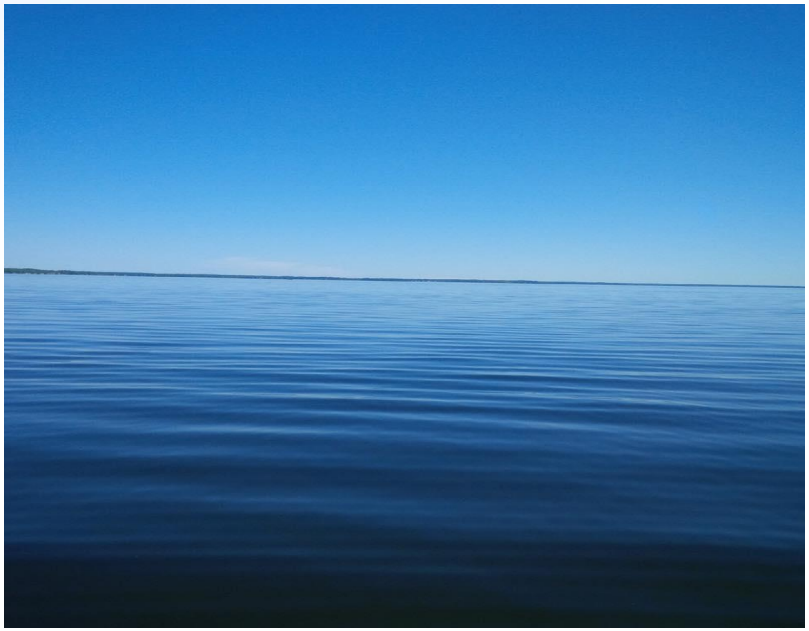
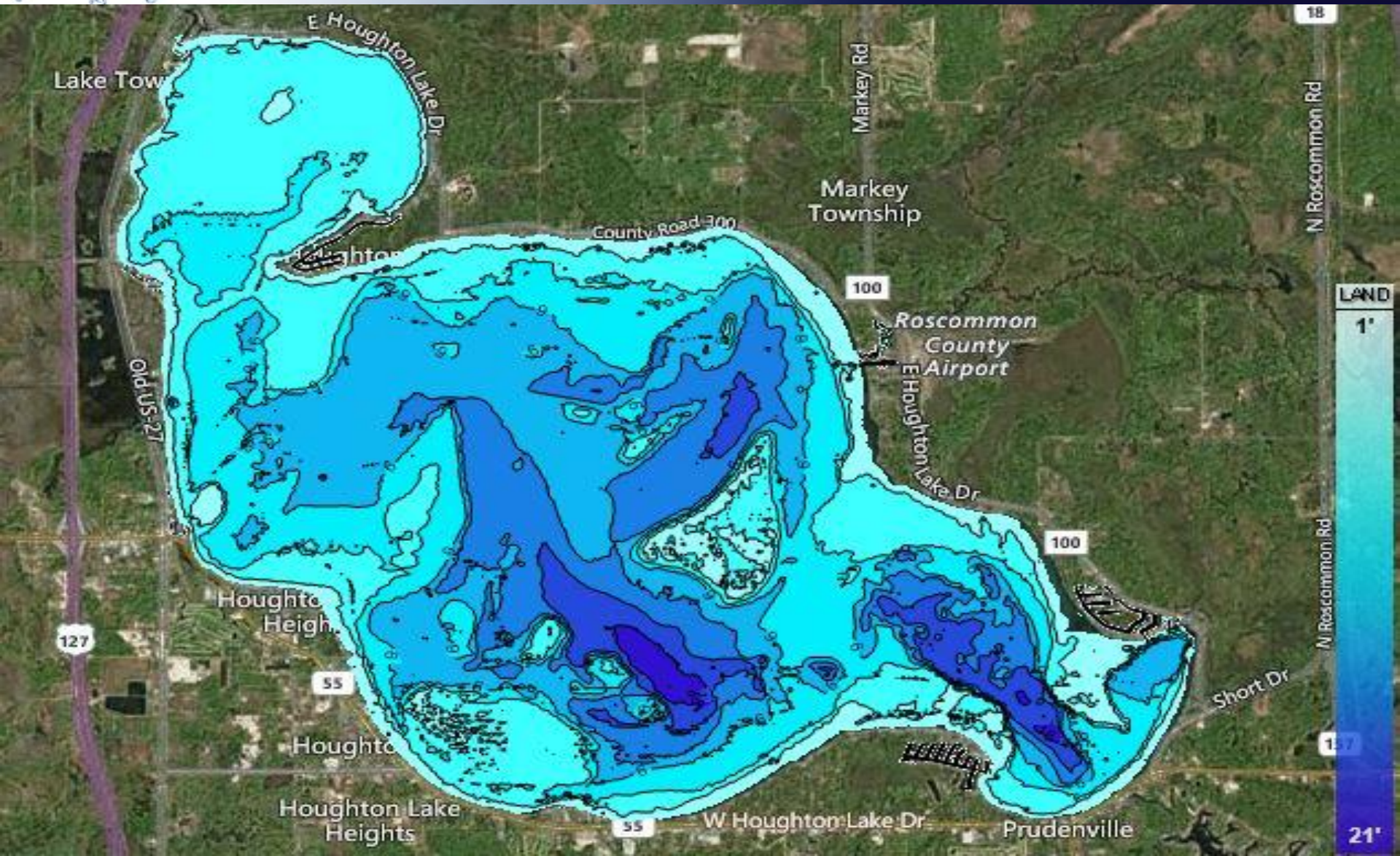
A Preview of the Higgins Lake Management Plan Evaluation: Case Study-Houghton Lake

Houghton Lake Facts

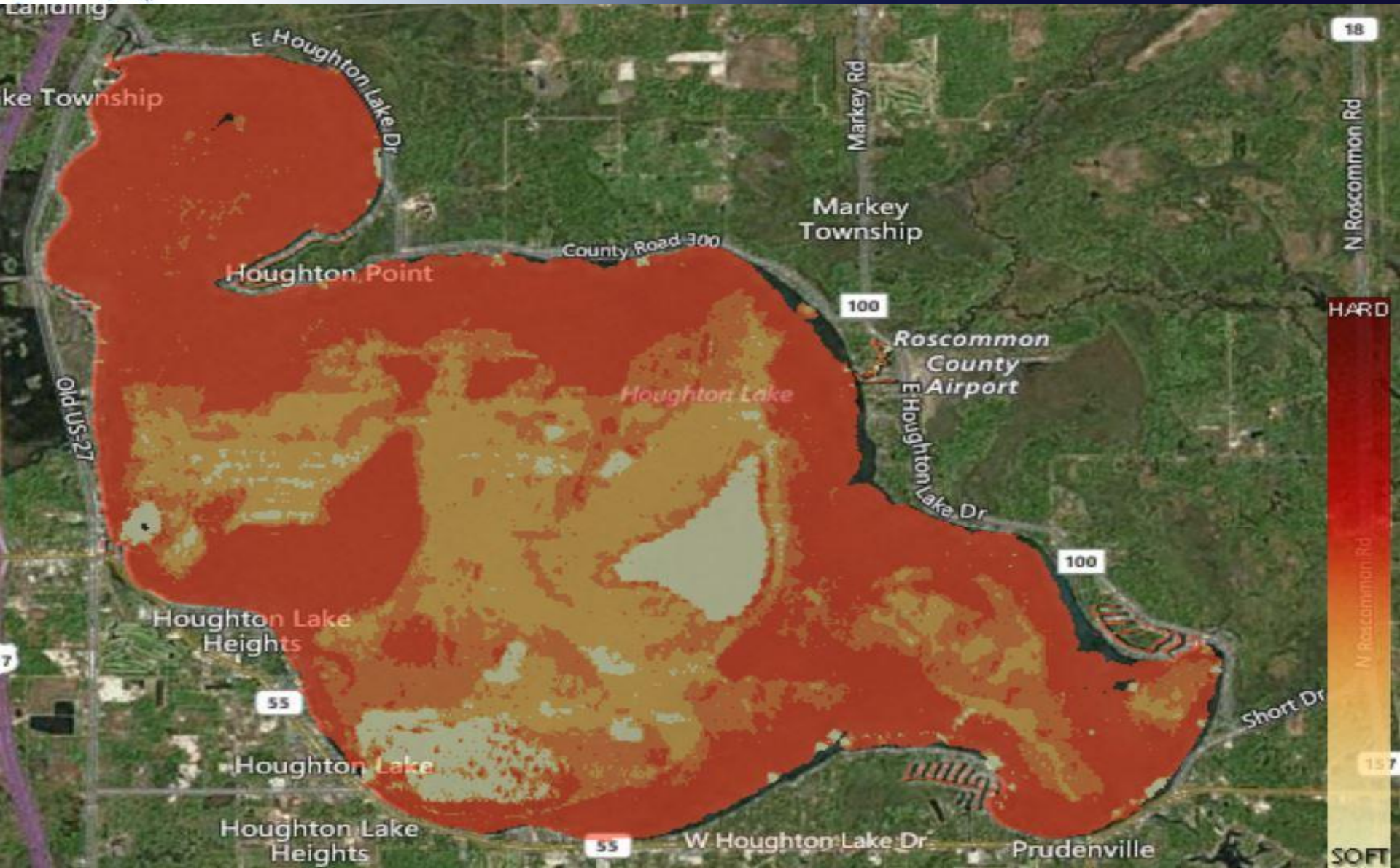
- 22,044 acres in area
- 30.5 miles of shoreline
- Mean depth of 8.5 ft.
- Maximum depth of 21 ft.
- Elevation of 1,138 ft.
- Retention Time of 1.71 yrs.
- Lake level created in 1926



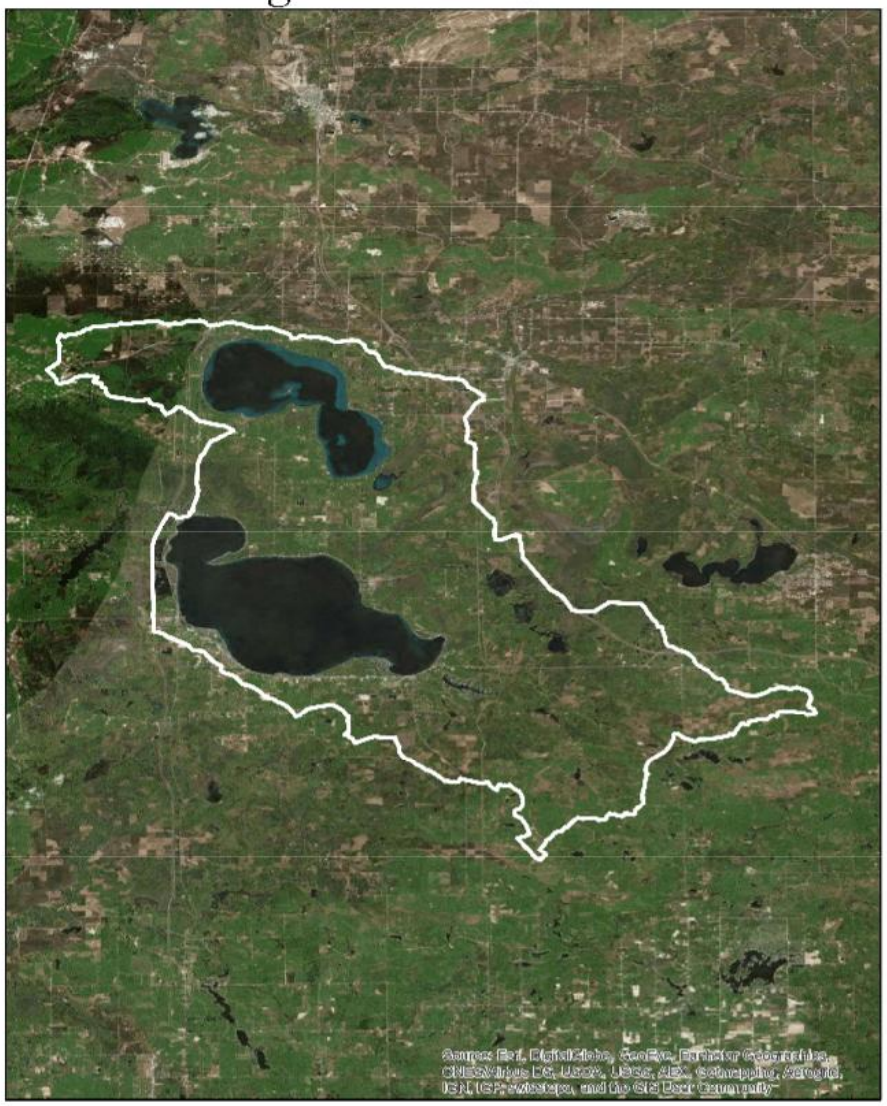
Houghton Lake Depth Contours



Houghton Lake Bottom Hardness



Houghton Lake Immediate Watershed

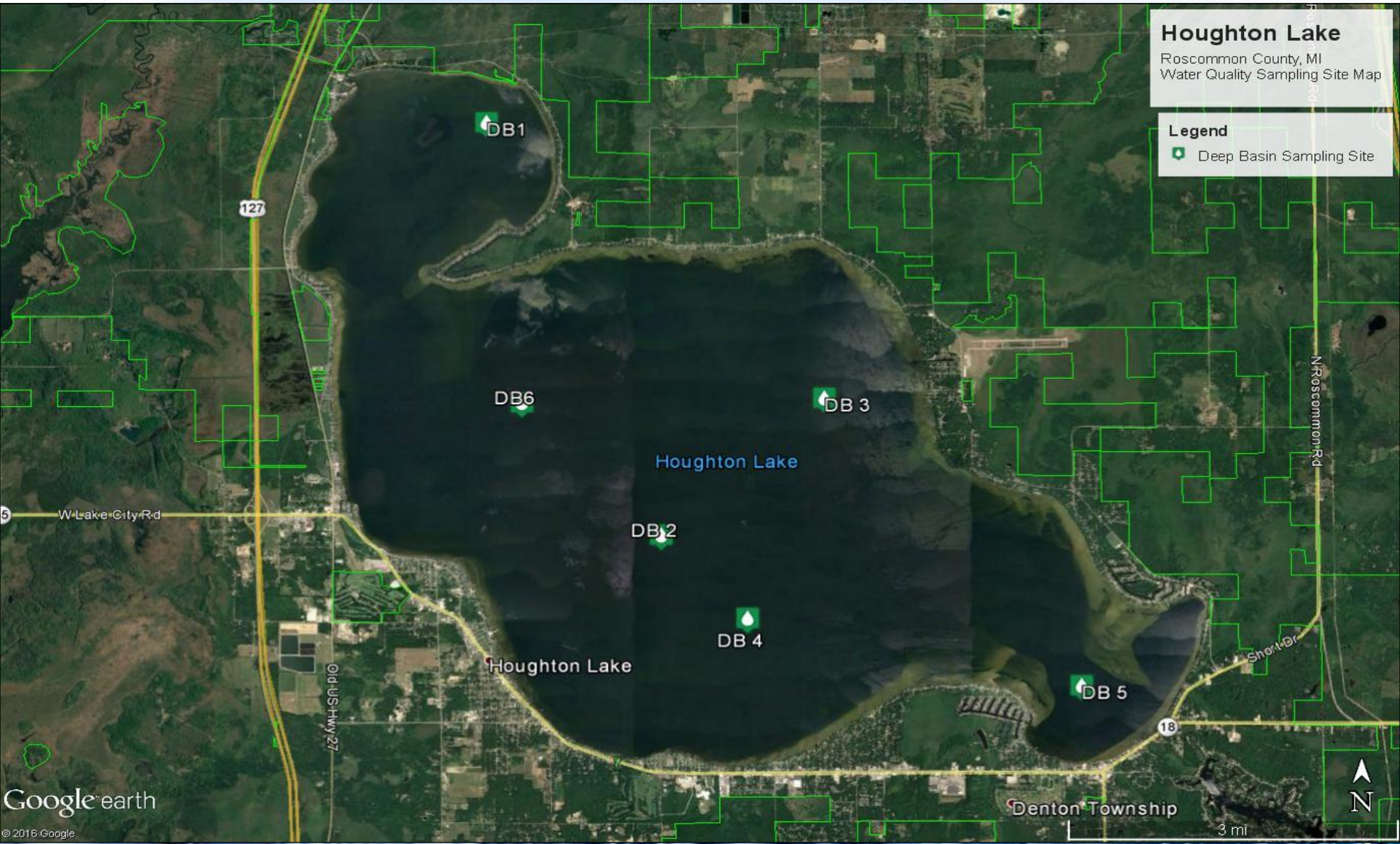


- 107,728.75 acres
- Watershed is 5.4X lake size = large watershed = moderate opportunities for pollution
- Largely forested

USDA-NRCS Soil Series	***General Characteristics***
Tawas and Lupton Mucks 0-1% slopes	Organic, deep, very poorly drained, high runoff potential
Grayling sand 0-6% slopes	Deep, excessively drained, low runoff potential
Graycalm-Klacking Sands 0-6% slopes	Deep, somewhat excessively drained, low runoff potential
Graycalm Sand 0-6% slopes	Deep, somewhat excessively drained, low runoff potential
Histosols and Aquents, ponded	Organic (peat), poorly drained, high runoff potential
Wakeley Muck	Deep, poorly drained, high runoff potential
Croswell-Au Gres sands 0-3% slopes	Deep, moderately drained, moderate runoff potential
Au Gres-Kinross-Croswell complex, 0-6% slopes	Very deep, moderate to poorly drained, moderate to high runoff potential

Houghton Lake Soils Map

Houghton Lake Deep Basin WQ Sampling Sites



Houghton Lake Tributary WQ Sampling Sites

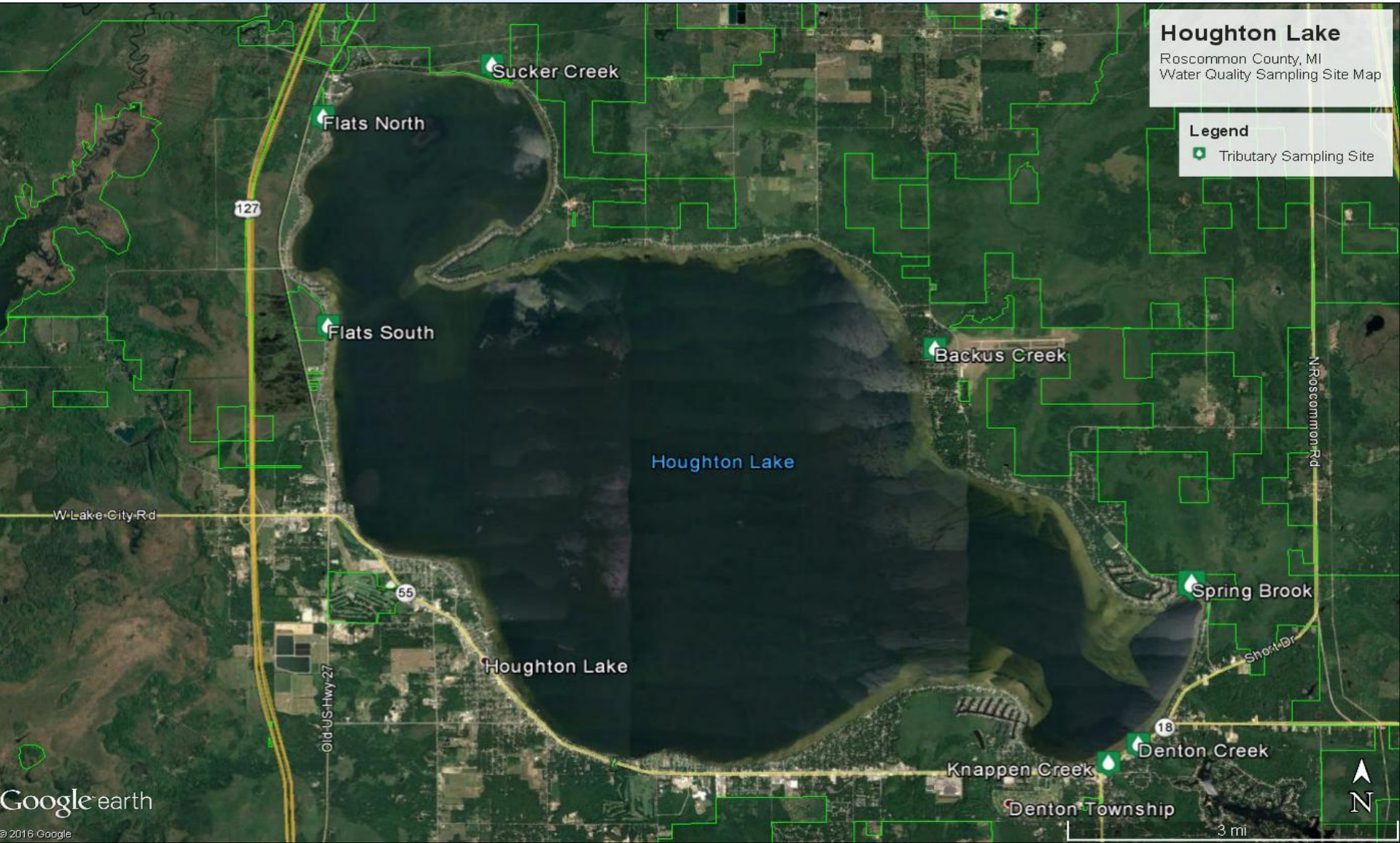


Figure 9a. Northwest canals

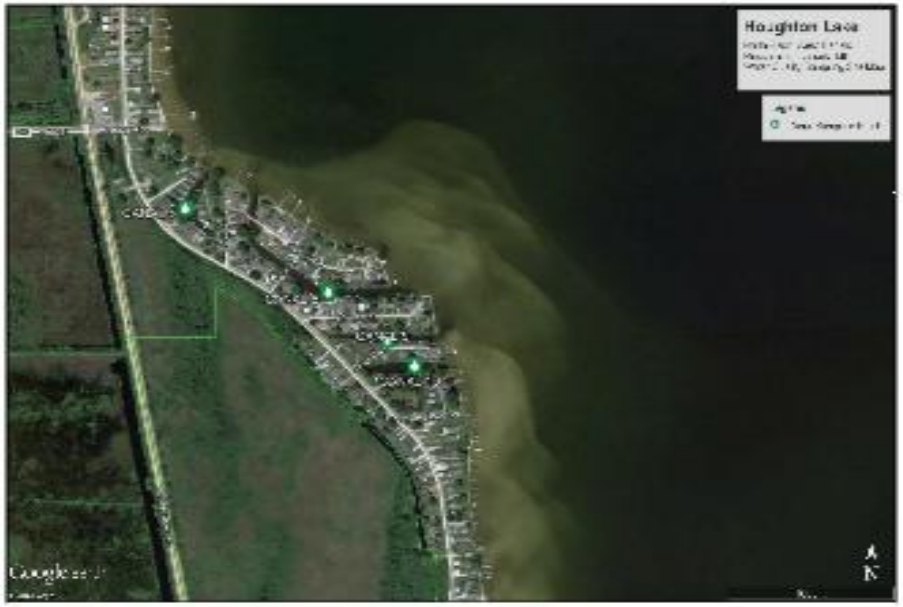


Figure 9b. Northwest canals

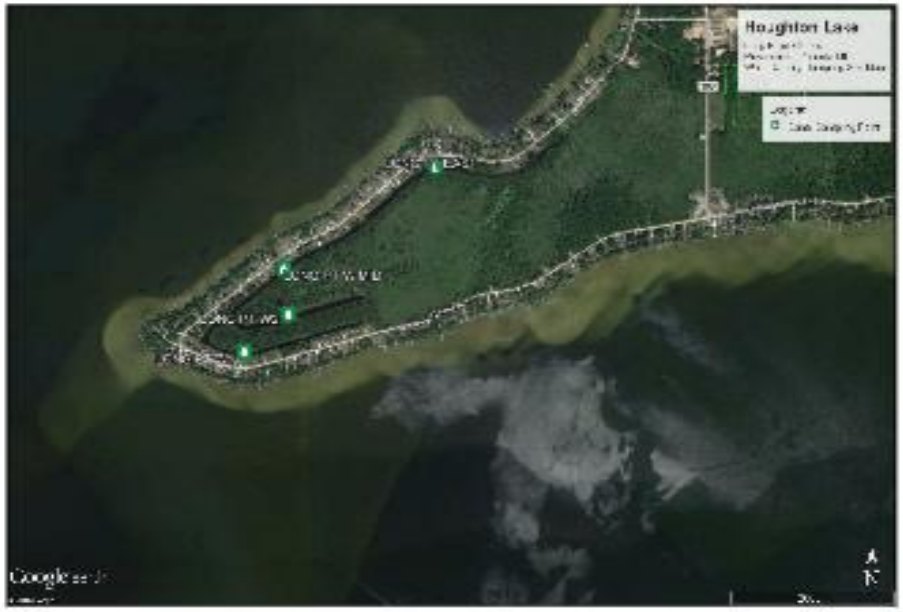


Figure 9c. Long Point canals

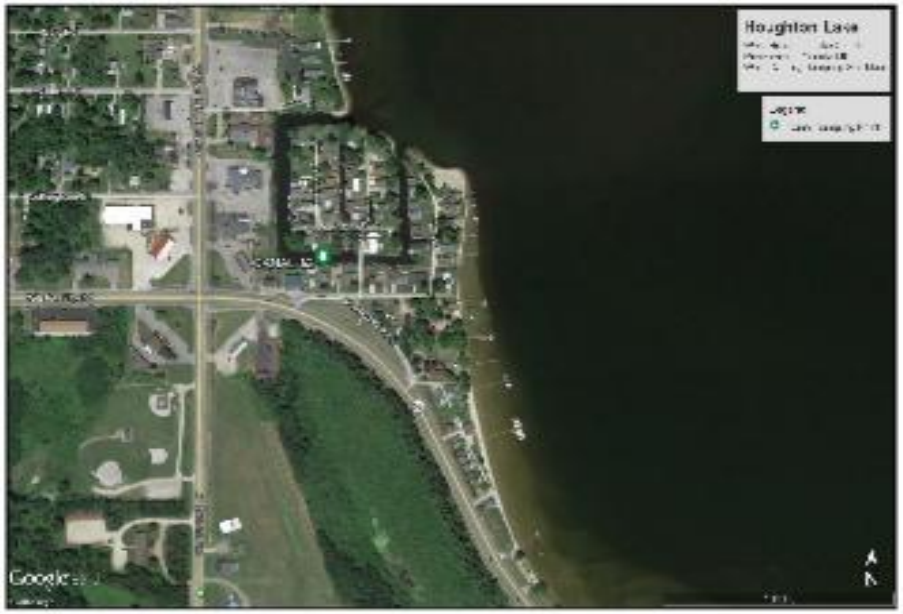
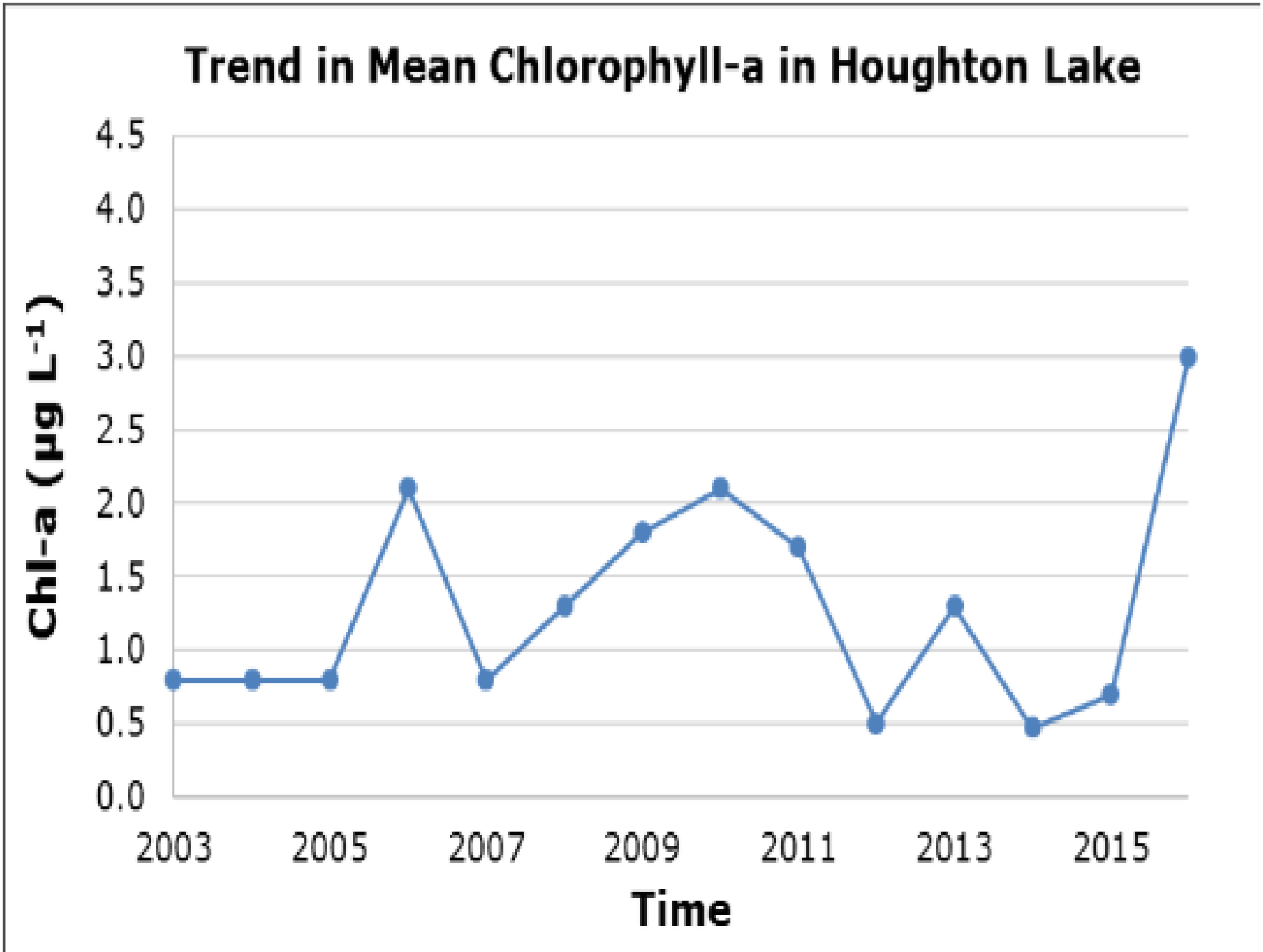
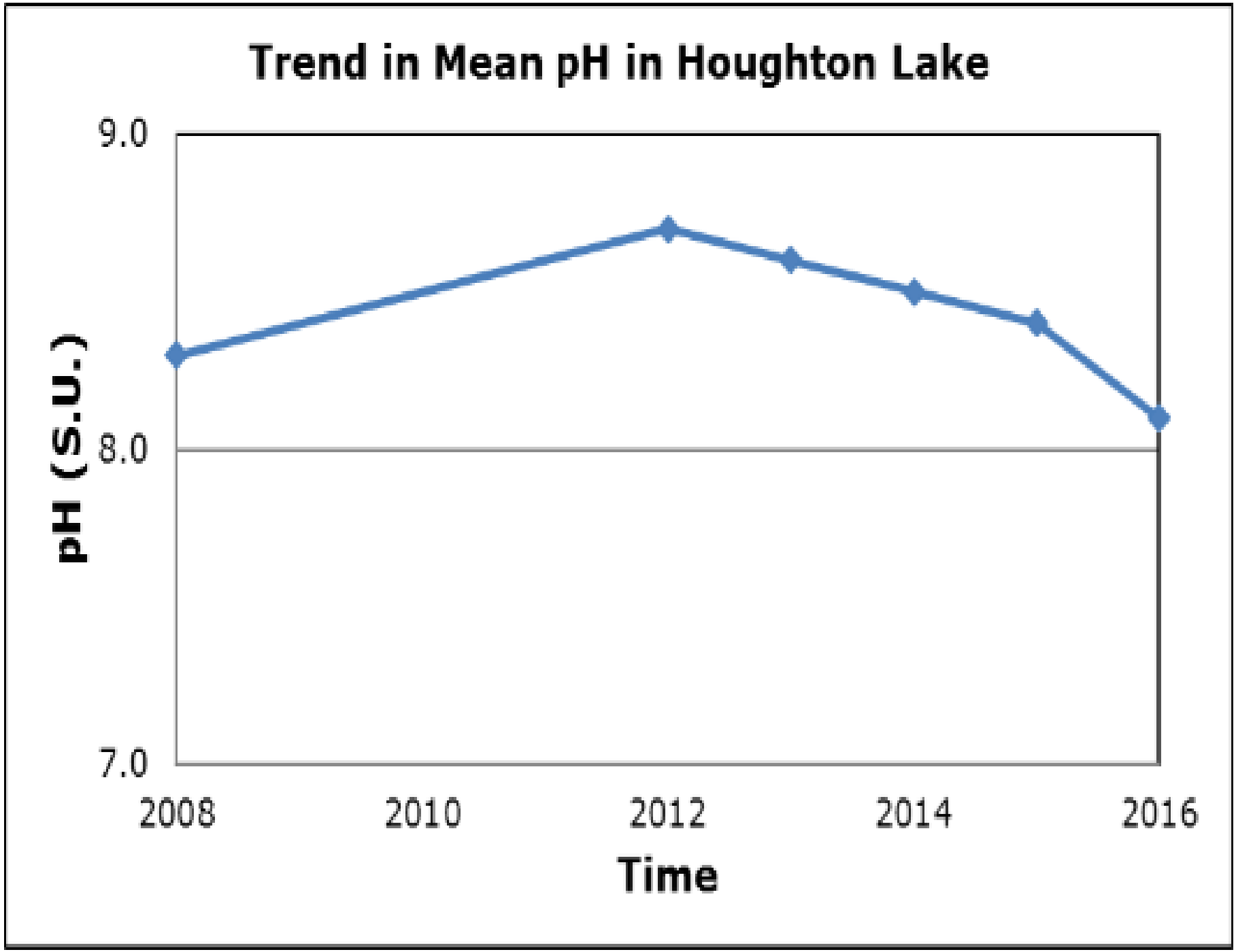


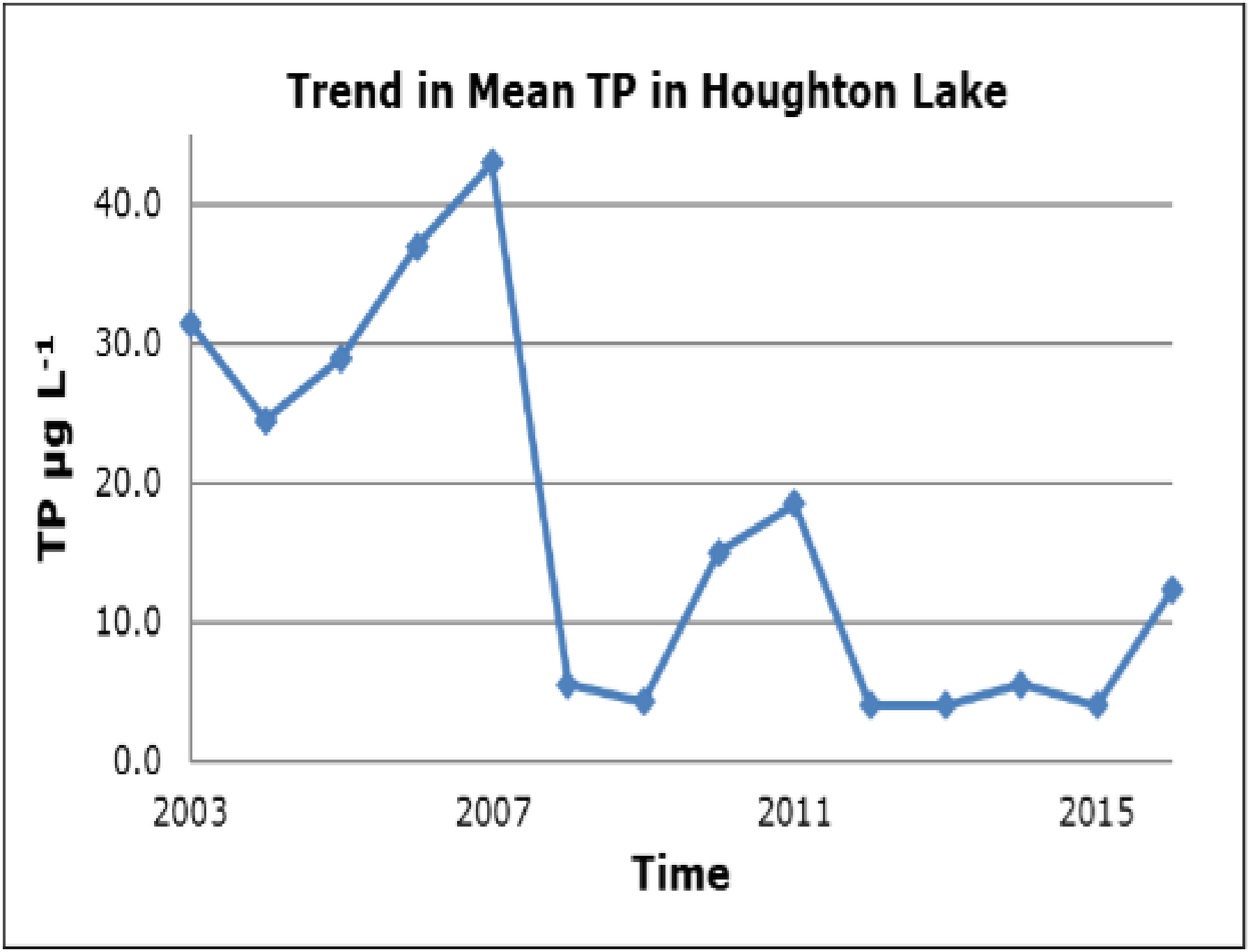
Figure 9d. West Canal

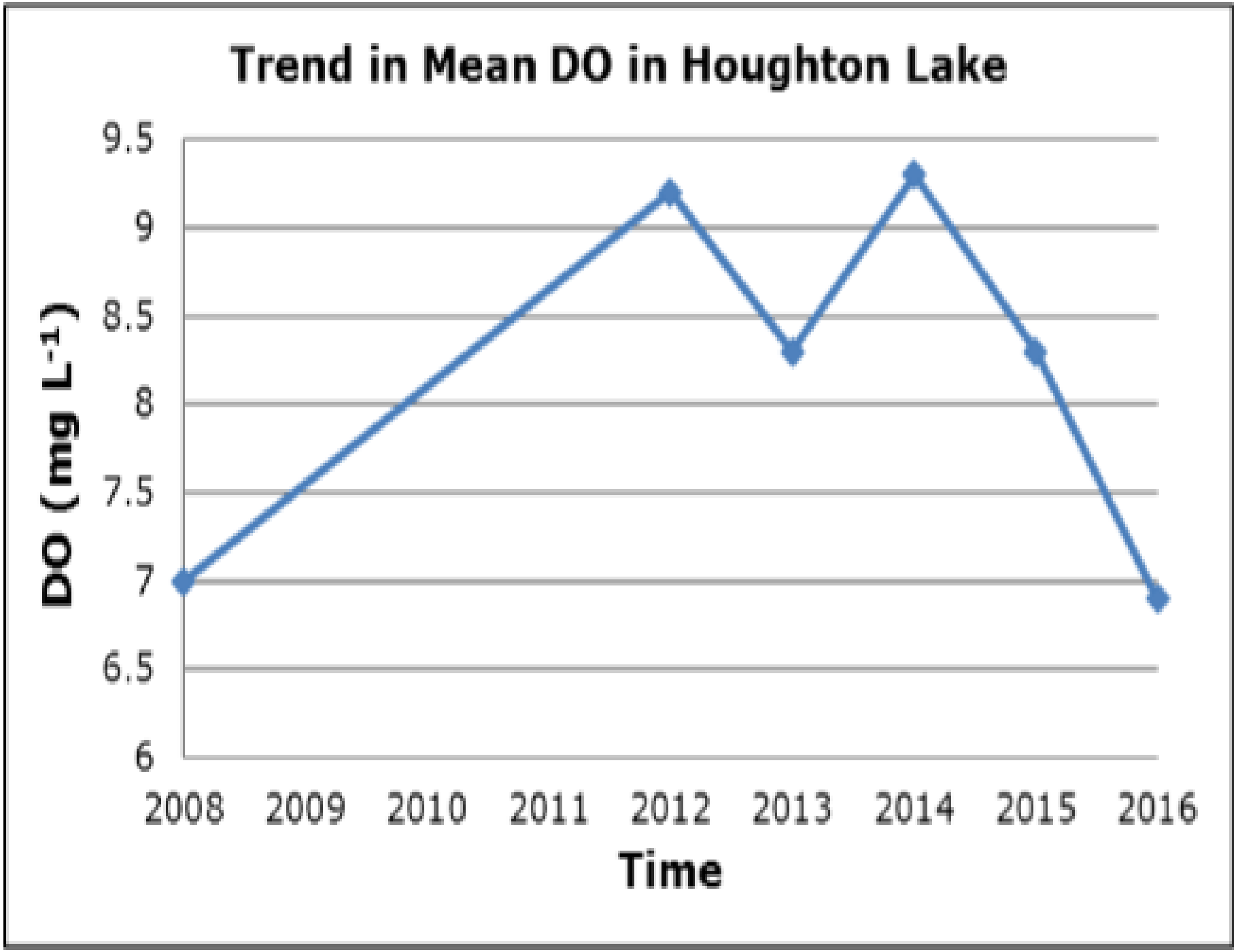
Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Algae Sample Location	Dominant Algal Genera
DB #1	*Chlorella* sp., *Scenedesmus* sp., *Spirogyra* sp., *Mougeotia* sp.
DB #2	*Chlorella* sp., *Scenedesmus* sp., *Spirogyra* sp., *Closterium* sp.
DB #3	*Chlorella* sp., *Pediastrum* sp., *Spirogyra* sp., *Mougeotia* sp.
DB #4	*Chlorella* sp., *Scenedesmus* sp., *Zygnema* sp., *Mougeotia* sp.
DB #5	*Chlorella* sp., *Pediastrum* sp., *Spirogyra* sp., *Mougeotia* sp.
DB #6	*Chlorella* sp., *Scenedesmus* sp., *Spirogyra* sp., *Closterium* sp.


Trend in Mean Chlorophyll-a in Houghton Lake
Chl-a (µg L-1)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2003
2005
2007
2009
2011
2013
2015
Time


Trend in Mean pH in Houghton Lake
9.0
8.0
7.0
pH (S.U.)
2008
2010
2012
2014
2016
Time


Trend in Mean TP in Houghton Lake
40.0
30.0
20.0
10.0
0.0
TP µg L-1
2003
2007
2011
2015
Time


Trend in Mean DO in Houghton Lake
9.5
9
8.5
8
7.5
7
6.5
6
DO (mg L-1)
2008
2009
2010
2011
2012
2013
2014
2015
2016
Time

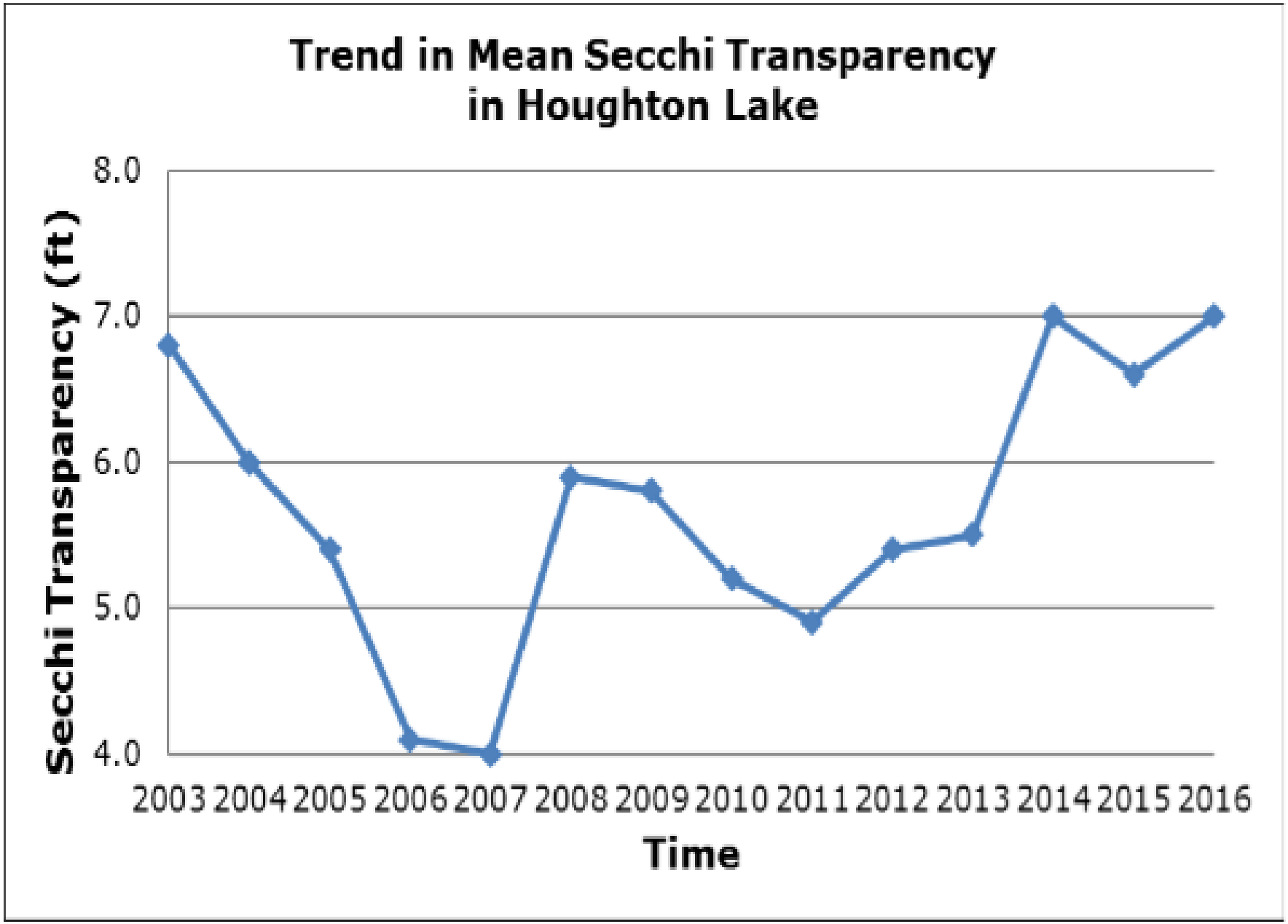


Figure 16. Mean secchi transparency with time in Houghton Lake (2010-2016)

Trib Name	*Water Temp ºF*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*TP mg L^{-1}*	*Ortho-P mg L^{-1}*	*TSS mg L^{-1}*	*Chl-a µg L^{-1}*
Flats-N	82.2	6.5	8.1	210	120	<0.010	0.013	<10	4.0
Flats-S	82.4	6.8	8.1	243	108	0.021	0.011	<10	4.0
Sucker Creek	81.5	1.5*	7.5	499*	152*	0.300*	0.110*	140*	11.0*
Denton Creek	81.5	7.0	8.0	238	125	0.013	<0.010	<10	4.0
Bacus Creek	81.5	7.0	8.0	221	97	<0.010	<0.010	<10	3.0
Spring Brook	81.0	7.2	8.1	252	130	0.049*	0.032*	<10	5.0
Knappen Creek	80.0	6.9	8.0	366*	176*	0.015	0.013	<10	4.0

Houghton Lake GPS Sampling Point Map

Houghton Lake Survey Grid Points

Houghton Lake Invasive Species

Figure 6. Eurasian Watermilfoil (©RLS, 2006).

Figure 7. Curly-leaf Pondweed (©RLS, 2006).

Figure 8. Starry Stonewort (USGS photo).

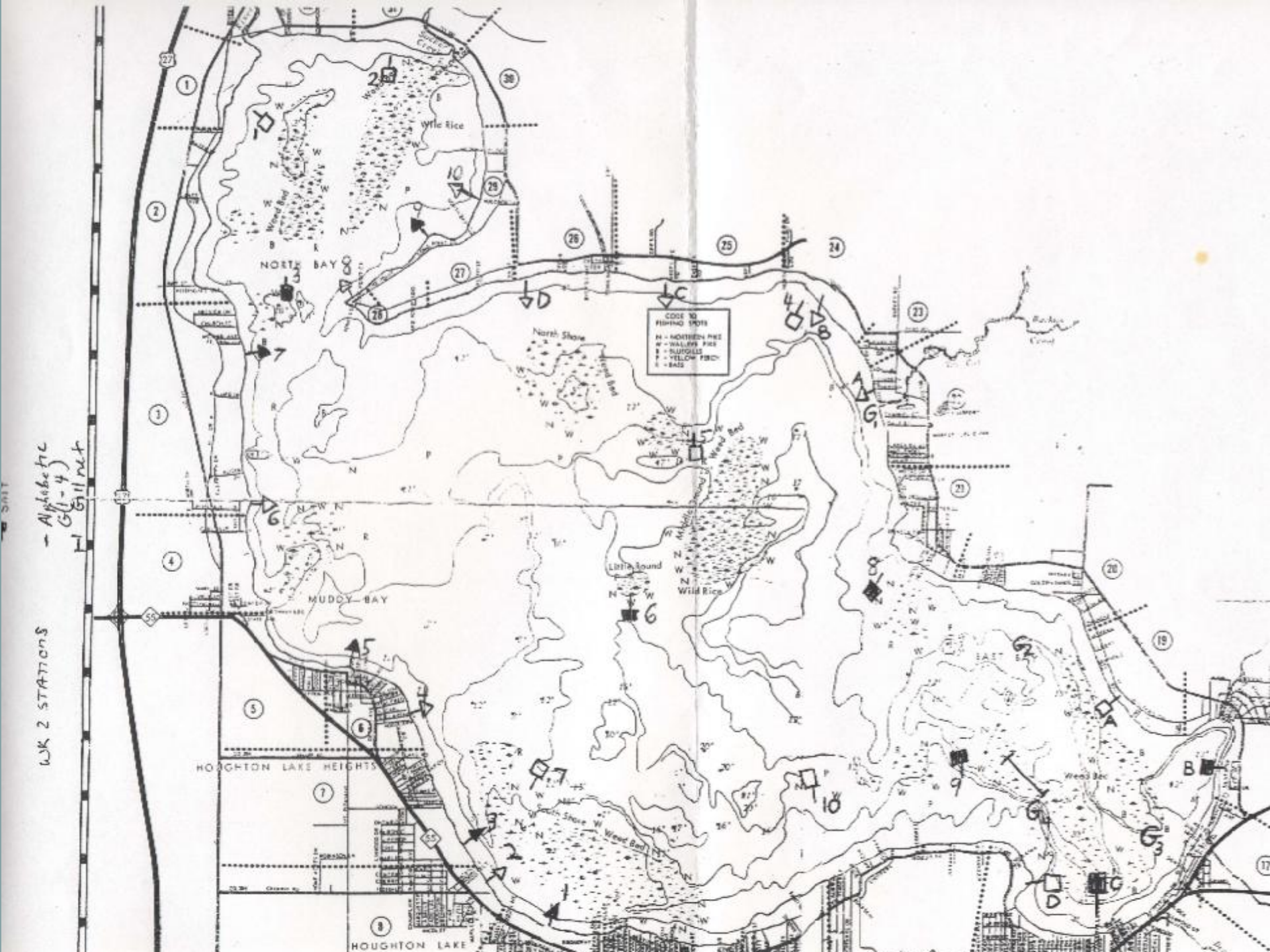
Figure 9. Purple Loosestrife (©RLS, 2006).

Figure 10. Phragmites. (©RLS, 2006).

Hybrid Watermilfoil (Eurasian Watermilfoil + Native Watermilfoil)

Grows thicker, wider, faster than EWM and is VERY TOLERANT to herbicides!

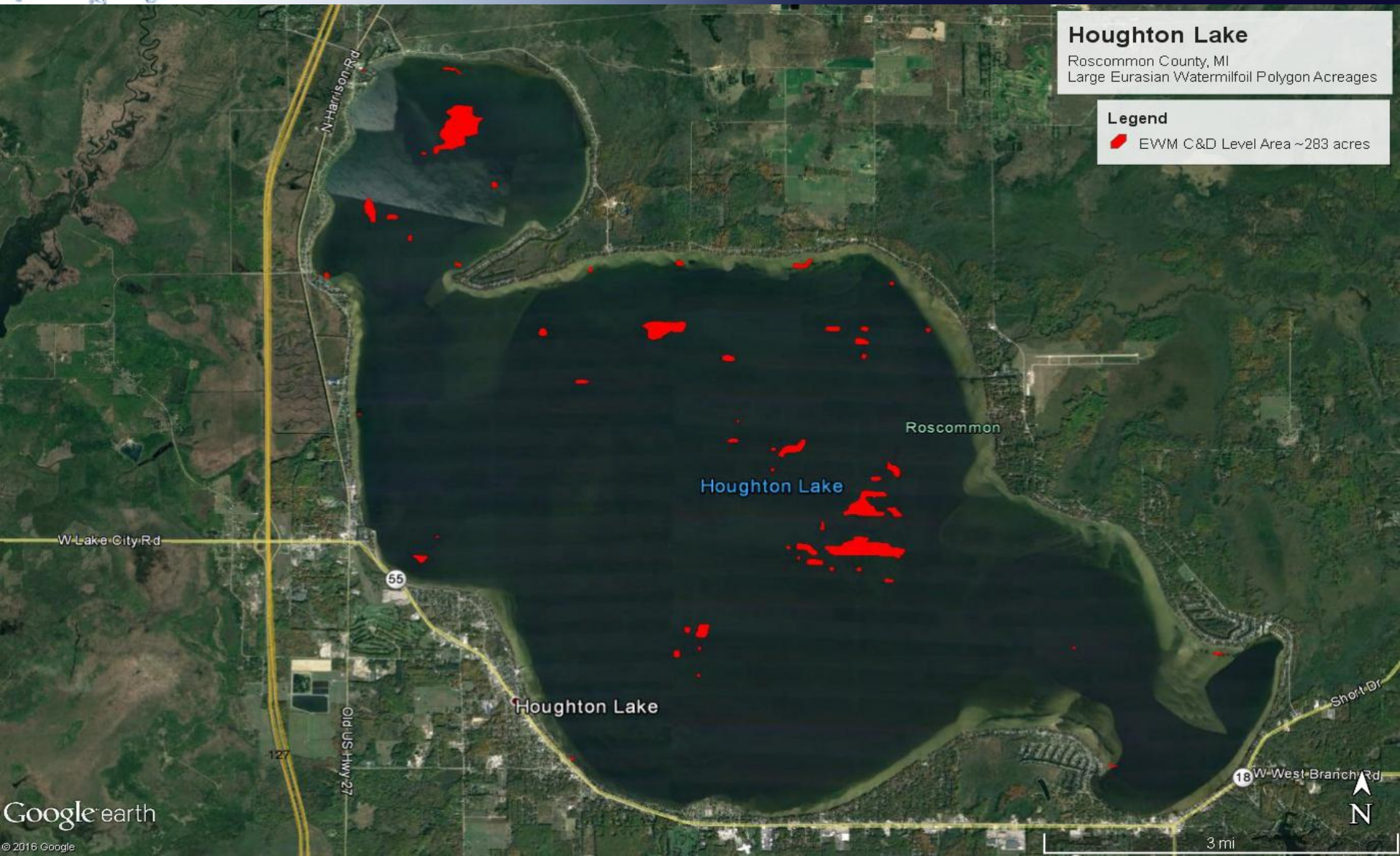
EWM Overgrowth in Other Lakes:

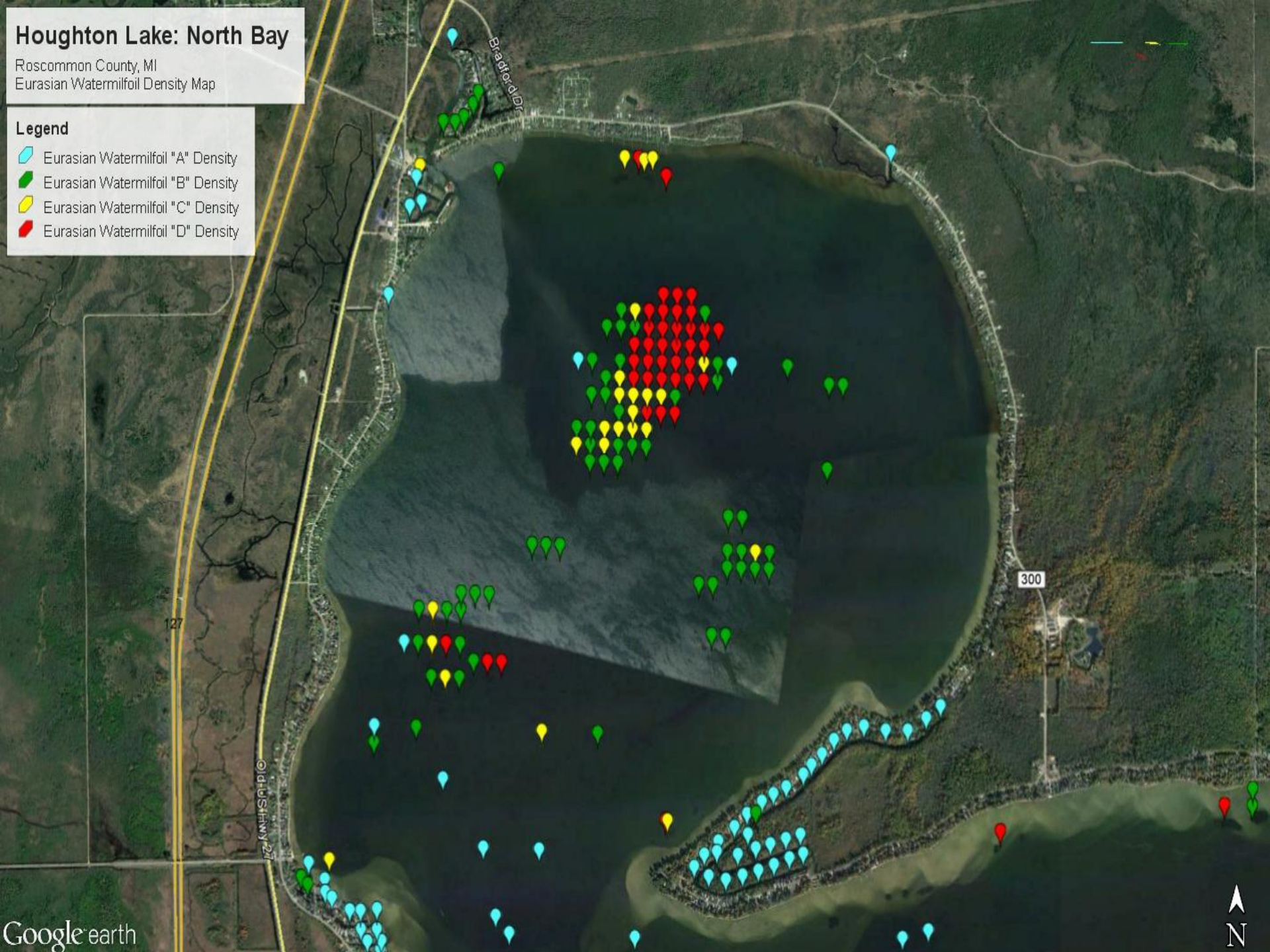


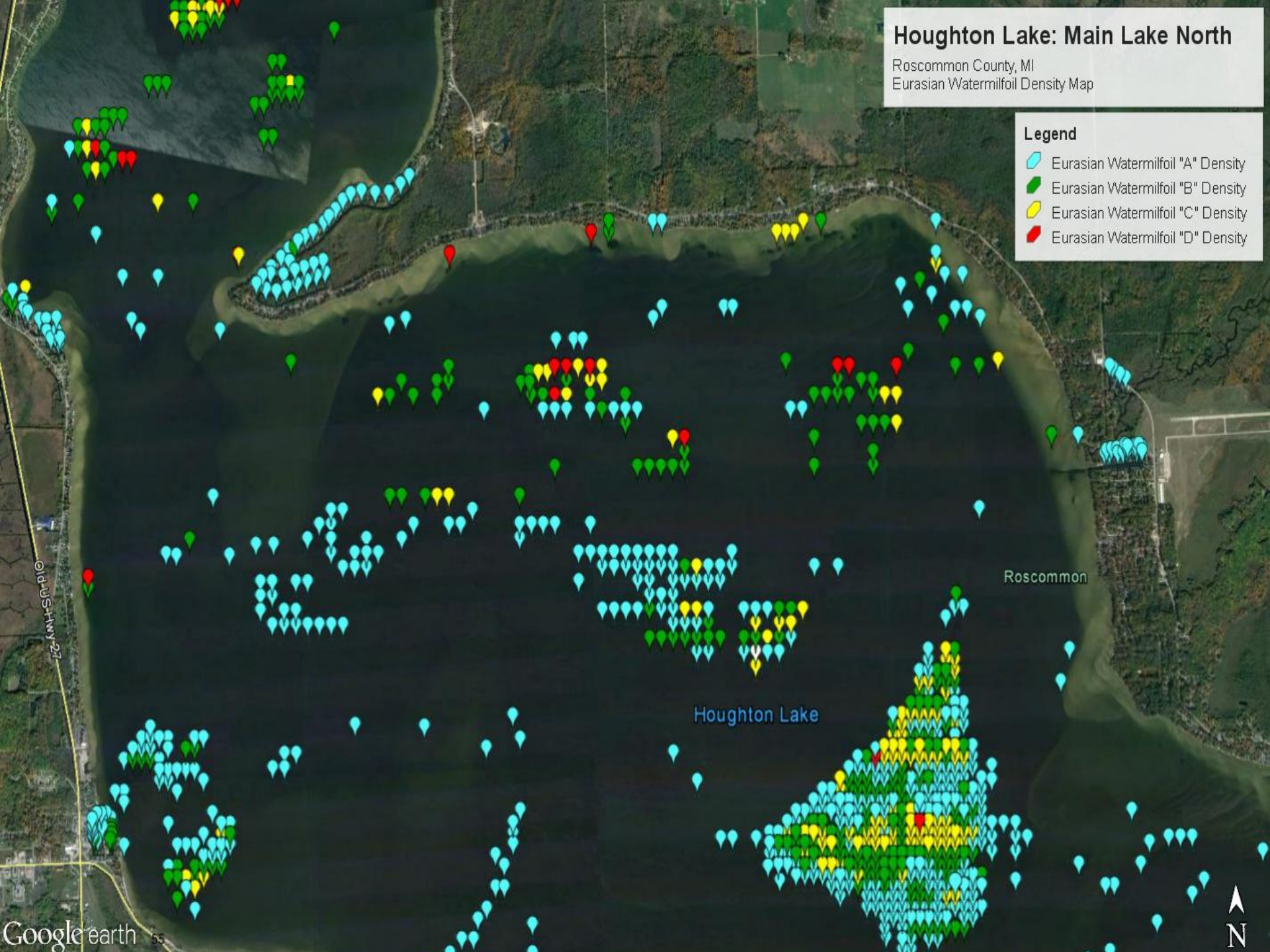
WK 2 STATIONS

- Alphabetic G(1-4) Gillnet

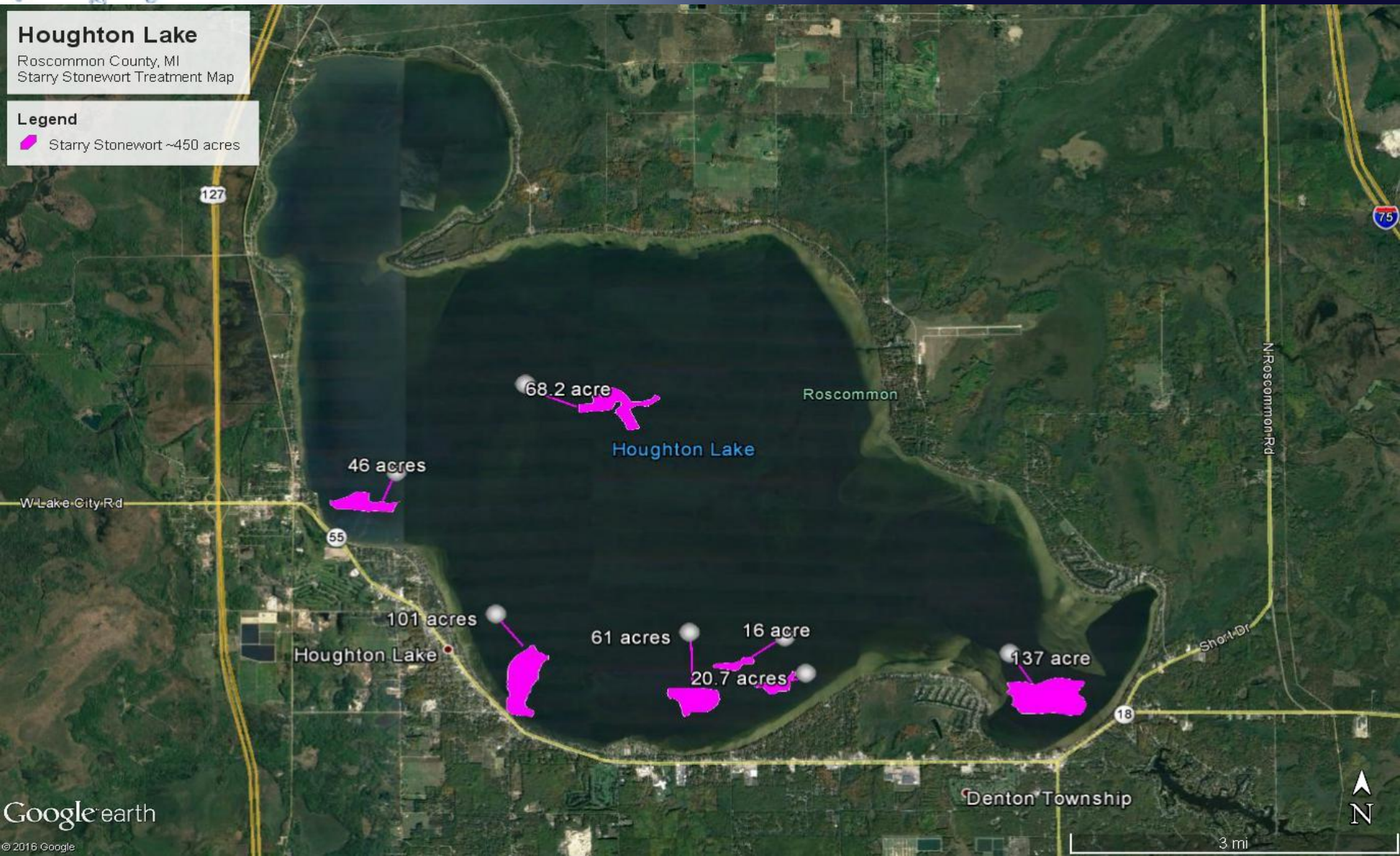
Houghton Lake HWM Treatment Areas

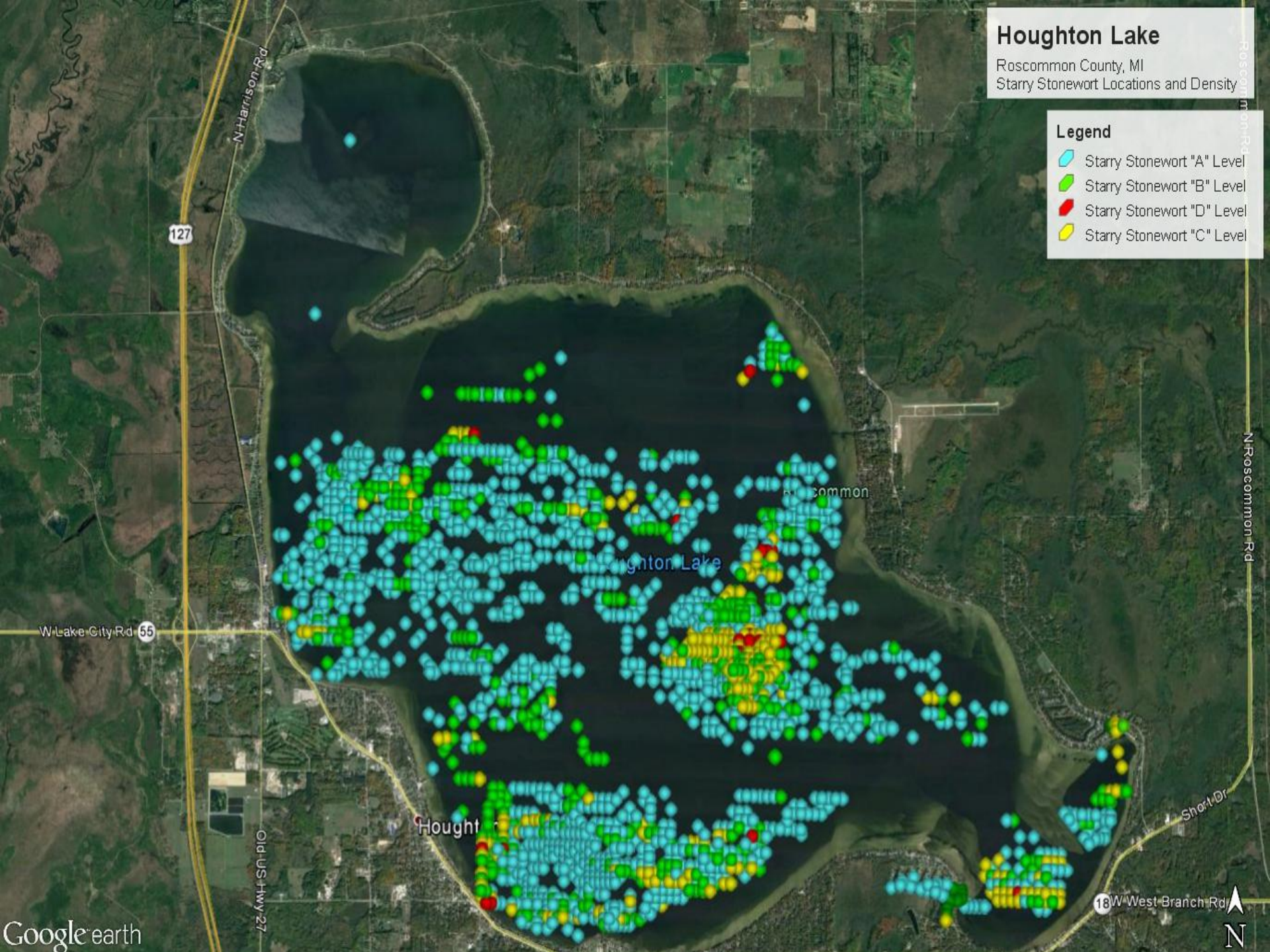


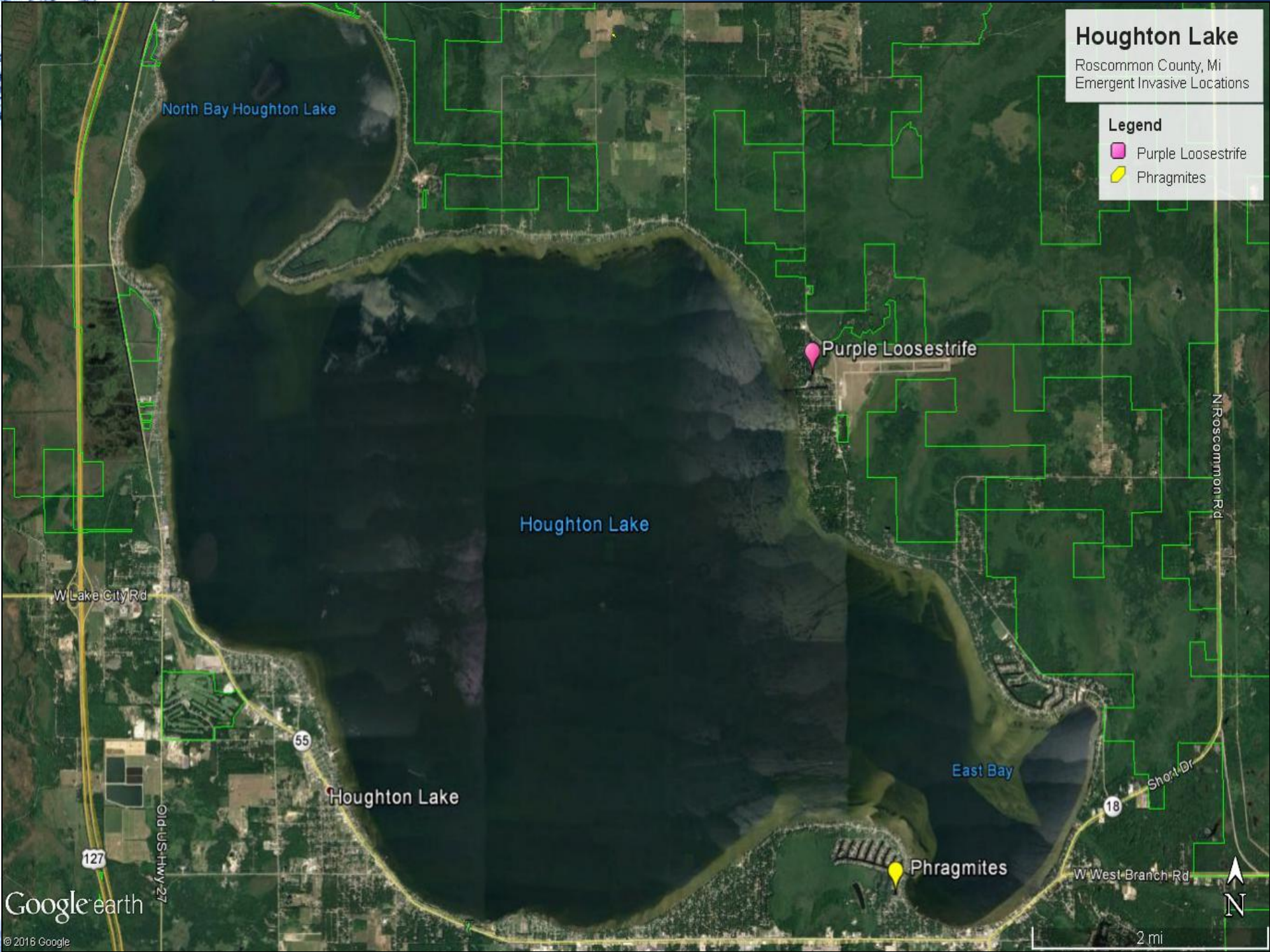

Houghton Lake: North Bay
Roscommon County, MI
Eurasian Watermilfoil Density Map
Legend
Eurasian Watermilfoil "A" Density
Eurasian Watermilfoil "B" Density
Eurasian Watermilfoil "C" Density
Eurasian Watermilfoil "D" Density
Bradford Dr
127
Old US Hwy 27
300
Google earth
N


Houghton Lake: Main Lake North
Roscommon County, MI
Eurasian Watermilfoil Density Map
Legend
Eurasian Watermilfoil "A" Density
Eurasian Watermilfoil "B" Density
Eurasian Watermilfoil "C" Density
Eurasian Watermilfoil "D" Density
Roscommon
Houghton Lake
Old US-Hwy-27
Google earth
N

Houghton Lake Starry Stonewort Treatment Areas

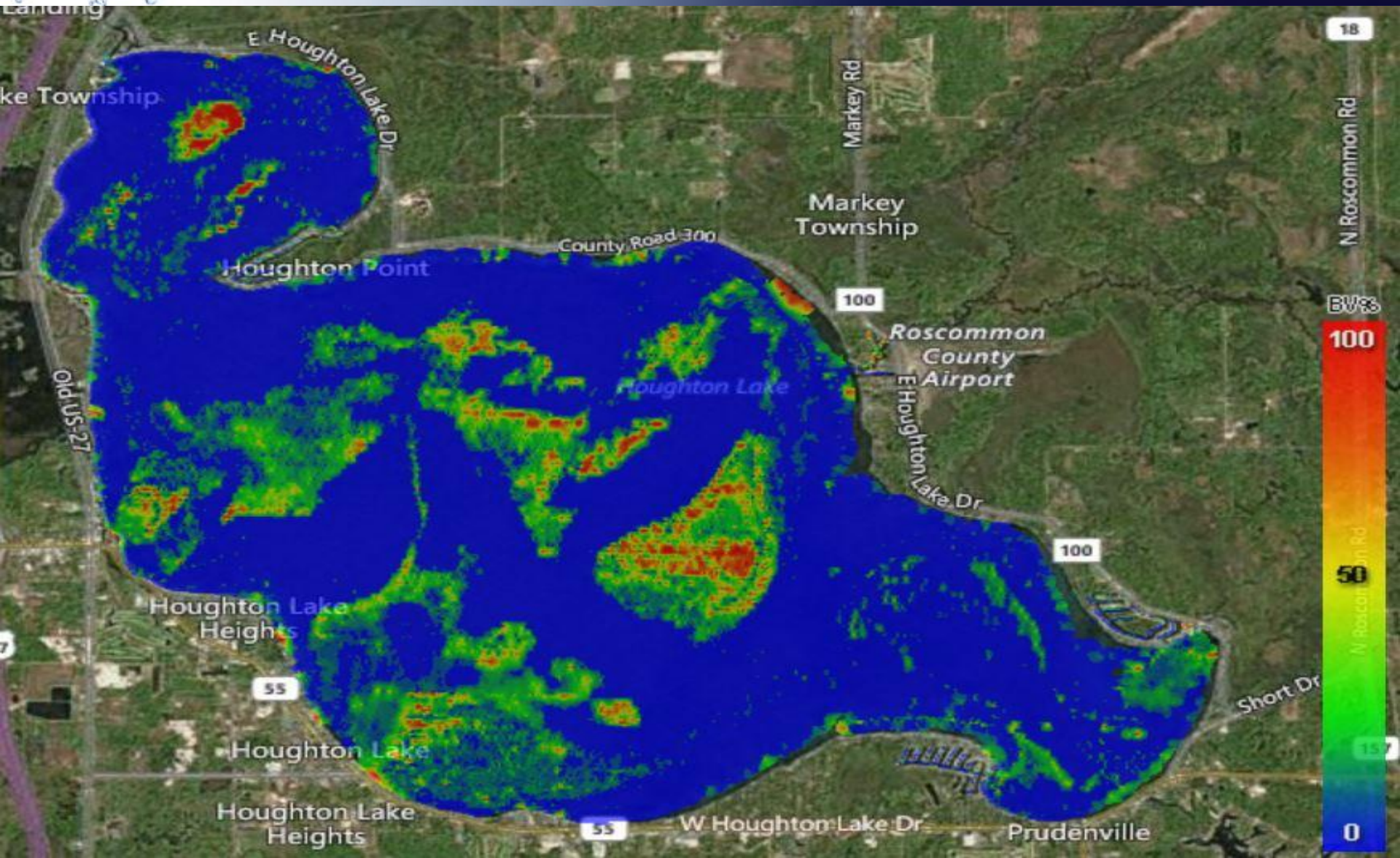



Houghton Lake
Roscommon County, MI
Starry Stonewort Locations and Density
Legend
Starry Stonewort "A" Level
Starry Stonewort "B" Level
Starry Stonewort "D" Level
Starry Stonewort "C" Level
N Harrison Rd
127
N Roscommon Rd
W Lake City Rd
55
Old US Hwy 27
Short Dr
W West Branch Rd
18
Google earth
N


Houghton Lake
Roscommon County, Mi
Emergent Invasive Locations
Legend
Purple Loosestrife
Phragmites
North Bay Houghton Lake
Purple Loosestrife
Houghton Lake
N Roscommon Rd
W Lake City Rd
55
Houghton Lake
East Bay
Short Dr
18
Old US Hwy 27
127
Phragmites
W West Branch Rd
Google earth
© 2016 Google
N
2 mi

Year	*# Walleye Stocked*	*Average Walleye Length (inches)*
1979	68,936	--
1980	106,717	--
1981	178,757	--
1982	26,699	--
1983	39,400	--
1984	24,739	3.5
1985	70,663	2.2
1986	62,450	2.5
1986	45,500	2.3
1987	17,000	3.6
1988	75,200	2.6
1989	67,150	3.4
1990	106,049	1.8
1990	19,420	4.4
1991	101,050	3.5
1993	158,282	1.6
1994	10,000	2.6
1995	7,150	4.4
1999	152,346	1.9
2001	319,494	1.5
2005	212,568	1.5
2011	75,063	1.4

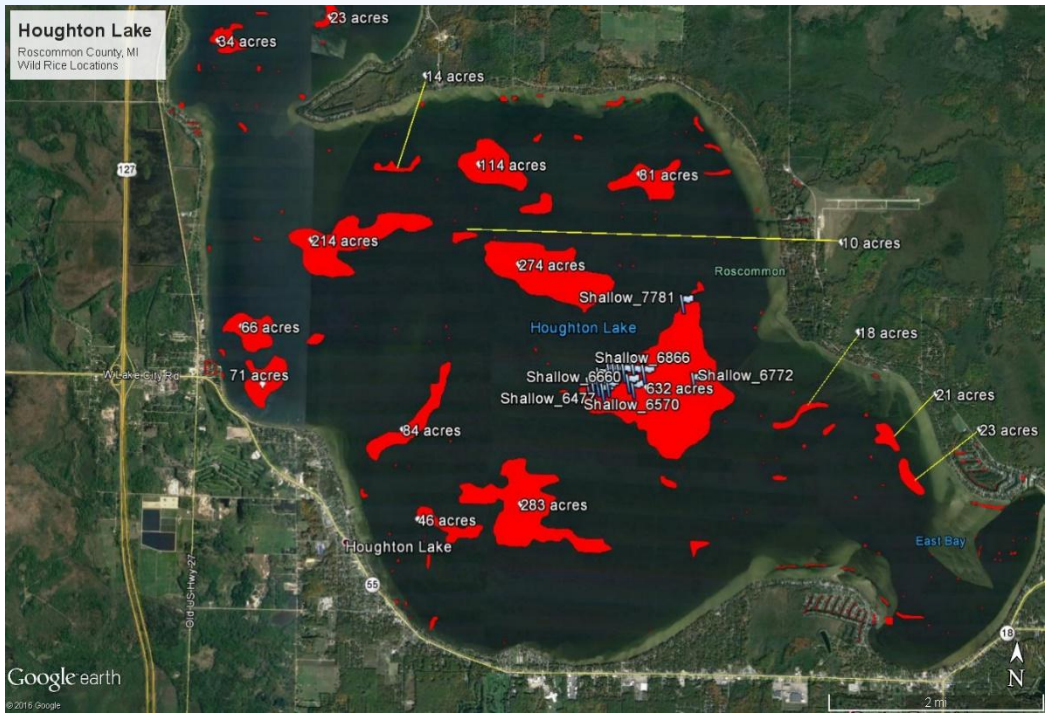
Houghton Lake Aquatic Vegetation Biovolume



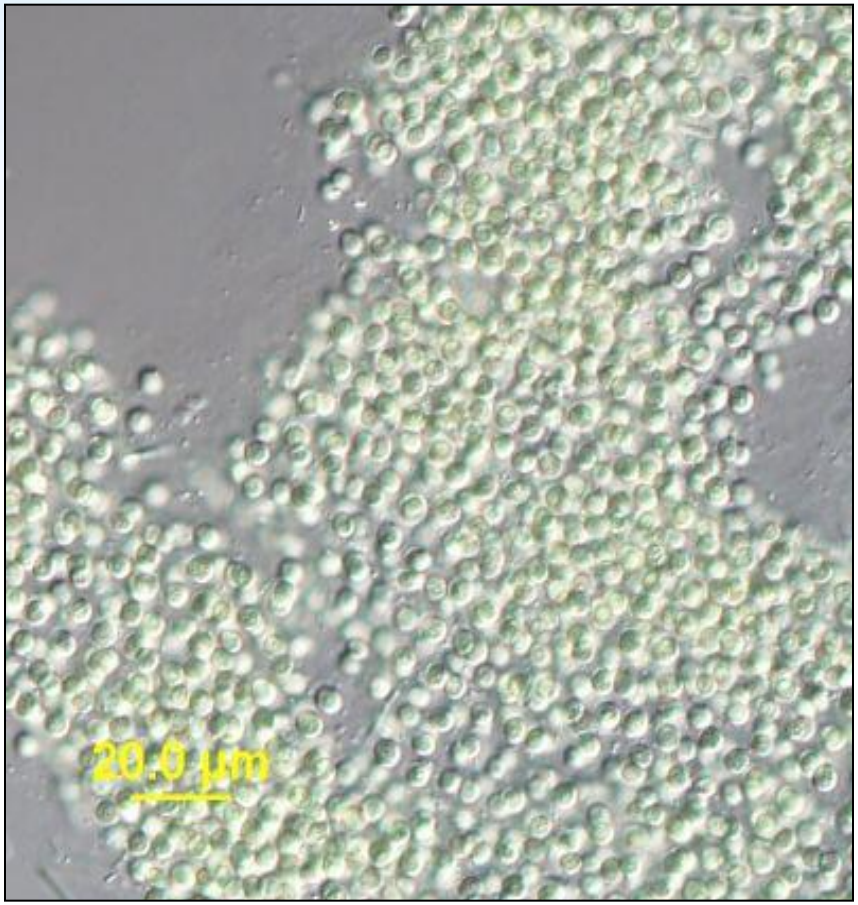
Native Aquatic Plant Species Name	Aquatic Plant Common Name	% Cover	Aquatic Plant Growth Habit
Chara vulgaris	Muskgrass	32.4	Submersed, Rooted
Potamogeton pectinatus	Thin-leaf Pondweed	1.3	Submersed, Rooted
Potamogeton amplifolius	Large-leaf Pondweed	1.0	Submersed, Rooted
Potamogeton zosteriformis	Flat-stem Pondweed	2.8	Submersed, Rooted
Potamogeton gramineus	Variable-leaf Pondweed	0.8	Submersed, Rooted
Potamogeton robbinsii	Fern-leaf Pondweed	0.5	Submersed, Rooted
Potamogeton natans	Floating-leaf Pondweed	0.2	Submersed, Rooted
Potamogeton praelongus	White-stem Pondweed	20.5	Submersed, Rooted
Potamogeton richardsonii	Clasping-leaf Pondweed	1.5	Submersed, Rooted
Ranunculus sp.	Buttercup	0.1	Submersed, Rooted
Megalodonta sp.	Water Marigold	0.1	Submersed, Rooted
Potamogeton pusillus	Small-leaf Pondweed	0.01	Submersed, Rooted
Potamogeton illinoensis	Illinois Pondweed	3.1	Submersed, Rooted
Myriophyllum sibiricum	Northern Watermilfoil	0.03	Submersed, Rooted
Myriophyllum verticillatum	Whorled Watermilfoil	0.01	Submersed, Rooted
Zosterella dubia	Water star grass	0.03	Submersed, Rooted
Drepanocladus revolvens	Water scorpion moss	0.02	Submersed, Non-Rooted
Vallisneria americana	Wild Celery	2.5	Submersed, Rooted
Elodea canadensis	Common Waterweed	1.3	Submersed, Rooted
Ceratophyllum demersum	Coontail	0.4	Submersed, Non-Rooted
Utricularia vulgaris	Bladderwort	1.4	Submersed, Non-Rooted
Najas guadalupensis	Southern Naiad	12.4	Submersed, Rooted
Najas flexilis	Slender Naiad	4.9	Submersed, Rooted
Nymphaea odorata	White Waterlily	0.8	Floating-Leaved, Rooted
Nuphar variegata	Yellow Waterlily	1.1	Floating-Leaved, Rooted
Lemna minor	Duckweed	0.02	Floating-leaved, Non-Rooted

33 Species!

Houghton Lake Wild Rice



Microcystis in Canals



Chemical Herbicides

Benefits

- Fast-acting
- Relatively low-cost
- Some are “broad-spectrum”
- Easy to obtain MDEQ permits

Limitations

- Long-term impacts unknown
- Have to re-apply within and among seasons for sustained control
- Hybrid species now rapidly building resistance to many existing herbicides
- Some are costly

Mechanical Harvesting

Benefits of Harvesting

- Removes some plant debris and associated organic nutrient
- Can reduce need for herbicides but is generalist
- Should not be used on species that fragment such as milfoil
- Immediate result

Limitations of Harvesting

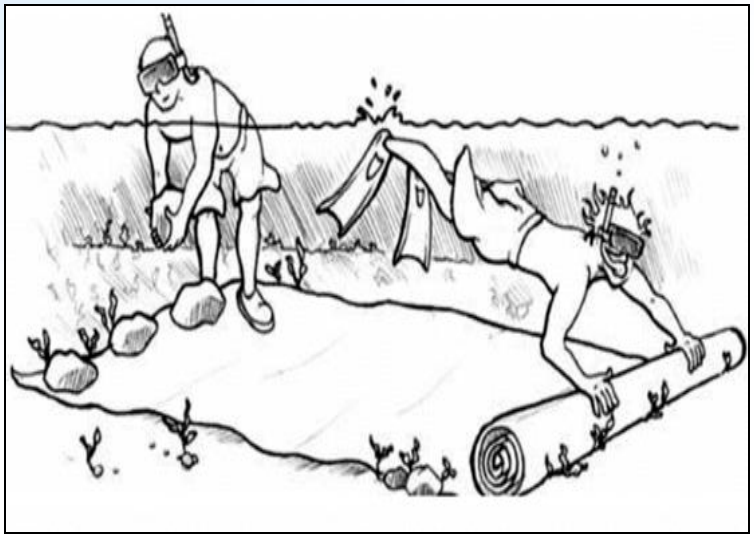
- Can increase biomass of fragment-producers
- Can create floating debris
- May need to be repeated in single season due to re-growth

DASH Boat Weed Removal

- Removes some plant debris and associated organic nutrient
- Can reduce need for herbicides
- Can be used on milfoil and species that fragment
- Requires MDEQ/USACE permit
- Cost ~$1K-$3k per acre
- Can be permanent

enthic Barriers and Weed Rollers

- Prevents plants from germinating; non-chemical
- Costly and localized control
- Great option for beach areas



Boat Wash Station

- Cooperative effort between HLA and HLIB
- Reduces transfer of invasive species into Houghton Lake
- Will require education of locals and visitors
- Sets a good precedent for community involvement in lake management

iological Control: *Galerucella* sp.

Benefits

- Non-chemical agent
- Effective on stands of Purple Loosestrife
- Self-propagating
- Fast turn over rate on life cycle within a given season
- Stocking rate declines with time
- Cost effective

Limitations

- Uncertainty exists on stocking density needs
- Stocking density needs may be highly site-specific

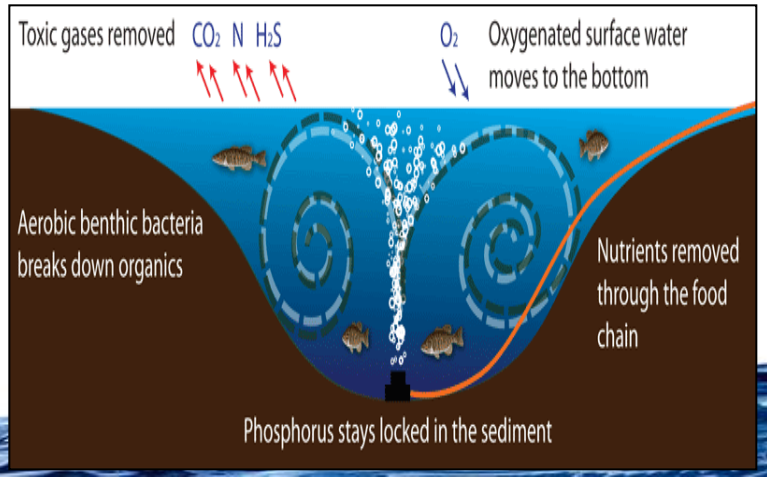
Laminar Flow Aeration

Benefits

- Non-chemical agent
- Sustainable
- Reduces weeds, mucks, improves sediment, restores lake
- Addresses dissolved oxygen depletion issue on lake
- Good for fishery/ecosystem health
- Supported by academic peer reviewed-research

Limitations

- Initially costly
- MDEQ testing requirements
- Requires electrical supply for compressors/easement



ibutary Nutrient/Sediment Filters

- Non-chemical agent
- Sustainable
- Reduces nutrients and sediment loads to the lake which reduces algae/plants
- Good for fishery/ecosystem health
- Reasonable Cost (ranged $3K-$10K per filter which lasts around 4-5 yrs..

Lake Management Activity	Primary Goal	Secondary Goal	Best Locations to Use
Aquatic herbicide treatment of hybrid milfoil	To reduce areas where the milfoil is dense	To prevent dense areas from spreading in the lake	Main Lake (only dense areas of growth)
Aquatic Herbicide treatment of Starry Stonewort	To reduce areas where it is dense	To prevent plant from carpeting lake bottom	Main Lake; Canals if needed for dense growth
Suction Harvesting	To remove selective areas of dense invasive plants in Middle Grounds/North Bay/Canals	To reduce dependency on chemical herbicides	Main Lake (small invasive polygons in Middle Grounds), Canals
Benthic Barriers/Weed Rollers	To prevent germination of nuisance weeds in beach areas or canals	To reduce dependency on chemicals in nearshore areas	Beach areas, Canals
Wild Rice Cultivation	To allow for new growth of Wild Rice	To increase habitat for Waterfowl	Middle Grounds, North Bay
Laminar Flow Aeration/Bioaugmentation	To reduce odorous muck in canals and aerate sediments	To holistically manage the muck and weeds in the canals	Canals (especially P1-PM canals and MKP-5 canal)
Tributary Nutrient Barriers	To reduce nutrients and solids entering Houghton Lake	To reduce weed growth associated with incoming nutrients	Tributaries (especially Sucker Creek and Spring Brook)
Lake Vegetation Surveys/Scans	To determine % cover by invasives and use as data tool	To compare year to year reductions in nuisance vegetation areas	Main Lake, Canals
Boat Washing Station	To clean boats of invasives before entering the lake	To educate boaters on the proper cleaning of boats and on invasives	South Bay; more if affordable in future and if pilot successful
Water Quality/Sediment Monitoring	To troubleshoot areas that have poor water quality	To compare trend in water quality parameters with time	Main Lake, Canals, Tributaries
Macroinvertebrate Sampling	To determine baseline populations	To determine if herbicides have an impact on populations	Areas proposed to be treated in Main Lake

Proposed Houghton Lake Management Improvement Item	*Estimated 2017 Cost*	*Estimated 2018 Cost*	*Estimated 2019-2021 Cost*
Herbicides for Hybrid Watermilfoil and Starry Stonewort and/or DASH Boat removal of invasives, Permit Fees[1]	$400,000	$350,000	$250,000
Professional Limnologist Services (limnologist surveys, sampling, contractor oversight, education)[2]	$65,000	$65,000	$65,000
Attorney Fees	$5,000	$5,000	$5,000
Assessment Appeals	$3,000	$3,000	$3,000
Canal Aeration Systems	$70,000	$50,000	$50,000
Tributary Filter Buffers	$10,000	$0	$0
Boat Washing Station	$140,000	$20,000	$20,000
Audit, Bond, Insurance	$1,400	$1,400	$1,400
Professional Memberships	$100	$100	$100
Mailings, Publication	$2,000	$0	$2,000
Contingency (15%)[3]	$104,475	$74,175	$59,475
TOTAL ANNUAL ESTIMATED COST	$800,975	$568,675	$455,975
APPROX. ANNUAL COST PER UNIT OF BENEFIT[4]	$	$	$

Questions?