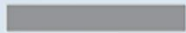


# *Monitoring and Detecting Hydrilla: Three Case Studies in New York and New Jersey*

By Chris Doyle, CLM  
*Director of Biology*



SÖLITUDE  
LAKE MANAGEMENT

Restoring Balance. Enhancing Beauty.

# Types of Aquatic Plant Surveys

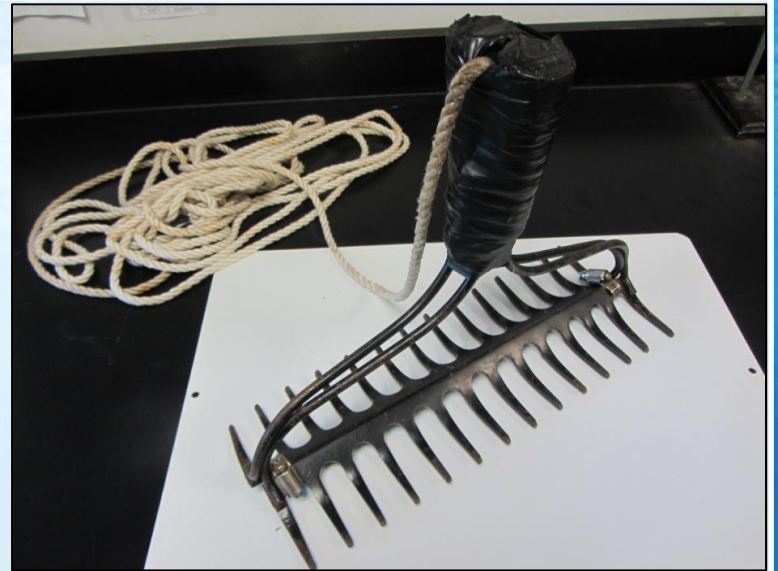
- **Visual Surveys**
  - Commonly Used, Easy to Perform
  - Difficult to Quantify Results/Repeat
- **Biomass Sampling**
  - 1-meter quadrant
- **Transect Sampling**
- **Remote Sensing**
- **Point Intercept Method**
  - Developed by ACOE (Technical Note MI-02: 1999)



**“Adaptive Monitoring”**



# Point Intercept Aquatic Plant Survey (PIM)






- **Developed by ACOE**
  - Modified by Cornell University
  - Tweaked by SLM
- **Accepted Methodology by Regulators**
  - Recommend one survey location/hectare
  - I prefer 1+ location per littoral zone acre (~100-125/day)
- **Assign Plant Mass Densities**
  - No plants, trace, sparse, medium, dense
  - Assigned to overall submersed plants
    - Then assigned to each different plant species

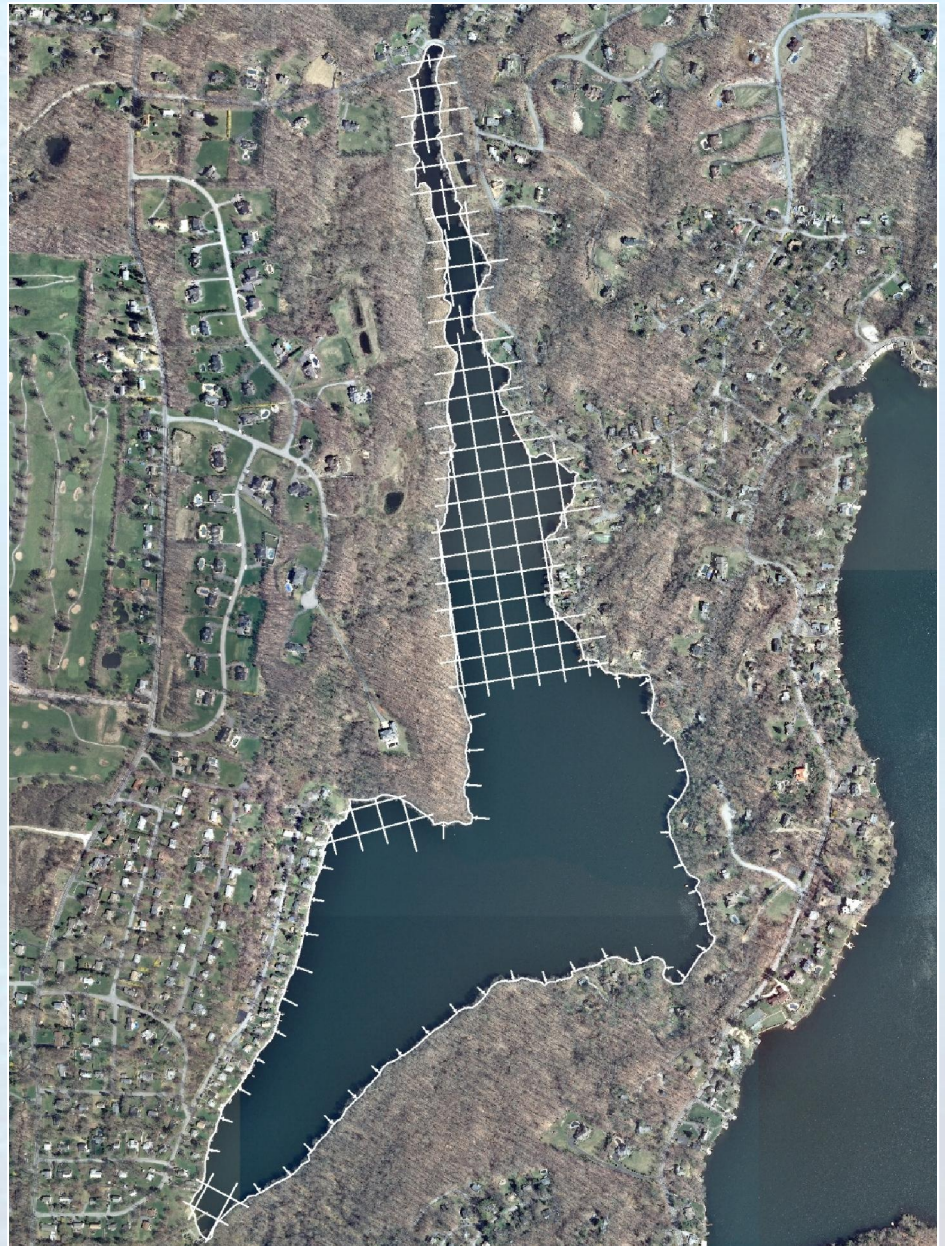
Abundance	Abundance #	Dry Weight (g/m <sup>2</sup> )	Mean Weight (g/m <sup>2</sup> )	Description
No Plants (“0”)	0	0.0	0.0	Bare Rake
Trace (“T”)	1	~0.0001-0.9999	0.5	Finger-full
Sparse (“S”)	2	~1.0000-24.9999	13.0	Hand-full
Medium (“M”)	3	~25.0000-99.9999	62.5	Covers Rake
Dense (“D”)	4	~100.0000-400.0000+	250.0	Difficult to get plant mass into the boat





# Overlay Grid on the Littoral Zone

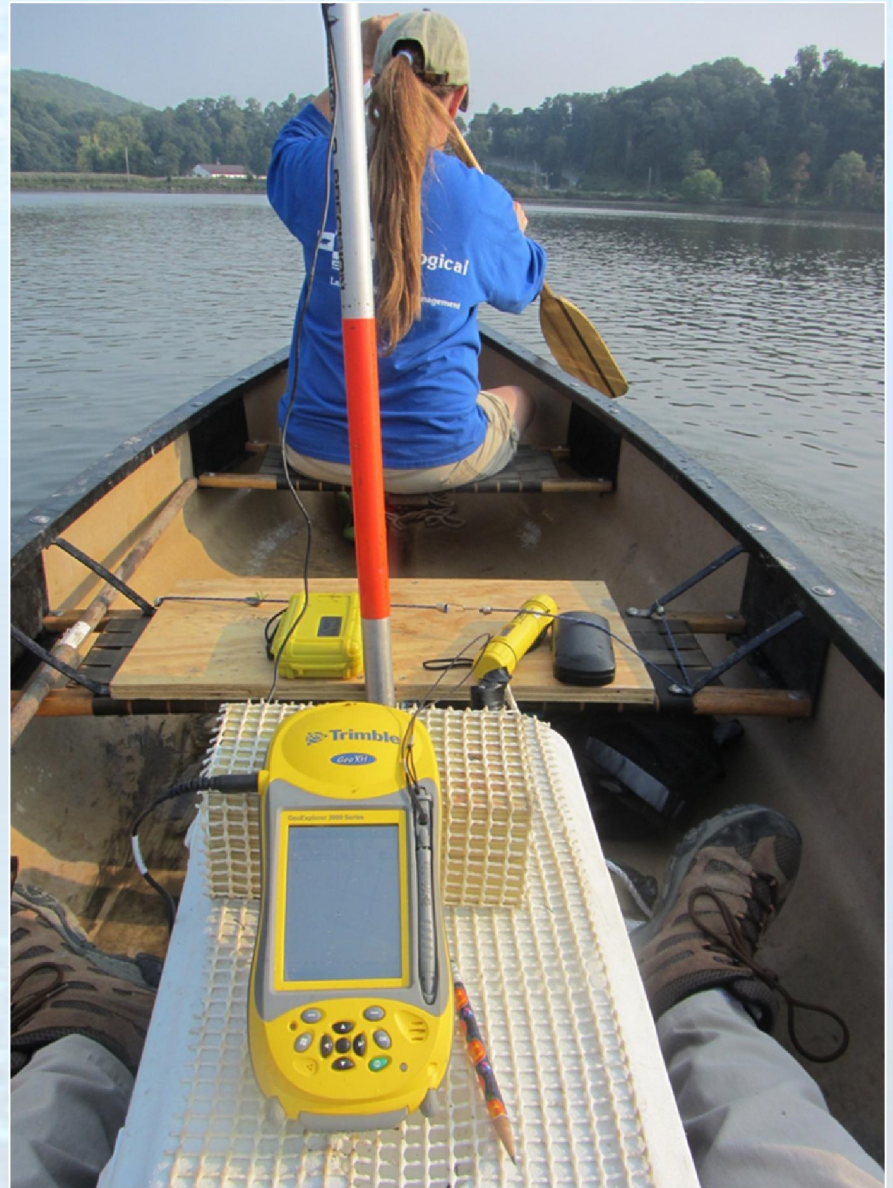
- **50-meter Grid**
  - Project Specific (Hydrilla)
  - Smaller = more sampling
  - Larger = less sampling
- **# of Weed Rake Tosses**
  - One, Two or Three
  - More Tosses =  more Target or RTE species
  - But.....
    -  more effort
    -  overall abundance





# Field Equipment

- **Weed Rake**
- **GPS Unit**
  - GeoXH Handheld
  - Sub-decimeter accuracy
    - w/post processing
- **Boat**
  - Prop Motor Boat
    - Access, tides, bridges, SAV growth
  - Air Boat
  - Canoe
  - On Foot





# Frequency of Occurrence Table

## Aquatic Macrophyte Abundance Distribution September 22, 2015

Aquatic Macrophytes	Total		Trace		Sparse		Medium		Dense	
	Sites	%	Sites	%	Sites	%	Sites	%	Sites	%
Total Sites	50	100%								
Overall Plant Abundance	40	80%	8	20%	5	13%	13	33%	14	35%
Small Duckweed	33	66%	19	58%	10	30%	2	6%	2	6%
Brittle Naiad	31	62%	5	16%	9	29%	9	29%	8	26%
Eurasian Water Milfoil	29	58%	13	45%	10	34%	5	17%	1	3%
Coontail	18	36%	16	89%	1	6%	1	6%	0	0%
Great Duckweed	16	32%	14	88%	2	13%	0	0%	0	0%
Northern Naiad	16	32%	8	50%	6	38%	2	13%	0	0%
Water Chestnut	15	30%	8	53%	5	33%	1	7%	1	7%
Spatterdock	6	12%	4	67%	2	33%	0	0%	0	0%
Wild Celery	4	8%	3	75%	1	25%	0	0%	0	0%
Water Stargrass	4	8%	4	100%	0	0%	0	0%	0	0%
Benthic Filamentous Algae	3	6%	2	67%	1	33%	0	0%	0	0%
Common Waterweed	2	4%	1	50%	0	0%	1	50%	0	0%



# Sample Abundance and Distribution Map

- Project Maps
  - Sample Station
  - Water Depth
  - Total SAV
  - Each Individual Plant

## For Example:

If a site has 17 different aquatic plants; 20 total maps will be produced

Project Specific Maps: Richness,  
Plant Groupings: Native/Invasive,  
or Pondweeds, etc.



ALCYON LAKE  
Aquatic Vegetation Survey  
August 28, 2014

67 sampling points

Plant Density

- = No Plants
- = Trace Plants
- = Sparse Plants
- = Medium Plants
- = Dense Plants

Percent Distribution

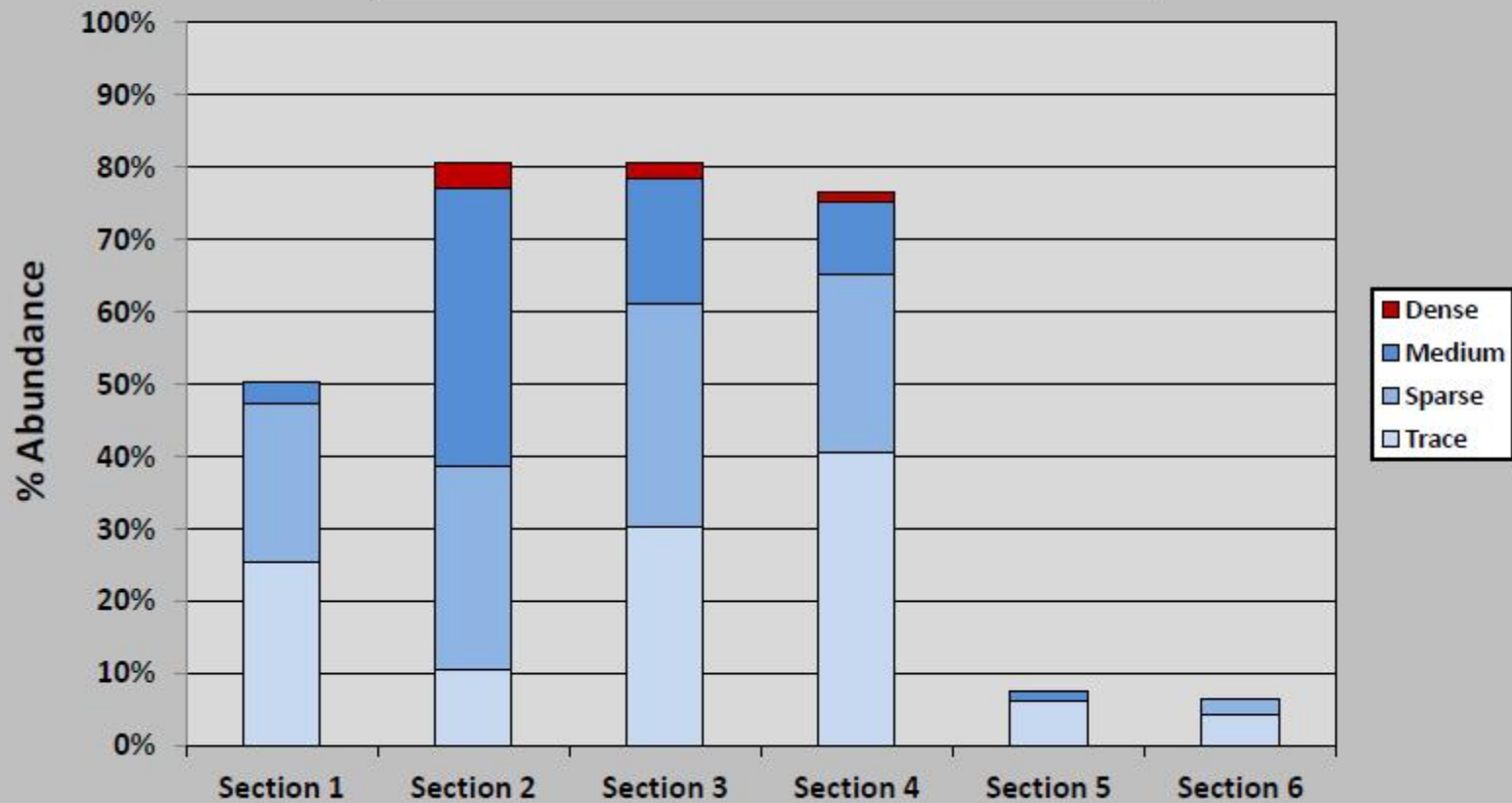
Abundance	Sites	Percent
Total	79	91%
Trace	20	25%
Sparse	30	38%
Medium	12	15%
Dense	17	22%



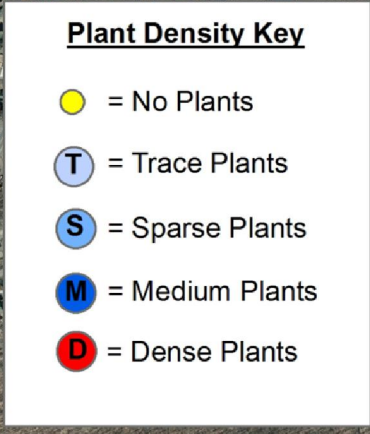
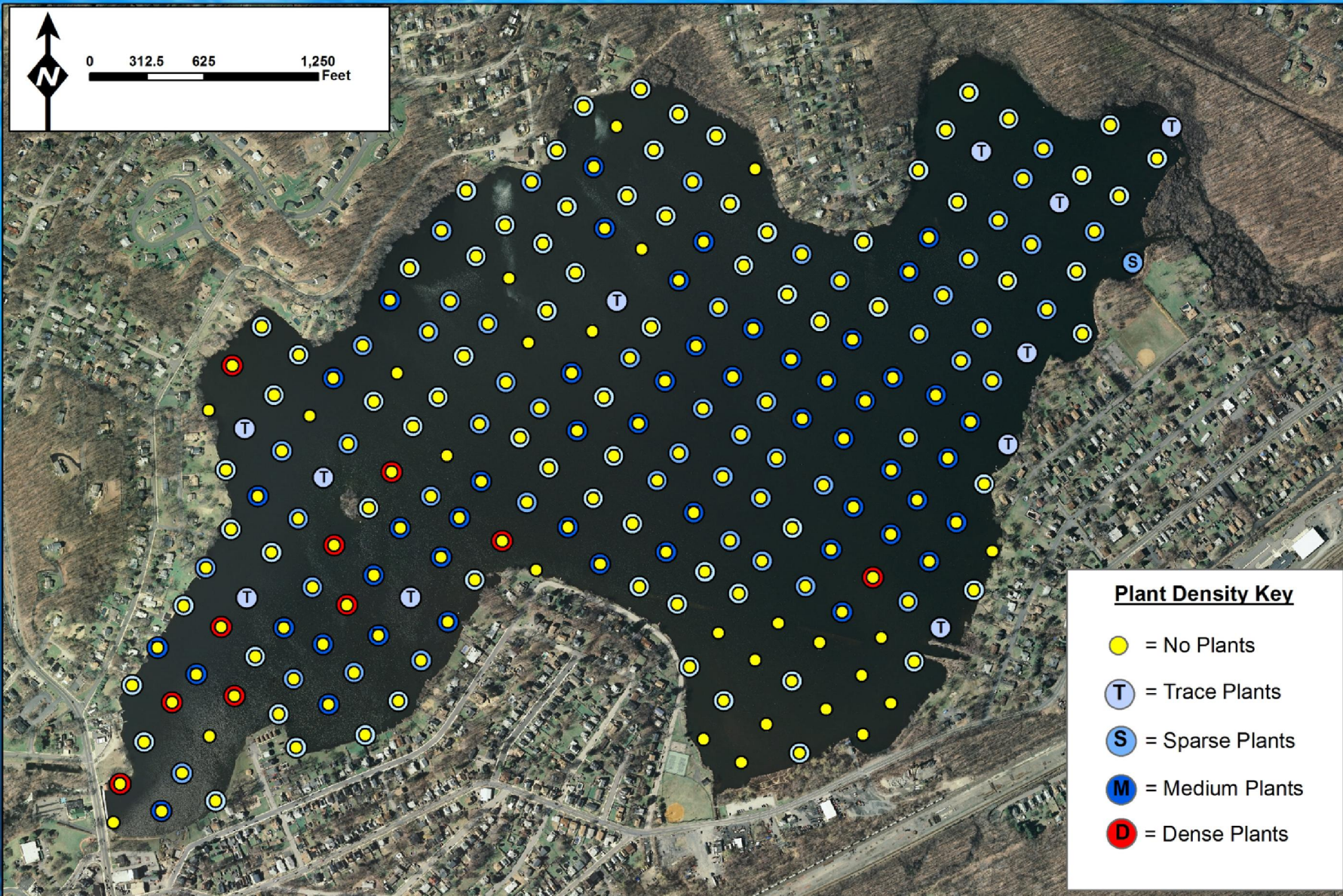
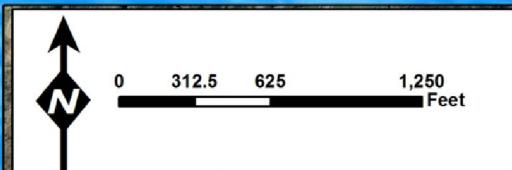
# Advantages of PIM Plant Mapping

- **Standard Method**
  - Important Part of Multi-year SAV Control Projects
- **Repeatable**
  - Suitable to track abundance and distribution changes of specific plants over time
    - Pre and Post SAV Control Efficacy
  - Site Comparisons
- **Can be Conducted by Volunteer Groups**
  - **Limitations:** GPS capabilities and Plant ID Skill

**Wild Celery (*Vallisneria americana*)**  
**Percent Abundance by Section**  
**D&R Canal**







**Eurasian Water Milfoil (*Myriophyllum spicatum*) Distribution  
Lake Musconetcong Aquatic Vegetation Survey**

**September 20, 2010**



# Hydrilla Tuber Monitoring

## Hydrilla Tuber Density

- Hydrilla tuber density over time
- Based on methods described by Johnson (2013) and NC State
- Post Hole Digger
  - 187 cm<sup>2</sup> plug
  - Calculate tubers/m<sup>2</sup>
- Increase # cores over time







# Project Challenges

- **Undefined Littoral Zone**
  - Where to start?
- **2,300+ acres, 35+ miles shoreline**
  - Traditional PIM: 15-20 days
- **2016 Budget: 6 Days**
- **Staff and Equipment Access**
  - Security Clearance
  - Mandatory Boat/Equipment Cleaning





# Three Phase Approach to 2016 Hydrilla Monitoring

## 1. Aquatic Plant Bio-volume Mapping

Hydroacoustic mapping

Assumed Littoral Zone

## 2. PIM Aquatic Plant Mapping

On select areas from Phase 1

Coves and Shorelines

## 3. Tuber Monitoring

Stations Selected from

Phase 2 Results





# Phase 1: Hydroacoustic Plant Mapping

## 1. Side Scan Fathometer

## 2. Data Collection

- Late August
- Boat Speed: > 8 mph
- Shorelines, coves and littoral zone
- 18 hours on water data collection
- 20-minute runs (file size)

## 3. Data Outputs

- Uploaded to Manufacturer Server (QC/Interpolation)
- Reprocessed with Spatial Analyst
- ArcMap 10.3
- Bathymetry and Bio-volume Maps



# Submersed Aquatic Plant Bio-volume

## 1. % of SAV in Water Column

- Ex. Plants at Surface = 100%
- Ex. Water Depth 10 ft.; Plant Height 5 ft. = 50%

## 2. Displayed in a Color Array

## 3. Doesn't Differentiate Species

### Biovolume (%)



0 - 20



20 - 40



40 - 60



60 - 80



80 - 100



No Data/Not Surveyed



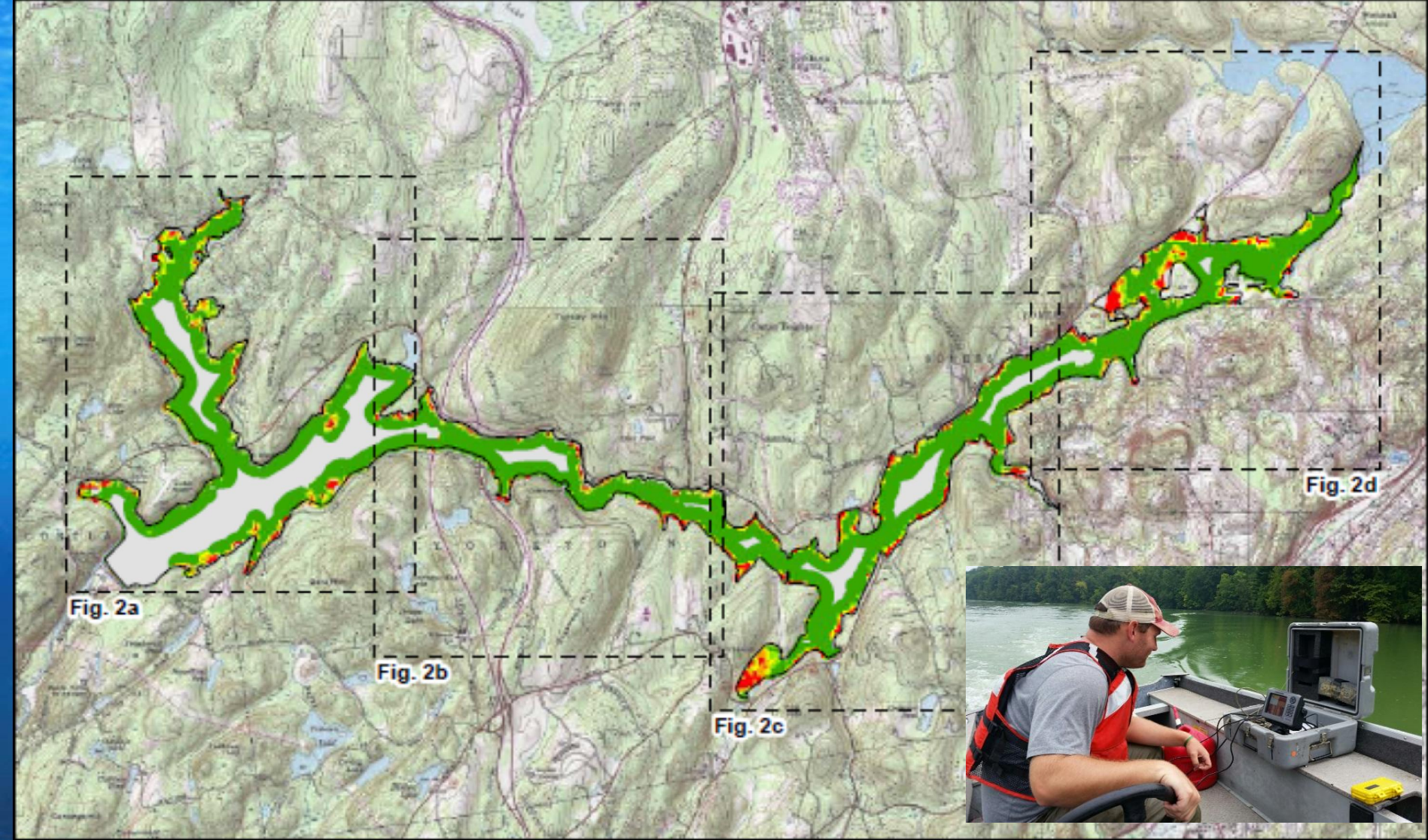


Fig. 2a

Fig. 2b

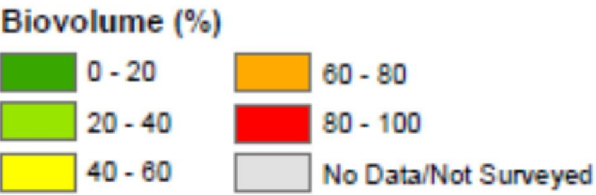
Fig. 2c

Fig. 2d



**New Croton Reservoir**  
Westchester County, NY  
Biovolume

Legend:

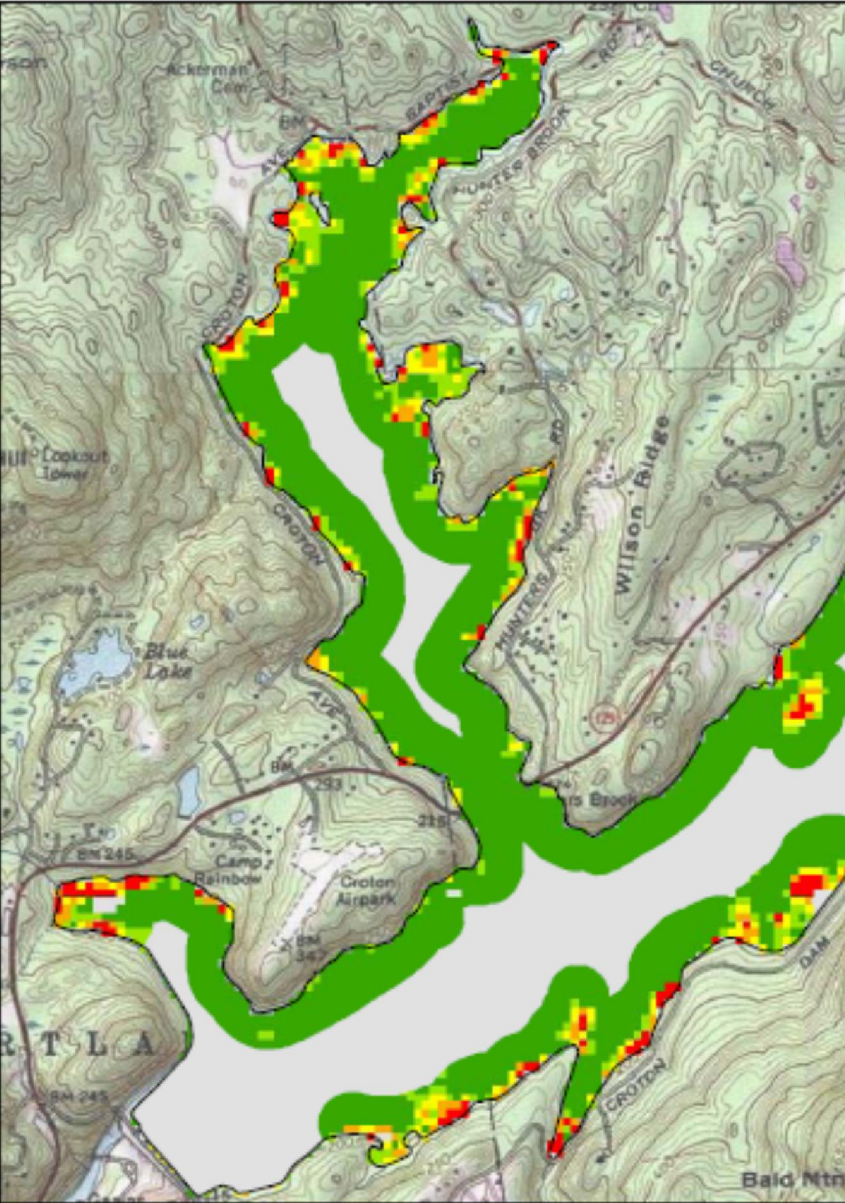


**SOLITUDE**  
LAKE MANAGEMENT  
888-480-5253  
WWW.SOLITUDELAKEMANAGEMENT.COM



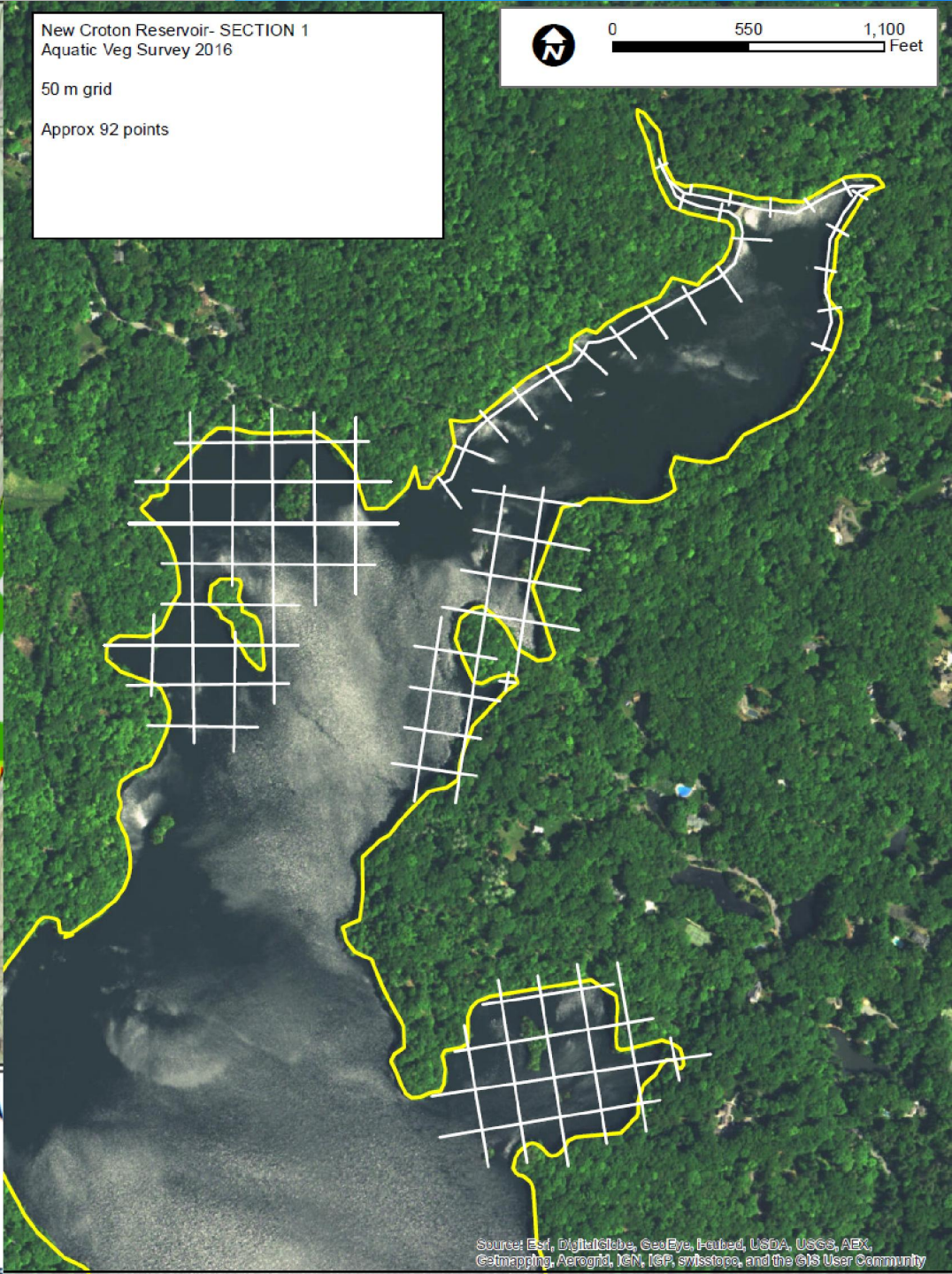
FIGURE:	SURVEY DATE:	MAP DATE:
2	8/30-9/1/16	11/30/16





New Croton Reservoir- SECTION 1  
Aquatic Veg Survey 2016

50 m grid  
Approx 92 points



**New Croton Reservoir**  
Westchester County, NY

**Biovolume**

Legend:

Biovolume (%)	
	0 - 20
	20 - 40
	40 - 60
	60 - 80
	80 - 100
	80 - 100
	No Data/Not Surveyed

FILES:	SURVEY DATE:	MAP DATE:
0a	RFD_01/16	11/03/16

0 0.5

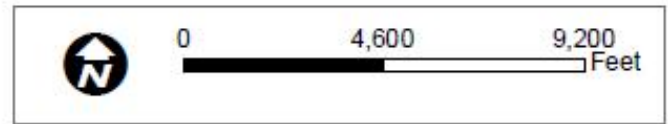
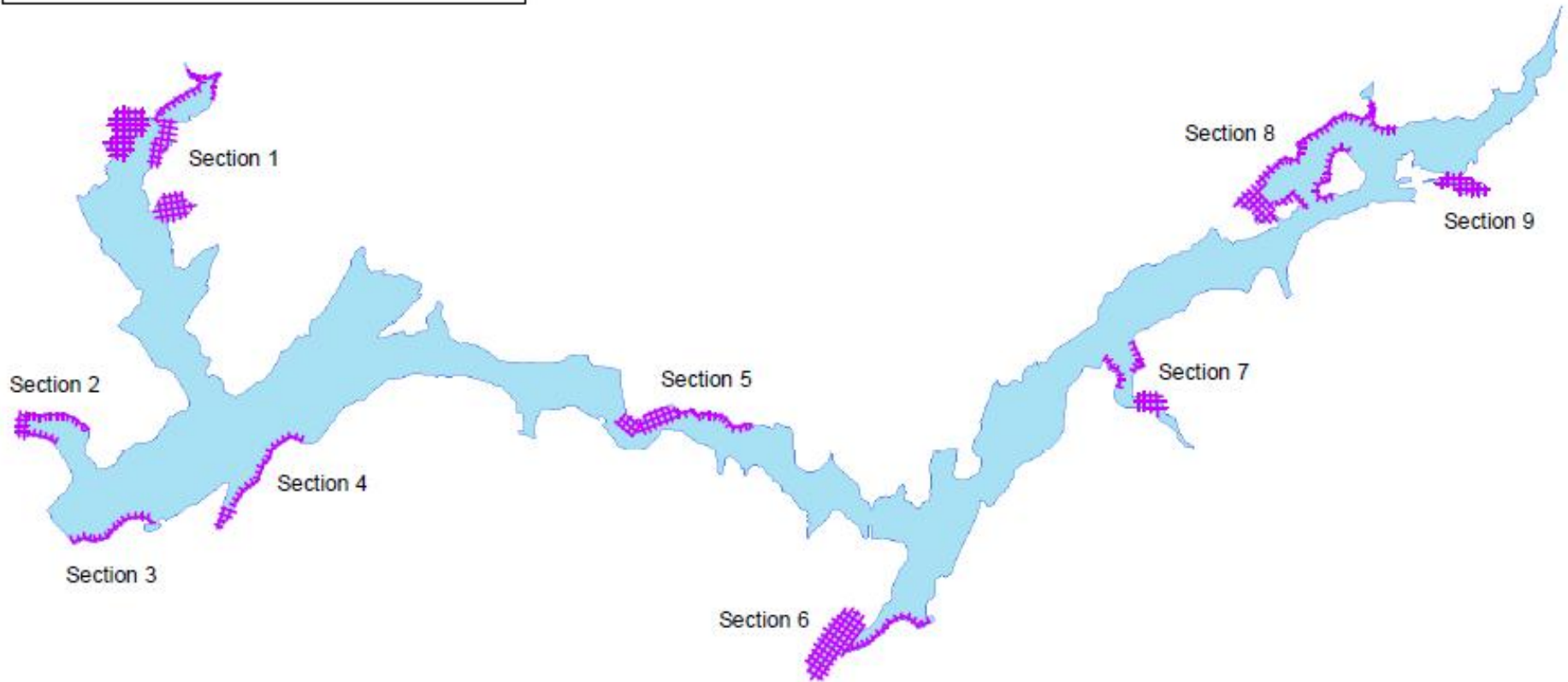
Source: Esri, DigitalGlobe, GeoEye, Earthstar, USDA, USGS, AeroX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



New Croton Reservoir- Overview  
Aquatic Veg Survey 2016

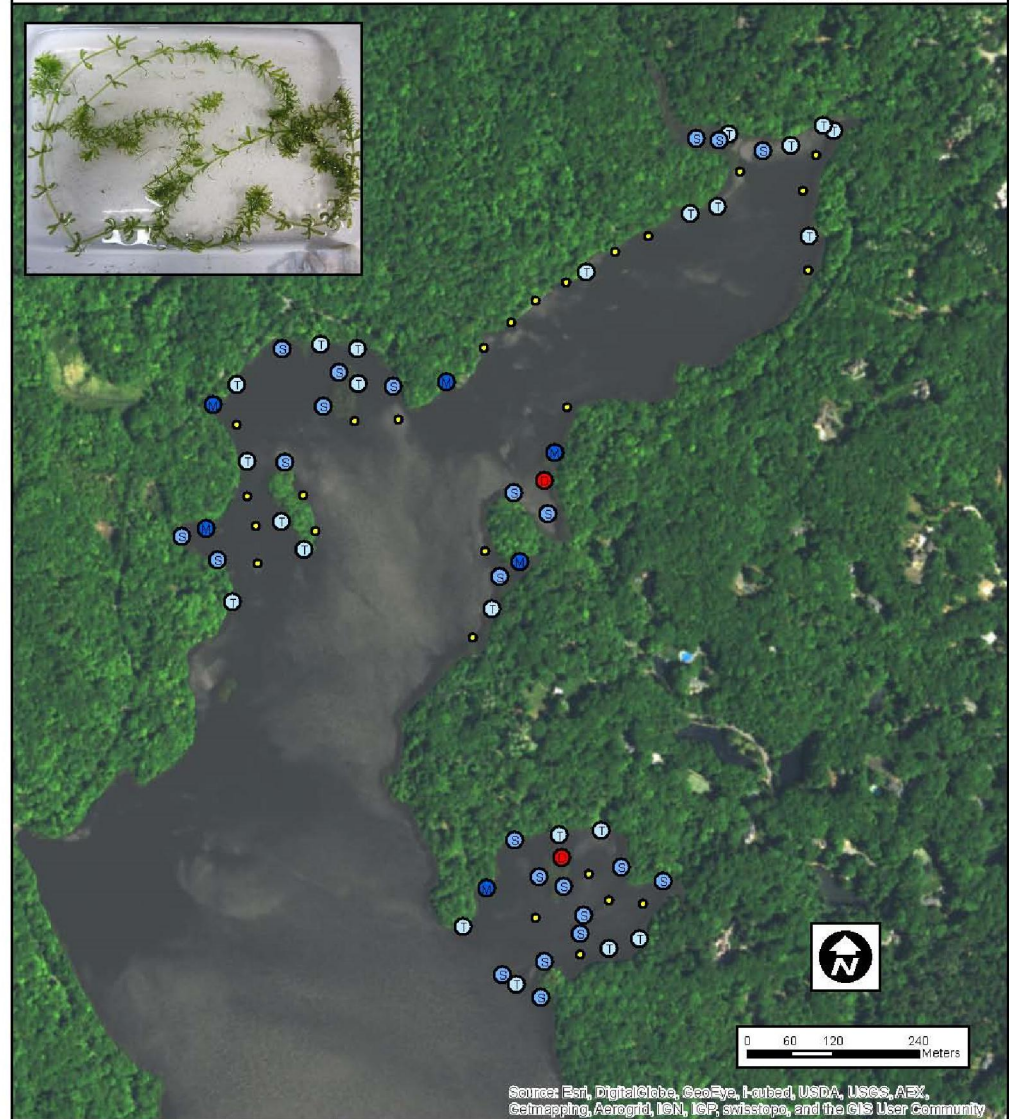
Sections 1-9

50 meters grid



# Phase 2: PIM Mapping

- Late September
- 9 Sections
- 342 Stations
- 2 tosses/station
- 50-meter grid
- All SAV species



Source: Esri, DigitalGlobe, GeoEye, i-loud, USDA, USGS, AEX, Geomatics, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

New Croton Reservoir  
Section 1

Aquatic Vegetation Survey  
September 28, 2016  
80 Sites

Percent  
Distribution

Abundance	Sites	Percent
Total	54	68%
Trace	23	43%
Sparse	23	43%
Medium	6	11%
Dense	2	4%

Plant  
Density

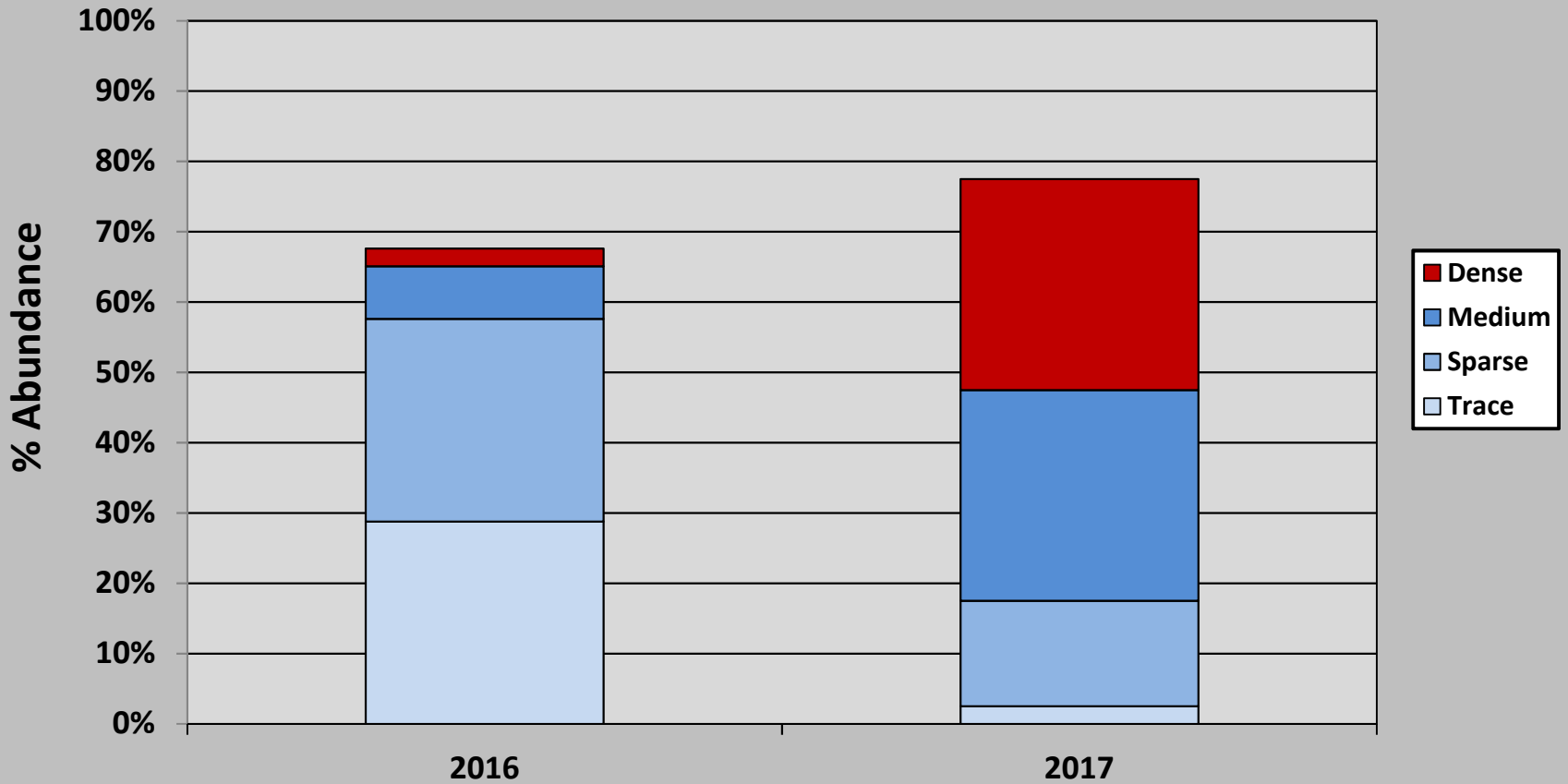
- No Plants
- Trace Plants
- Sparse Plants
- Medium Plants
- Dense Plants



# 2016 New Croton Reservoir SAV Frequency of Occurrence

Common Name	Scientific Name	# Occurrences	% Occurrence
Overall SAV		339	99.1%
Coontail	<i>Ceratophyllum demersum</i>	310	90.6%
Eurasian Water Milfoil	<i>Myriophyllum spicatum</i>	306	89.5%
Hydrilla	<i>Hydrilla verticillata</i>	114	33.3%
Benthic Filamentous Algae		111	32.5%
Water Smartweed	<i>Polygonum amphibium</i>	44	12.9%
Small Duckweed	<i>Lemna minor</i>	20	5.8%
Great Duckweed	<i>Polyrhiza spirodela</i>	14	4.1%
Common Watermeal	<i>Wolffia columbiana</i>	13	3.8%
Brittle Naiad	<i>Najas minor</i>	10	2.9%
White Water Lily	<i>Nymphaea odorata</i>	3	0.9%
Leafy Pondweed	<i>Potamogeton foliosus</i>	3	0.9%
Long-leaf Pondweed	<i>Potamogeton nodosus</i>	3	0.9%
Clasping-leaf Pondweed	<i>Potamogeton richardsonii</i>	1	0.3%
Bassweed	<i>Potamogeton amplifolius</i>	1	0.3%
Spikerush	<i>Eleocharis sp.</i>	1	0.3%

**Hydrilla (*Hydrilla verticillata*)**  
**Percent Abundance 2016/2017**  
**New Croton Reservoir**  
**Section 1**

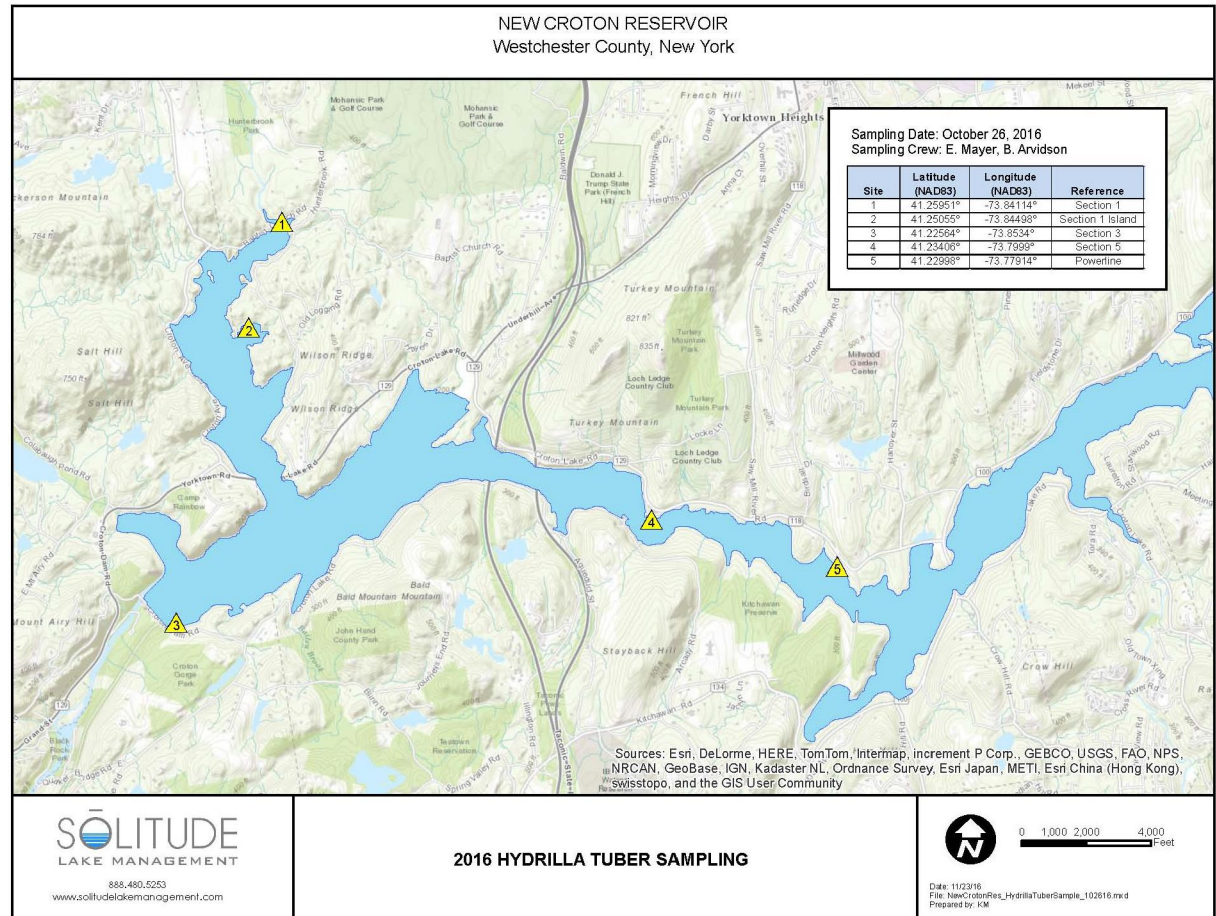




# Phase 3: Hydrilla Tuber Monitoring

- November
- 5 Stations
- 3-4 Cores per station

Site	Description	# Cores	Tubers (m <sup>2</sup> )	Turions (m <sup>2</sup> )
NCR-1	Section 3; corner of dam	3	1299.4	0
NCR-2	Section 1; Inlet Cove	4	187.6	0
NCR-3	Section 1; Islands	4	1112.2	26.8
NCR-4	Section 5; Boat Launch	3	1997.8	53.4
NCR-5	North Shoreline by Power Lines	4	1031.8	26.8



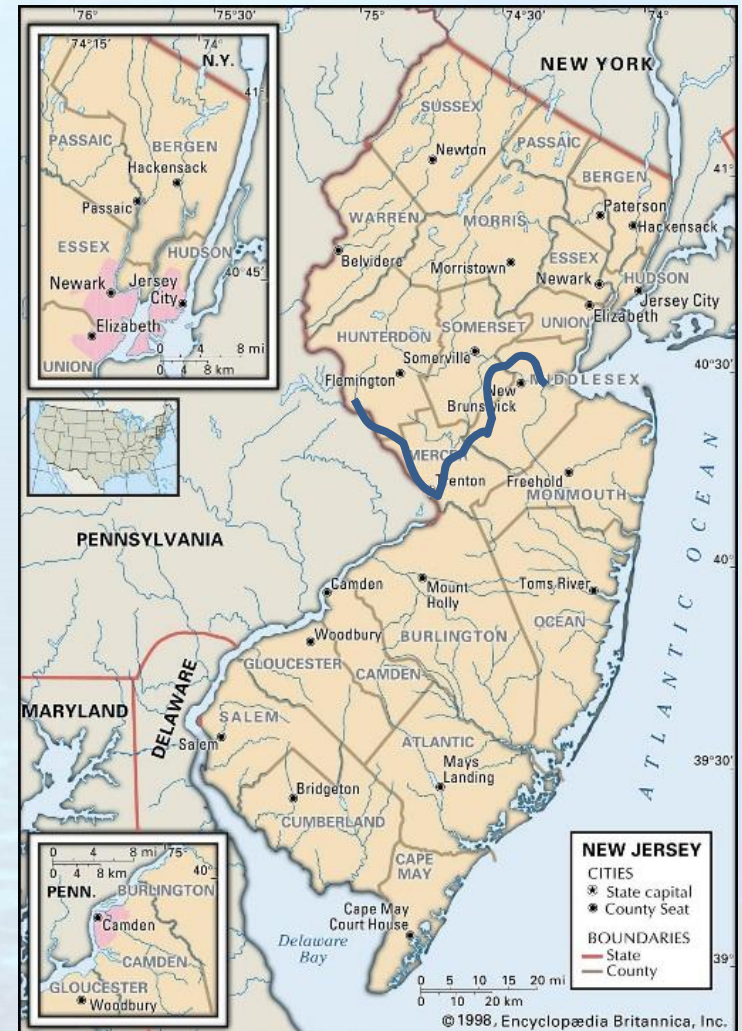
# Case Study #2: The D&R Canal

## Project Site

- Delaware & Raritan Rivers
- Central New Jersey
- Constructed in 1830's
  - Mostly hand-dug
  - Anthracite: PA to NJ
- Length: 66 miles
- Operated by the NJWSA
- 100 MGD Water Transfer

For more information on the Project:

<http://www.njwsa.org/hydrilla.html>





# D&R Canal



- **Numerous Stakeholders**
  - NJDEP, NJDF&W, D&R Canal Commission, NJ Div. of Parks, ACOE, Many Friends Organizations
  - Nine Canal Water Users (5 potable)
- **Primary Goal: Suitable Water Flow**
- **2016: Flow Decrease ➔ Mechanical SAV Removal**
  - July discovered **hydrilla**
- **2016 SAV Monitoring**
  - Modified PIM Mapping (Sept.)
  - Hydrilla Tuber Monitoring (Nov.)

# D&R Canal: Getting it Right

- **2016 Project Challenges**
  - Timing of Discovery
  - RFP Process
  - Limited Budget
  - How to Map SAV in a Canal
  - Access to Canal
- **2016 Project Goals**
  - Determine Extent of Hydrilla Infestation
  - Develop a Multi-year Control Project
    - Consider all the Stakeholders
  - Repeatable







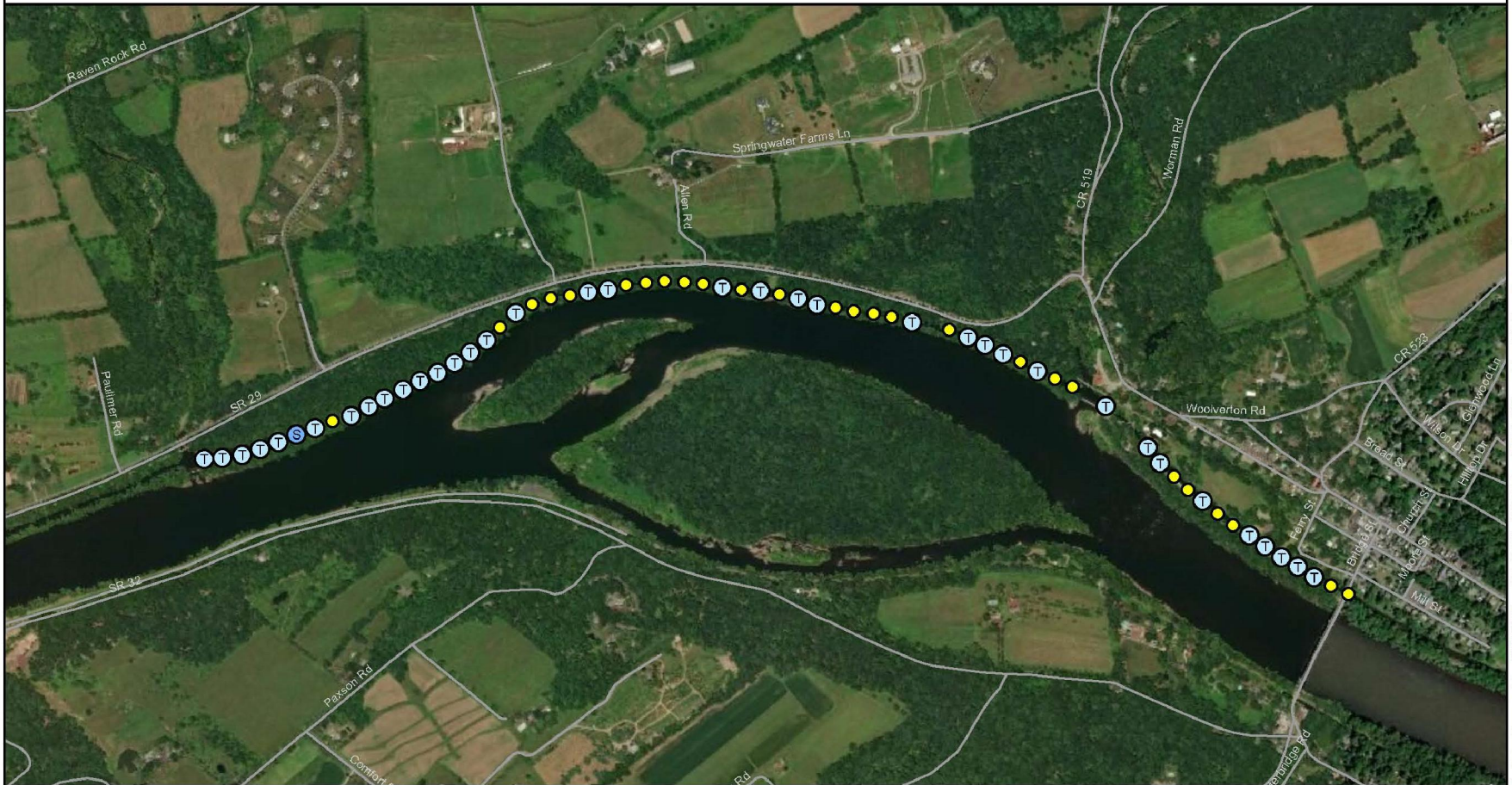
50-75 ft.







NON-TREATMENT AREA  
 OVERALL AQUATIC PLANT ABUNDANCE  
 SEPTEMBER 21, 2018



DELAWARE & RARITAN CANAL  
 Non-Treatment Area  
 Aquatic Vegetation Survey  
 September 21, 2018

Total Sample Sites: 63

Plant  
 Density

- = No Plants
- ⊕ = Trace Plants
- ⊙ = Sparse Plants
- ⊕ = Medium Plants
- = Dense Plants

Percent  
 Distribution

Abundance	Sites	Percent
Total	37	59%
Trace	36	97%
Sparse	1	3%
Medium	0	0%
Dense	0	0%

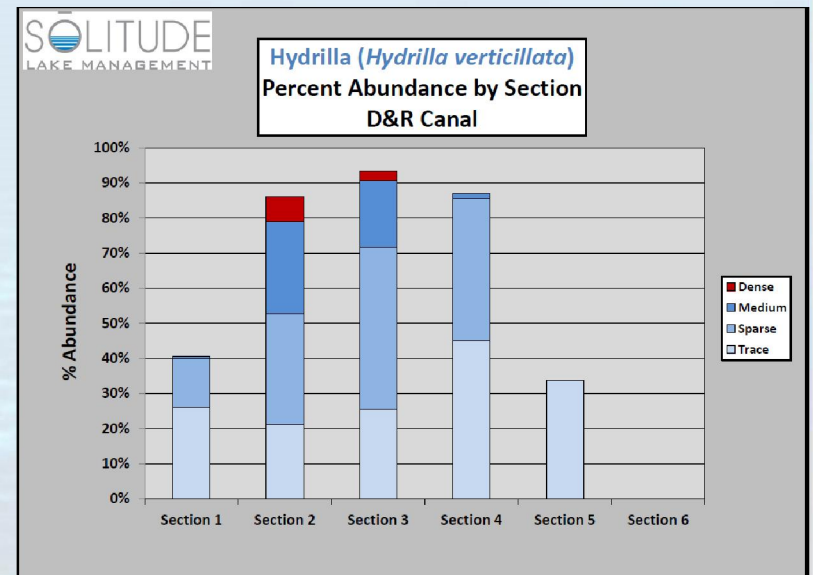


0 280 560 1,120  
 Feet

# 2016 SAV Monitoring

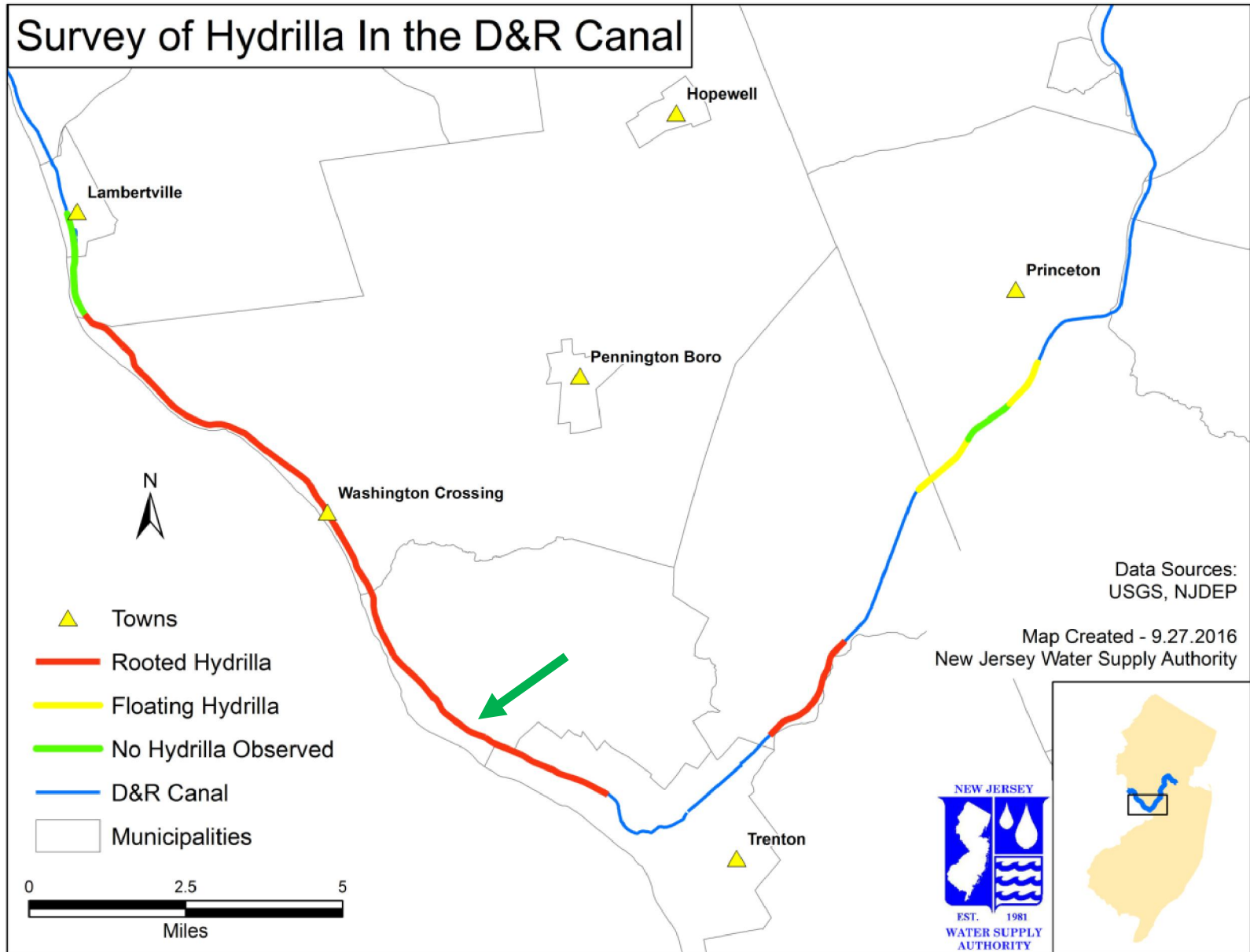
## Pre-Control Monitoring

- 18.31 Miles
- 597 GPS-referenced Stations
  - 2 tosses per station (West/East Shore)
  - 50 meters apart
- Started Upstream
  - Visual Surveys
  - Discovered on Main Canal
- Documented all SAV
- 2017 SAV Man. Plan





# Survey of Hydrilla In the D&R Canal



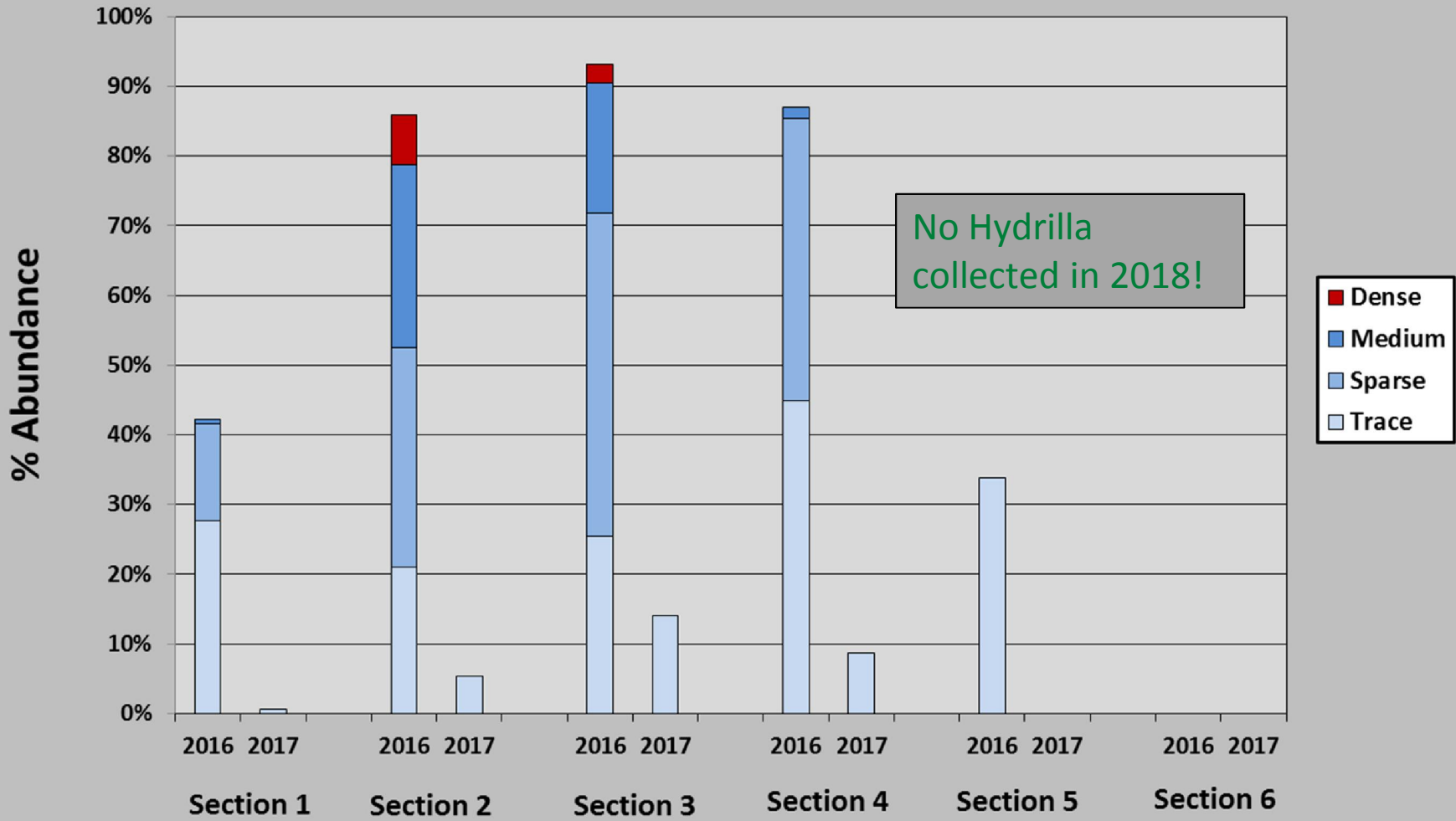
# 2017-2019 Hydrilla Control Program

- **Low-dose Fluridone Injection (May-Sept.)**
- **2017 SAV Monitoring**
  - Re-map Treatment Area
  - Hydrilla Tuber Monitoring
  - Map Entire D&R Canal
    - 1813 GPS-referenced Stations
    - Confirmed Hydrilla Extent
    - Discovered Fanwort
  - Supplemental Weekly/Monthly Surveys
- **2018 SAV Monitoring**
  - Treatment Area and Tuber Monitoring only





**Hydrilla (*Hydrilla verticillata*)  
2016 vs 2017 Percent Abundance by Section  
D&R Canal**

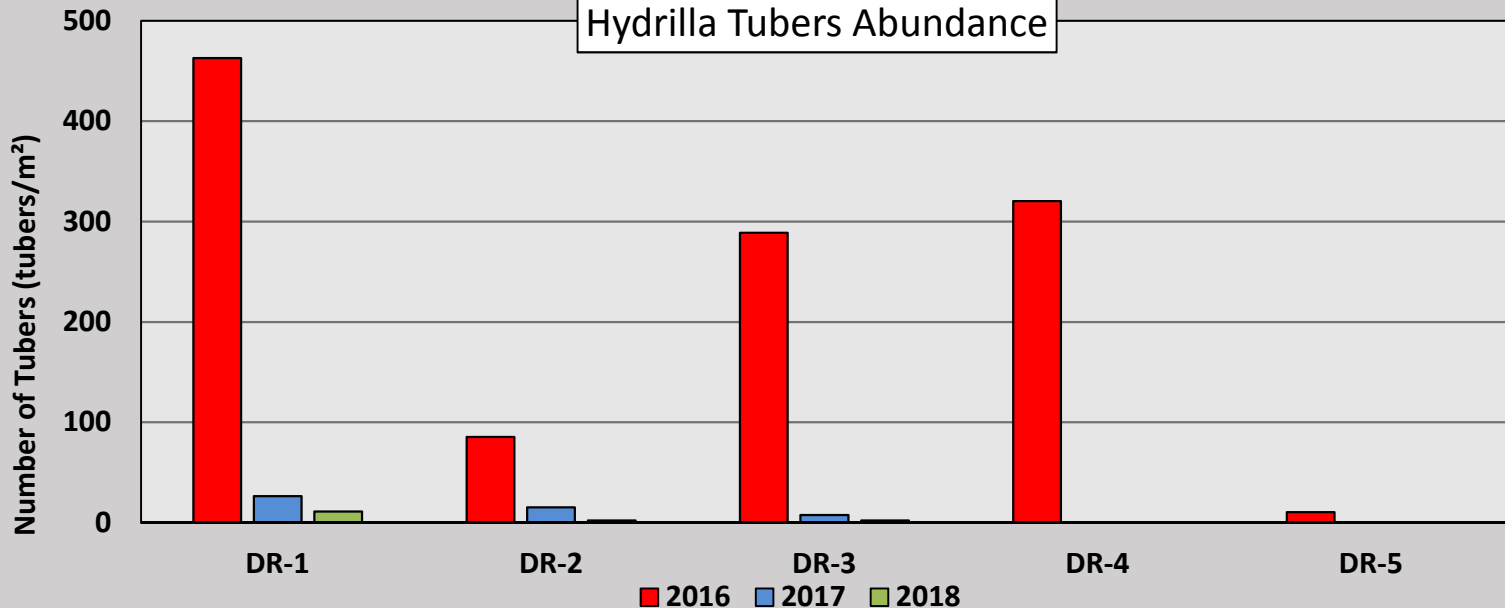


# Hydrilla Tuber Monitoring

Tuber Sampling Stations	2016 (tubers/ m <sup>2</sup> )	2017 (tubers/ m <sup>2</sup> )	2018 (tubers/ m <sup>2</sup> )
DR-1	462.8	26.5	11.2
DR-2	85.6	15.2	2.2
DR-3	288.9	7.6	2.2
DR-4	320.4	0	0
DR-5	10.7	0	0



D&R Canal  
2016 vs. 2017 vs. 2018  
Hydrilla Tubers Abundance





# Case Study #3: Lower Hudson River SAV Monitoring

- **Croton River, Westchester County, NY**

- Downstream of the New Croton Reservoir
- Flows into Hudson River
- **Hydrilla Discovered 2013**
- River Mapped in 2014

- **2015 SAV Monitoring**

- Funded by Hudson River Estuary Program
  - NYSDEC
  - Support from New England Interstate Water Pollution Control Commission (NEIWPC)



# Project Goals

## Croton River Hydrilla Management Plan

- Lead Agency
- Source of Funding
- Stakeholder Engagement
- Hydrilla Established Outside of Croton River?

## 2015 Hudson River SAV Monitoring

- Identify Suitable Hudson River SAV Locations
  - PIM Mapping (**Reasonable Effort**)
  - Hydrilla and Wild Celery Target Species
    - But document all species
  - Hydrilla Tuber Monitoring (if hydrilla confirmed)
- Develop a Priority Ranking for Locations
  - Future Monitoring Efforts





# Sampling Locations

## 46 Locations

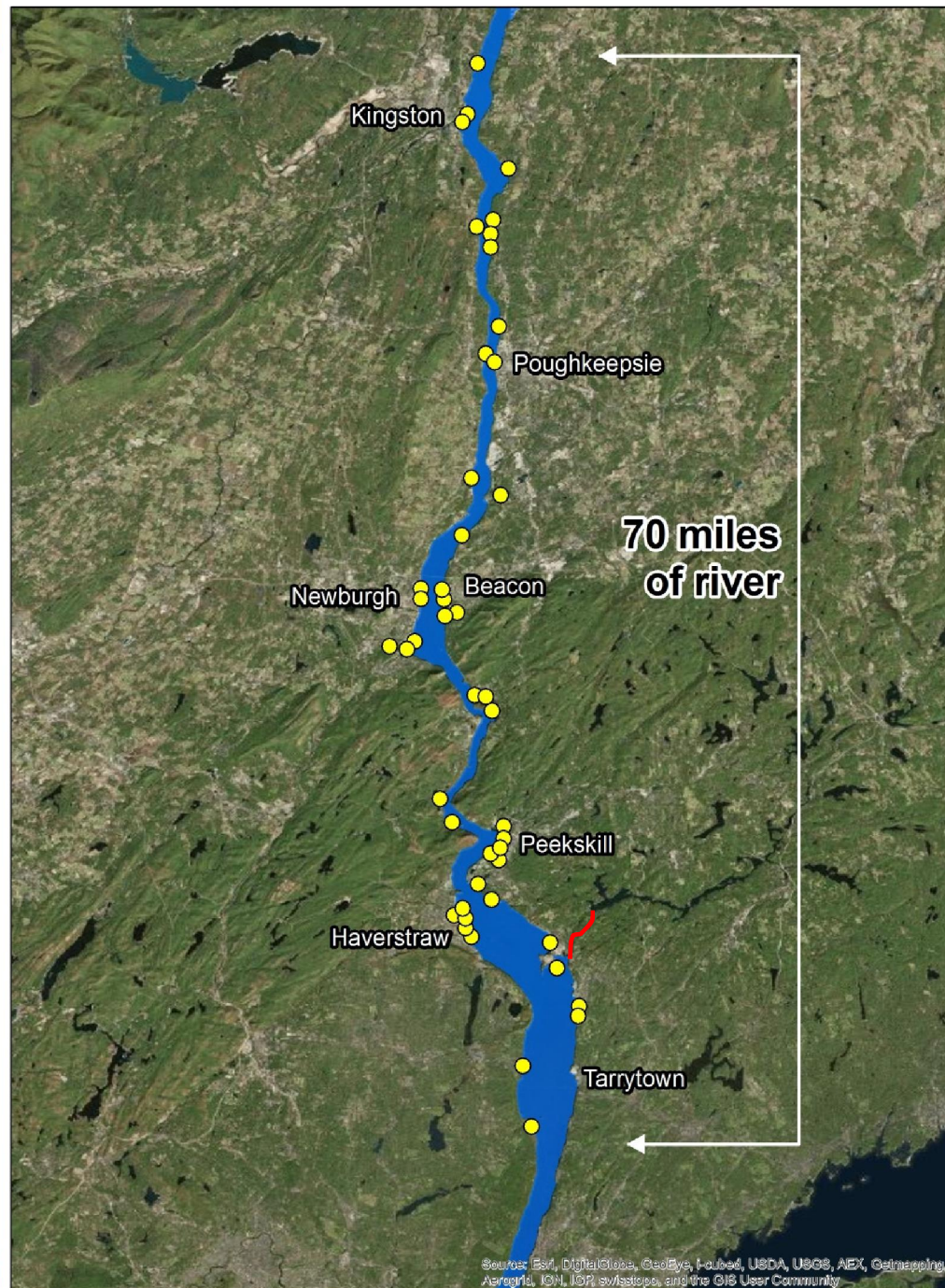
- 70 mile stretch of the Hudson River
- Marinas, boat launches, backwaters and marshes
- Six Counties
- Near Five Bridges

## Selected by NYSDEC

- +/- Four Locations

## Size Range:

- .07 acres to 639 acres





# Project Challenges

## Finding SAV Habitat

- Turbidity, wind, tidal action, shoreline, water depth

## Location Access

- No boat launches
- Tidal
- Bridges
- Property Owners

## Time Line

- 8 weeks to conduct field surveys

## Location Variability/Acreage

## Travel Time

- Estimated 120 hours driving to/from sites

## COONTAIL (*Ceratophyllum demersum*) DISTRIBUTION



Source: Esri, DigitalGlobe, GeoEye, Earthstar, USDA, USGS, AeroX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

**ANNSVILLE CREEK**  
Hudson River Hydrilla Monitoring  
September 22, 2017

Sampling Stations: 75

Plant Density	Symbol	Description
No Plants	Yellow circle	No Plants
Trace Plants	White circle	Trace Plants
Sparse Plants	Blue circle	Sparse Plants
Medium Plants	Dark blue circle	Medium Plants
Dense Plants	Red circle	Dense Plants

Percent Distribution	Abundance	Sites	Percent
	Total	23	31%
	Trace	8	35%
	Sparse	13	57%
	Medium	2	9%
	Dense	0	0%



# Grid Size Changes

## Fish Kill Creek Bay

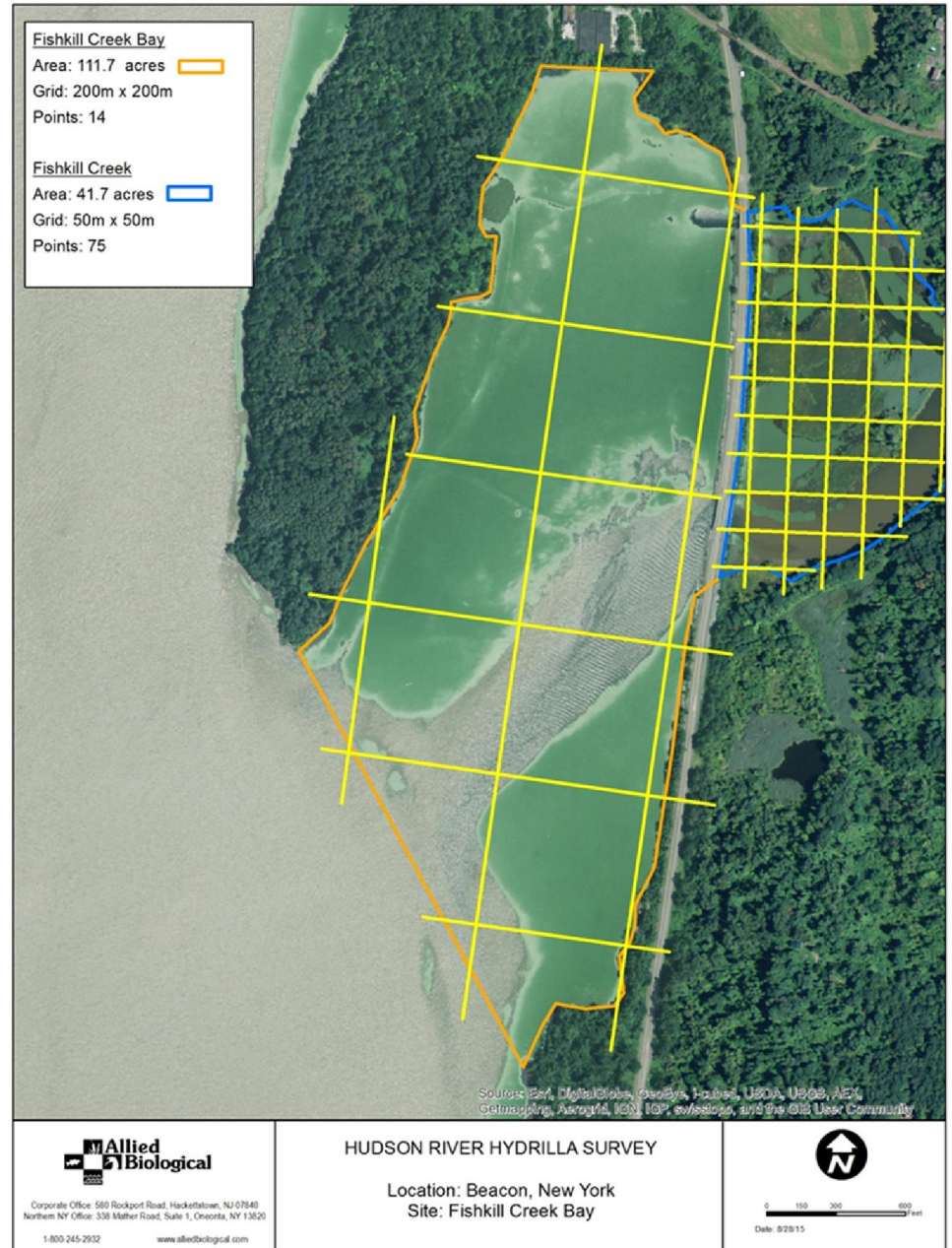
111.7 acres

- 200 m grid: 14 sites
- 100 m grid: 50 sites
- 50 m grid: ~145 sites

## Fishkill Creek

41.7 acres

- Used 50 m grid
- 75 Sites



# 2015 Results

## 46 Different Locations

- Most used a 50 m grid

## 1,838 GPS-referenced Sites

- Two tosses/site

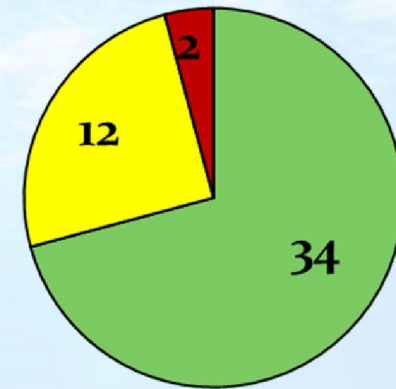
## 1,102 sites with SAV

- 59.95% of the sites
- Most species collected at >5%

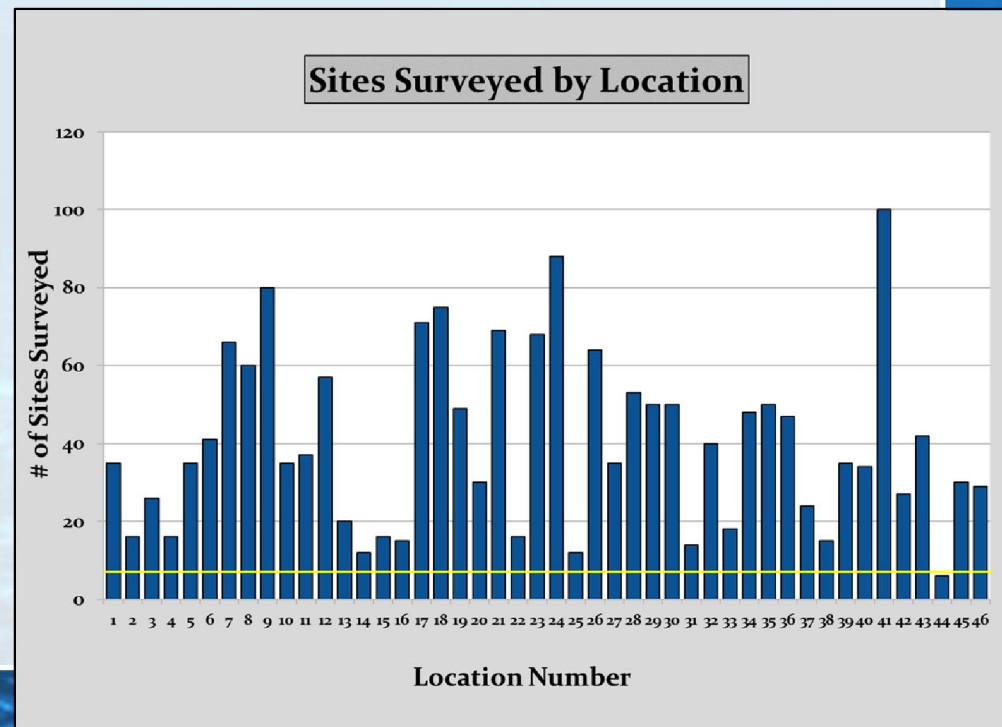
## 384 Maps Generated

## No Hydrilla Documented!

- Dominant: Small Duckweed
- 3 of top 4 SAV were Invasive
  - EWM, WC, BN



50 m grid 100 m grid 200 m grid





# Priority Ranking Criteria

- **SAV Habitat Quality**
  - SAV Diversity
  - SAV Abundance
- **Keystone Species Present**
  - Common Waterweed
  - Wild Celery
- **Proximity to Croton River**

**In General:** Marinas and Boat Launches on the Hudson River are **Poor** SAV Habitat

Low Priority	Moderate Priority	High Priority
Nyack Memorial Park BLS	Bowline Point Park	Half-moon Bay
Haverstraw Bay Park	Cedar Brook Pond	Georges Island Park
Haverstraw Marina	Lent's Cove	Popolopen Creek
Minisceongo Yacht Club	Moodna Creek	Dickie Brook
Piermont Marsh	Hyde Park Marina	Croton Bay
Viking Boat Yard	Fishkill Creek Bay	Annsville Creek
Newburgh Boat Launch Site	Marlboro Yacht Club	Iona Marsh
Front Street Marina	Vanderbilt Mansion Cove	Moodna Creek Bay
Sloop Hill Boat Launch Site		Constitution Marsh
Riverfront Green Park		Foundry Cove Bay
Peekskill Land Park		Foundry Cove
Denning's Point Bay		Wappinger's Creek
Riverfront Park		Norrie State Park
Waryas Park		Black Creek Preserve
Poughkeepsie Yacht Club		Fishkill Creek
Chelsea Boat Launch Site		Sleightsburg Park
Shepherd's Landing/Mariners		Vanderburgh Cove
Charles Rider Boat Launch Site		Kemey's Cove
Scarborough Park		Kingston Point Park Marsh

# Moving Forward

## 2016

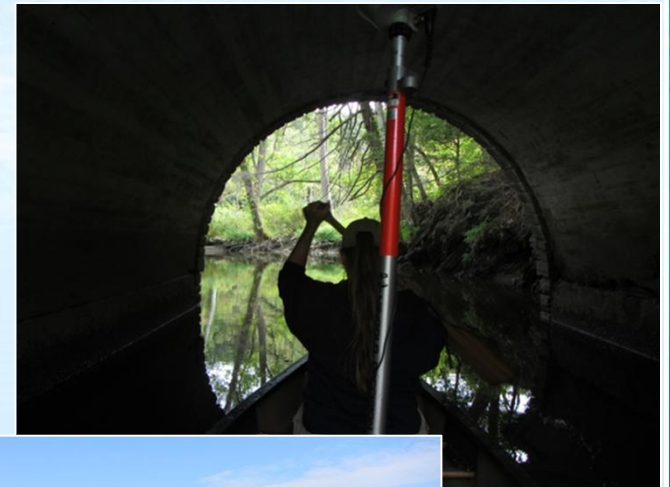
- Volunteer Surveys

## 2017 to 2021

- Surveys Added to Croton River Hydrilla Control Project
- 22 High Priority Locations

## 2018

- Added 8 new Lower Hudson Locations
- NYSDEC Funded Upper Hudson Surveys
  - 18 Locations
  - North of Kingston, NY



For more information on the Project:

<https://www.dec.ny.gov/animals/106386.html>



# Thank you! Questions?

By Chris Doyle, CLM

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