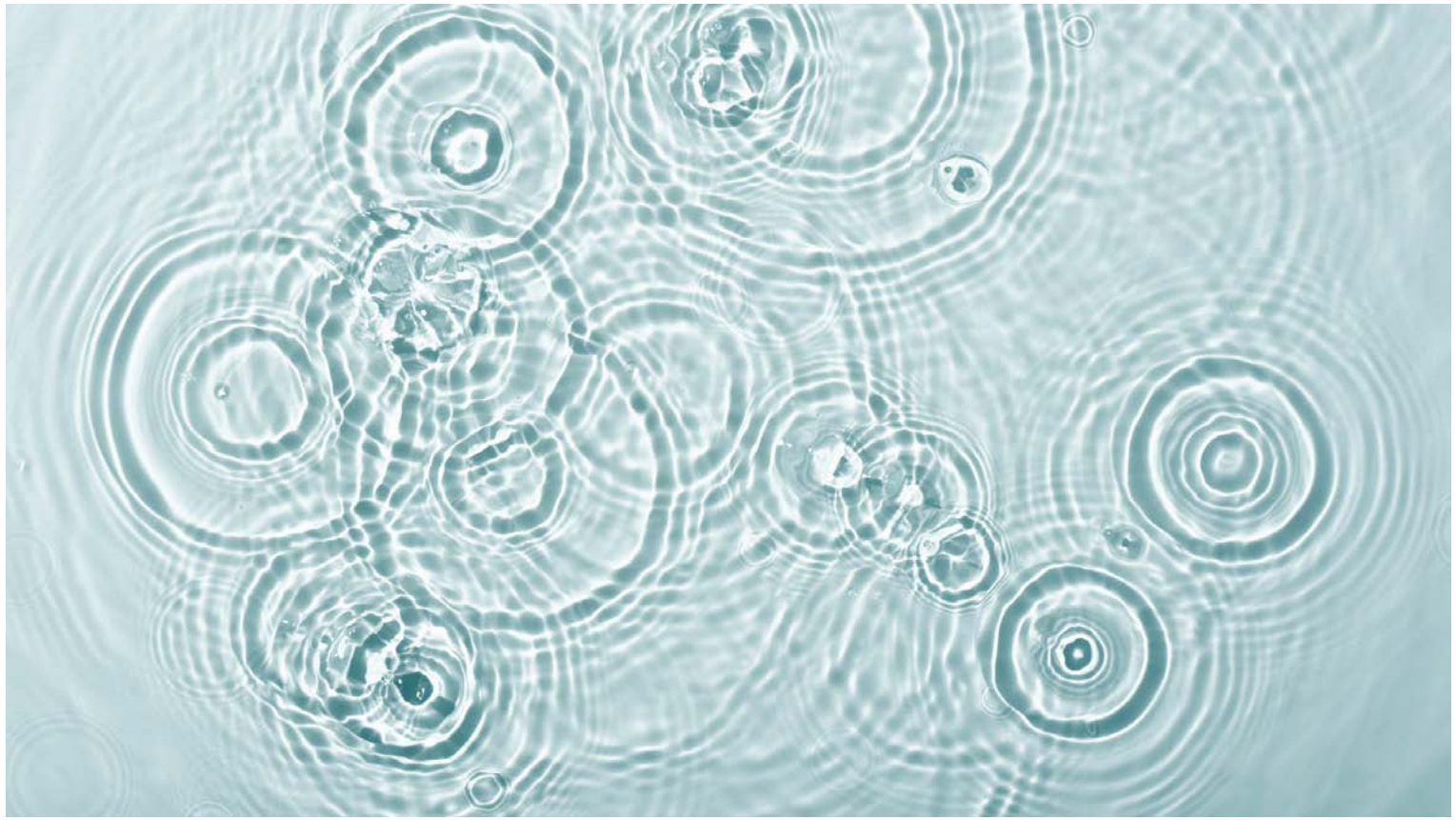
CUNY CREST

SCIENCE & TECHNOLOGY TO SUSTAIN THE EARTH

Brooklyn College

The City University of New York

WATER



INTEGRATED WATER RESOURCE MANAGEMENT

Holistic approach to planning and managing water supply, wastewater, and stormwater systems

Resiliency framework to monitor hard, natural, and nature-based shoreline features

Interdisciplinary research with Prof. Dianne Greenfield and Prof. Meghan Ference

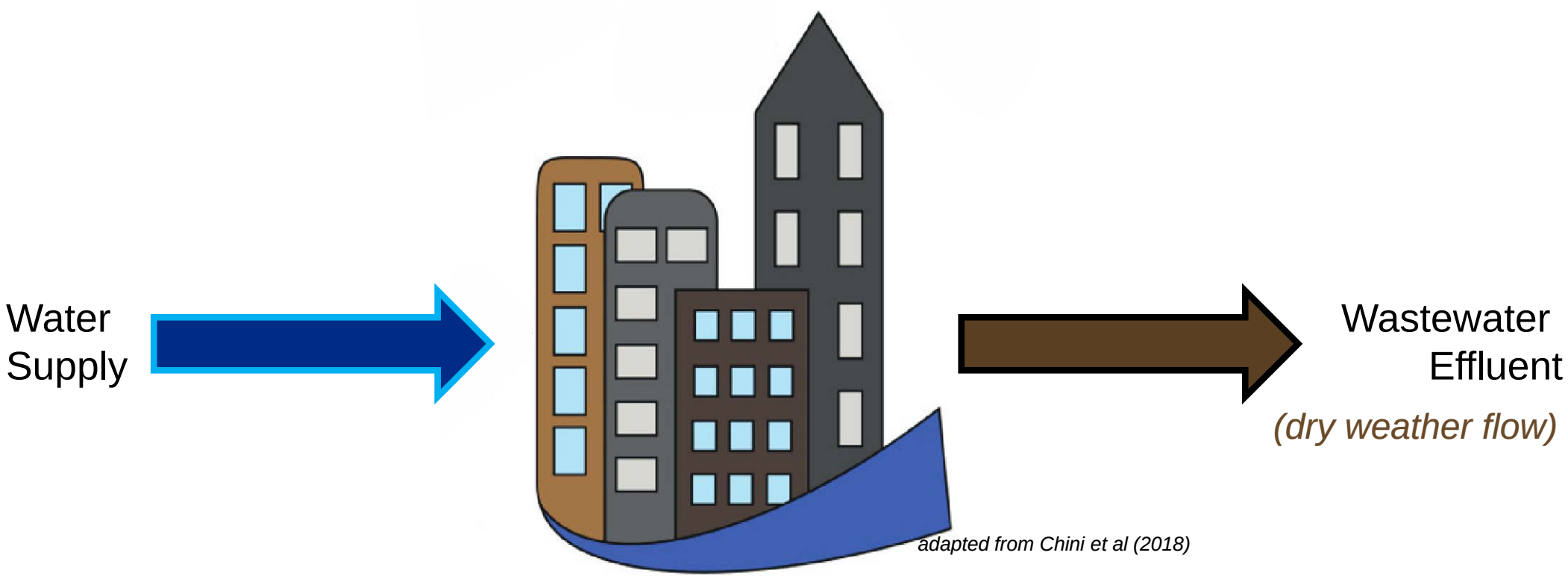
Storytelling tools

NEW YORK CITY WATER INFRASTRUCTURE

- Stormwater management
- Watershed
- Freshwater, estuarine, and coastal marine water

HOW DOES URBANIZATION ALTER WATER FLOWS?

Water Supply/ Wastewater Release

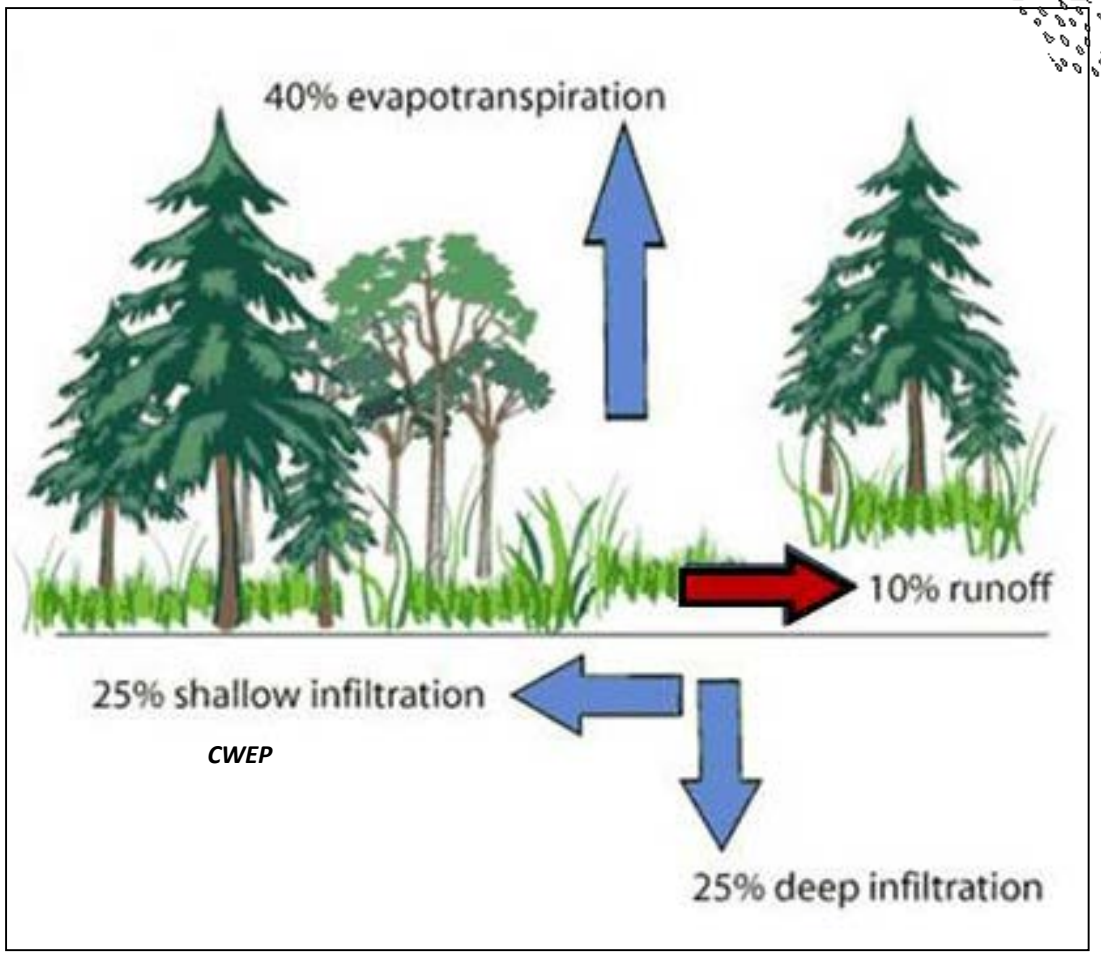


adapted from Chini et al (2018)

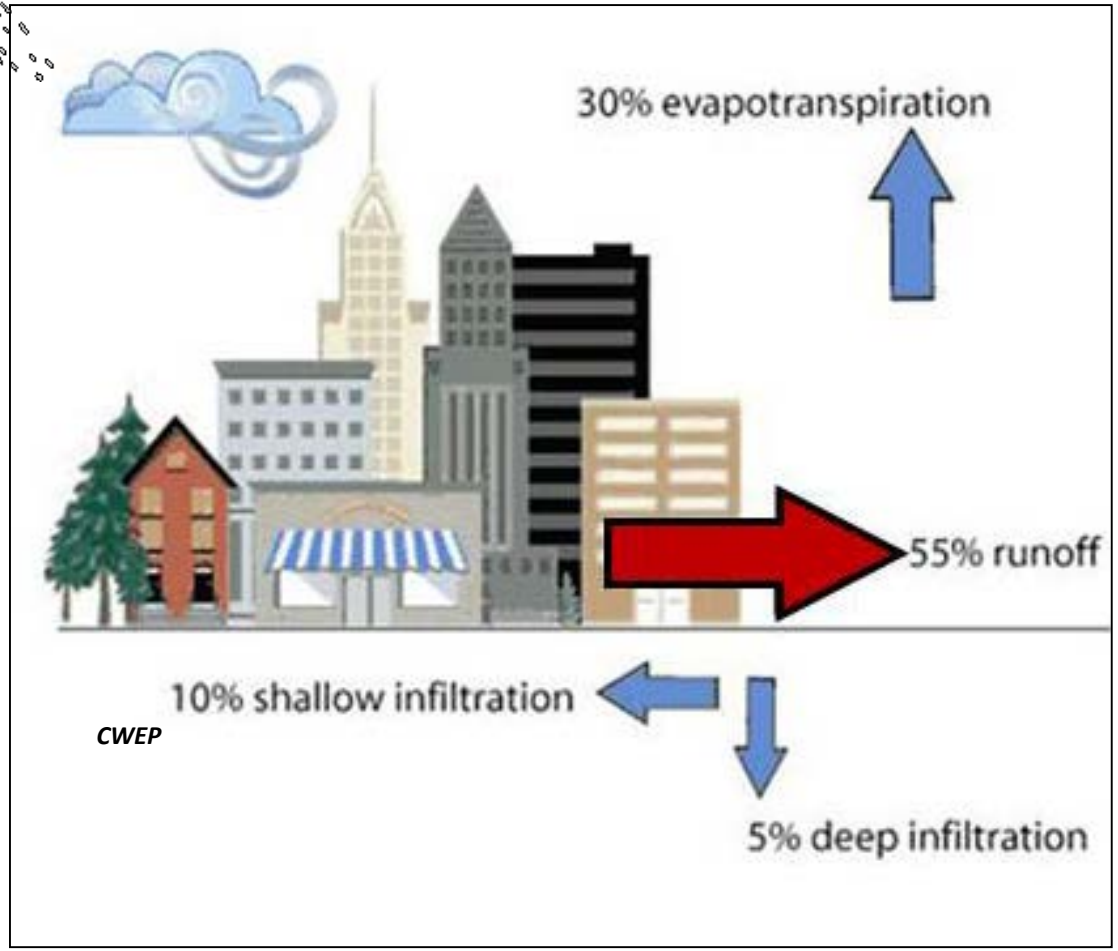
HOW DOES URBANIZATION ALTER WATER PATHWAYS?

Precipitation and Runoff

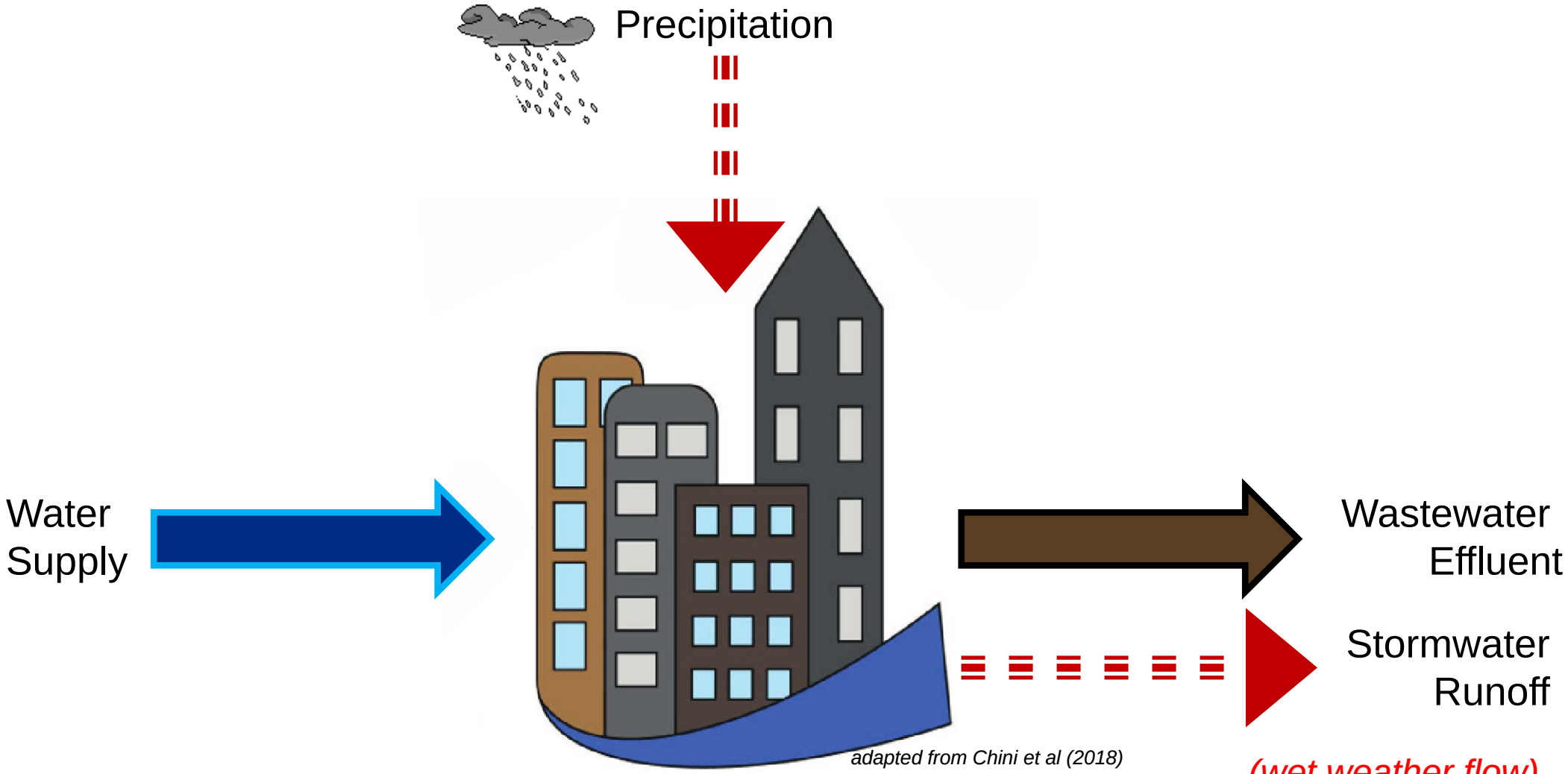
Natural/Rural



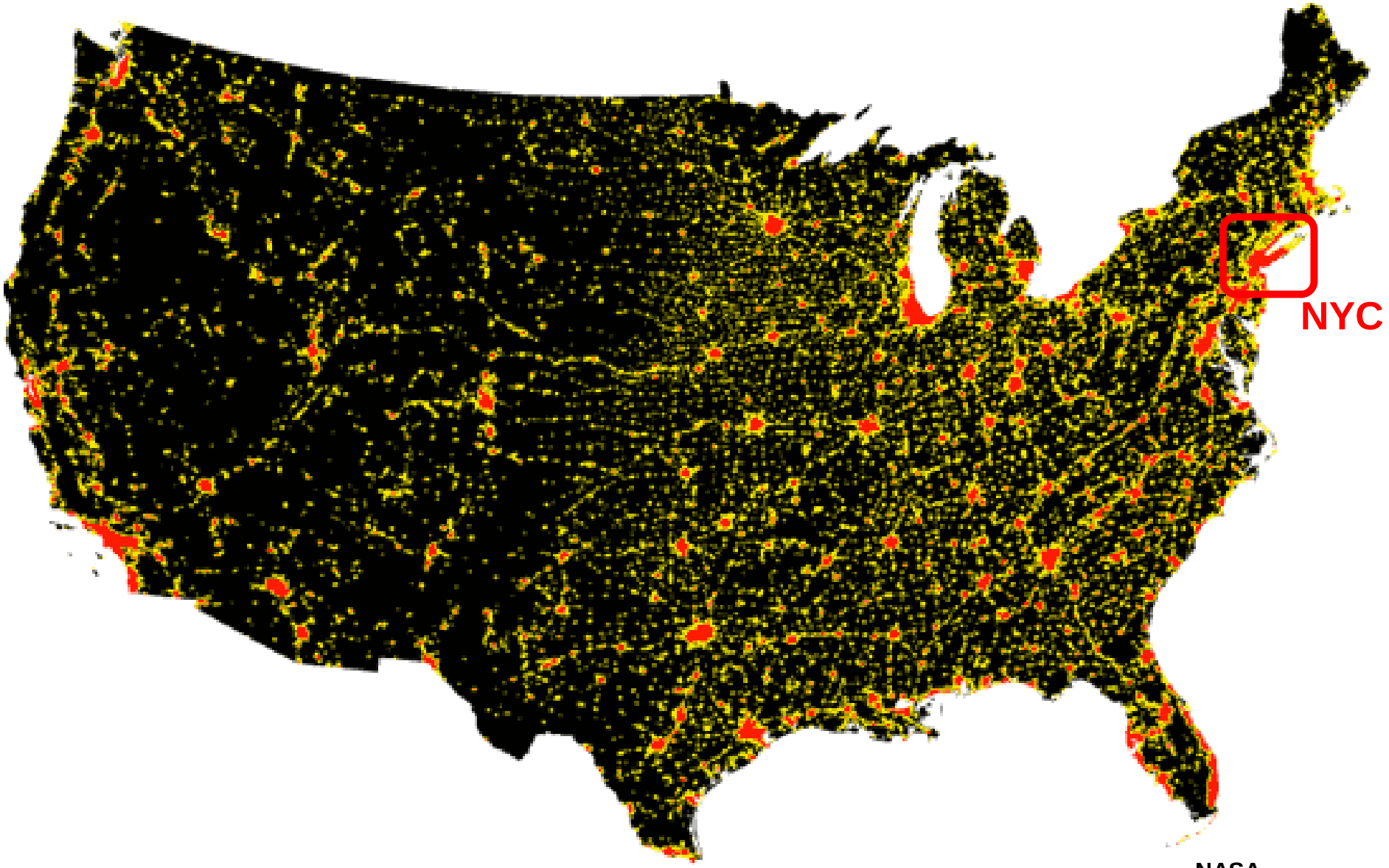
Urban



HOW DO STORMS CHALLENGE URBAN WATER FLOWS & PATHWAYS?

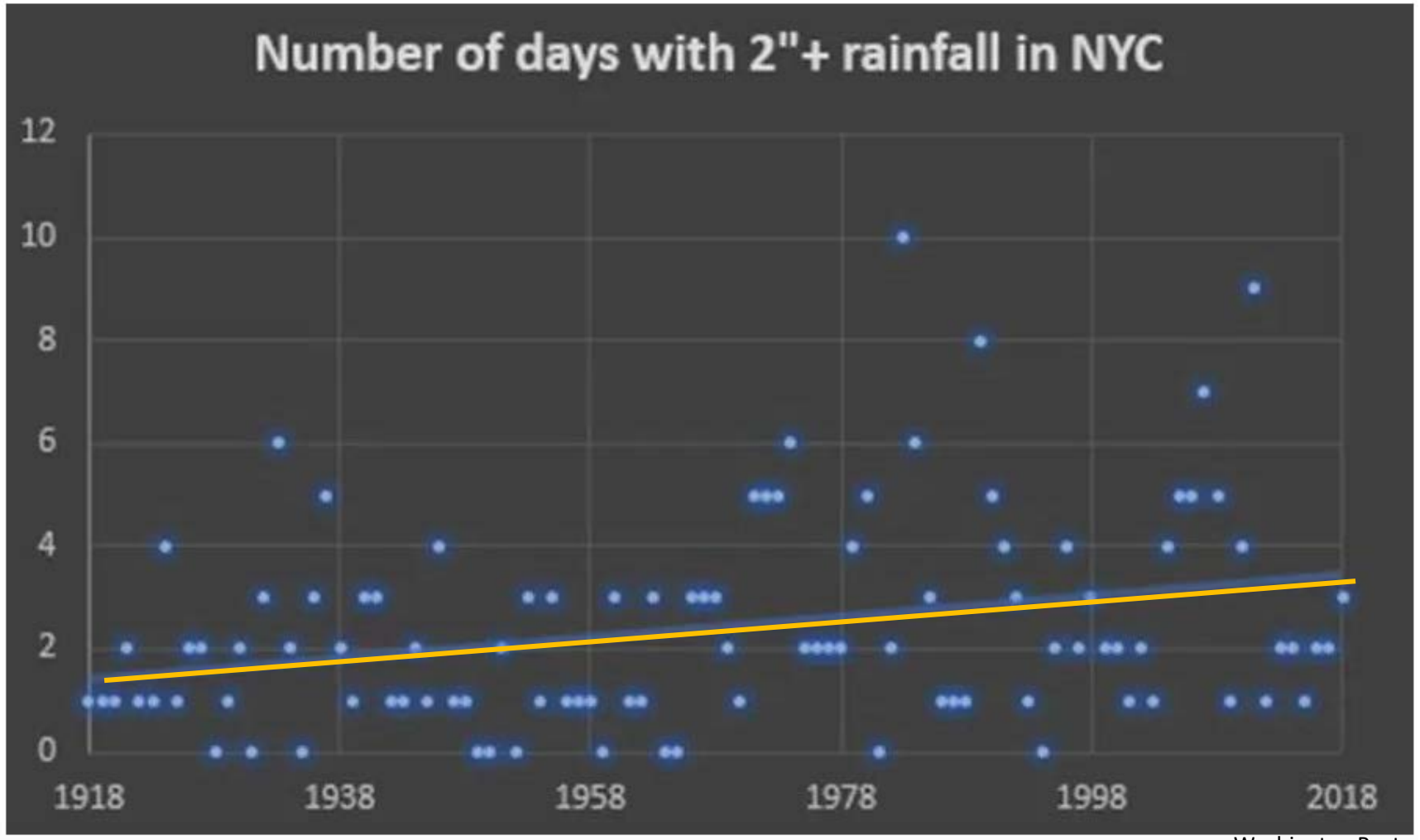


adapted from Chini et al (2018)



NASA

NYC's Stormwater Challenge



Washington Post

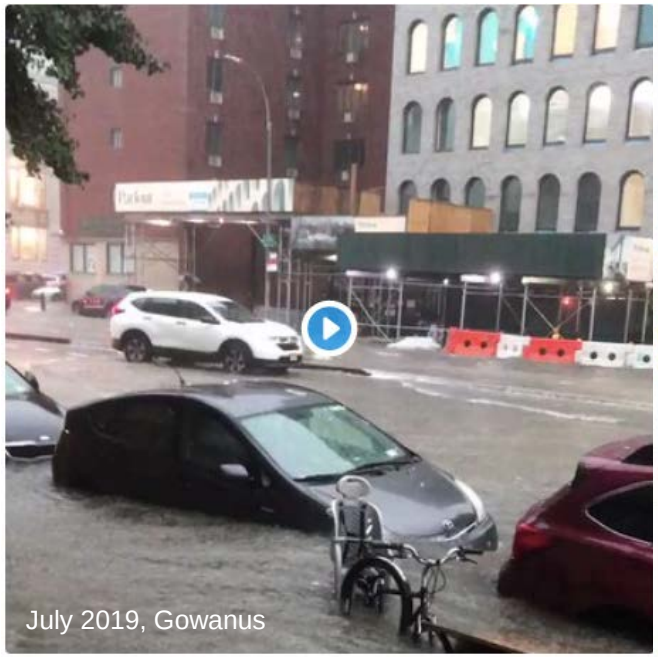
Past 60 years: average summertime rainfall has increased by 2.5 inches

Past 100 years: number of days with rainfall topping 2 inches has doubled

'New normal': storms with higher precipitation volumes and greater intensity

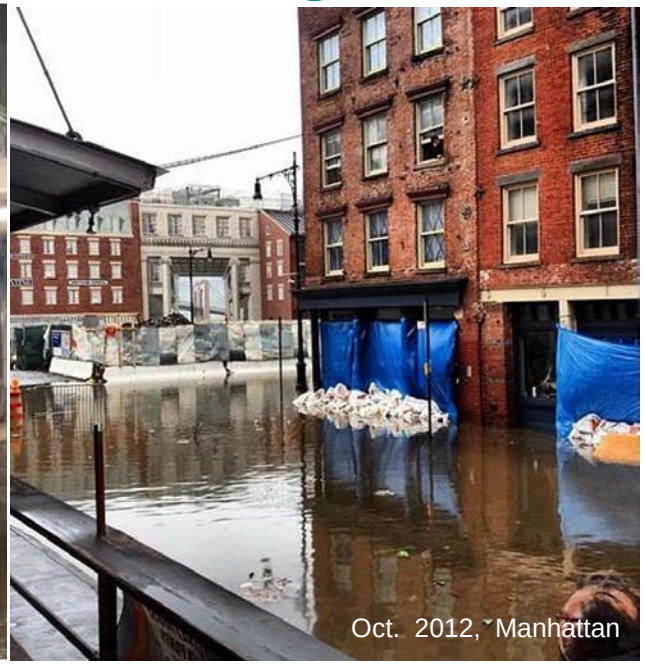
WHAT PROBLEMS DOES INTENSE PRECIPITATION CAUSE?

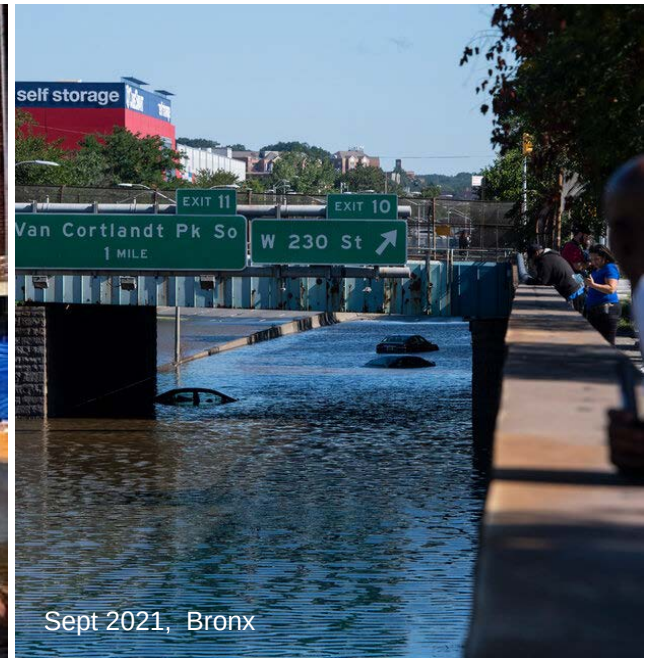
Flash Flooding



2019 ‘Cloud Burst’

Chronic/Moderate Storm Event





2012 Superstorm Sandy/2021 Hurricane Ida

Extreme Storm Events

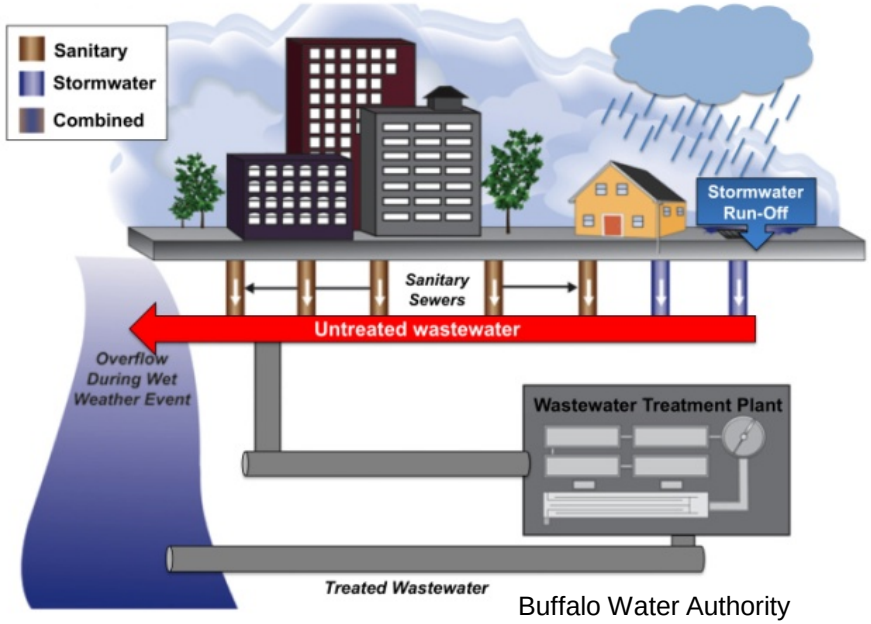
Fatalities, loss of property

2012 Superstorm Sandy: 40 deaths in NYC, $19 billion in damages & lost economic activity

2021 Hurricane Ida: 45 deaths in NY/NJ area, $50 million in damages in NY downstate

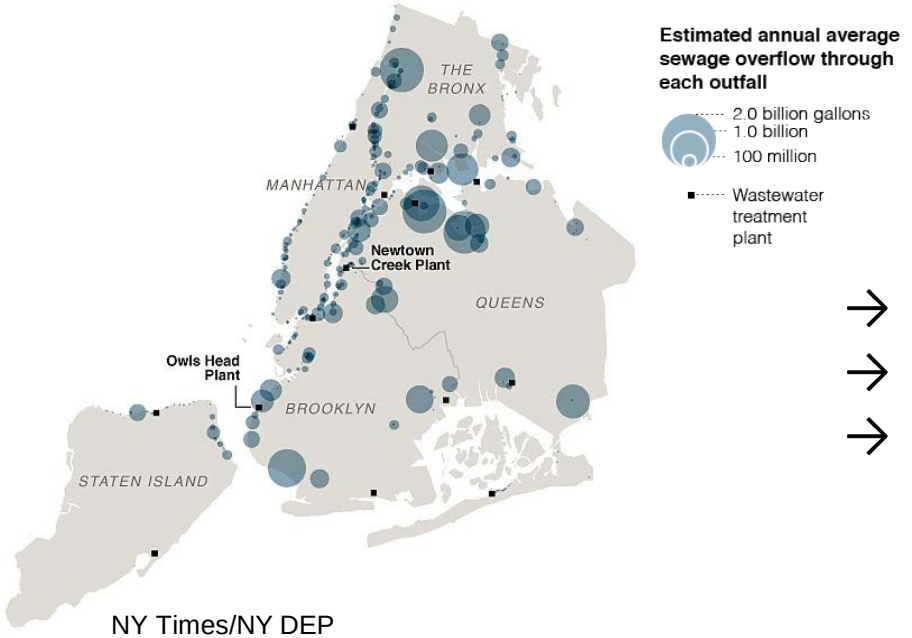
WHAT PROBLEMS DOES INTENSE PRECIPITATION CAUSE?

Pollutant Loading: *Failing System During Storms!*



Buffalo Water Authority

NYC combined sewer overflows (surface inputs)



NY Times/NY DEP

→ ***nutrients***
→ ***heavy metals***
→ ***sewage & pathogens***

- NYC non-compliant with the EPA CWA
- harmful algal/nuisance blooms, localized hypoxia
- $1 billion annual losses in tourism
- $10s millions annual losses in commercial fishing

SOLUTIONS: GREY INFRASTRUCTURE UPGRADES?

Centralized Treatment: Pipes, Pumps, & Large-Scale Storage

Wastewater Recovery Facility-Brooklyn

Combined Sewer Pipe-Brooklyn

CSO Storage Facility-Brooklyn

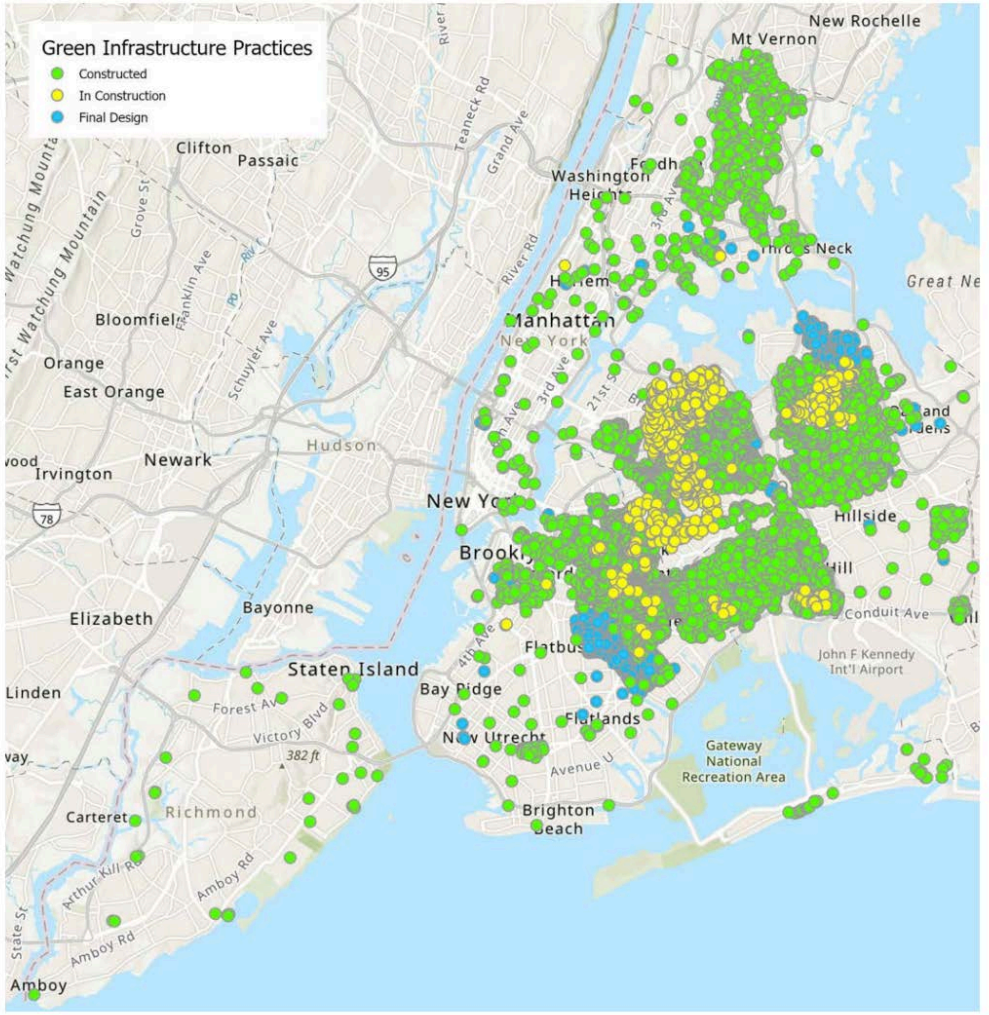
NYC GREEN INFRASTRUCTURE PROGRAM

$771 million currently budgeted through fiscal year 2032

2,094
Greened Acres from 2010-2021

11,553
Assets constructed

$1B+
Committed since 2012



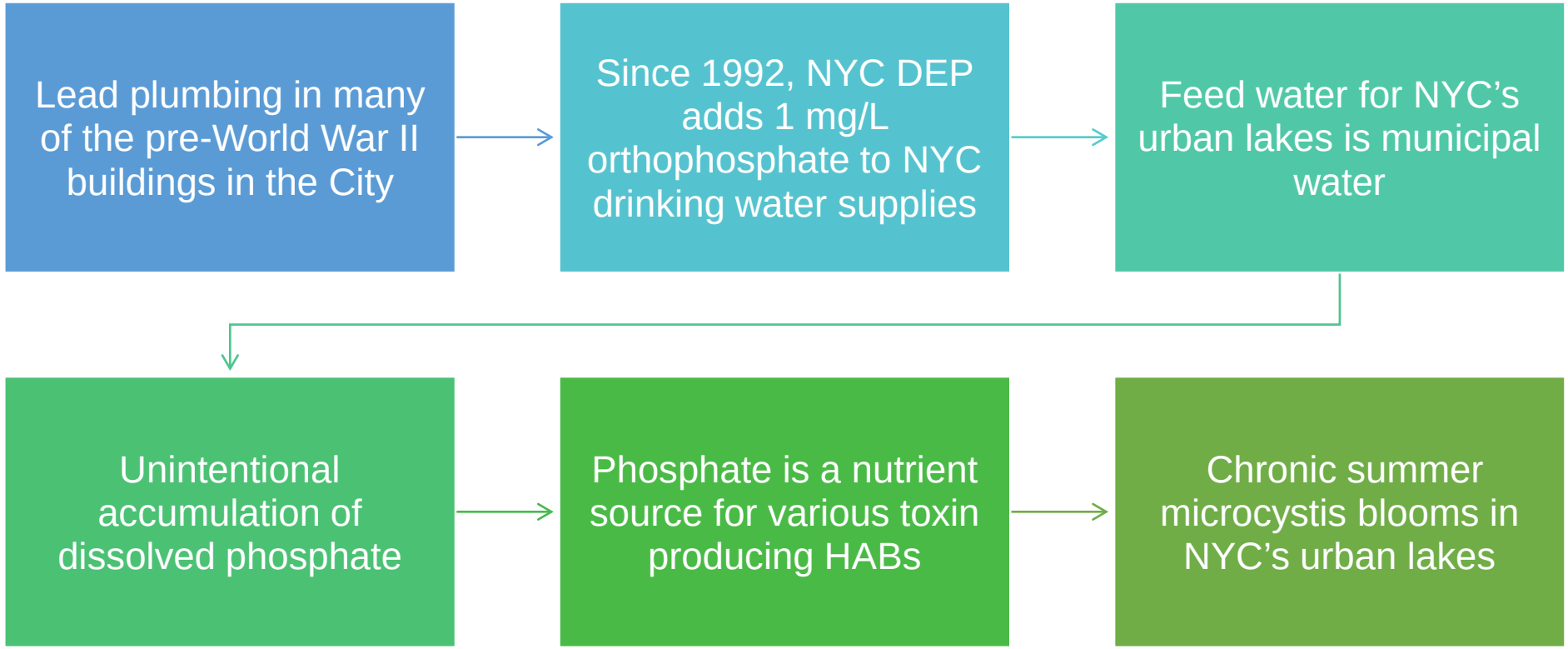
SCIENCE
TECHNOLOGY
ENGINEERING
ARTS
MATHEMATICS

FIELD INVESTIGATIONS

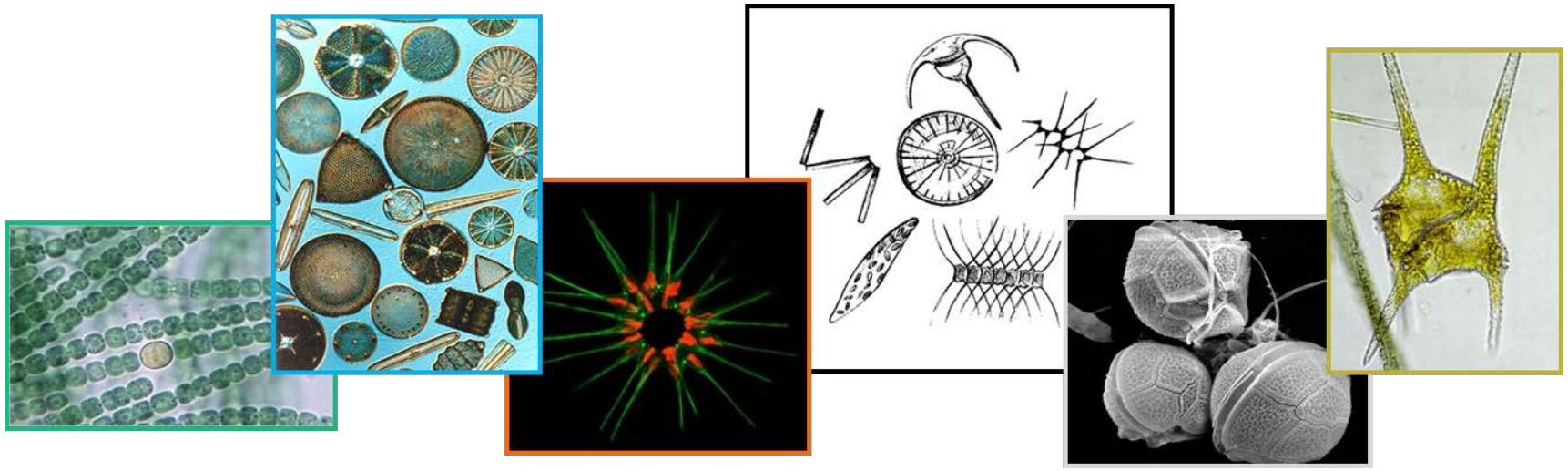
LAB REPORTS

ARTS AND JOURNALISM

NYC’s URBAN LAKES IN DANGER



PHYTOPLANKTON AS SENTINELS OF CHANGE



Photosynthetic: Generate ~50% atmospheric O_2

Influence regional & global biogeochemical cycling

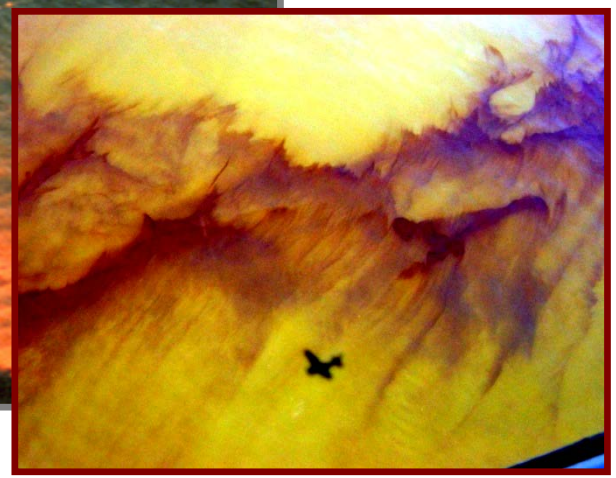
Base of aquatic food webs

Growth and productivity regulated by light, nutrients, temperature, microbial & food web interactions among others

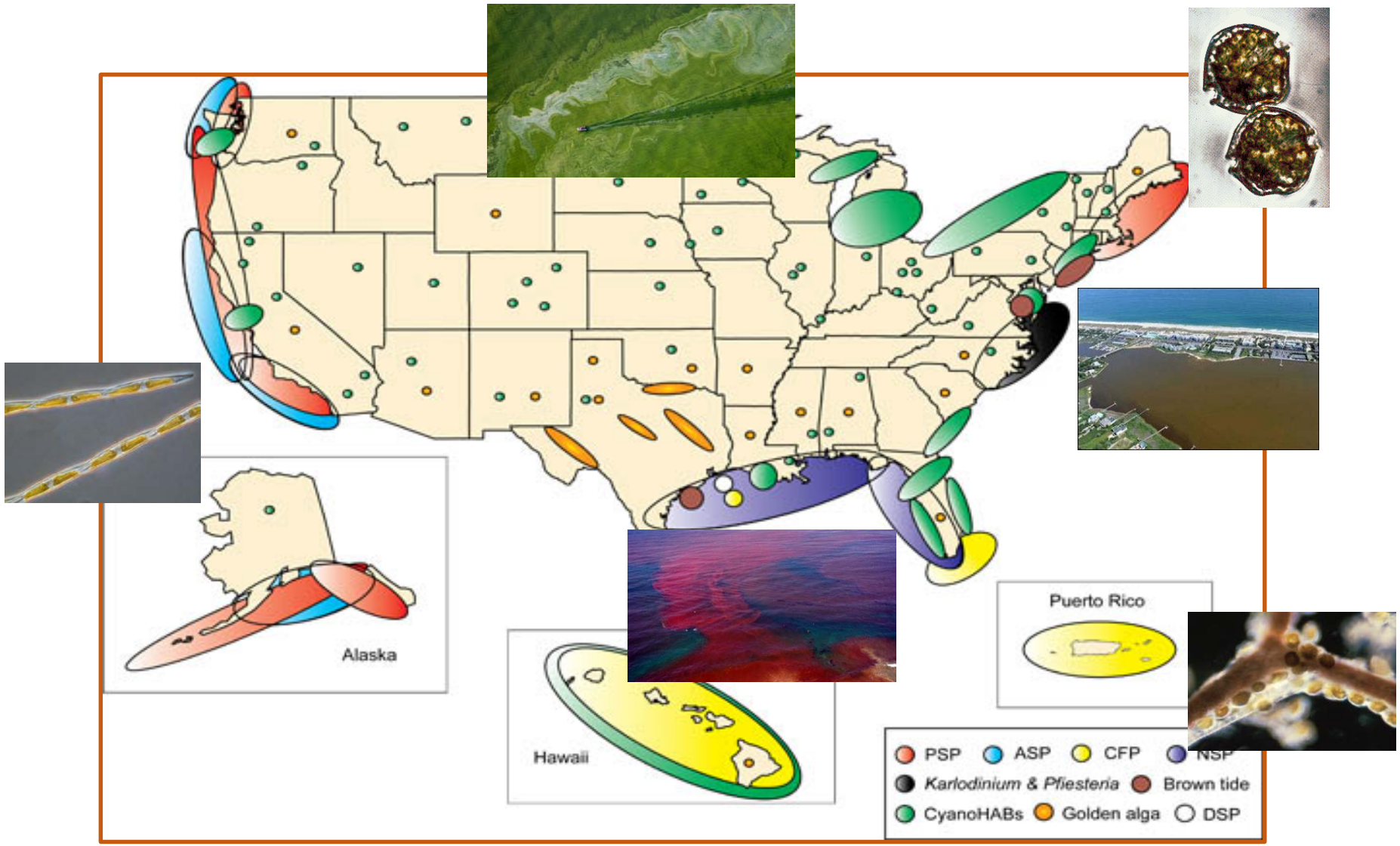
Short life cycle/rapid division rates

HARMFUL ALGAL BLOOM (HAB)

Significant, often rapid increase in algae that causes negative ecological, health, and or economic impacts.



HABs IN THE US

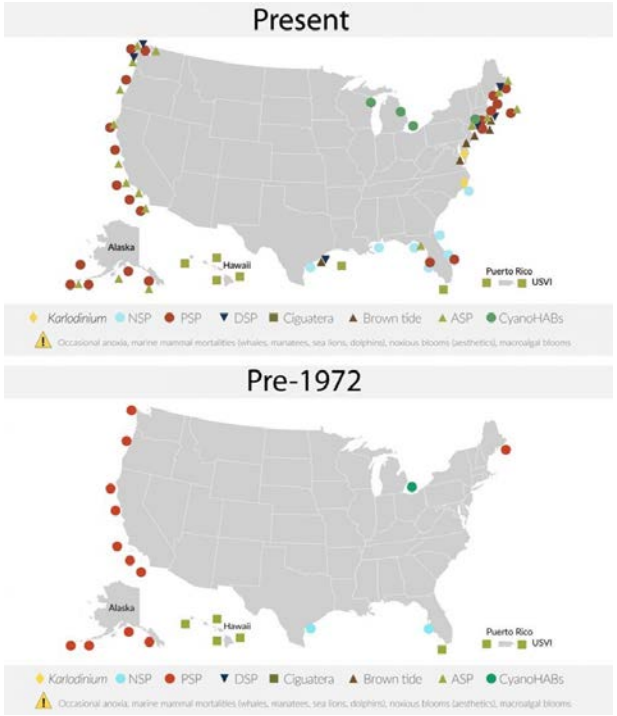


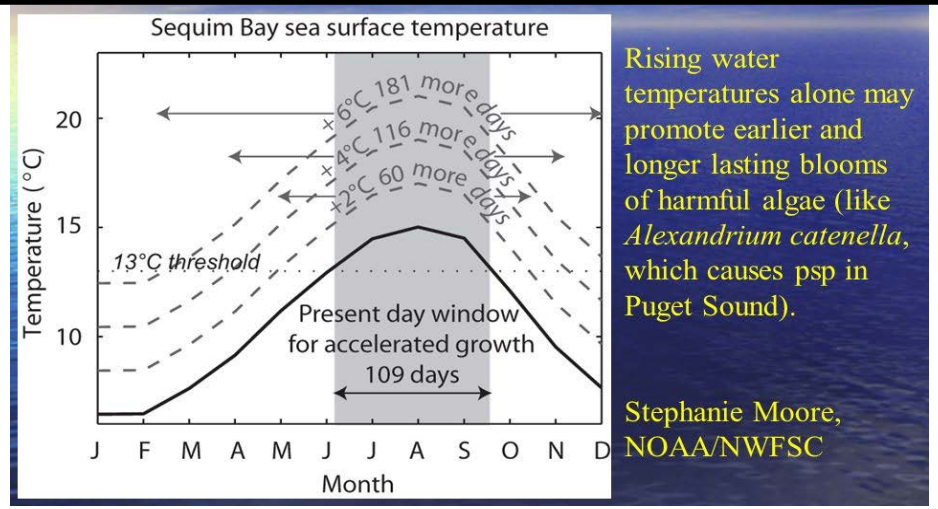
HABs AND CLIMATE CHANGE

Growing seasons will lengthen

Waters become increasingly warm and stagnant

Combined with other anthropogenic stressors (such as nutrient enrichment), this creates ideal environments for HAB and hypoxia proliferation





Rising water temperatures alone may promote earlier and longer lasting blooms of harmful algae (like *Alexandrium catenella*, which causes psp in Puget Sound).

Stephanie Moore, NOAA/NWFSC


PROSPECT PARK

WHY DOES THIS MATTER?

Microcystis blooms produce toxins

Toxins are harmful to living organisms if ingested

- wildlife (fish)
- domestic animals (dogs)
- humans

Public's perception of health risk is a big problem for City Parks

Disrupts recreational services

- Parks are an urban oasis for NYCers since 1800s
- Haven throughout the COVID-19 pandemic

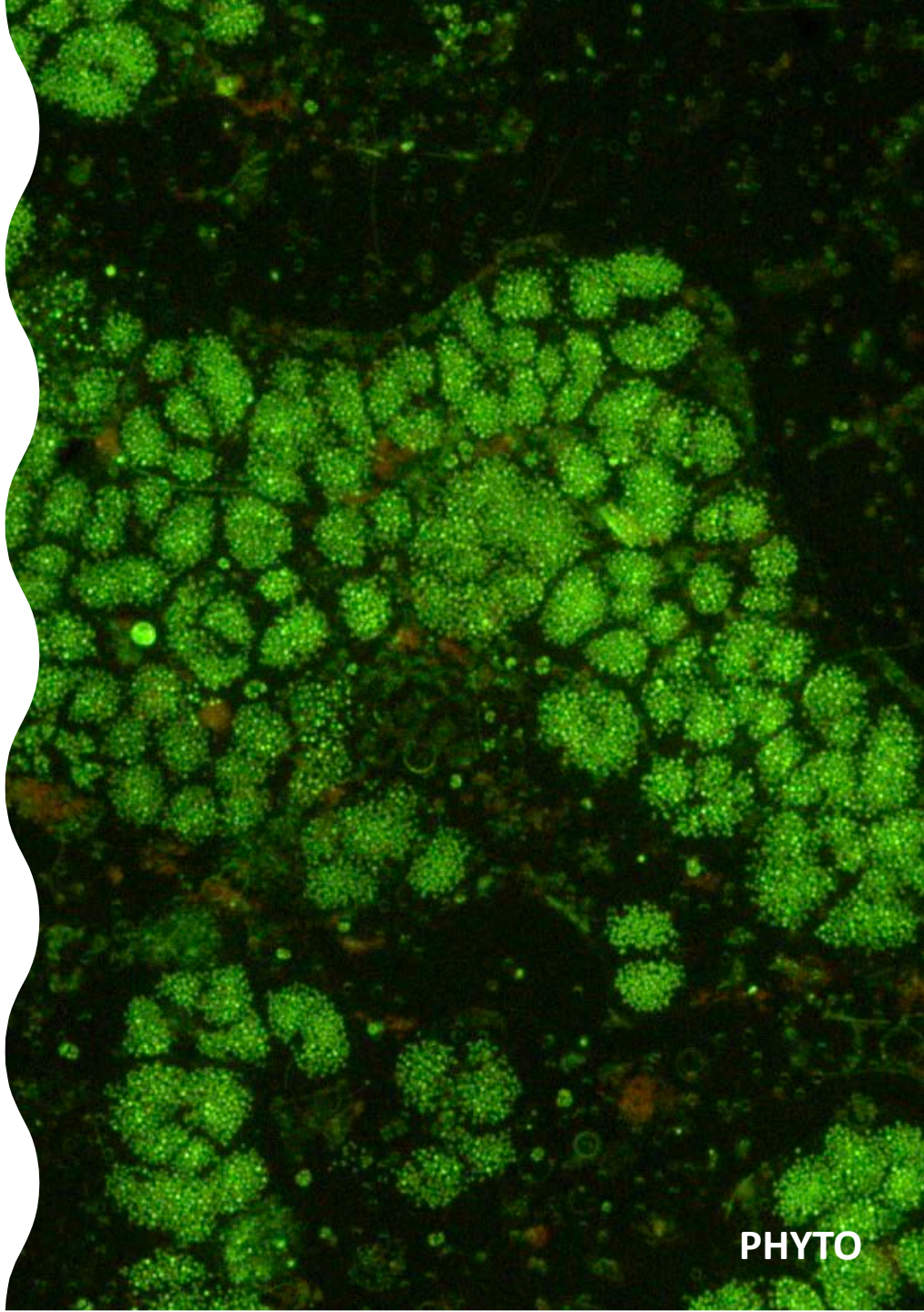
HIGH PHOSPHORUS CONCENTRATIONS & MICROCYSTIS BLOOMS AT PROSPECT PARK

In the summer of 2011, the concentration of phosphorus in the feed water to Prospect Park Lake measured 0.63 ± 0.07 mg P/L (± 1 SD; n=10)

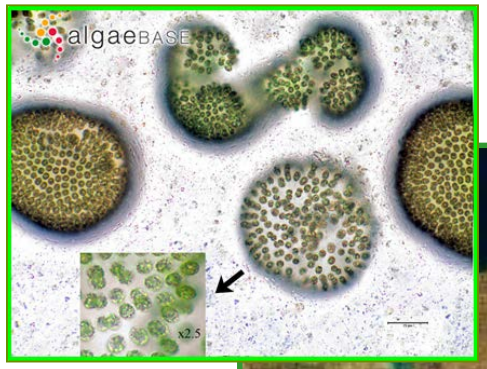
Resulting in a loading rate for the lake of 47 mg P m^2/d

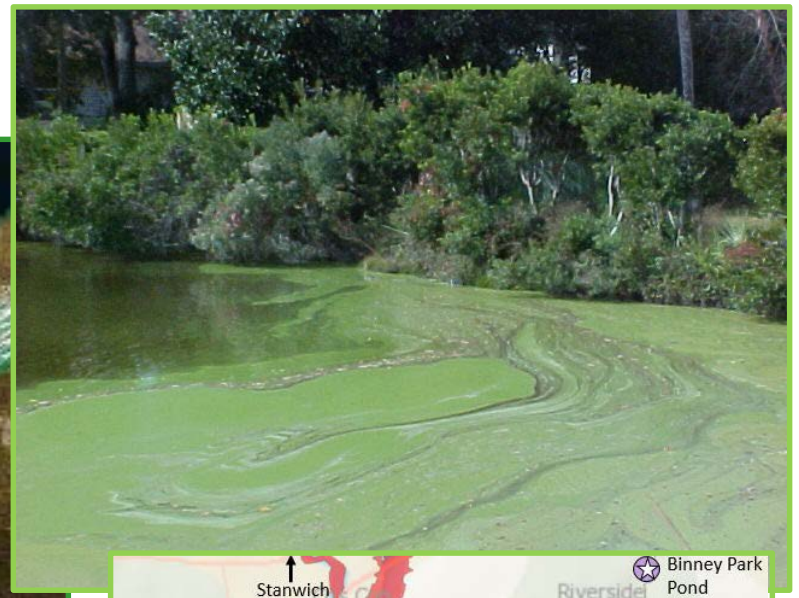
- Surpassing limits considered healthy for the ecosystem

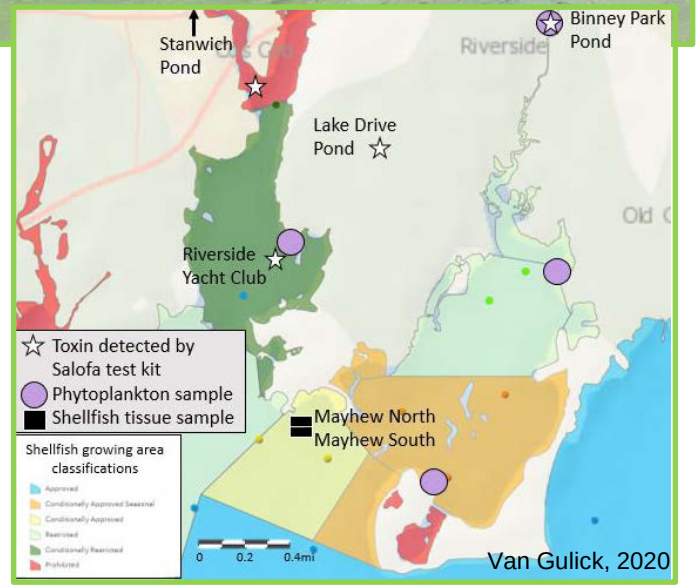
Every summer, Prospect Park Lakes have chronic and significant microcystis blooms



WHY YOU SHOULD CARE ABOUT *Microcystis* spp.



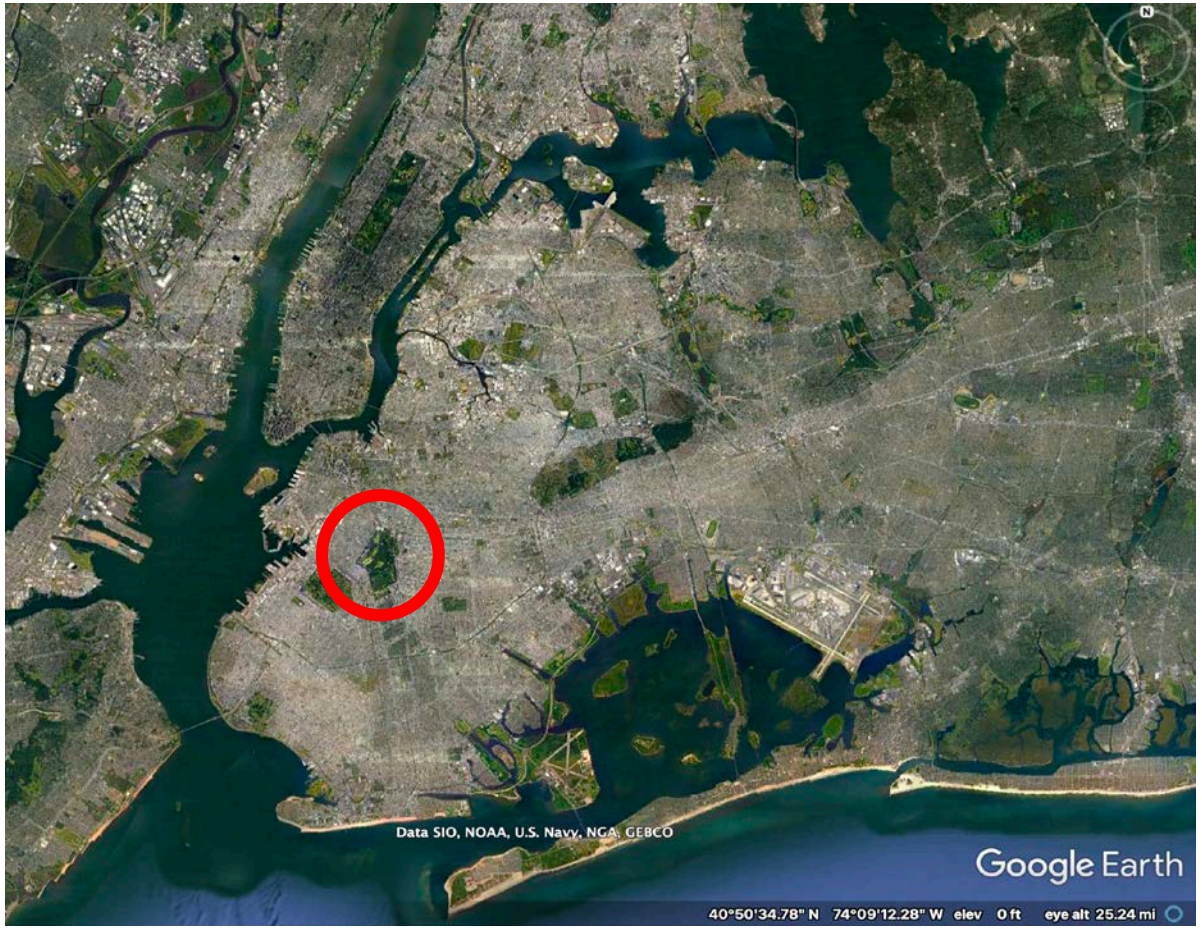




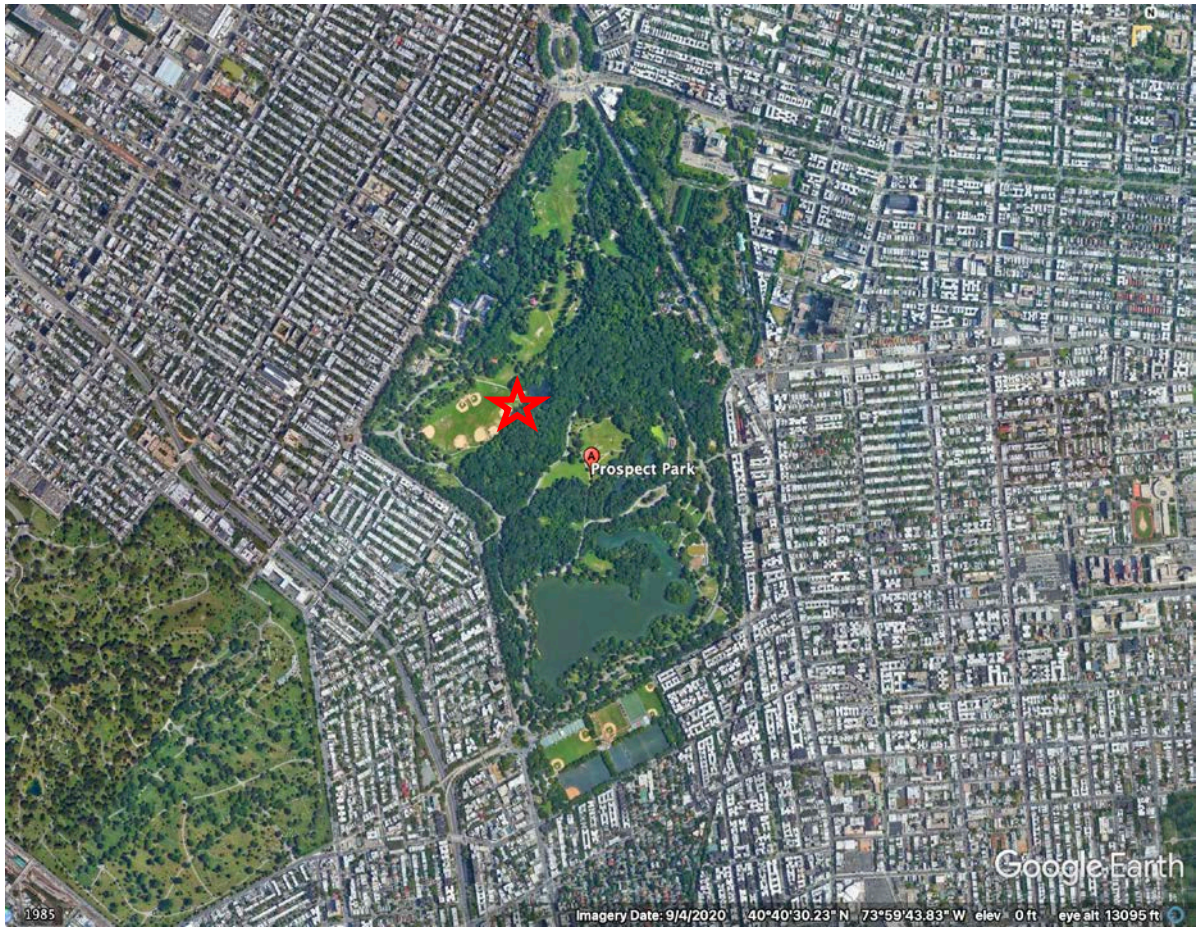
Cyanobacteria: largest #HABs worldwide; *Microcystis* is the most common genus. Produces microcystins which contaminate drinking water, accumulate in shellfish, cause liver failure, respiratory & dermatological ailments, and even death. Recurs in CT/NY waterways.

LOCATION

New York City



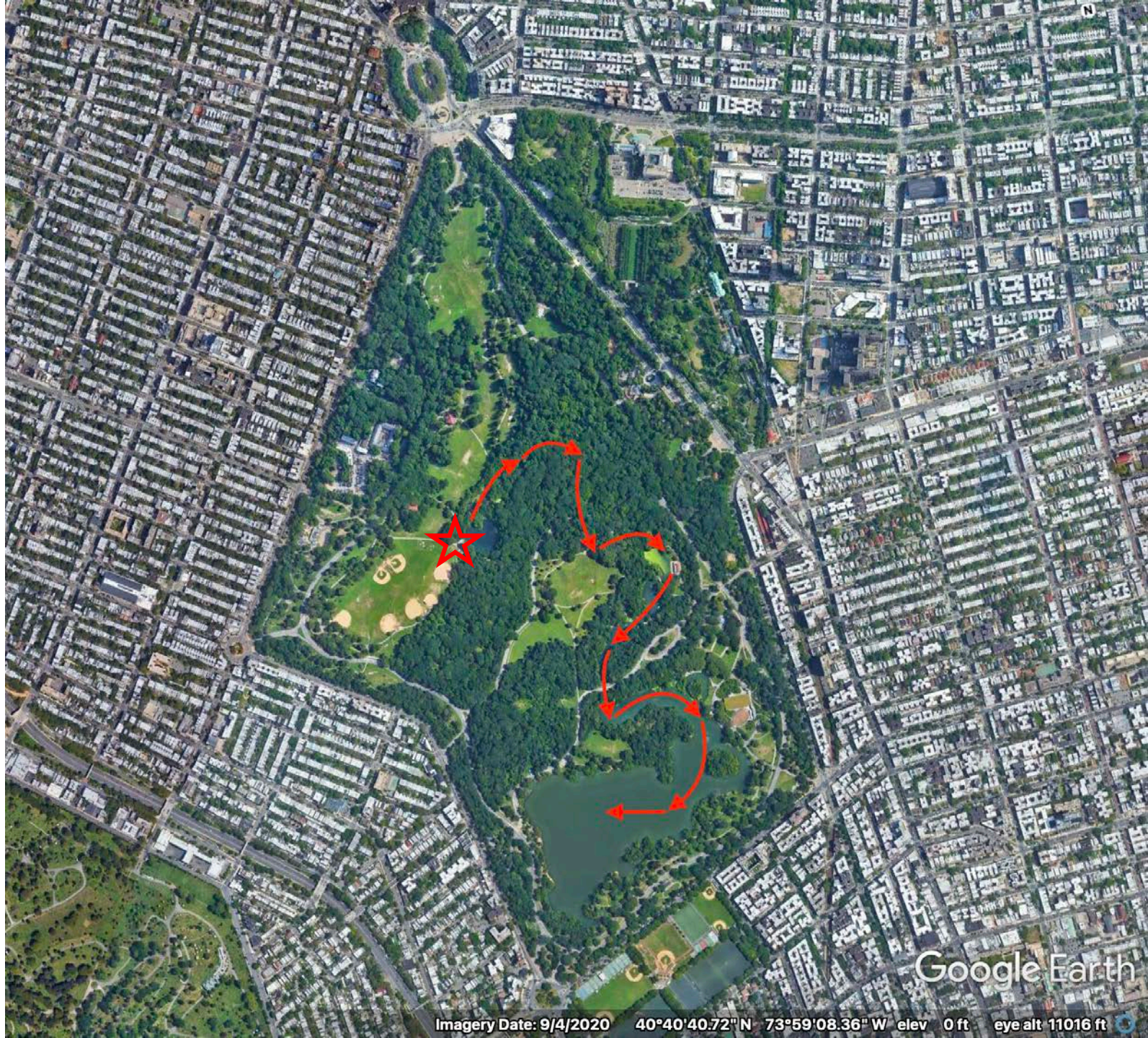
Prospect Park, Brooklyn



PROSPECT PARK WATERCOURSE

Municipal water input begins at the northwest corner

Flows down elevation, through watercourse series of streams and lakes



PROSPECT PARK WATERCOURSE

Municipal water input begins at the northwest corner

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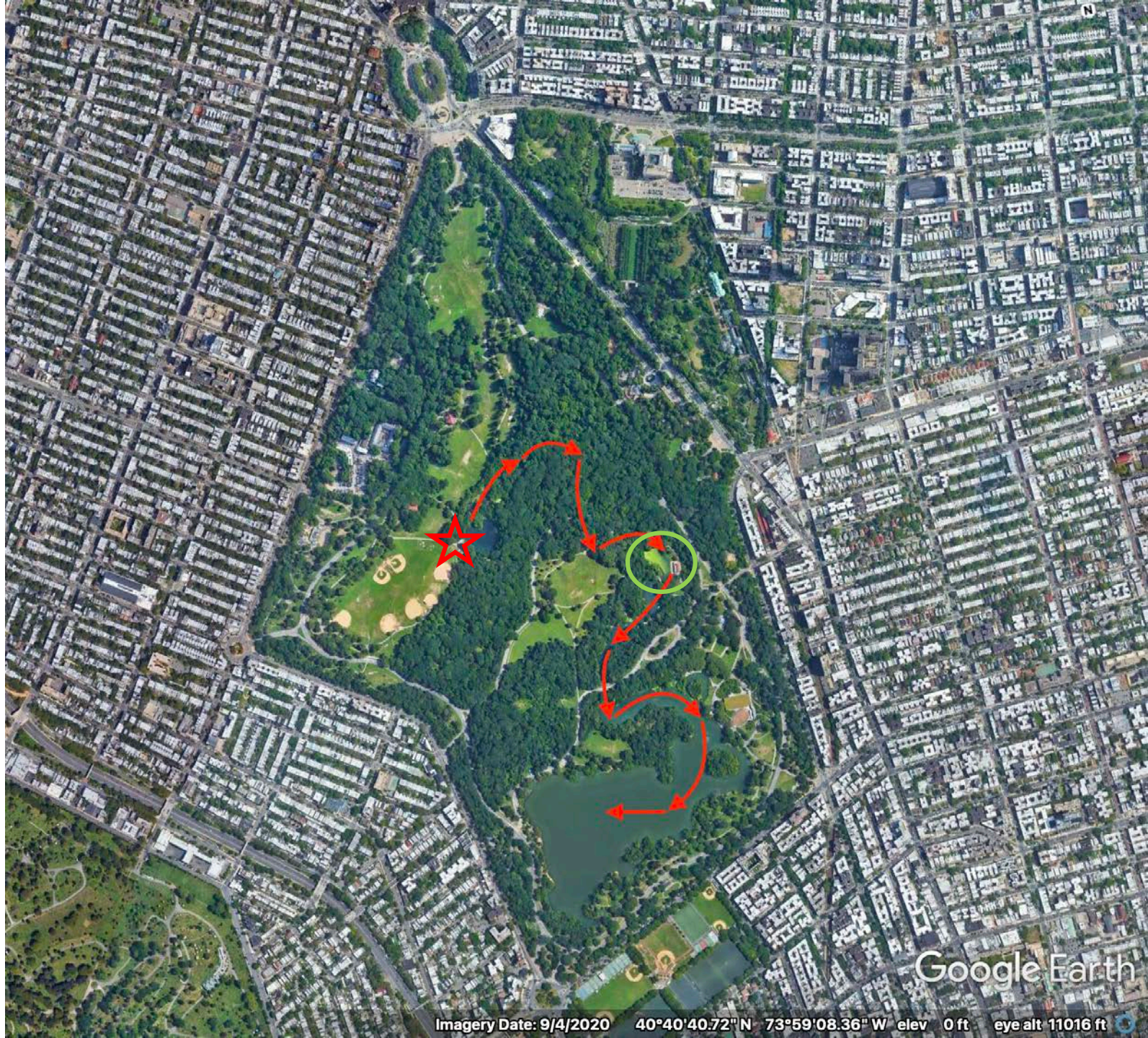
Microcystis bloom hot spot at the Boathouse + Audubon Center



BOATHOUSE + AUDUBON CENTER

PPA

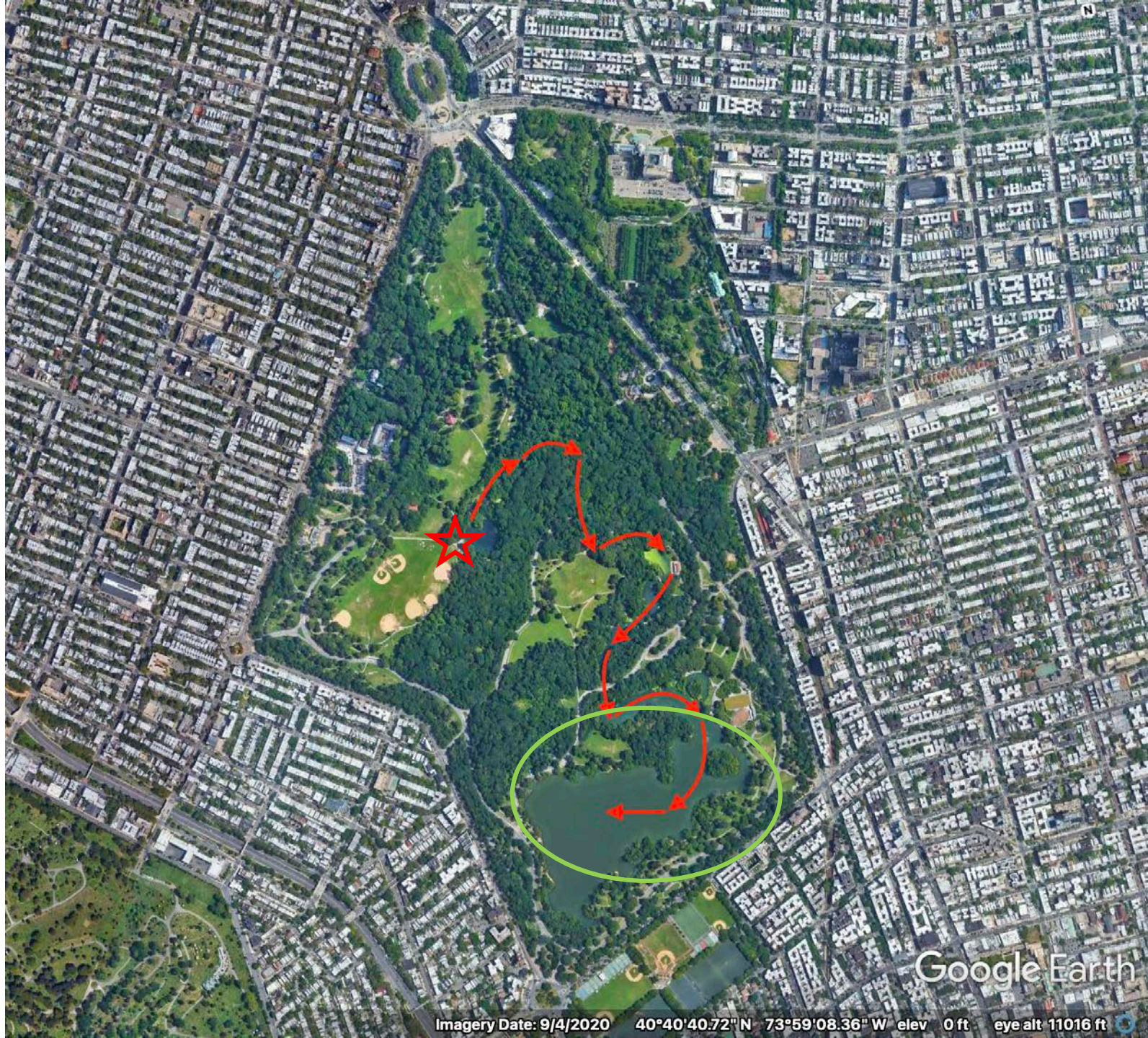
PROSPECT PARK WATERCOURSE

Municipal water input begins at the northwest corner

Flows down elevation, through watercourse series of streams, and lakes

Microcystis bloom hot spot at the Boathouse + Audubon Center

Microcystis bloom hot spot at Prospect Park Lake



SOLUTIONS?

PHOSPHATE REMOVAL BEFORE ENTERING THE WATERCOURSE LAKES TO DECREASE HABs

MODULAR HYBRID GREEN INFRASTRUCTURE ecoWEIR™ TECHNOLOGY

(patented 2017)

NOVEL HYBRID GI SYSTEM

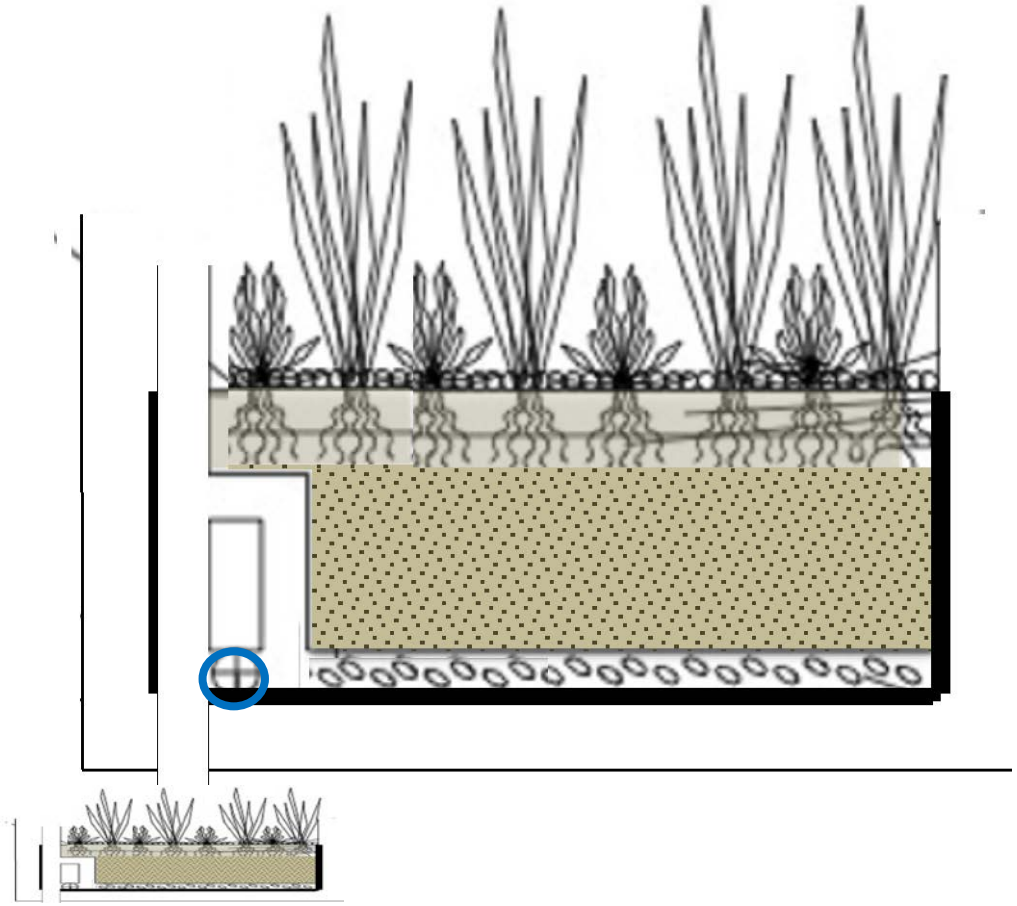
ecoWEIR™

Confined modular GI system

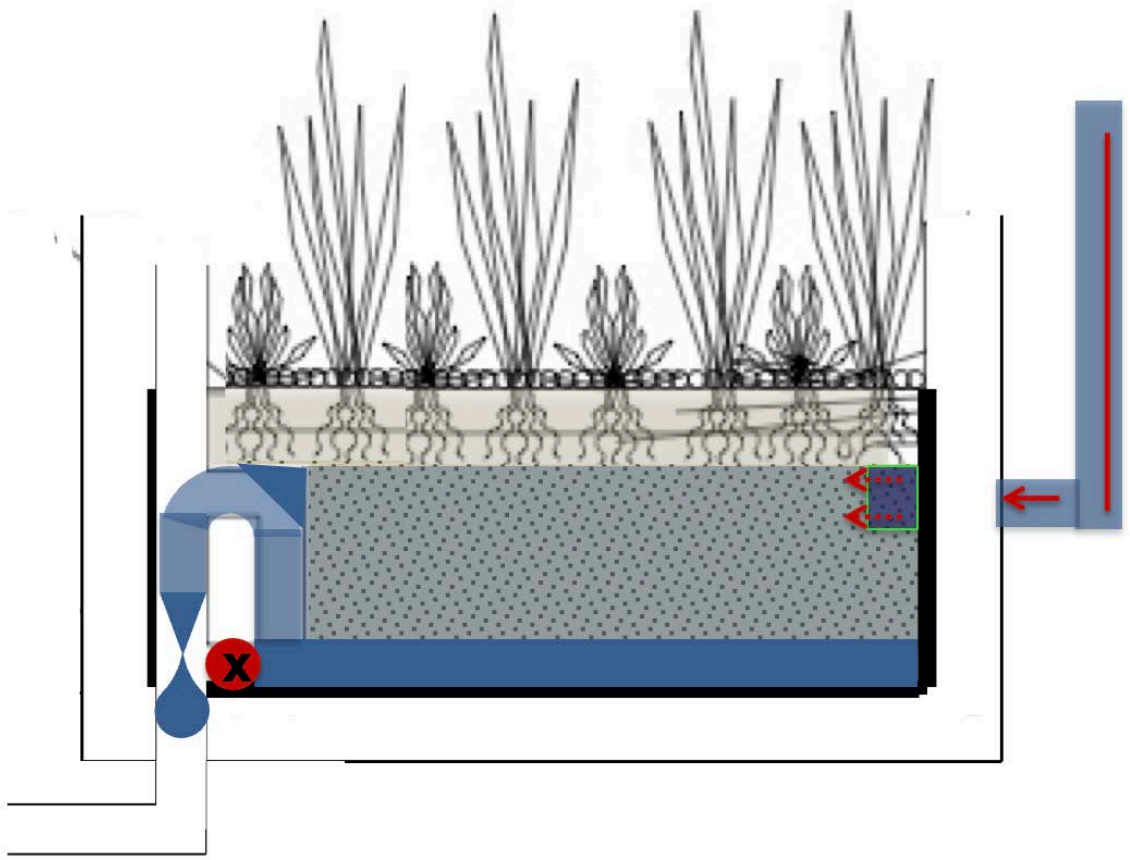
Integrated with a series of specialized pipe and valve system

Activates passive GI systems

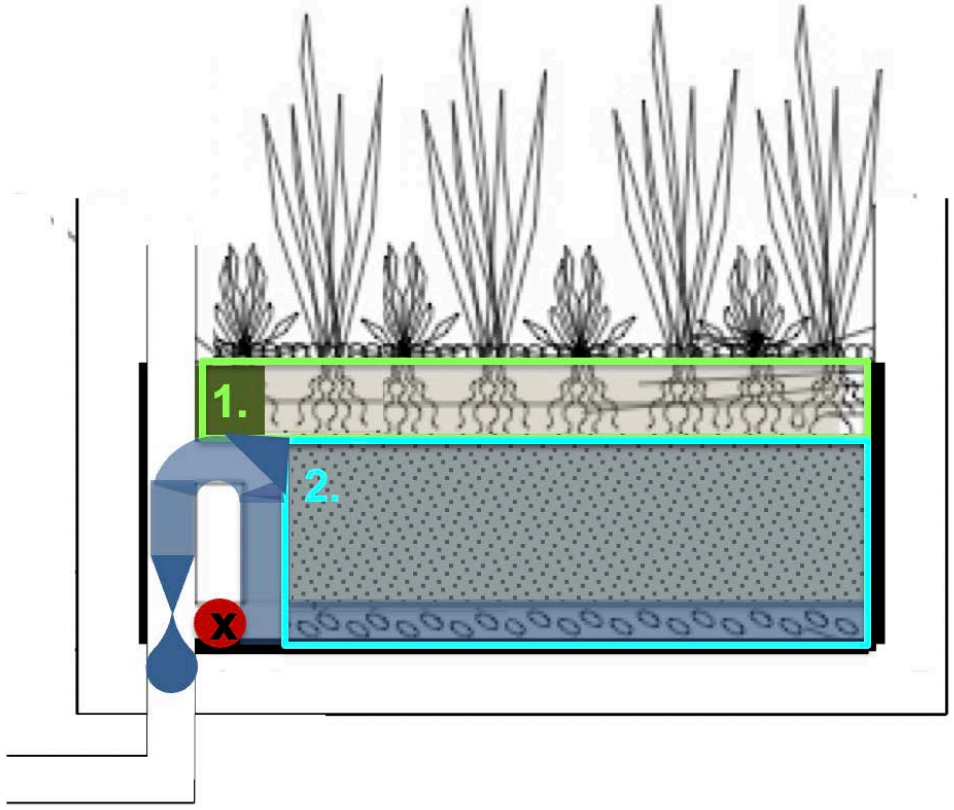
- Intercepts and stores known volumes
- Controls water retention time and soil conditions



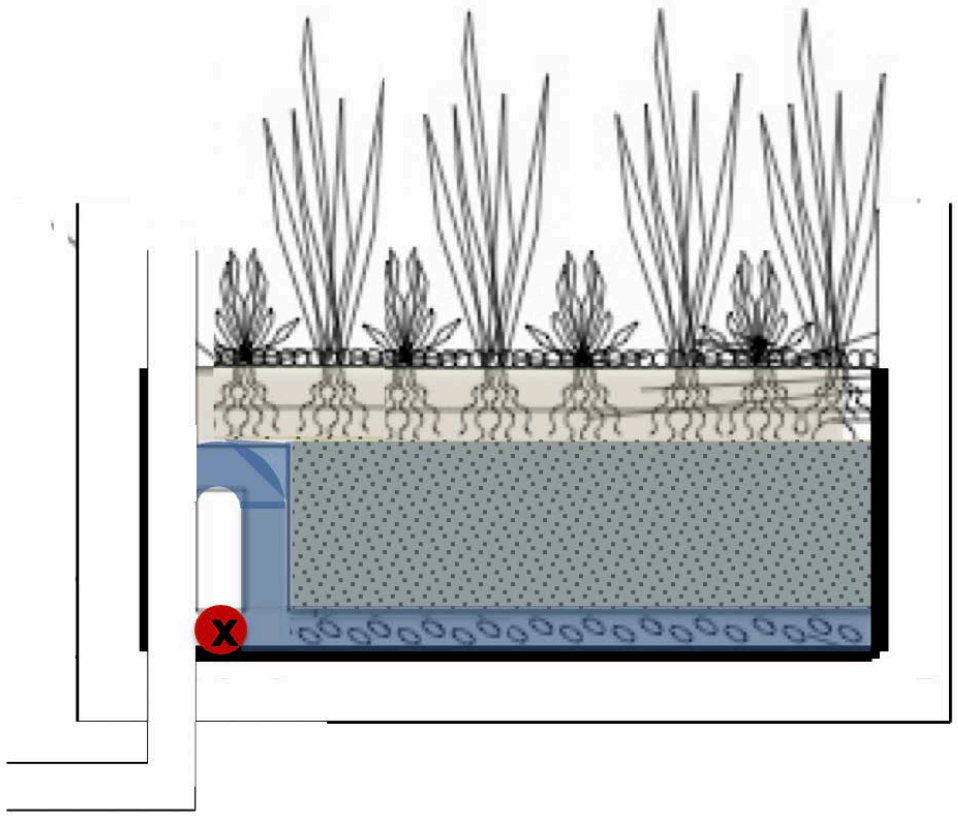
ecoWEIR™ HYBRID GREEN INFRASTRUCTURE



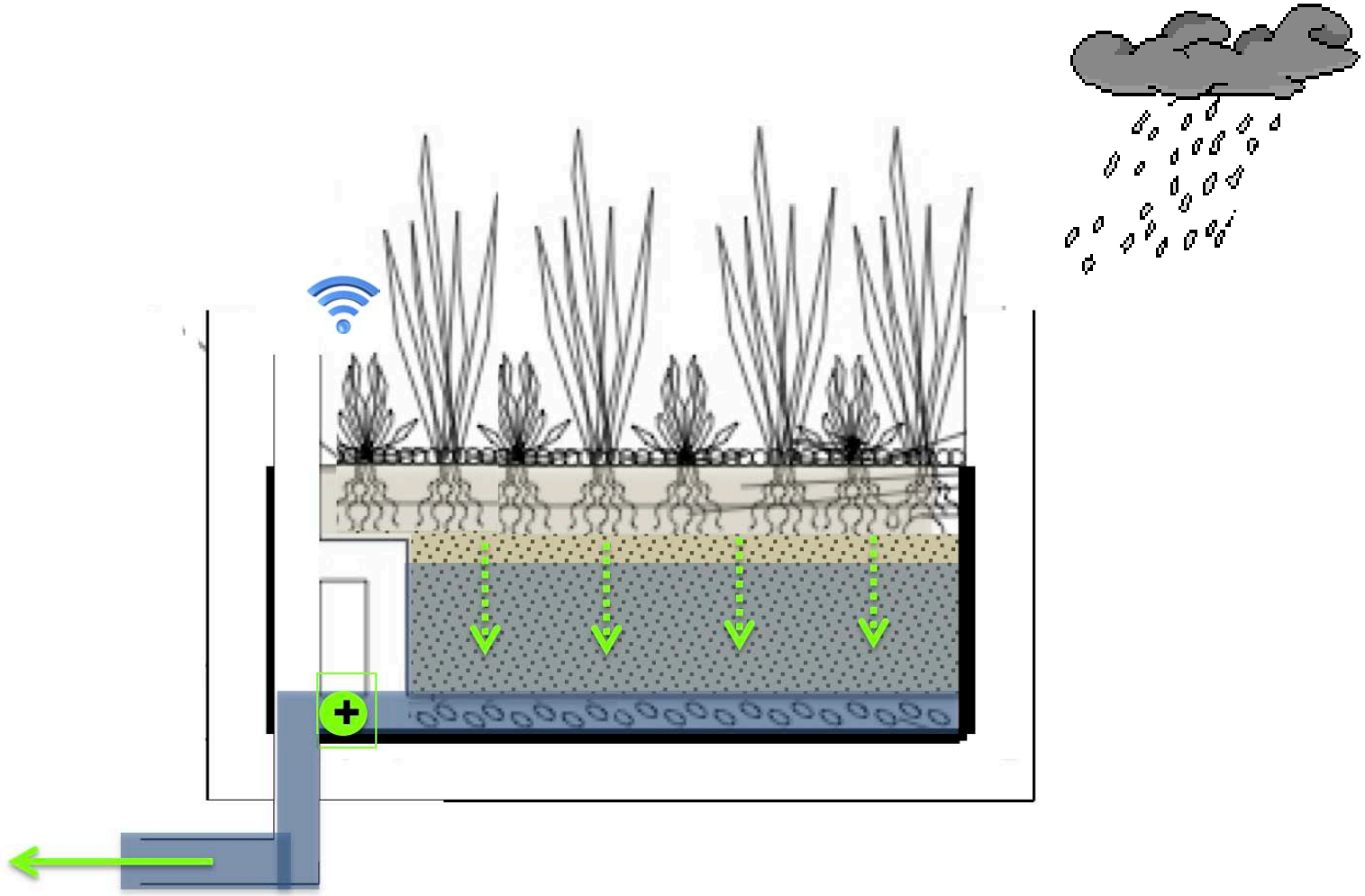
MAXIMIZES POLLUTANT REMOVAL



WATER STORAGE & REUSE



MADE OPERATIONAL

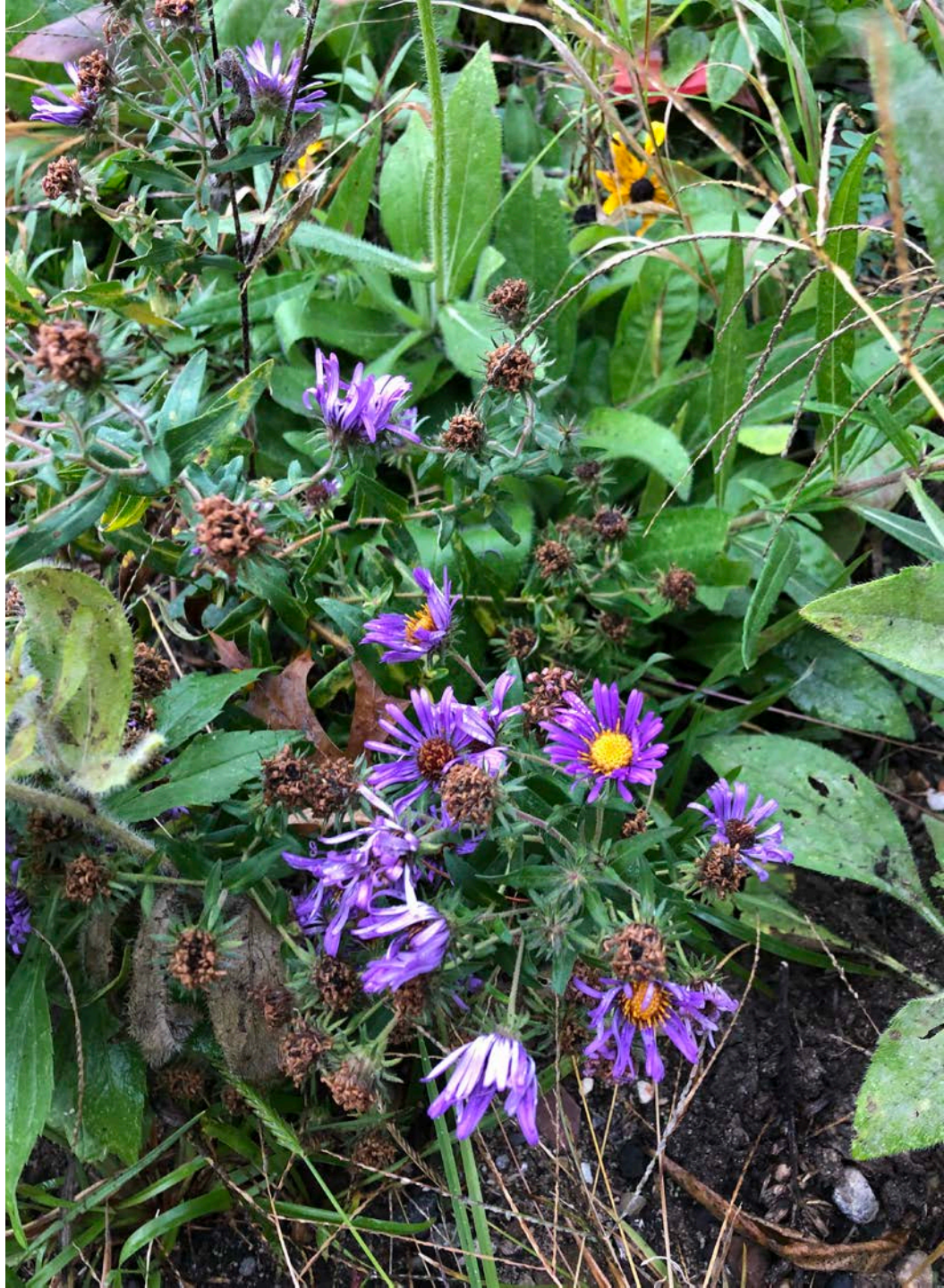


GOAL AND OBJECTIVES

To evaluate the potential of ecoWEIR™ installations in Prospect Park for mitigating HABs

Determine the phosphate removal efficiency

Assess to what extent this removal offsets microcystis growth and toxin production



ecoWEIR™ PILOT SITES

Meadow

Native flowers

Lawn

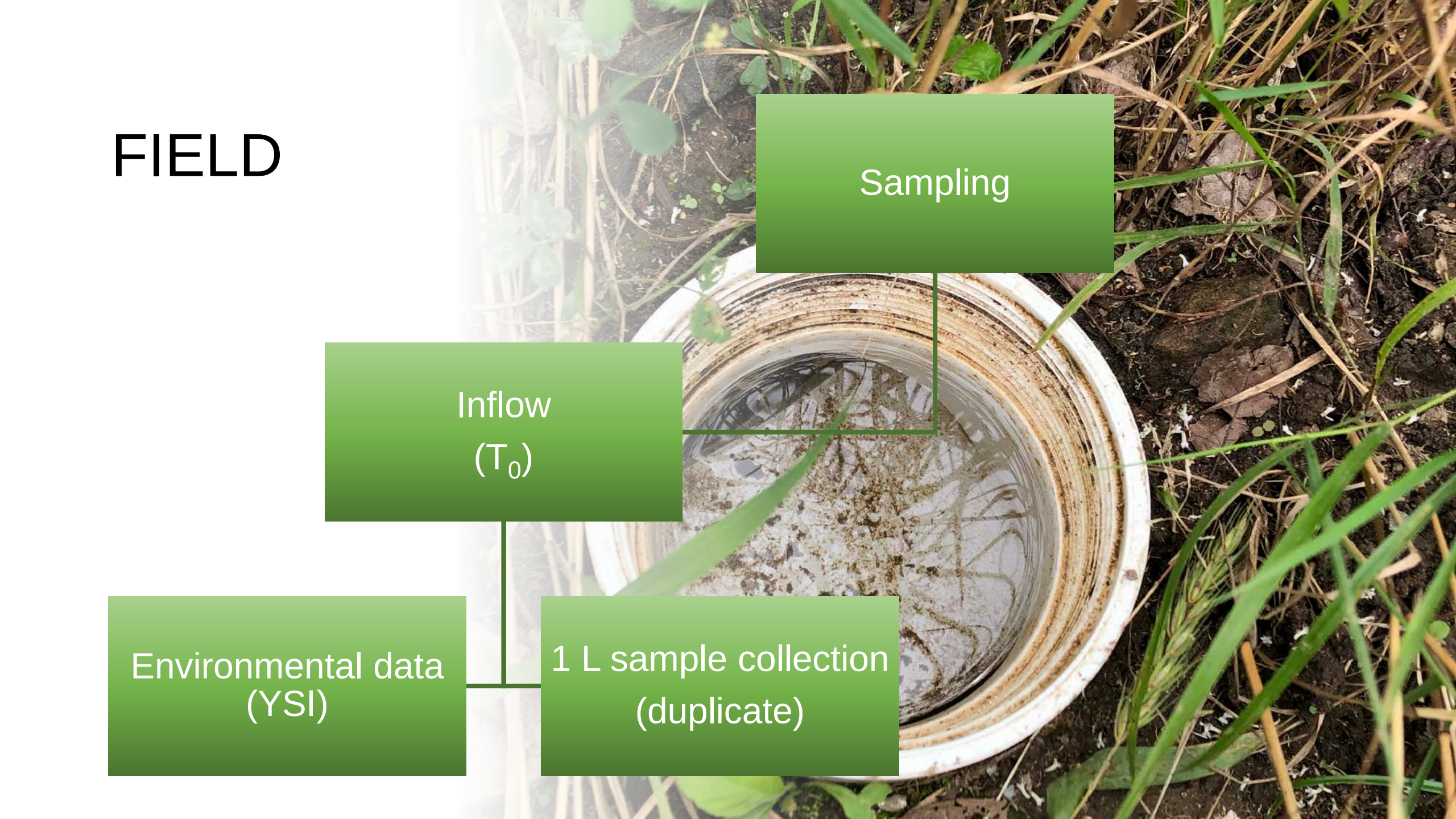
Grass

MEADOW

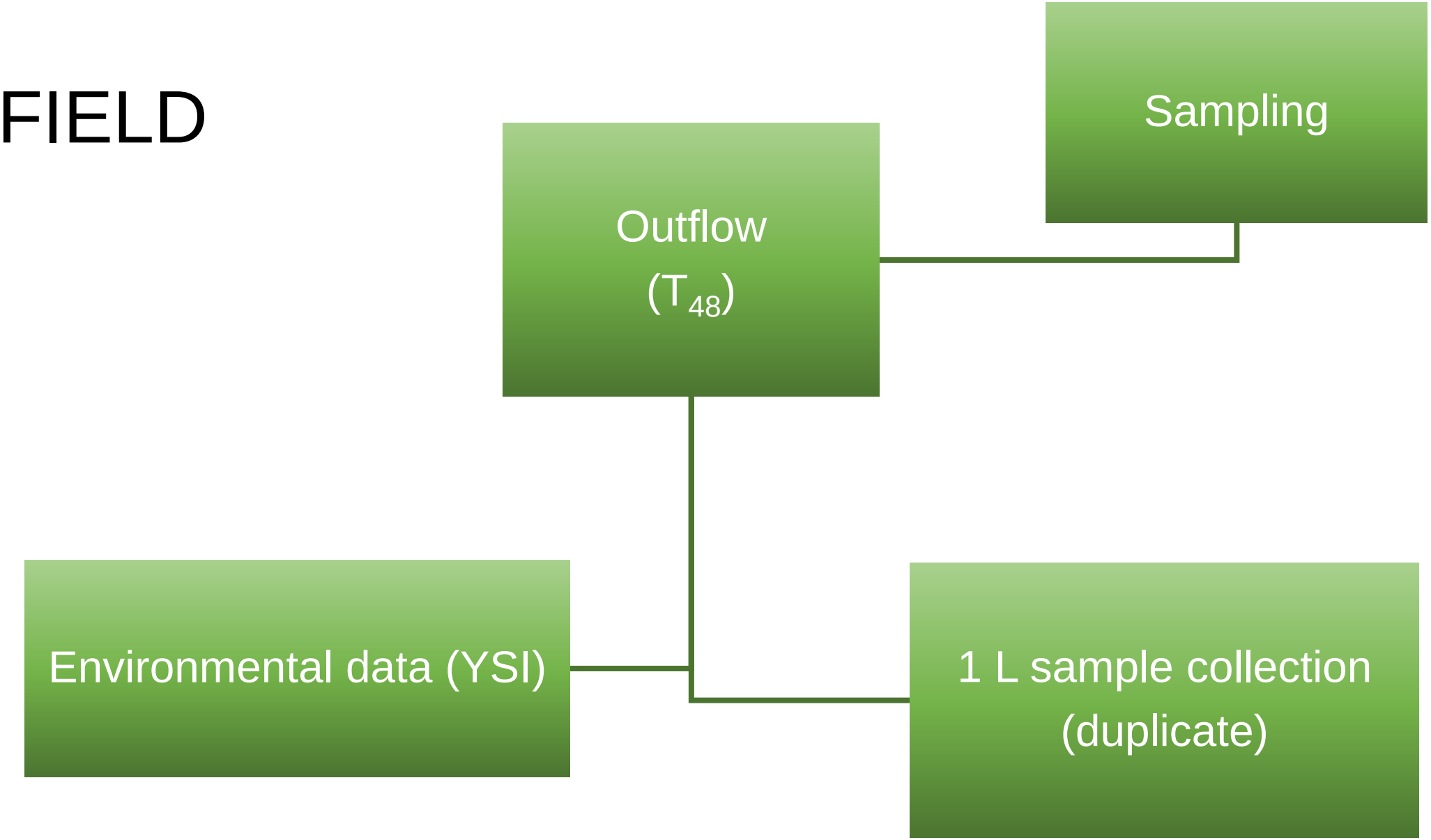
LAWN

FIELD MATERIALS & METHODS

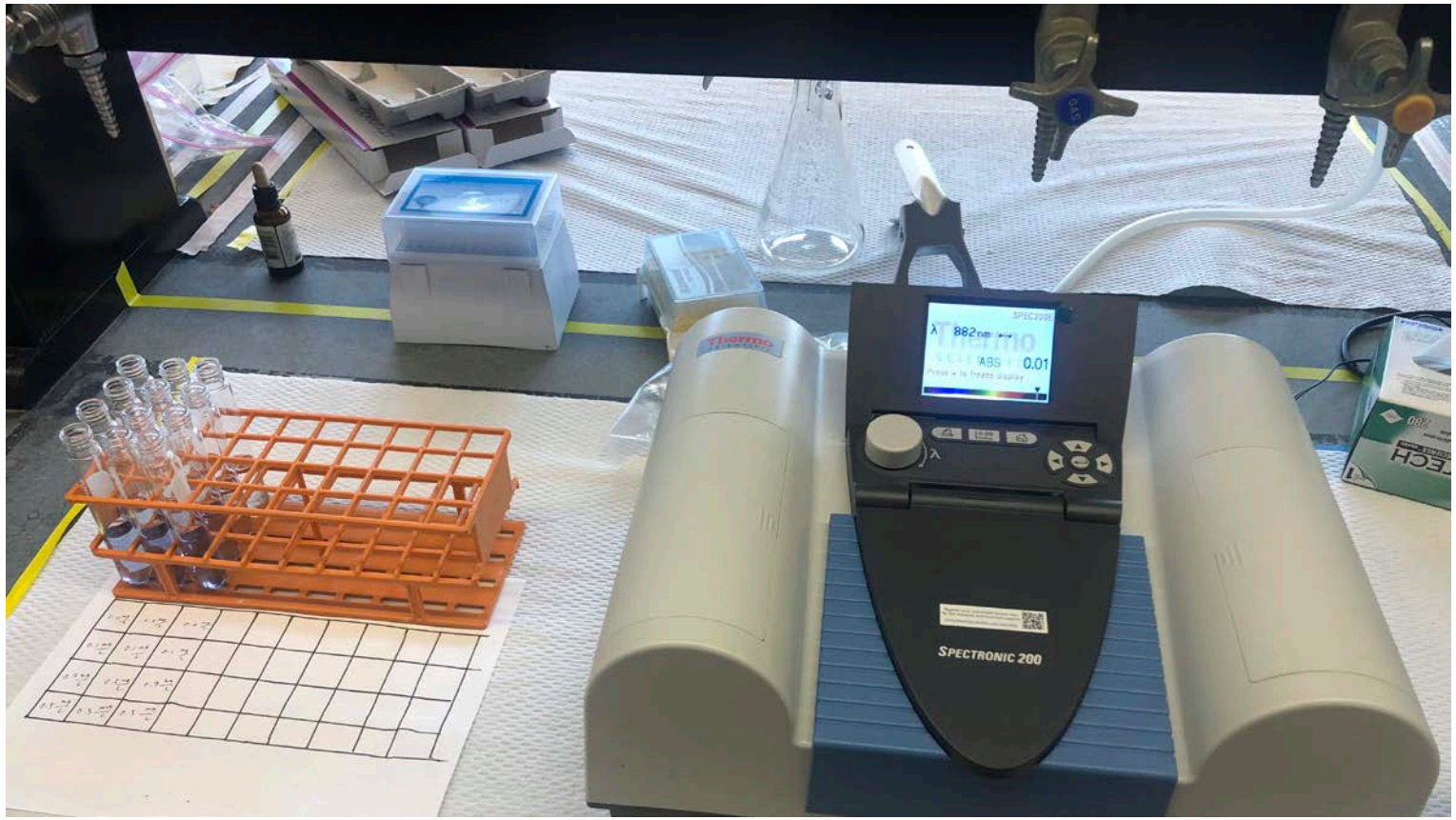
FIELD


Sampling
Inflow
(T_0)
Environmental data
(YSI)
1 L sample collection
(duplicate)

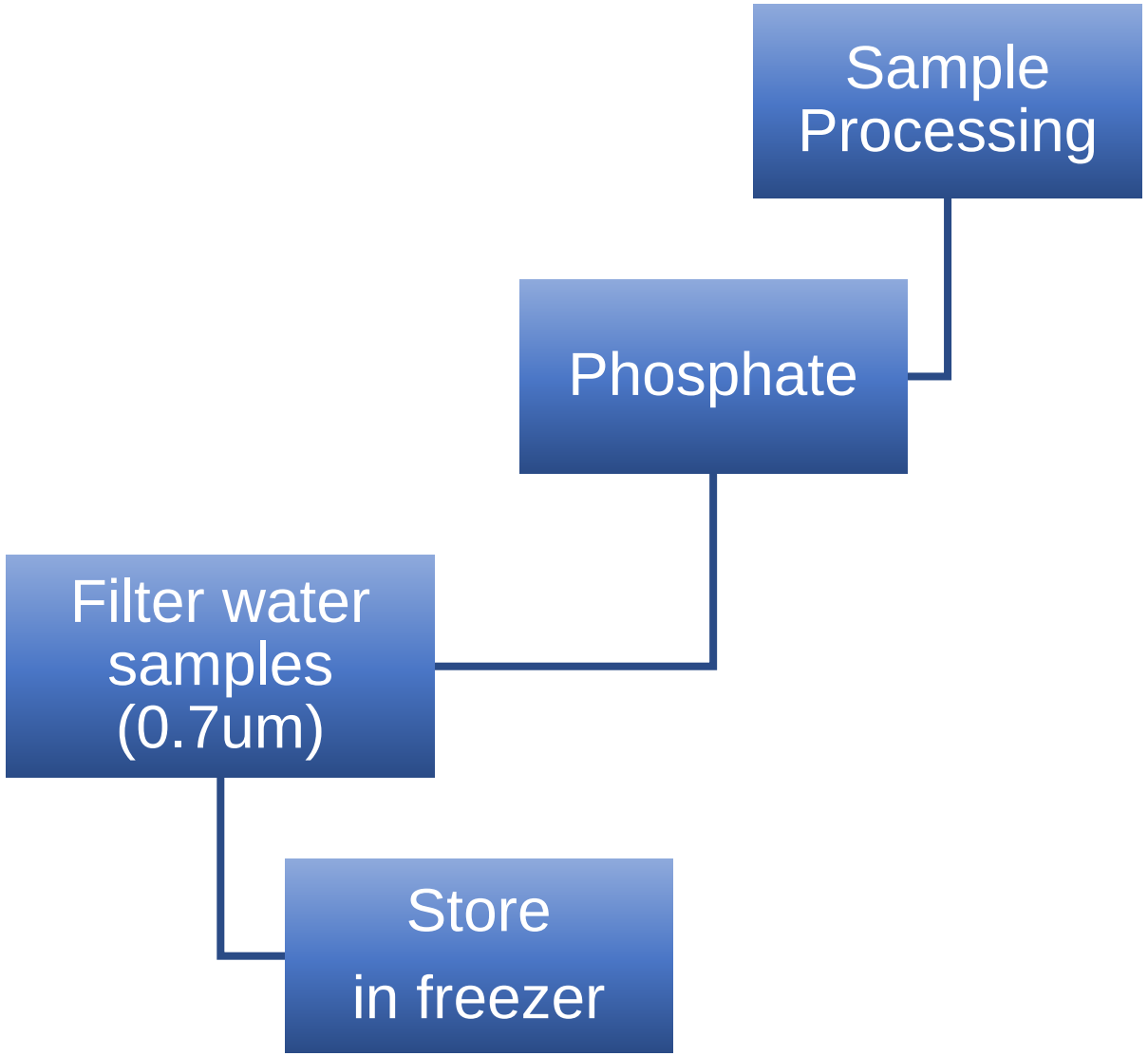
FIELD


Sampling
Outflow
(T_{48})
Environmental data (YSI)
1 L sample collection
(duplicate)

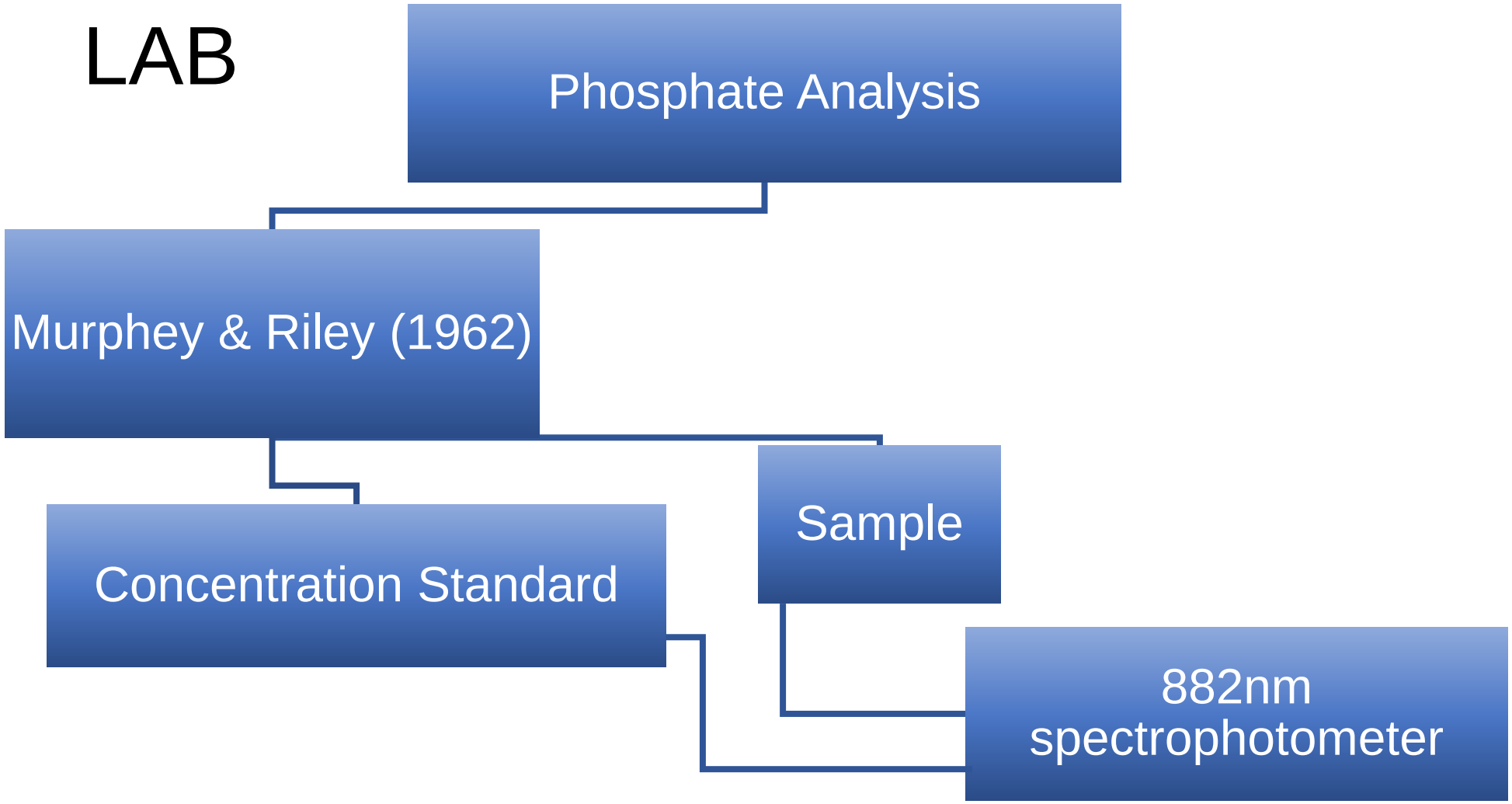
LAB MATERIALS & METHODS



LAB


Sample Processing
Phosphate
Filter water samples (0.7um)
Store in freezer

LAB


Phosphate Analysis
Murphey & Riley (1962)
Concentration Standard
Sample
882nm spectrophotometer

Environmental parameters

- pH
- Temperature
- Dissolved oxygen

multiparameter
YSI

Phosphate

spectrophotometric analysis

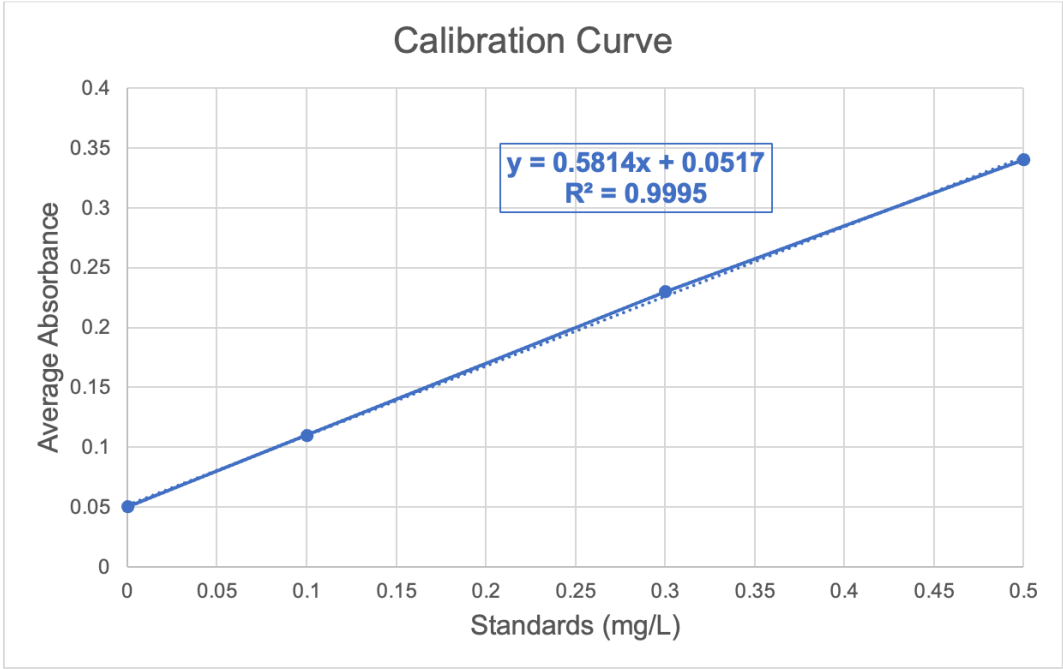
DATA ANALYSIS

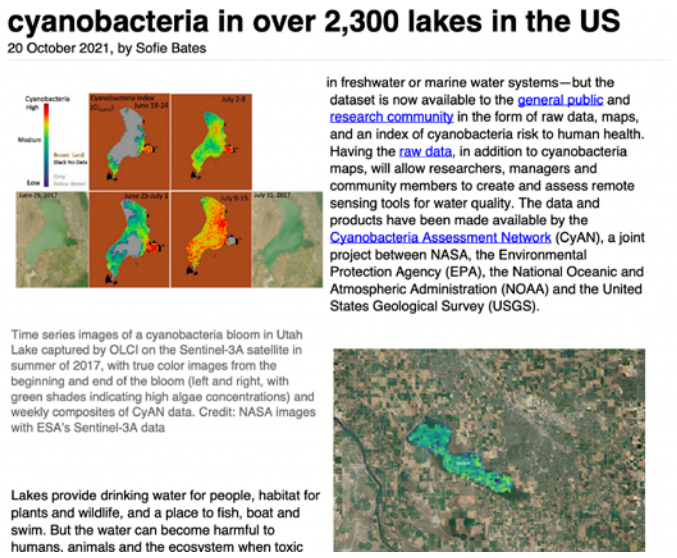
Determination of Phosphate in Natural Waters
KH_2PO_4

Standards (mg/L)	Abs1	Abs2	Abs3	Average Abs	Concentration (mg/L or ppm)
0	0.05	0.05	0.05	0.05	-0.002923977
0.1	0.11	0.11	0.11	0.11	0.100275198
0.3	0.23	0.23	0.23	0.23	0.306673547
0.5	0.34	0.34	0.34	0.34	0.495872033

$$x = \frac{y - 0.0517}{0.5814}$$

x = Concentration
y = Average Absorbance Value





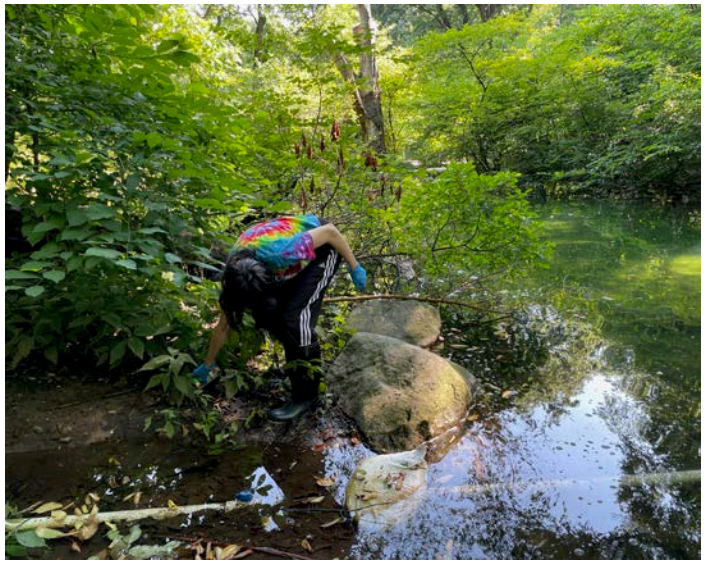
cyanobacteria in over 2,300 lakes in the US

20 October 2021, by Sofie Bates

in freshwater or marine water systems—but the dataset is now available to the general public and research community in the form of raw data, maps, and an index of cyanobacteria risk to human health. Having the raw data, in addition to cyanobacteria maps, will allow researchers, managers and community members to create and assess remote sensing tools for water quality. The data and products have been made available by the Cyanobacteria Assessment Network (CyAN), a joint project between NASA, the Environmental Protection Agency (EPA), the National Oceanic and Atmospheric Administration (NOAA) and the United States Geological Survey (USGS).

Time series images of a cyanobacteria bloom in Utah Lake captured by OLCI on the Sentinel-3A satellite in summer of 2017, with true color images from the beginning and end of the bloom (left and right, with green shades indicating high algae concentrations) and weekly composites of CyAN data. Credit: NASA images with ESA's Sentinel-3A data

Lakes provide drinking water for people, habitat for plants and wildlife, and a place to fish, boat and swim. But the water can become harmful to humans, animals and the ecosystem when toxic



PLANS FOR SUMMER 2023

Monitor for phosphate removal through growth season

Time-series microcystis incubations with ecoWEIR™ inflows and outflows from the season

ArcGIS StoryMaps

Remote sensing images of cyanobacteria in lakes

SIGNIFICANCE

If successful, PPA will install ecoWEIR ™ systems underneath the park’s fields

Other city parks are also following the study

ARTS

Multimedia Communication

B-roll, video interviews, audio interviews, and photojournalism

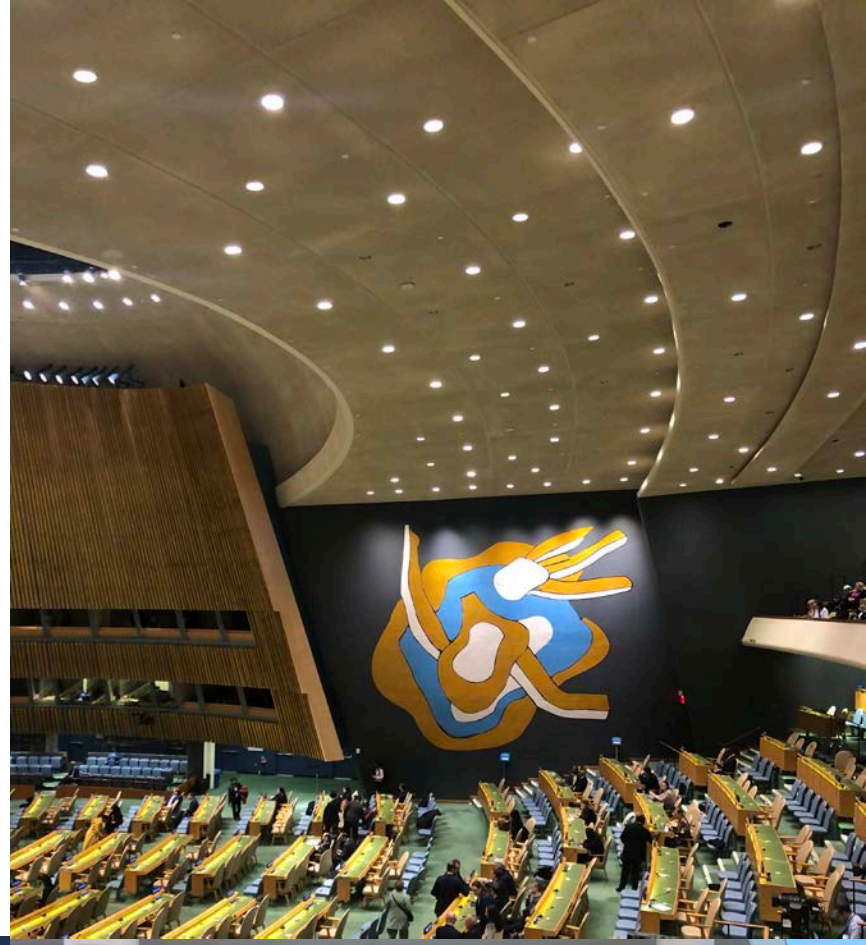
Painting, poetry, performance, noise, and filmmaking

INTERDISCIPLINARY RESEARCH AT BROOKLYN COLLEGE (NOAA + CUNY FUNDED)

BROOKLYN COLLEGE INSTALLATION GI TEST BED SITE

BROOKLYN COLLEGE

In situ GI test bed



BE YOURSELF

TAKE CARE OF WATER AS IF YOUR LIFE DEPENDS ON IT, BECAUSE IT DOES.

GREAT SOUTH BAY B-ROLL