

EcoLogic Memorandum

TO: Chris Gandino, OCDWEP
FROM: Liz Moran, EcoLogic, LLC
RE: Onondaga Lake 2011 Macrophyte Monitoring Results
DATE: February 28, 2012

This memorandum summarizes the 2011 Onondaga Lake macrophyte monitoring results. The annual macrophyte monitoring program consists of two elements: aerial photographs and field verification. The maps referred to herein are collected at the end of this memorandum.

Aerial Photographs Methodology

Aerial photographs were taken in on September 19 2011 by Air Photographics Inc. Air Photographics was on stand-by to conduct the flight in August, but optimal conditions of wind and water clarity did not occur until September. Prior to authorizing the late-season flight, the County conferred with Bob Johnson and conducted shoreline evaluation of the macrophytes to assess whether senescence was going to be a factor. Senescence was not observed; therefore, the County gave the Air Photographics permission to proceed with flight despite the lateness of the season (EcoLogic personal communication with C. Gandino).

Prior to the flight, ten field verification, or ground-truthing, sites were marked in the lake with large buoys, which are visible as orange dots in the photographs. The photographs were transferred to digital format, georeferenced and copied to a DVD that was sent to EcoLogic. The georeferenced photographs were imported into ArcGIS and the margins of the macrophyte beds were manually delineated using heads-up digitizing technique.

Ground-truthing (Field Verification) Methodology

On September 26 2011, within one week of shooting the aerial photographs, a ground-truth sampling effort was conducted. Onondaga County Department of Water Environment Protection (OCDWEP) staff visited each of the ten ground-truthing sites (Map 1) and collected data on species composition and relative abundance. These data were used to verify that objects delineated in the air photographs were macrophyte beds.

Macrophyte growth may be affected by substrate type and wave energy. These two factors were used in 2000 to divide the lake into five distinct strata as indicated in Map 1, based on substrate type and wave energies (EcoLogic 2001).

Results – 2011 Aerial Photography Interpretation

A total of 398 acres of macrophytes were delineated from the 2011 aerial photographs (Map 2). The most dense macrophyte beds were located in Strata 1, 5 and 4. Each of these strata was characterized as having a dominant substrate of oncolites. Work conducted by Madsen et al (1996) concluded that finer-grained sediments typically support a greater abundance and variety of macrophytes, whereas oncolite sediments produce less. In 2000, EcoLogic conducted a stepwise multiple linear regression to determine if significant trends existed between sediment composition and plant percent cover or biomass. Sediment was categorized as silt, fine sand, medium sand, coarse sand, or oncolites based on grain size analysis. Based on this regression analysis, oncolites did not exhibit a significant correlation with plant cover or biomass (EcoLogic, 2001). This finding is supported by the 2011 distribution of dense macrophyte beds in strata characterized as oncolite substrate (Maps 3 and 6). The oncolite substrate does not appear to limit macrophyte growth in these strata.

Strata 2 and 3 (Maps 4 and 5) exhibited less dense macrophyte cover in 2011. The substrate of Stratum 2 was characterized as Wastebeds, which in 2000 was described as a hard crust covering much of the area. This crust may limit plant establishment along the Wastebeds in this stratum. The substrate of Stratum 3 was characterized as fine sediment. In the regression analysis conducted by EcoLogic in 2000, fine sand was positively and significantly correlated with both percent cover and biomass. Based on this analysis, plant growth in Stratum 3 should not be limited by substrate.

Wave energy was another factor used to define the strata of Onondaga Lake. Of the three strata with the most dense macrophyte beds, each is characterized with different wave energy: Stratum 1 is Low Energy, Stratum 5 is Medium Energy, and Stratum 4 is High Energy. The visual appearance of consistent density of macrophyte beds within all three Energy types in these strata in 2011 suggests that wave action does not substantially limit macrophyte growth in these three areas. With respect to wave energy in strata with less dense macrophyte beds, Stratum 2

is characterized as Medium, and Stratum 3 is characterized as High. Plant growth in Stratum 3 may be limited by wave energy.

Trends

The overall coverage of macrophytes in 2011 was similar to both the 2009 and 2010 delineated values (382 and 409 acres, respectively). For all three years – 2009 through 2011 – percent coverage of the littoral zone was around 50% (Figure 1).

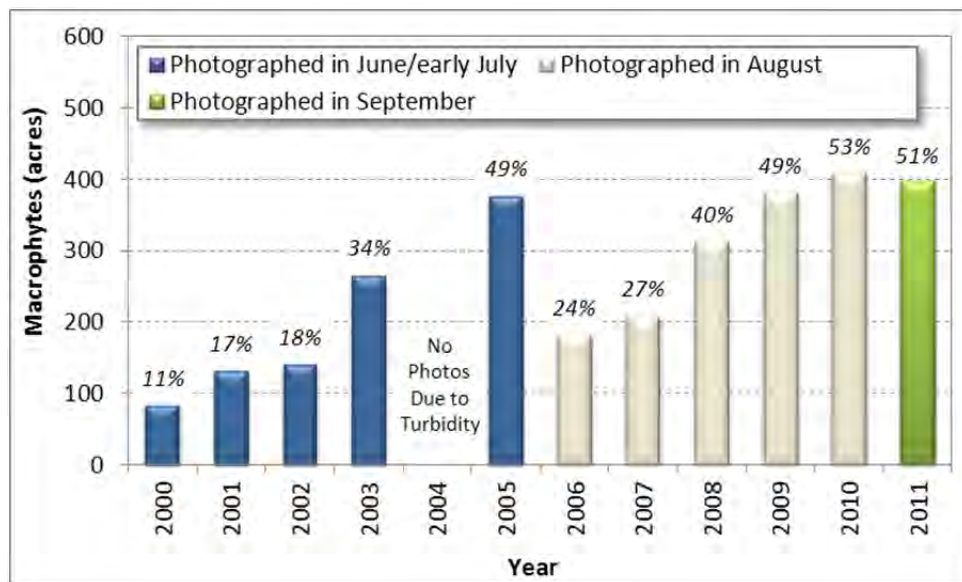


Figure 1. Acreage of macrophytes in Onondaga Lake, as digitized from aerial photography, for 2000 through 2011.

The changes in density and distribution of macrophytes since the first aerial photography fly-over in 2000 are also evident in Figure 2.

Since the inception of the aerial photography fly-overs in 2000, the timing of the flight has changed. To obtain the best quality photographs, the right combination of clear flying weather, clear water and well-established macrophytes must be met. Starting in 2000 and through 2005, photographs were taken in June or early July. There were no photographs taken in 2004 due to high turbidity. From 2006 to 2010, photographs were taken in August. In 2011, the photographs were taken on September 19. These different timeframes – June/early July, August, and September – are color-coded in Figure 1.

Onondaga Lake Macrophyte Program - Aerial Photo Interpretation Over Time

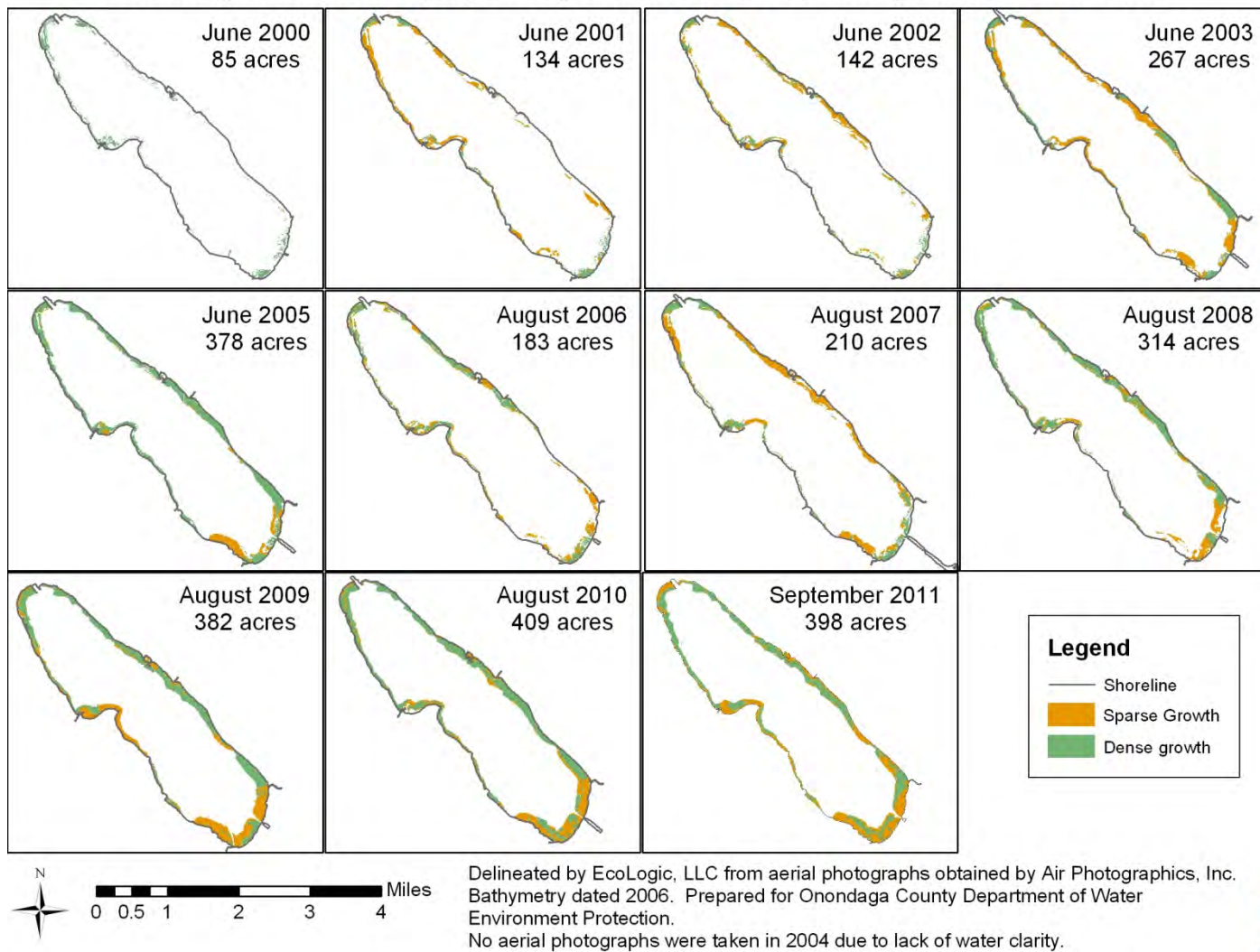


Figure 2. Onondaga Lake macrophyte aerial photograph interpretation over time.

As noted in previous reports, the drop in overall coverage observed between 2005 and 2006 (Figure 1) may be attributable to seasonal variability in plant growth between June 2005 and August 2006, or some other unidentified event. Seasonal differences are usually evident in a plant community as different species will be expanding or declining at a slightly different time of the growing season. Despite the seasonal differences that may exist when comparing the photographs taken at different points in the growing season, it is clear from the aerial images that coverage of macrophytes has steadily increased through 2009. The acreage has stabilized from 2009 through 2011, at around 400 acres.

From 2009 through 2011, the macrophyte coverage appears to have stabilized at approximately 50% of the littoral zone, which is defined as the area of about 777 acres from the shoreline to a water depth of 6 meters. There are two possible interpretations of this perceived stabilization:

1. The lake's macrophyte community has plateaued, or reached its maximum capacity, and is likely to remain in the zone of approximately 50% coverage of the littoral zone due to limitations such as substrate, wave energy, or other environmental conditions.
2. The aerial photography methodology has reached its limit. The ability to perceive plants from aerial photographs diminishes with water depth and water clarity. If the macrophyte beds are extending deeper in to the lake, the beds may not be visible – and therefore not delineated – in the aerial photographs.

During delineation of the macrophyte beds in 2011, there were areas in the aerial photographs where it was more difficult to discern the edges of the beds at greater water depths. It is possible that the edges of the beds extended deeper than could be ascertained in the aerial images.

The depth at which aquatic plants have been documented in Onondaga Lake has increased since 2000 (Table 1). Overall, the maximum depth at which plants were found in 2010 – the year of the last macrophyte survey – was 6.2 meters. In each stratum in 2010, the average of maximum plant depths of transects ranged from 4.1 to 5.9 meters.

Table 1. Plant maximum depth of growth 2000-2005, Onondaga Lake 5-year macrophyte survey program.

Stratum	Average of Transect Maximum (with Strata Maximum) Depth of Plants (m)		
	2000	2005	2010
1	1.5 (2.0)	5.9 (6.5)	5.9 (6.2)
2	1.9 (2.7)	4.4 (6.8)	4.2 (4.9)
3	1.7 (2.5)	3.0 (3.6)	4.1 (4.4)
4	2.7 (3.4)	4.1 (5.5)	4.8 (5.7)
5	2.7 (3.7)	5.0 (6.2)	5.1 (5.9)

The 2006 bathymetric contours were super-imposed on the 2011 aerial images, to assess the discernibility of macrophyte beds relative to approximate water depth. Overall, the edges of macrophyte beds that were discernible in the aerial image approximately corresponded to the 4-m to 6-m contour range. There will be some variability in the bathymetric contours relative to the actual water depth at any given time, for two reasons: first, contours are often derived from point elevation data, and therefore are estimates of real-world bathymetry; second, water elevation fluctuates from season to season.

In the 2011 aerial images, the visible macrophyte beds correlate generally with the 4- to 6-meter contours of the 2006 bathymetry shapefile. The field observations in 2010 identify the maximum depth of plant growth generally between 4 and 6 meters. Based on this correspondence between the field observations and aerial images, it appears as though the methodology for delineating macrophyte beds yields results consistent with real-world observations. For this to continue to be true in the future, the importance of highest possible water clarity on the day of the fly-over cannot be overstated.

The water clarity is measured as Secchi disk transparency. Review of the data set from 2000 through 2011 resulted in the following tabulation of Secchi transparency at the time of the aerial photography fly-over for each year. This summary provides a baseline in which the effect of water clarity on the visibility of the plants in aerial photos may be considered. There is insufficient information at this time to assess whether a difference in Secchi transparency from year to year translates into a significant impact to the visibility of macrophyte beds in the aerial photographs.

Table 2. Summary of Secchi Readings around the time of the aerial photography fly-over.

Year	Fly-Over Date	Secchi Date (N days from flight)	Secchi readings (m)	
			Nearshore Stations Average (min - max)	South Deep
2000	6/20	6/21 (+1)	2.48 (1.5 – 2.9)	na
2001	6/26	6/26 (0)	1.68 (1.5 – 1.9)	na
2002	7/13	7/8 (-5)	1.43 (1.1 – 1.9)	na
2003	7/1	6/30 (-1)	2.10 (1.4 – 2.8)	na
2004	No flight	--	--	--
2005	6/23	6/22 (-1)	1.84 (1.0 – 2.3)	na
2006	8/9	8/7 (-2)	1.59 (1.4 – 1.8)	na
2007	8/1	7/23 (-8)	1.68 (0.9 – 2.5)	1.5
2008	8/20	8/18 (-2)	na	4.2
2009	8/8	8/3 (-5)	>1.2 to >1.4*	5.8
2010	8/17	8/16 (-1)	>1.3 to >1.5*	2.5
2011	9/19	9/16 (-3)	2.00 (1.7 – 2.2)	na
2000-2011	Jun-Sep	Jun-Sep	1.75 (0.9 – 2.9)	3.5

Aerial fly-over dates obtained from prints of aerial images.

Secchi dates are measurements taken on sample dates closest to the aerial fly-over date.

na = indicates no Secchi reading available for this date.

*Nearshore readings were reported with Secchi disk visible on the bottom.

Results – Ground-Truthing (Field Verification)

The ground-truthing effort identified eight taxa at ten sites (Table 2). Coontail and Common waterweed were the most widely distributed species, found at 90% or more of the sites. Eurasian water milfoil, Southern naiad and Water star grass were found at 70% to 80% of the sites. The remaining taxa were found at 30% or fewer of the sites.

Relative abundance where present was greatest for Coontail, Water star grass, and Sago pondweed, ranging from 33% to 45%. Coontail had the highest overall (lakewide) relative abundance (44%), with Water stargrass at second-highest (31%); the remaining taxa were present at 10% or less.

Table 2. 2011 Ground-Truthing Results.

Species	Where Present		Overall
	Percent of Sites	Relative Abundance	Relative Abundance
Coontail (<i>Ceratophyllum demersum</i>)	100%	45%	44%
Common water weed (<i>Elodea canadensis</i>)	90%	5%	4%
Eurasian water milfoil (<i>Myriophyllum spicatum</i>)	80%	8%	6%
Southern naiad (<i>Najas quadalupensis</i>)	80%	5%	4%
Water star grass (<i>Zosterella dubia</i>)	70%	45%	31%
Sago pondweed (<i>Stuckenia pectinata</i>)	30%	33%	10%
Common stonewort (<i>Chara vulgaris</i>)	20%	1%	0.2%
Curly leaf pondweed (<i>Potamogeton crispus</i>)	10%	5%	0.5%

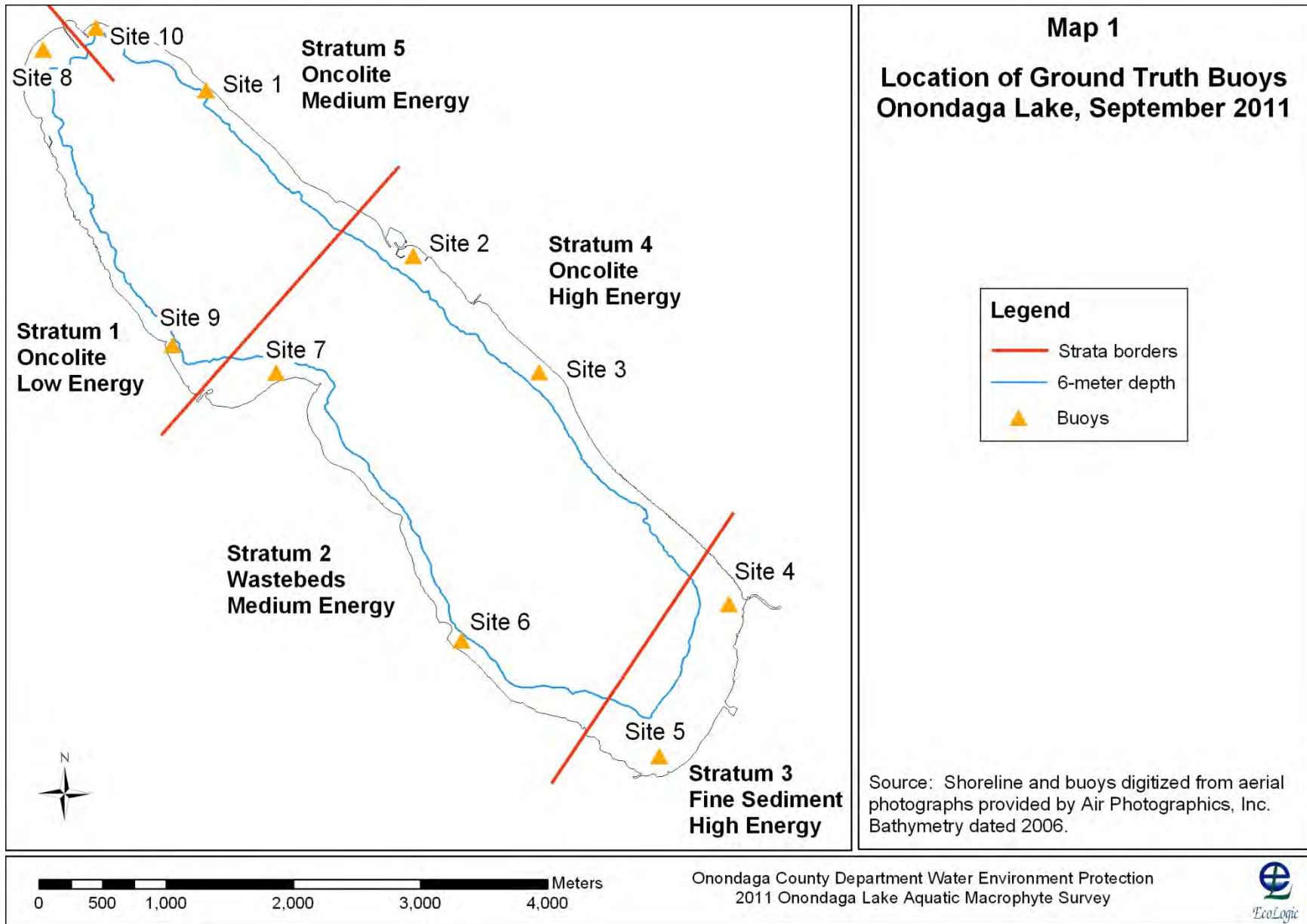
Verification – Aerial Photograph Interpretation and Ground-truthing

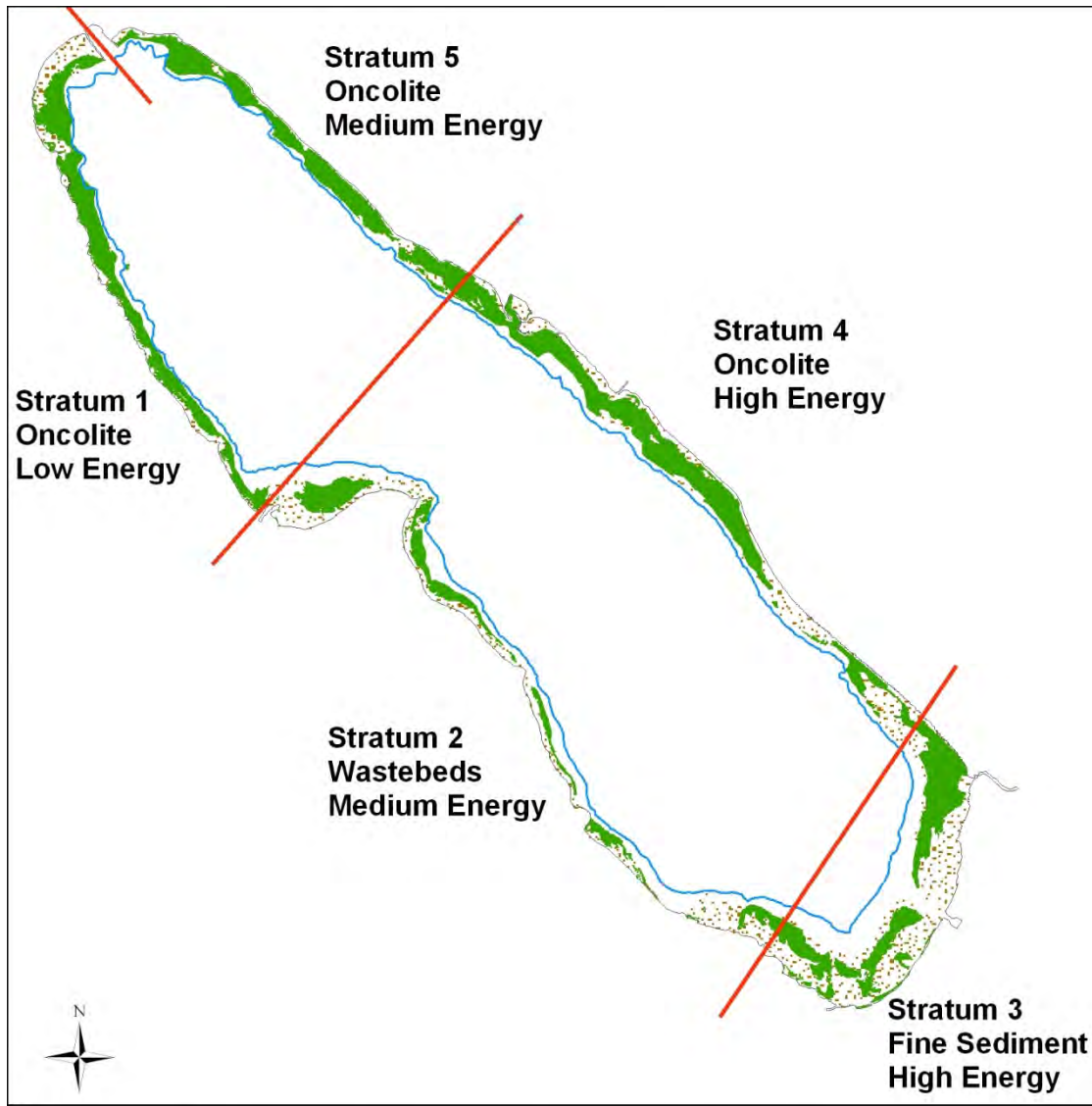
There was very good agreement between the results of the ground-truthing compared to the digitized macrophytes (Maps 7 through 16). While some areas of metaphyton growing adjacent to macrophytes beds can be difficult to distinguish in the aerial photographs, it does not appear that these areas comprise a significant part of the delineations. Overall, the ground-truthing seems to verify that the photo delineations are a reasonable interpretation of macrophyte distribution in the lake.

References

- Madsen, J.D., J.A. Bloomfield, J.W. Sutherland, L.W. Eichler and C.W. Boylen. 1996. The aquatic macrophyte community of Onondaga Lake: Field Survey and Plant Growth Bioassays of Lake Sediments. *Lake and Res. Mgmt.* 12(1): 59-71.
- EcoLogic 2001. 2000 Onondaga Lake Aquatic Macrophyte Monitoring Program. October 2001. Prepared for Onondaga County Department of Drainage and Sanitation.

Onondaga Lake Macrophyte Program
2011 Aerial Photograph Interpretation Maps





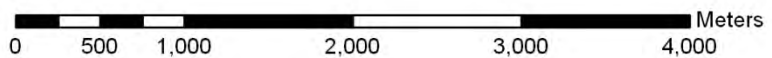
Map 2
Lakewide
Macrophyte Distribution
Onondaga Lake, September 2011

Legend

- Strata borders
- 6-meter depth
- Sparse macrophyte growth
- Dense macrophyte growth

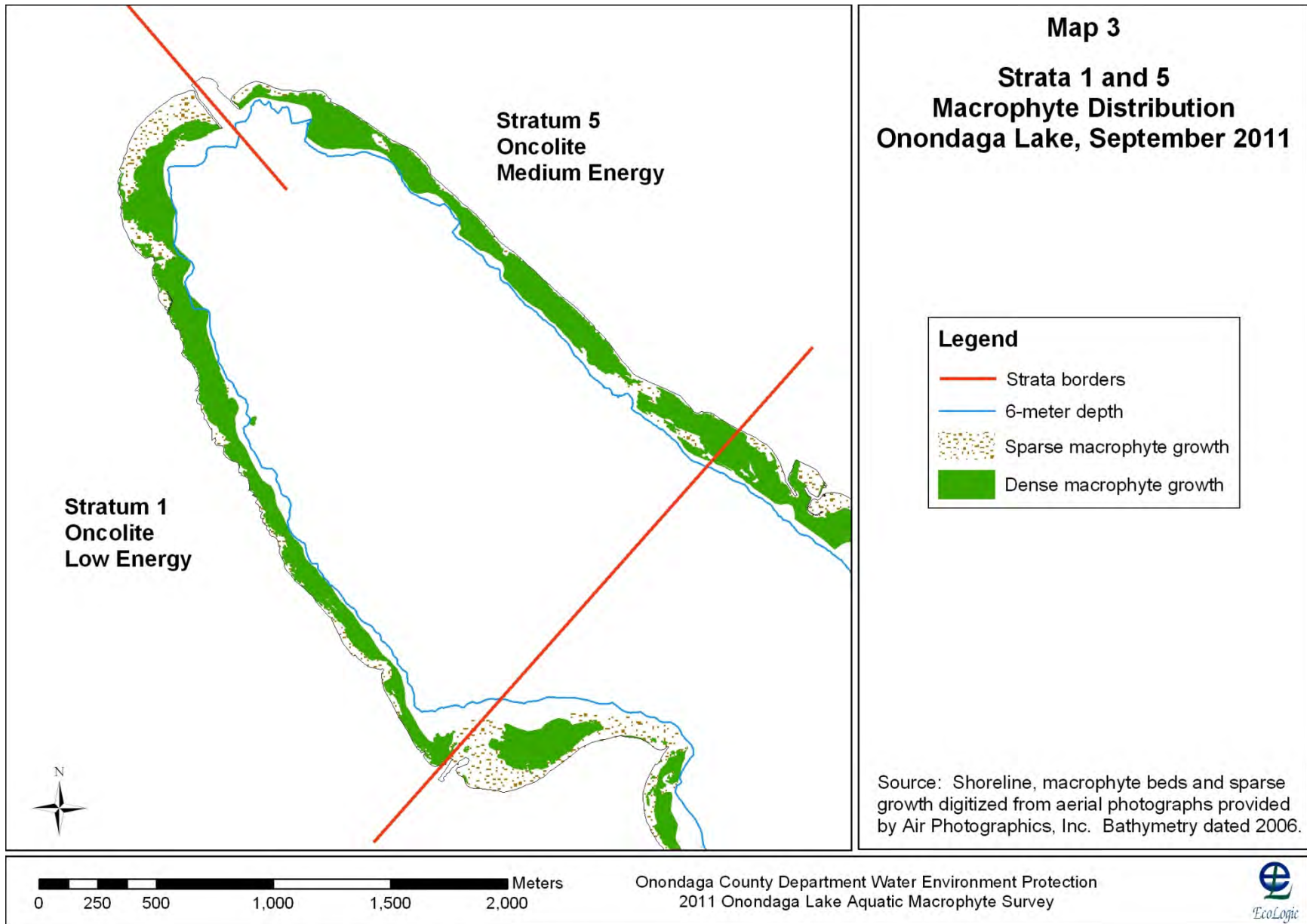
Estimated macrophyte area: 398 acres

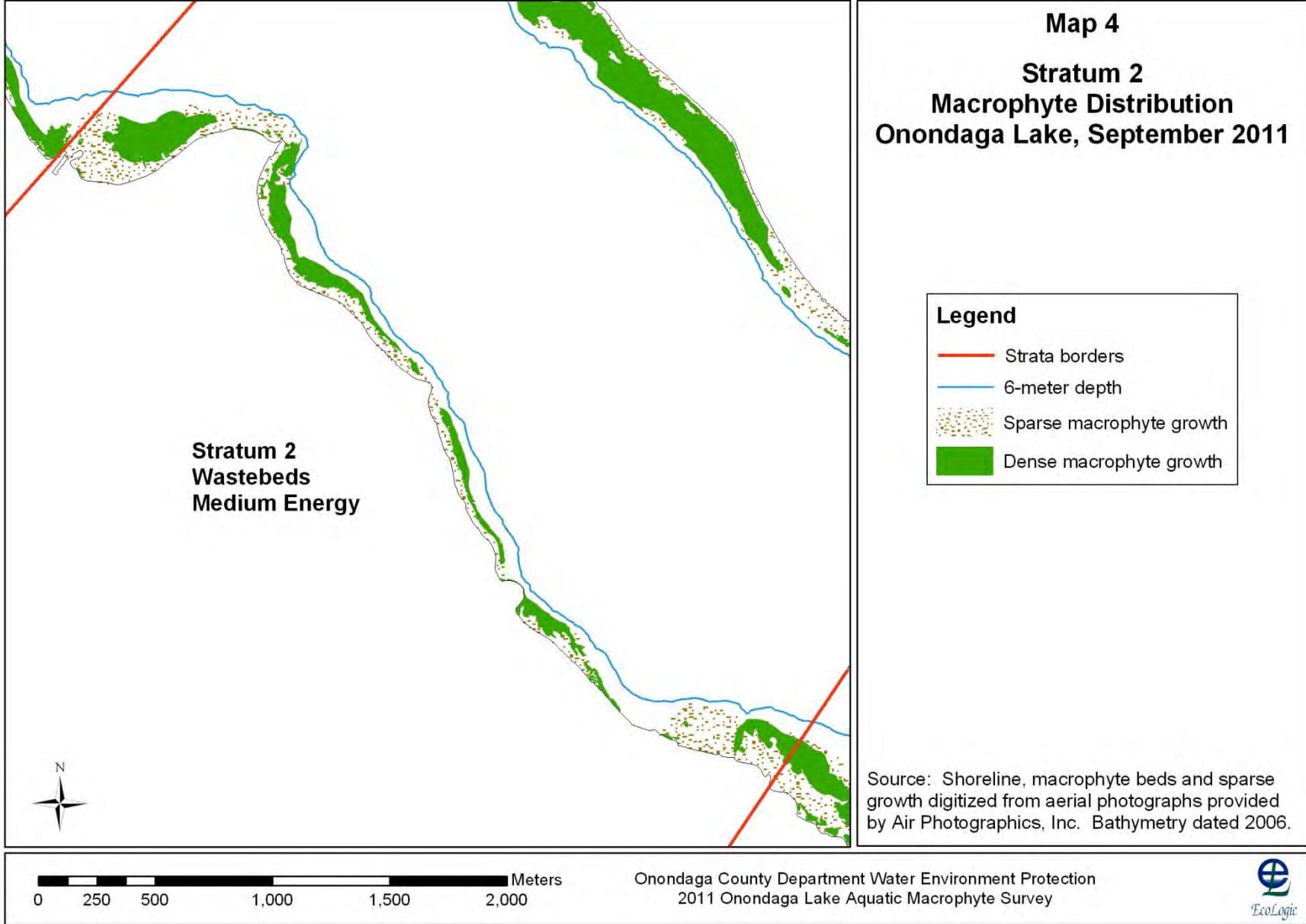
Source: Shoreline, macrophyte beds and sparse growth digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

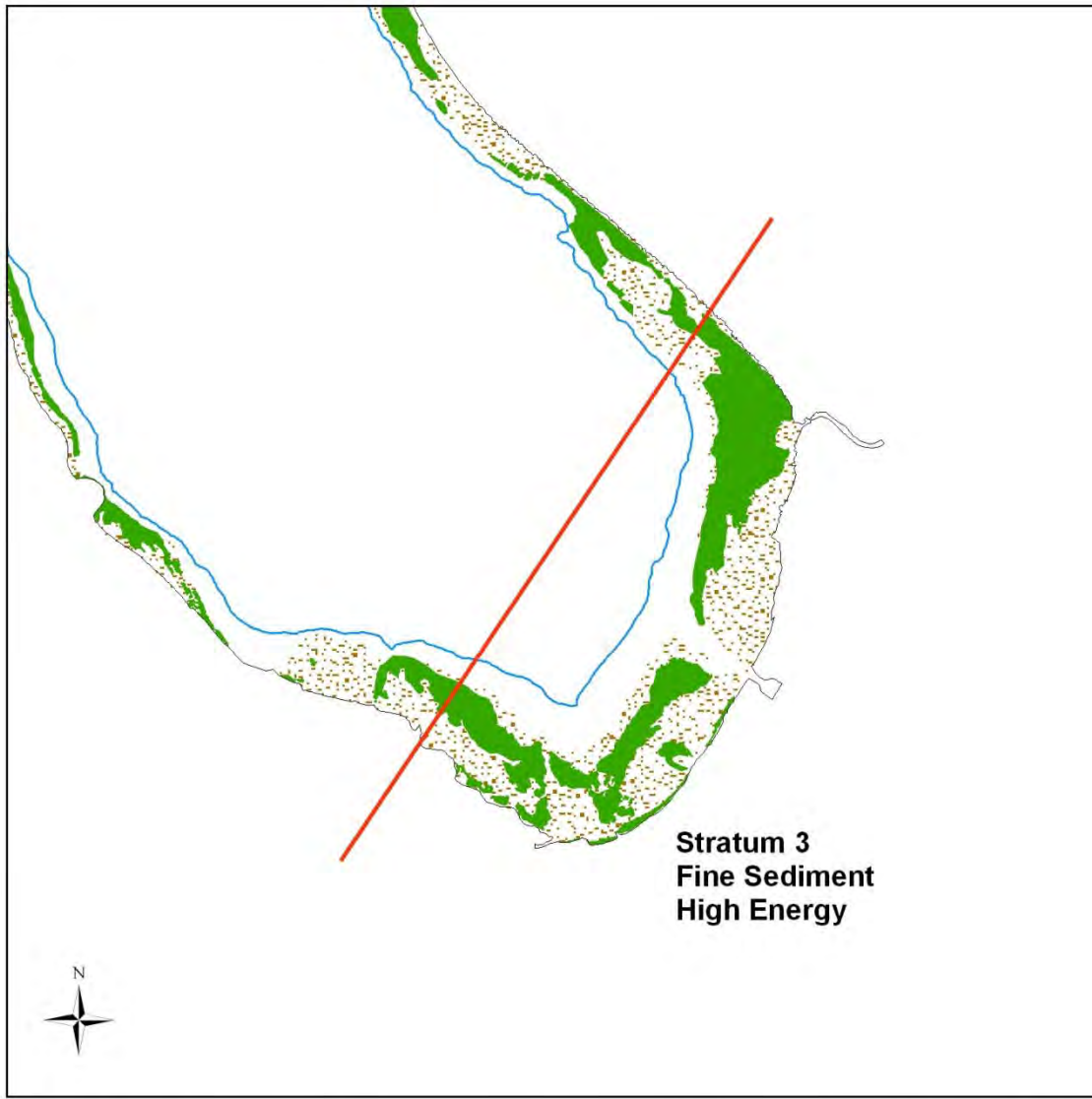


Onondaga County Department Water Environment Protection
 2011 Onondaga Lake Aquatic Macrophyte Survey

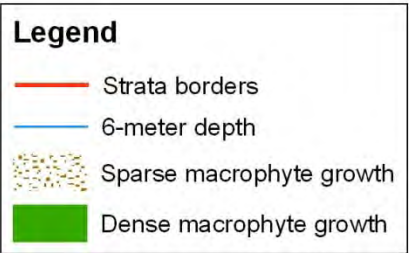




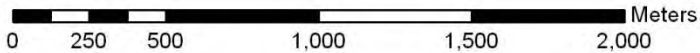




Map 5
Stratum 3
Macrophyte Distribution
Onondaga Lake, September 2011

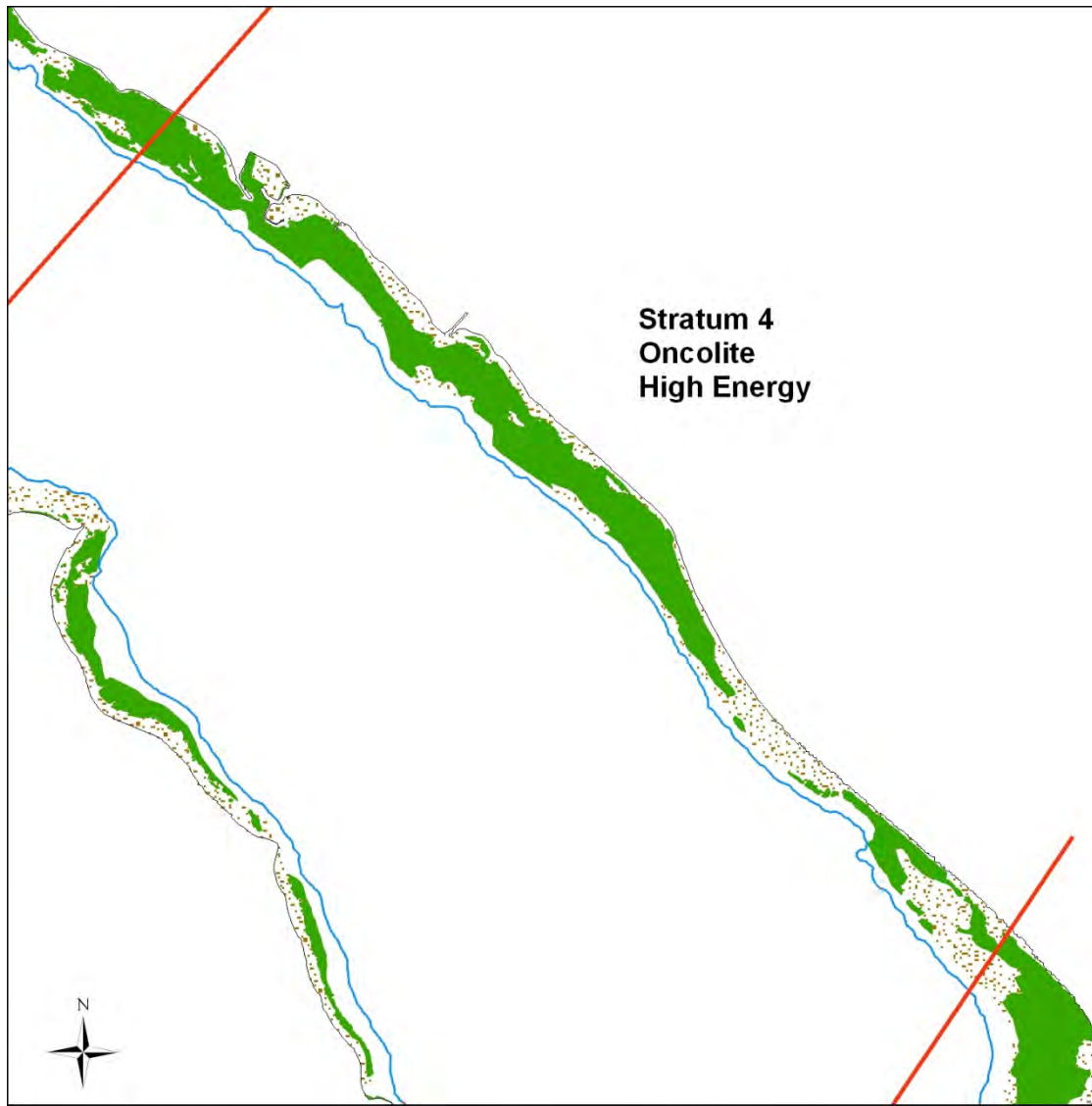


Source: Shoreline, macrophyte beds and sparse growth digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.







Onondaga County Department Water Environment Protection
2011 Onondaga Lake Aquatic Macrophyte Survey



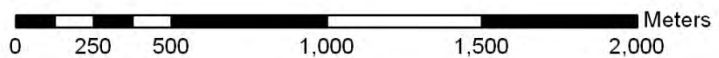


Map 6
Stratum 4
Macrophyte Distribution
Onondaga Lake, September 2011

Legend

-  Strata borders
-  6-meter depth
-  Sparse macrophyte growth
-  Dense macrophyte growth

Source: Shoreline, macrophyte beds and sparse growth digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.



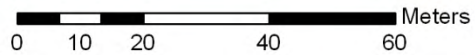
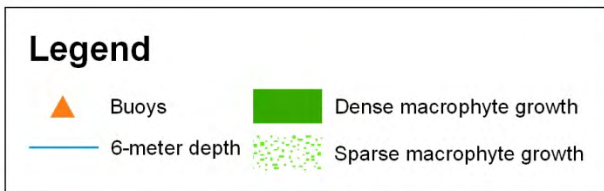
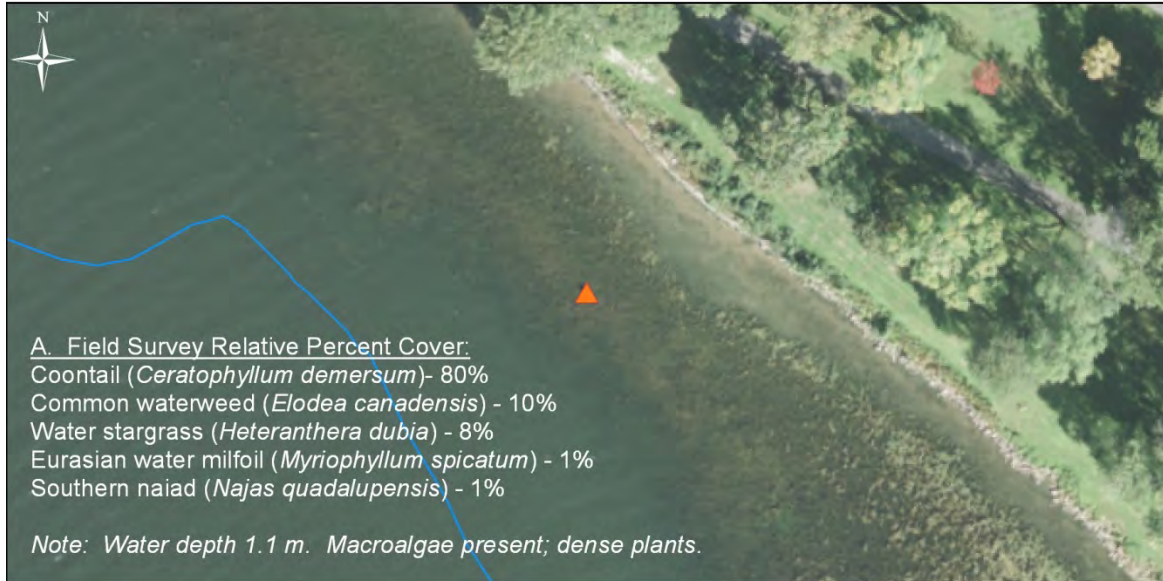
Onondaga County Department Water Environment Protection
 2011 Onondaga Lake Aquatic Macrophyte Survey



Map 7

Ground Truth Buoy Site 1

September 2011, Onondaga Lake



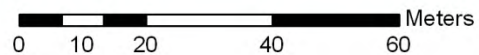
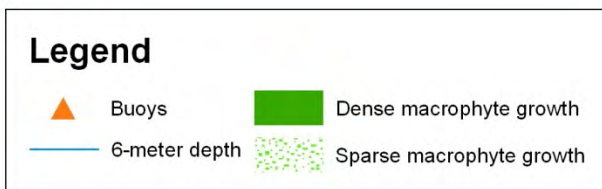
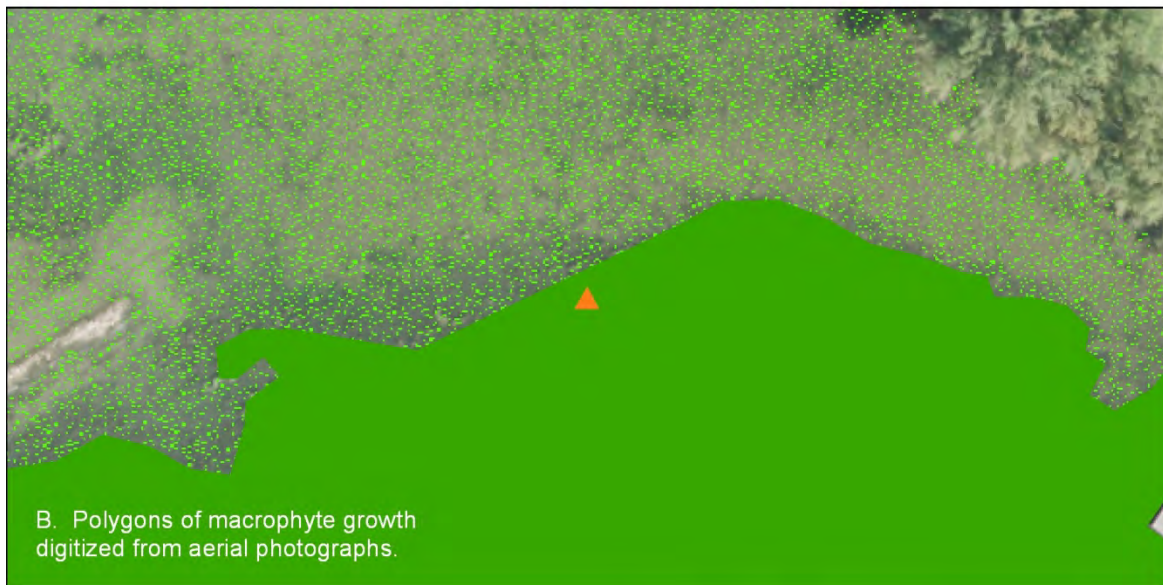
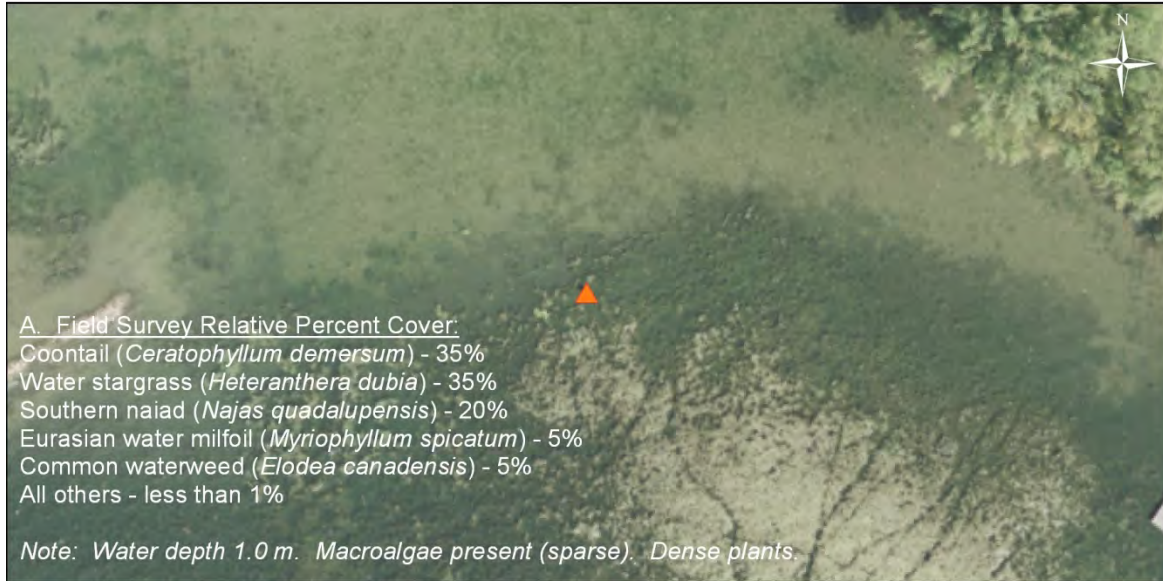
Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.



Map 8

Ground Truth Buoy Site 2

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

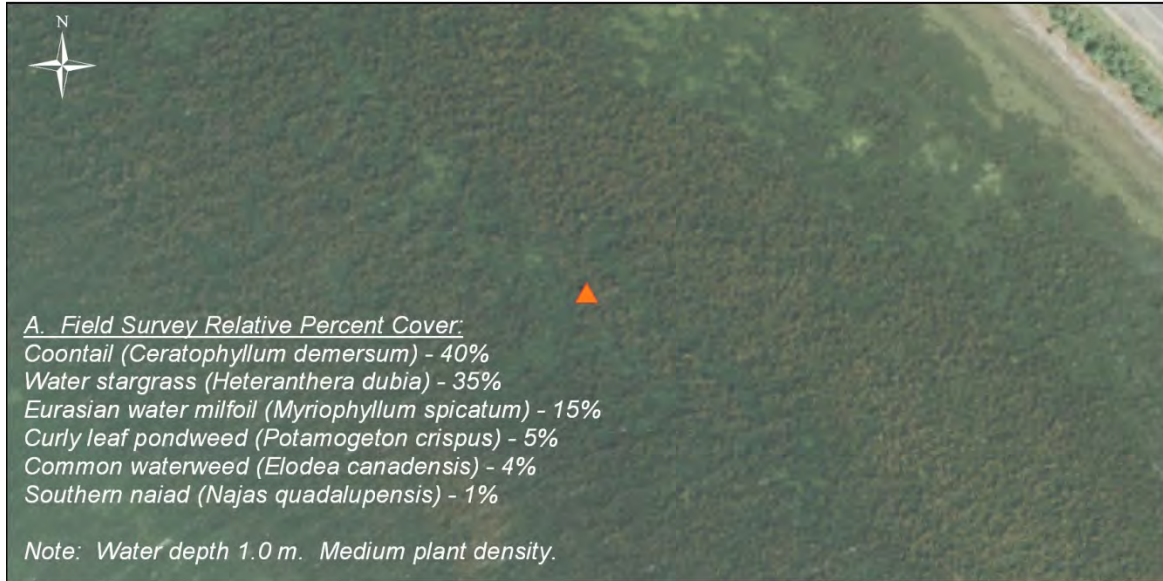


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Map 9

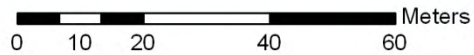
Ground Truth Buoy Site 3

September 2011, Onondaga Lake



Legend

-  Buoys
-  6-meter depth
-  Dense macrophyte growth
-  Sparse macrophyte growth



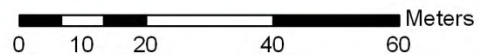
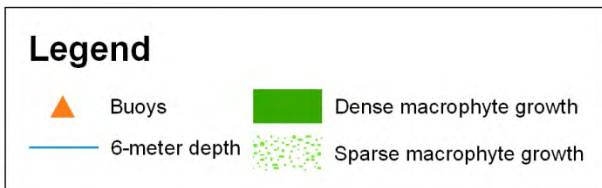
Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.



Map 10

Ground Truth Buoy Site 4

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

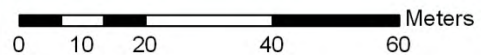
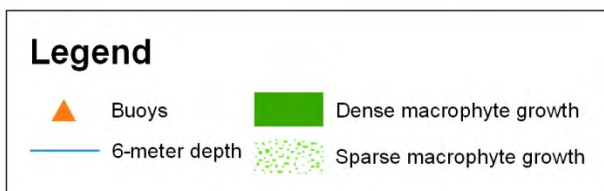
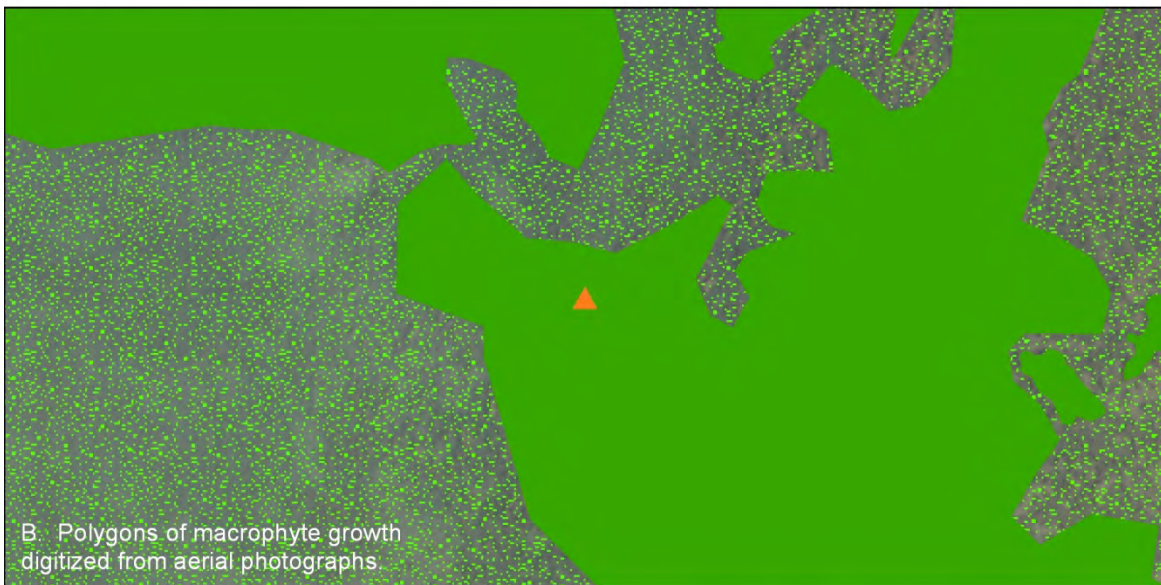
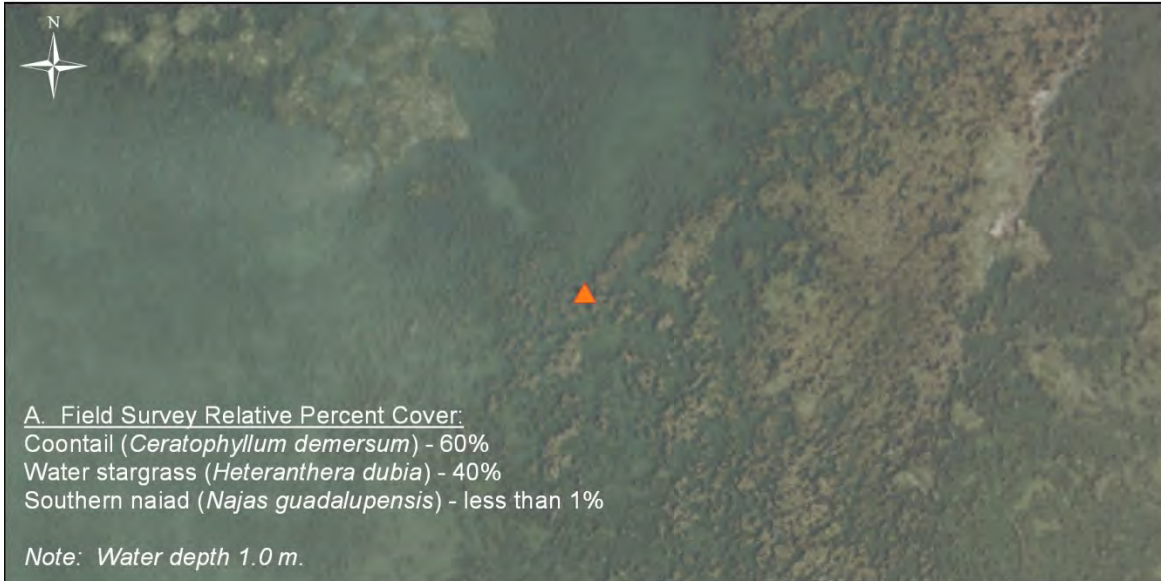


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Map 11

Ground Truth Buoy Site 5

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

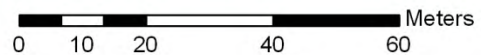
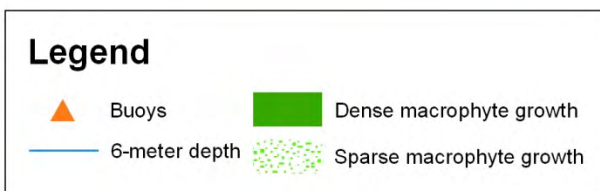
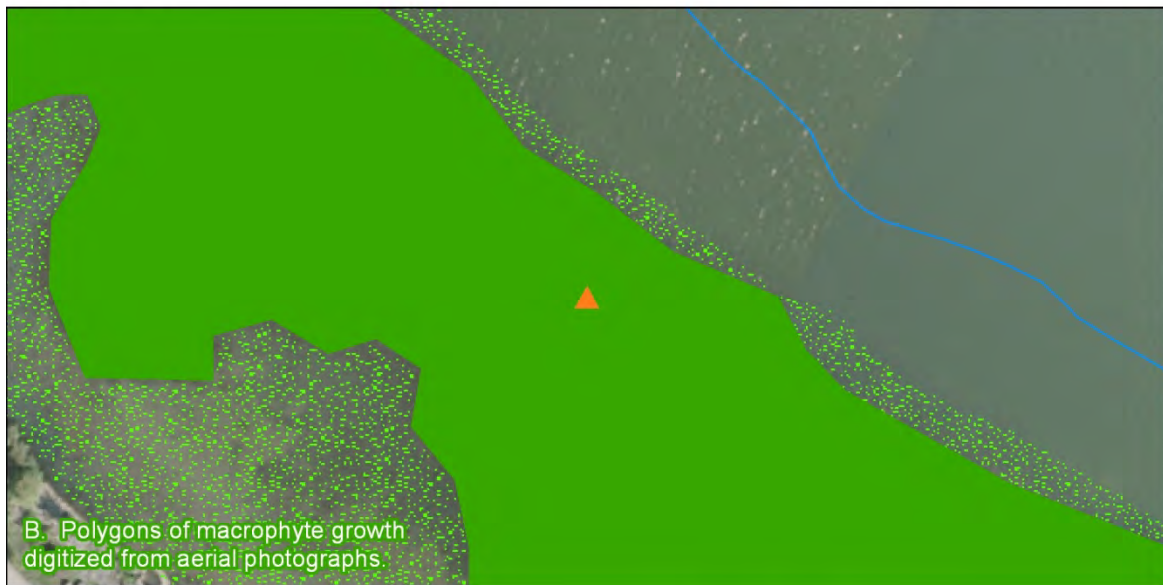
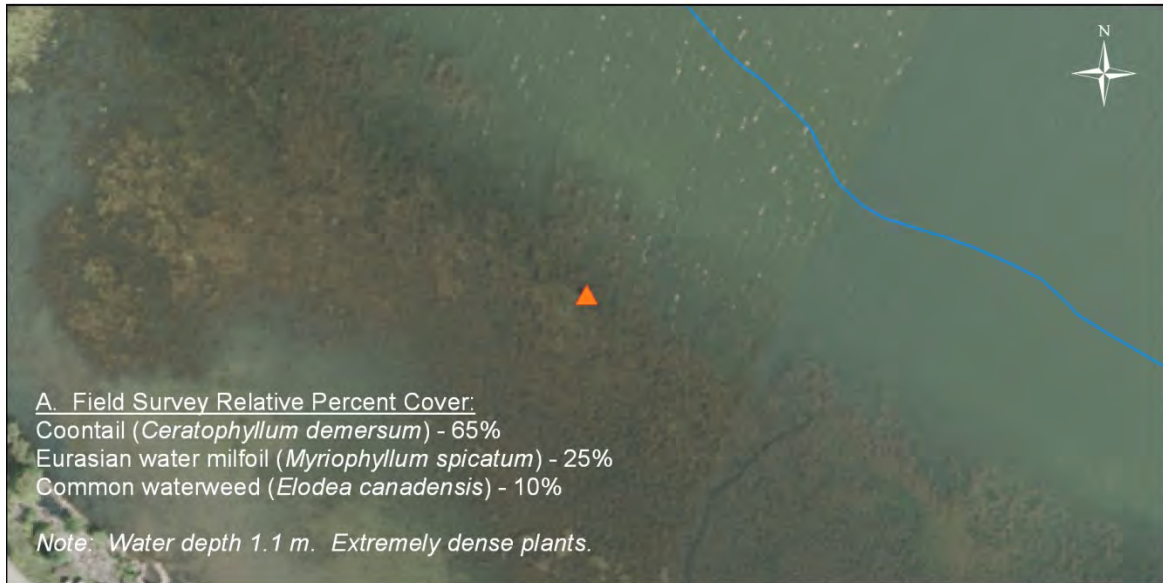


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Map 12

Ground Truth Buoy Site 6

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

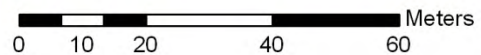
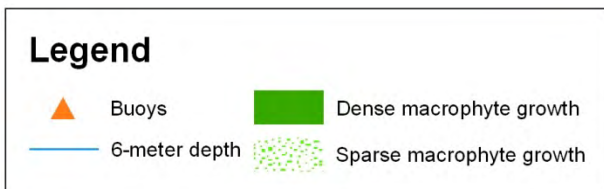
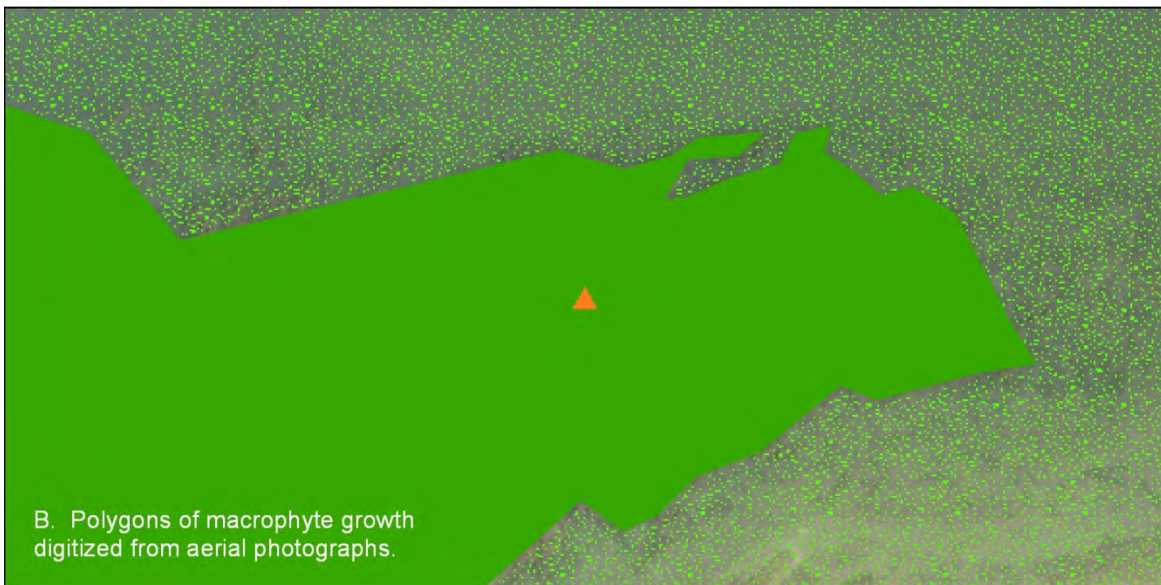
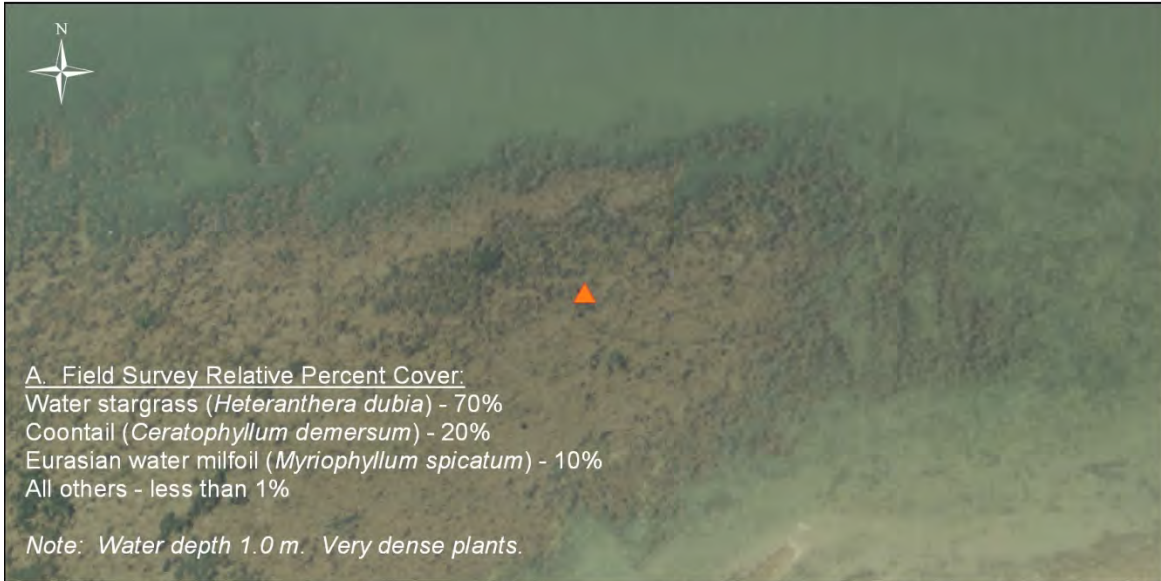


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Map 13

Ground Truth Buoy Site 7

September 2011, Onondaga Lake



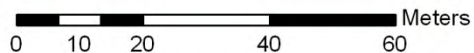
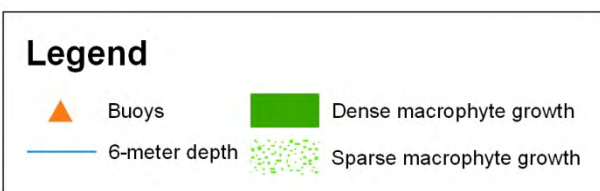
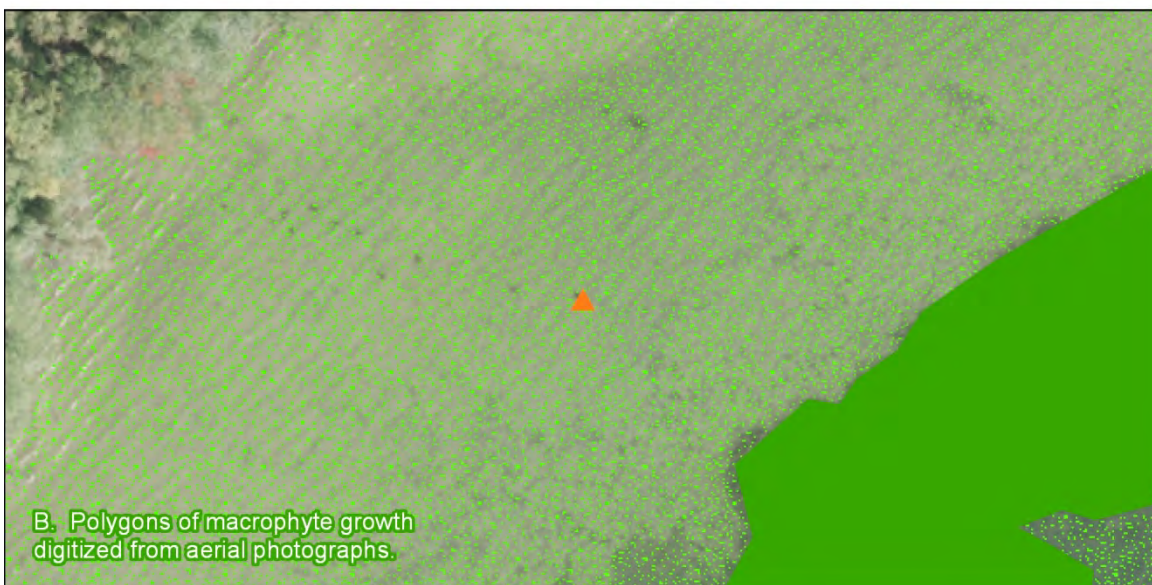
Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.



Map 14

Ground Truth Buoy Site 8

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

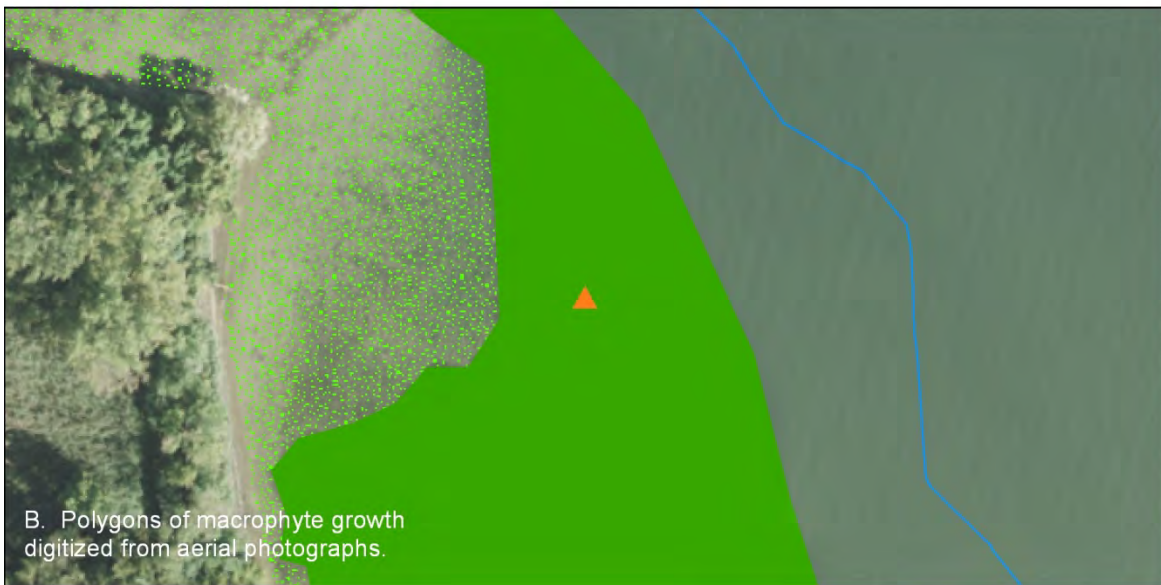
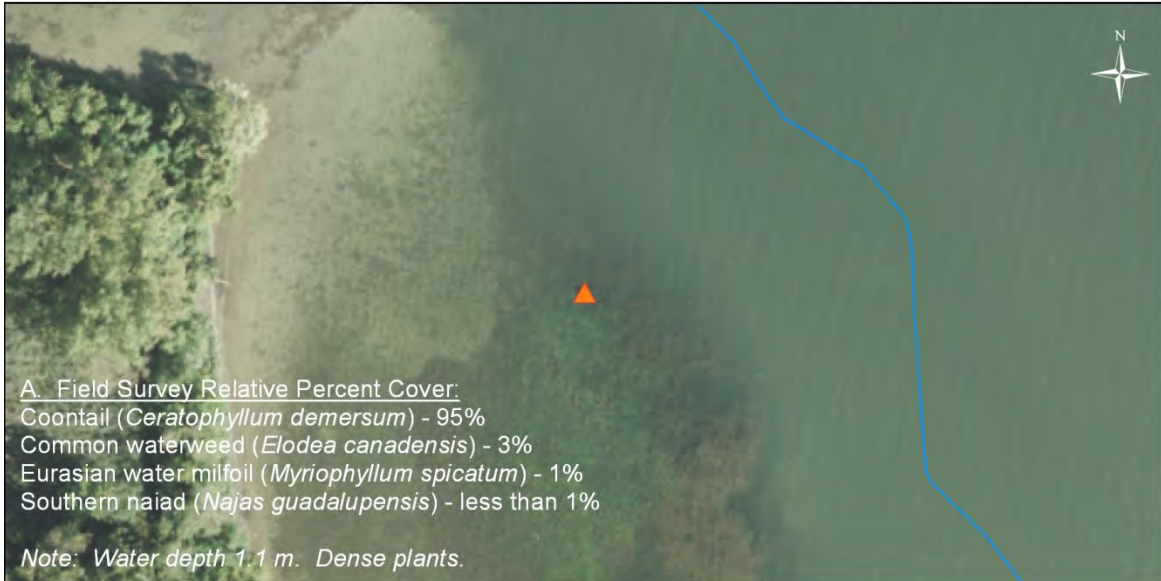


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Map 15

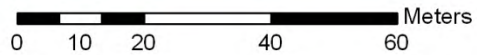
Ground Truth Buoy Site 9

September 2011, Onondaga Lake



Legend

	Buoys		Dense macrophyte growth
	6-meter depth		Sparse macrophyte growth



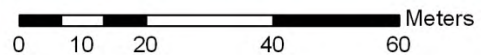
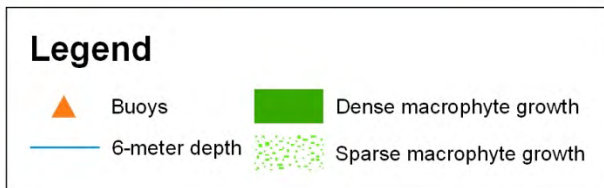
Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.



Map 16

Ground Truth Buoy Site 10

September 2011, Onondaga Lake



Source: Buoy locations and macrophyte polygons digitized from aerial photographs provided by Air Photographics, Inc. Bathymetry dated 2006.

