Assessment of Oakwood Lake
Township of Medford, Burlington County, New Jersey

Prepared for:

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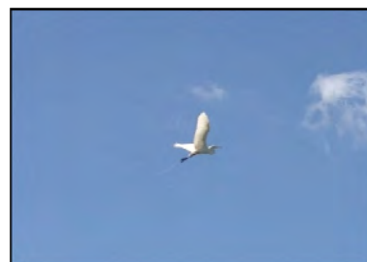

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Table of Contents

1.0 Introduction

Princeton Hydro, LLC (Princeton Hydro) was contracted by the Oakwood Lakes Community Association (OLCA) to perform an assessment of Oakwood Lake. This investigation focuses on mapping the problematic accumulation of organic detritus (leaf litter) and sediment in the southern half of the lake. While much of the sediment loading to Oakwood Lake originates in the lakes and streams discharging to the lake, and therefore from the watershed at large, the woody vegetation around the shoreline also contributes to the organic detritus load. This sediment loading is linked to or causes several issues in the lake including a simple loss of depth, navigation and access problems, water quality impairments, and nuisance aquatic plant growth. While the loss of depth and boating opportunities is an obvious problem the link to water quality declines and excessive aquatic plant and algae growth requires some further explanation. The accumulation of soft, organic-rich sediments creates an ideal habitat for aquatic plant and mat algae growth because it provides high nutrient concentrations, provides high light levels throughout the water column, and warms quickly, all of which can stimulate excessive primary production or growth. Excessive growth of algae and plants also causes issues including a loss of aesthetics, impaired swimming and boating, and potentially impaired dissolved oxygen levels which can impact the fishery. Even the accumulation of highly organic sediments can contribute to low dissolved oxygen conditions. In addition to these problems, the shallow and warm conditions created by sediment accretion in the lake may also contribute to the high bacteria counts in the lake.

This assessment therefore is focused primarily on mapping the sediment accumulation in the southern half of the lake as well as mapping areas of organic detritus. Some cursory water quality monitoring was also included to provide some baseline data. This data will be used to evaluate sedimentation in the lake and develop some management recommendations.

2.0 Bathymetric Assessment

A limited bathymetric assessment was performed in the southern half of the lake, the area of reported greatest impact, to determine lake depth, sediment thickness, and a field evaluation of sediment quality. The bathymetry study was conducted using a graduated sediment probe. Water depth or depth to unconsolidated sediment was recorded at each probe location. Depth to consolidated sediments was also recorded by driving the probe through the unconsolidated surficial sediments to the point of refusal, which is generally considered to be the original lake bottom, although this varies with sediment composition. Sediment thickness was obtained by subtracting water depth from depth to refusal. Each sounding was GPS-located using a Trimble Pro XRS. Sediment quality was assessed visually and consisted of visual observations during the collection of depth data as well as the inspection of cores and samples collected with a sediment corer.

Using this data a series of maps was prepared and modeled using ArcGIS which shows the water depth, sediment thickness, and the areas of organics or leaf litter accumulation. These maps are of sufficient quality to direct certain sediment removal operations such as hydro-raking, but will be insufficient to serve as a full-scale dredging plan. The bathymetry was conducted over two days, January 4 and January 17, 2013. All water depths were relative to the water surface elevation, which appeared to be at normal pool stage. One usage note is in order; this lake/tributary system flows northward therefore the "upper" or "upstream" areas are farthest south.

In total, 16.5 acres of Oakwood Lake was assessed, in addition to the small cove (0.5 acres) just north of the swimming beach (Map 1). Maximum depth in the southern half of the lake was just 6.4 feet, recorded in the scour pool of the culvert under the dam at the head of the southeast limb, and the assessed area had an average depth of 2.5 feet. These southern limbs are quite shallow overall, yet the remnant stream channels are still evident in the maps. North of the confluence of the two limbs the lake is deeper and the littoral margins tend to be somewhat steeper. There are several small islands in the lake and the surrounding areas are quite shallow.

The sediment map is more interesting and more complex (Map 2). The calculated volume of sediment was over 56,000 cubic yards which averages to a thickness of about 2.1 feet, however the thickness is highly variable throughout the lake. The northern portion of the assessed area had decreased sediment thickness, between 1.0 and 2.0 feet for the most part, although thickness increased along the margin. Thickness was much greater in the southern limbs, with the majority of the area between 2.0 and 4.0 feet, but maximum recorded thickness exceeded 5.0 feet in spots. As with the northern portion, the accumulation tended to be somewhat thicker along the margins, although not always. It is also worth noting that the accumulation in the northwestern cove was also quite thick, but more orderly than elsewhere clearly showing the original bottom contours.

The general pattern of accumulation, namely increased accumulation in the southern limbs and along the shoreline in general, is consistent with the hydraulics and morphometry (basin shape) of the lake. First, any sediment coming in from upstream, mostly at the heads of the limbs, preferentially settles in the upper end of the lake because of the slow current in these areas. Second, the accumulation of organics along the margins is consistent with proximity to the shorelines and henceforth to the trees.

Sediment type is an important consideration in the assessment as well. The organic detritus map shows that approximately 8.2 acres of the assessed area is subject to leaf litter accumulation; this is equivalent to about 50% of the total assessed area. The distribution roughly follows the sediment thickness maps and the areas of greatest continuous leaf litter accumulation are at the heads of the southern limbs: the upper 2.0 acres of the southwestern limb and 2.4 acres in the southeastern limb. Other areas of accumulation include the shoreline margin and in the numerous small coves and shoreward of the islands. The thickness of this accumulation varies, but for the most part is less than 1.0 feet thick and is comprised of leaves, conifer needles, and branches. No aquatic plant or algal material was identifiable, but this is not surprising given the timing of the field work and because this material breaks down fairly rapidly. The coarse organic material overlies an unconsolidated or loose layer of fine organic muck with sand, dark gray to greenish-gray in color. This layer represents the more advanced decomposed stage of the surface stratum and forms the bulk of the sediments in the lake. The consolidated layer, probably the original stream bed or flood plain is silty-clay. There was one area of significant sand accumulation at the outfall of Lower Birchwood Lake (identified on most maps as Timber Lake) as well an outfall coming from the northeast near the same location. The scour pool at the culvert also had a hard bottom, which may indicate this area was stabilized with riprap at some point.

3.0 Water Quality Sampling

As mentioned in the introduction, some modest water quality sampling was conducted, mainly to provide a baseline evaluation and a general sense of the lake. The sampling period, being mid-winter, is not ideal for identifying any water quality issues since most lakes typically experience problematic water quality conditions during the summer as a function of high temperatures, reduced oxygen solubility in warm water, and plant and algae growth. Five in-situ water quality samples were recorded, two in each of the southern limbs and one north (downstream) of the confluence. Samples were taken with a calibrated multi-probe water quality meter; Princeton Hydro is an NJDEP certified laboratory for the measurement of in-situ parameters including temperature, dissolved oxygen, pH, and specific conductance. A review of this cursory data showed the lake to be slightly neutral to acidic, consistent with other lakes in the area. While the dissolved oxygen (DO) concentrations were high overall, exceeding 10.5 mg/L at all sampled locations, the percent saturation varied from 85 to 90% (Table 1). Percent saturation is a figure that normalizes straight concentrations for temperature; as stated above oxygen solubility is inversely proportional to water temperature and increases as temperatures fall. While these values are acceptable, values below 100% indicate that there is some DO depression in the lake, most likely a result of the organic sediment which tends to lower DO as the organics are being decomposed by microbes.

The southeast cove showed slightly different water quality metrics than the southwest and central stations highlighted by increased specific conductance and marginally higher temperature and pH. Conductance is relatively low at all stations, again consistent with other lakes in the area as a result of watershed geology, but the conductance in the southeast cove is distinctly elevated. Specific conductance is a proxy measure of dissolved solids in water normalized for temperature. The slightly higher value in this cove could be a result of a number of factors including land use along Lower Birchwood/Timber Lake, but it seems likely that this is at least partially a result of the discharge from the Borough of Medford Lakes Wastewater Treatment Plant located about 6,000 feet upstream of Oakwood Lake as wastewater effluent typically has relatively high conductance values even within legal discharge limits. Overall, conductance is relatively low in the lake and this slight elevation is no cause for concern, but at a minimum it does suggest a detectable signature of the treatment plant.

Table 1: In-Situ Data

Oakwood Lake In-Situ Data 2013							
Station	DEPTH (meters)		Temperature	Specific Conductance	Dissolved Oxygen		pH
	Total	Sample	°C	mS/cm	mg/L	% Saturatio	S.U.
Southeast, Upper	0.30	0.20	6.21	0.179	11.01	88.5	7.07
Southeast, Mid	0.30	0.20	6.28	0.180	11.00	88.4	7.22
Southwest, Upper	0.30	0.20	5.99	0.110	11.11	87.0	6.95
Southwest, Mid	0.50	0.40	6.02	0.112	11.20	90.0	6.87
Central	1.50	1.00	6.02	0.140	10.68	85.8	6.66
		1.40	6.01	0.141	10.63	85.4	6.55

4.0 Management Recommendations

Management of sedimentation can be difficult to implement for a number of reasons including scale, cost, and regulatory burdens. There are two basic pathways to management: source control of sediment loading and direct removal. Source control is trying to manage the sediment loading prior to mobilization or deposition in the lake. While source control is the ultimate solution to sedimentation in lakes, it can be a very long and cumbersome project that requires concerted watershed-level efforts. Ultimately, even with source control in place that still leaves the problem of dealing with the sediment in-situ and thus requires dredging or some other type of removal activity. The following recommendations will discuss the benefits of various actions in each of these pathways.

Source Control

Ultimately source control is going to be rather difficult in Oakwood Lake for several reasons. First, the vast majority of the watershed lies outside the control of the OCLA and therefore there is little opportunity to implement the types of sediment control measures necessary to really control sediment loading in the watershed. Second, much of the leaf litter and other organic detritus in the lake is the result of having a vegetated shoreline. Thus, there is no reliable way to limit this type of loading. It does need to be stated that the benefits of a vegetated shoreline outweigh the negatives in providing shade and moderating temperature, stabilizing shorelines and reducing the potential for soil and bank erosion, and providing both habitat and forage in the form of deadfall and other litter. Third, there is little shoreline erosion or bank sloughing around the lake and where it does occur the effect is very localized and being addressed at the landowner scale. There are however several recommendations that could address some of the perceived problems.

One issue that was noted was the accumulation of sand linked to a stormwater outfall at the head of the southeast limb. The exact source of the outfall was not identified, but likely originates directly from Ramblewood Lane or North Lakeside Drive West. The source of this outfall should be traced and identified. Likely this is tied to a catch basin or series of catch basins. A regular maintenance program should be instituted with semi-annual (or more as needed) clean outs of the basin, as well as other basins within the purview of OLCA. If the catch basins lack a sump a catch basin insert is appropriate to allow capture of sediment. These are typically metal baskets with wire mesh, but even poly versions are now being manufactured. These basin inserts are typically inexpensive at less than $500, but they do require regular maintenance to maintain their solids trapping efficacy.

A second recommendation is to ensure that lakeside residents or those adjacent to tributaries avoid dumping organic debris such as leaf litter and lawn clippings either into the lake or the contributing channels. There was no evidence of such practices, but it is still important to make the community aware of this simple step.

Source control will probably offer little benefit on the whole to Oakwood Lake, but where practical it should be implemented.

Sediment Removal

The only real way to gain depth in Oakwood Lake is to implement some type of sediment removal program. Before delving into the workable solutions, it is worth examining some of the management techniques that were rejected because there is a lot of bad advice at large on the internet regarding this subject.

Aeration is a program that is sometimes touted as being able to help with sedimentation issues. The principle idea is that by aerating the water and maintaining vertical mixing that aerobic microbial respiration can be increased leading to more rapid decomposition of the sediments even to the point of reducing volumes and increasing depth. While this seems sound, even highly organic sediments rarely exceed 30% organics by volume, leaving at least 70% of the sediment that cannot be further degraded. It also ignores the fact that the extent of aerating the sediments would only be applicable to a thin surface layer. There are also practical considerations, such as very shallow depths, that would make aeration untenable. Indeed, aeration in such a shallow system with soft sediments could actually contribute to increased turbidity and other problems. While aeration is certainly a very effective tool in lake management, it has extremely limited ability to improve depth.

A second solution is the use of mixers or circulators. These are similar to the popular fountains, but instead are oriented horizontally in the water to increase lateral flow. Mixers can be effective against windblown accumulation of algae and debris but only work in very discrete locations such as confined corners and do nothing to reduce actual volumes, instead relying on redistribution rather than reduction. In addition, there is some risk incurred by these systems by running electricity through the water, especially in areas where swimming and other contact recreation is popular.

Finally, there is also a class of bacterial products, generally known as sludge removers, that are promoted as being able to decompose accumulated organics. As with aeration, the effectiveness of these products is overstated. In a confined pond, such as an ornamental pond or an industrial waste lagoon, with limited flow through and truly organic waste accumulation, these products can be effective. In natural systems that are flowing and where the sediment includes a large proportion of inorganic particles (soil particulates) their efficacy is much reduced.

Therefore, this leaves two viable options: hydroraking and dredging. Hydroraking is focused solely on the removal of accumulated detritus and plants and plant biomass. If the hydroraking is consistent with the removal of this type of material it can be performed without a permit. Hydroraking would likely be conducted with either a large rake or even a clam-shell or other bucket-type attachment deployed from an amphibious vehicle. Based on the composition of the sediment and the accumulation of leaf litter and other organic detritus throughout much of the highlighted areas this would result in an improvement in depth of only up to a foot. There are certainly areas where depth improvements would be greater, especially in some of the small coves or around docks and other encroachments that capture debris, but by and large the area wide use of hydroraking would probably provide limited relief. Once hydroraking veers into the removal of sediment as opposed to coarse organics or at a depth in the sediment where there are no longer recognizable leaves, branches, or root biomass, this becomes dredging and thus is a regulated activity.

Still, hydroraking could be of some use in Oakwood Lake. Given the relatively limited access to the lake at the swimming area, the distance to the head of the upper limbs (around 2,800 feet), and the lack of obvious spoils disposal points hydroraking would require the use of a barge to move hydroraked material as well as the amphibious vehicle. Using such a set-up approximately 0.5 acres could be hydroraked in a day. The cost would be approximately $1,500 to $2,000 per day for the amphibious vehicle and another $200 per day for the use of the barge. The best success using this approach would be to target smaller areas or those considered higher visibility or otherwise higher priority as decided by the OLCA.

Spot dredging also needs to be considered, especially to gain depth in discrete areas. The mechanics of spot dredging would not be significantly different than hydroraking but would allow the removal of sediments at a greater depth and could be accomplished with the same equipment set-up. The main difference would be in permitting. Maintenance dredging could be accomplished under Freshwater Wetlands Protection Act Rules General Permit 13 for Lake Dredging. This permit authorizes up to one acre of dredging in Palustrine emergent freshwater wetlands to restore or maintain a lake to its original bottom contours, in this case the consolidated sediment. If the dredging project does not disturb freshwater wetlands or transition areas, this permit is not required, however a professional wetland delineation is still warranted to substantiate that there are no wetlands. In addition, there would probably be some cursory sediment sampling for contamination analysis and geotechnical characteristics to determine end disposal of dredge materials as well as some additional bathymetry work to meet dredge standards. Once acquired, the permit is good for five years. In addition to the Freshwater Wetlands General Permit, a Flood Hazard Area Individual Permit would be required which would necessitate engineering plan preparation. Dam Safety would also need to be consulted. Finally, the Burlington County Soil Conservation District would also likely weigh in regarding materials handling and disposal. Costs associated with the permitting process include:

- Sediment Sampling and Supplemental Bathymetric Data $5,000 to $8,000
- Wetland Delineation $2,000
- Permit Application and Engineering Plan Preparation $7,000 to $12,000

The cost of the actual dredging would be similar to hydroraking at approximately $2,000 to $2,500 per day plus the cost of materials disposal. If the sediment is clean it can likely be disposed in an upland location inexpensively, otherwise it would require transport and disposal at a secure landfill facility; the fee for disposal would depend on the quantity and level of contamination, while transport would be dependent on the distance to the disposal facility.

Summary

Oakwood Lake is relatively shallow as a result of the natural morphometry of the lake basin and sediment infilling, particularly in the southern half of the lake. Much of the sediment in the lake is a relatively loose and highly organic muck and about 50% of the assessed portion of the lake is overlain by a layer of organic detritus including leaf litter, branches, conifer needles, and likely senesced aquatic plant and algae material. This layer tends to be relatively thin, less than a foot thick in most places, but it is thicker in others particularly near the shoreline and in some of the small coves. This layer appears to decompose relatively rapidly and contributes to the underlying organic muck which averages two feet thick but is greater than five feet in spots. In the southeastern corner of the lake adjacent to the Lower Birchwood/Timber Lake outlet there are some deposits of sands related to the culvert and another stormwater outfall.

Controlling sediment loading to the lake is difficult because there is a large watershed outside the control of the OCLA, the basin is conducive to accreting sediment, and the shorelines are well vegetated by trees. Some effort can be made to control some of the sediment loading to the lake, but the real issue is to control the excessive sediments in the lake that are impacting many facets of lake function. As such, mechanical removal of sediment in the lake was determined to be the appropriate action to increase depth.

There are two basic courses of action for improving depths in the lake. The first is hydroraking, which focuses on removing leaf litter, coarse organic detritus, aquatic plants, algae, and aquatic plant root mass. This is a relatively simple process that does not require a permit. The major drawback of hydroraking is that it provides a limited ability to improve depth in the lake. The removal of sediments without recognizable organic debris (i.e. leaves, branches, or roots) is considered dredging and therefore hydroraking in most places would be limited to removing about a foot of accumulated material. Dredging, which provides for removing all sediment and not just organic debris, is beneficial in allowing removal of all sediments to greater depth. There is of course a major drawback to dredging in that it is a regulated activity and thus requires permits. The permit application process is not simple and is relatively costly. Also, for the most part it will limit the area of disturbance to less than an acre. While an Individual Permit for dredging could be considered, this type of permit is much more complex to obtain and subject to outright denial. While hydroraking has its utility in removing accumulated leaf litter in Oakwood Lake its limitations must be recognized. Focusing on non-organic sediment or highly decomposed sediments will require a dredging permit. Ultimately, real efforts to manage sediment in the lake will likely require both approaches in conjunction.

Appendix: Maps

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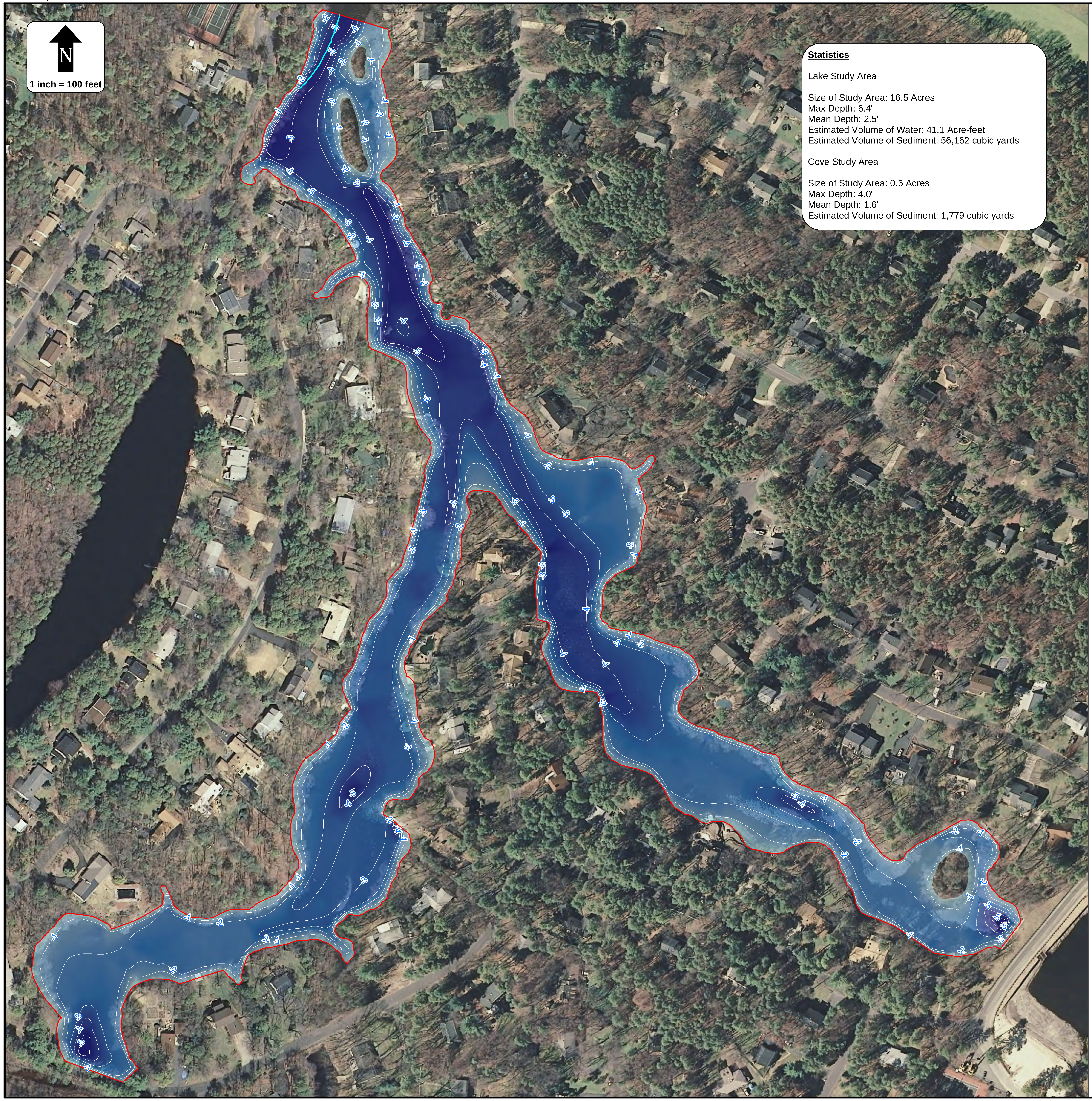

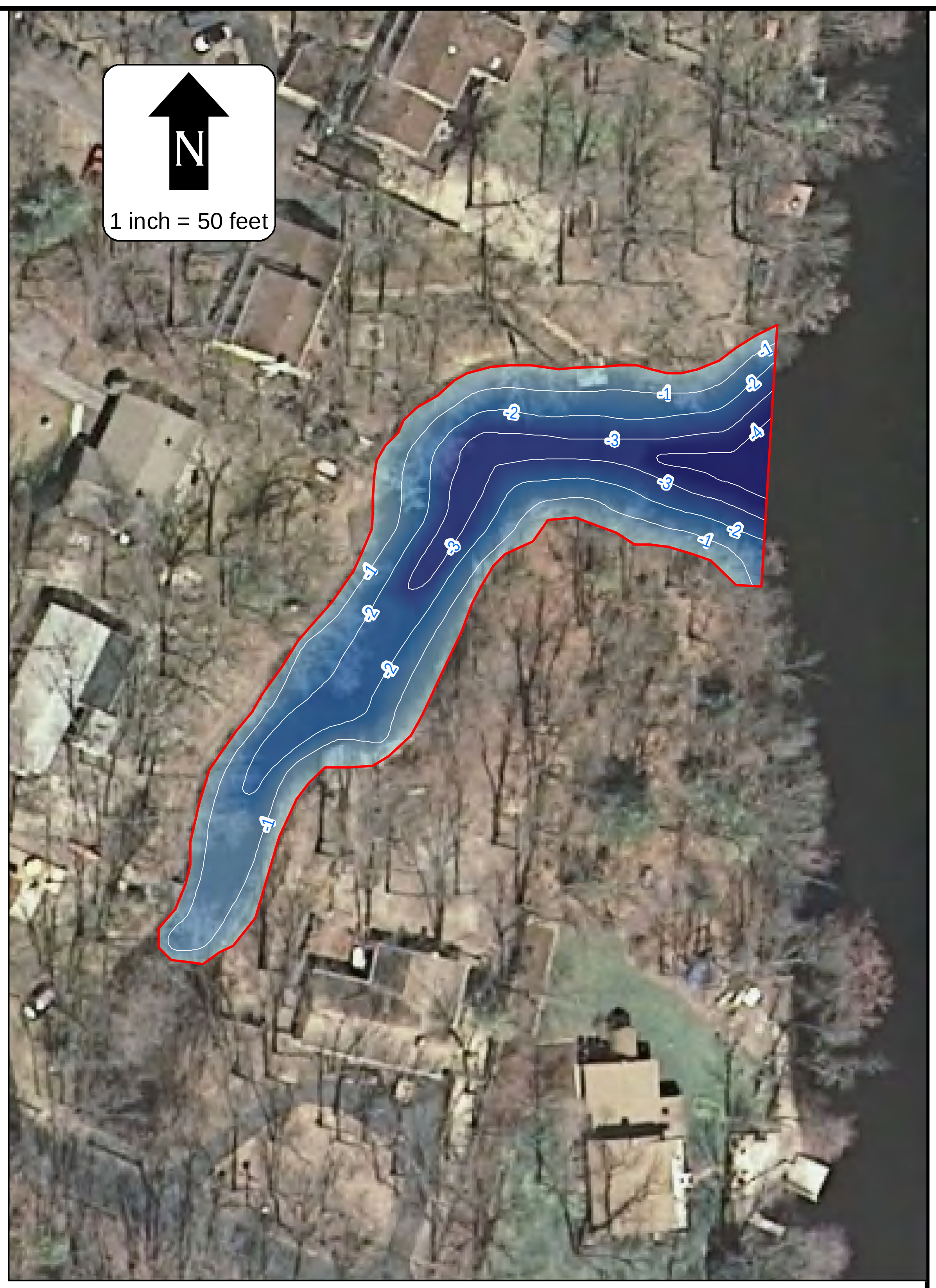

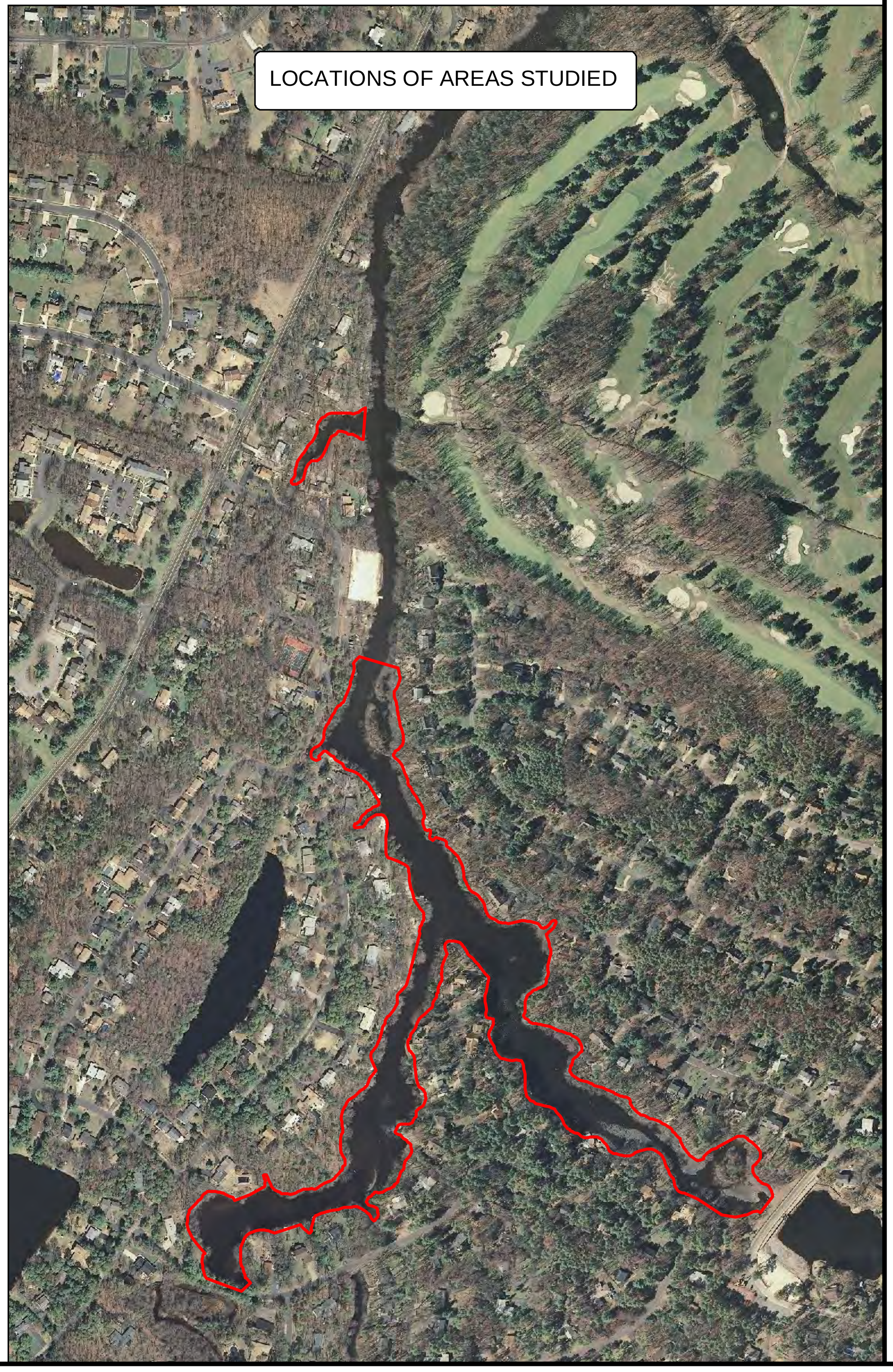

NEW JERSEY COUNTY MAP

SOURCES:

1. 2007 Aerial Photograph obtained from the NJ Geographic Information Network (NJGIN) website.
2. Bathymetric study conducted by Princeton Hydro on January 4 and January 17, 20213. Study conducted with a Trimble Pro XH GPS unit and a calibrated sounding pole.
3. All elevations are relative to water surface elevation equal to zero. This study and all elevations are not registered in a vertical datum.
4. All modeling, contouring and volume analysis completed with ESRI's ArcGIS 10.0

MAP PROJECTION: STATE PLANE NEW JERSEY (FEET) NAD83

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SCALES AS NOTED

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PROJECT NAME/LOCATION:

ASSESSMENT OF OAKWOOD LAKE

OAKWOOD LAKES COMMUNITY ASSOCIATION
15 OAKWOOD DRIVE
MEDFORD, BURLINGTON COUNTY, NJ

DRAWING NAME:

BATHYMETRIC STUDY

WATER DEPTH CONTOURS

Legend

Study Area Boundary
Water Depth Contours

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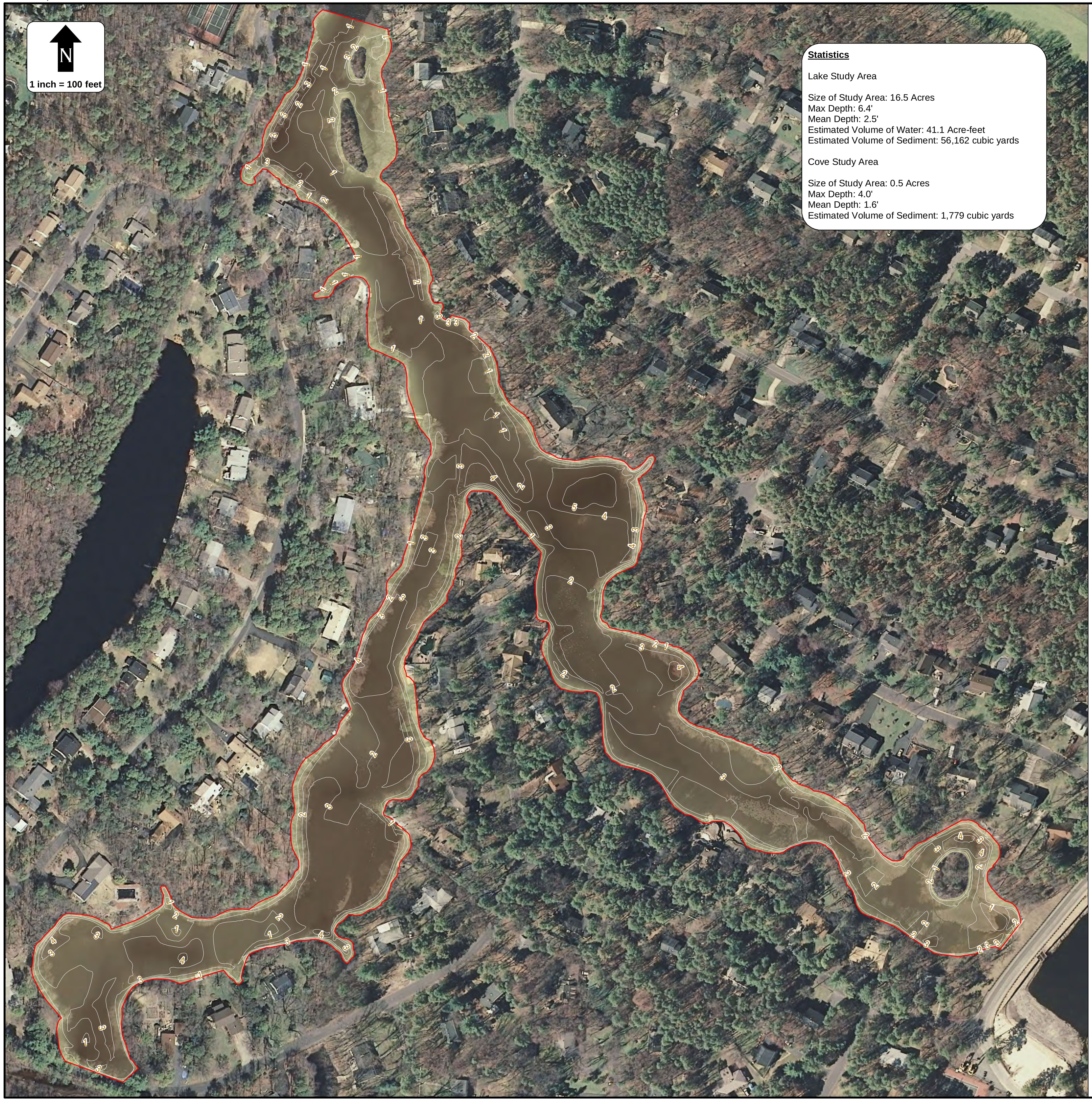

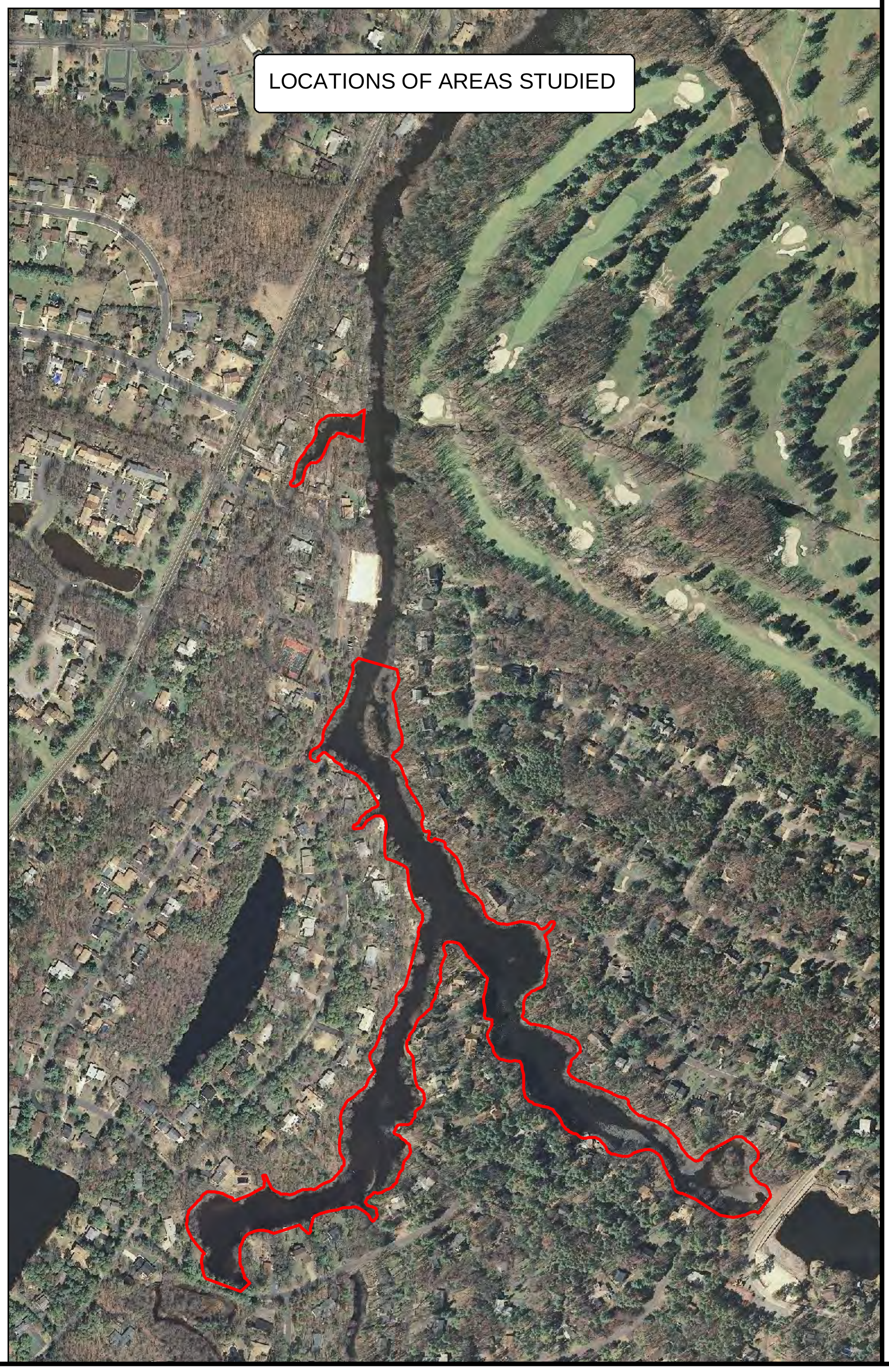

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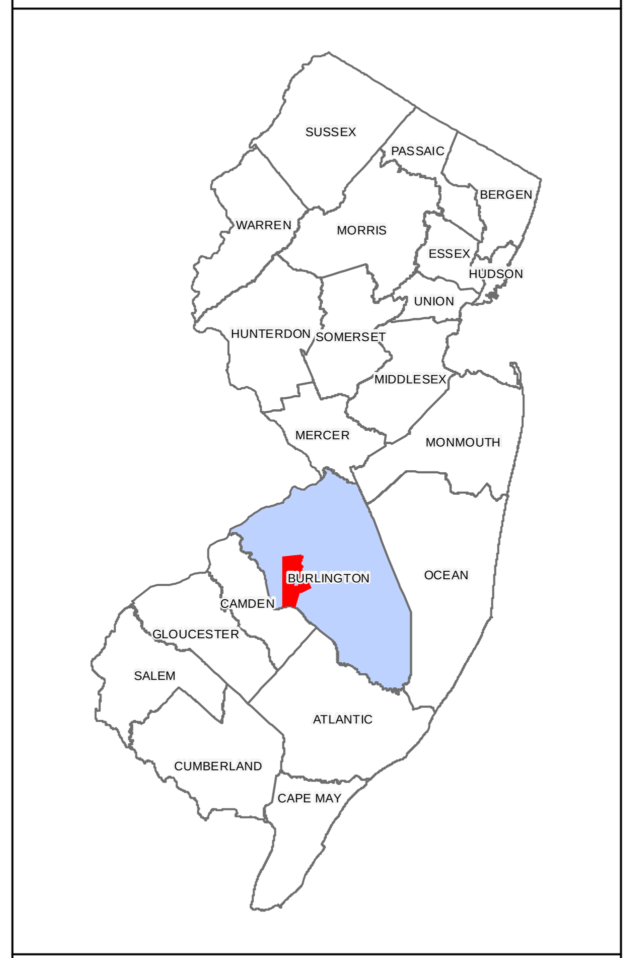

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MAP PROJECTION: STATE PLANE NEW JERSEY (FEET) NAD83

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DRAWING NAME:

BATHYMETRIC STUDY

SEDIMENT THICKNESS CONTOURS

Legend

- Study Area Boundary
- Sediment Thickness Contours - 2' Intervals

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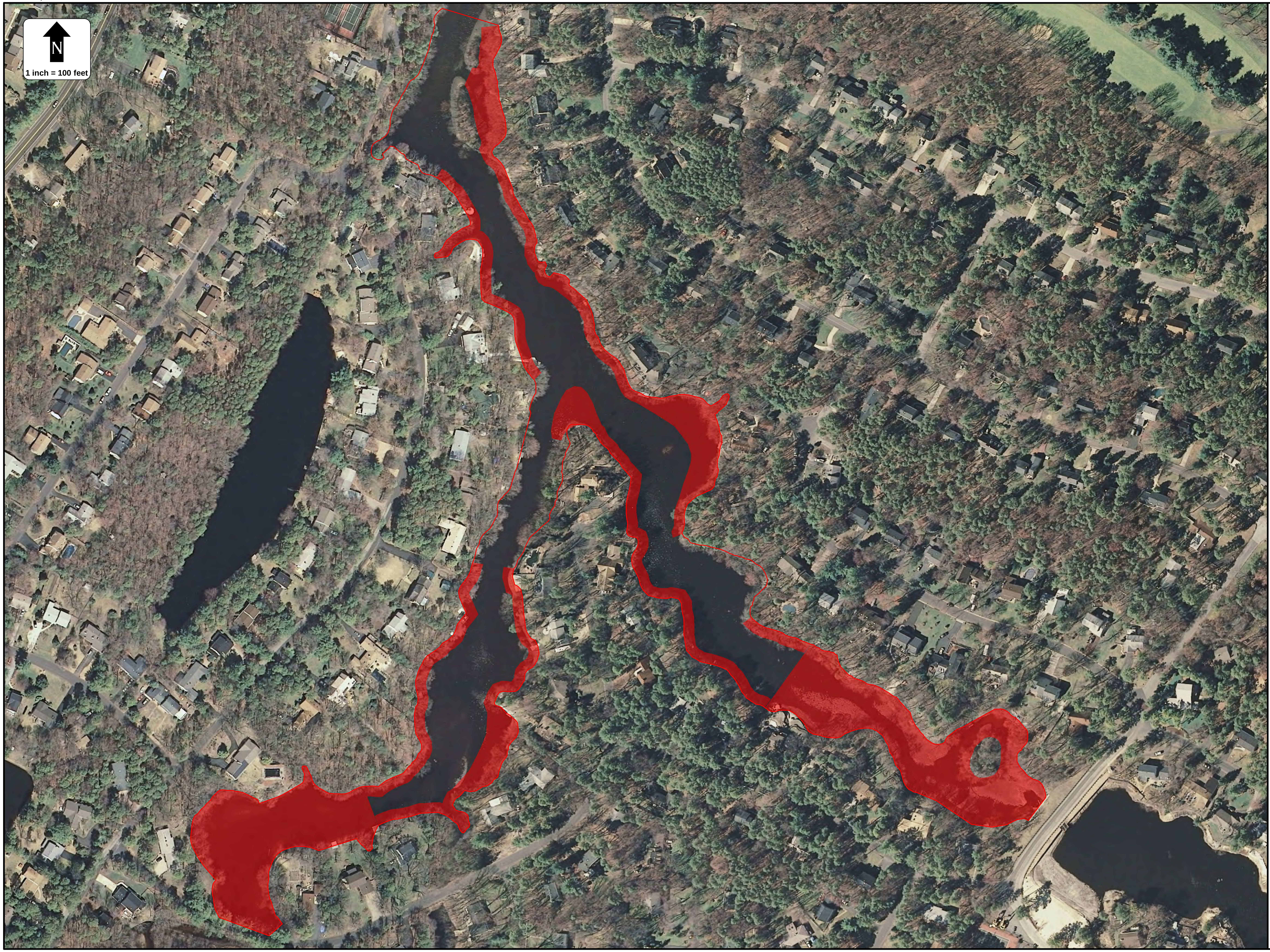
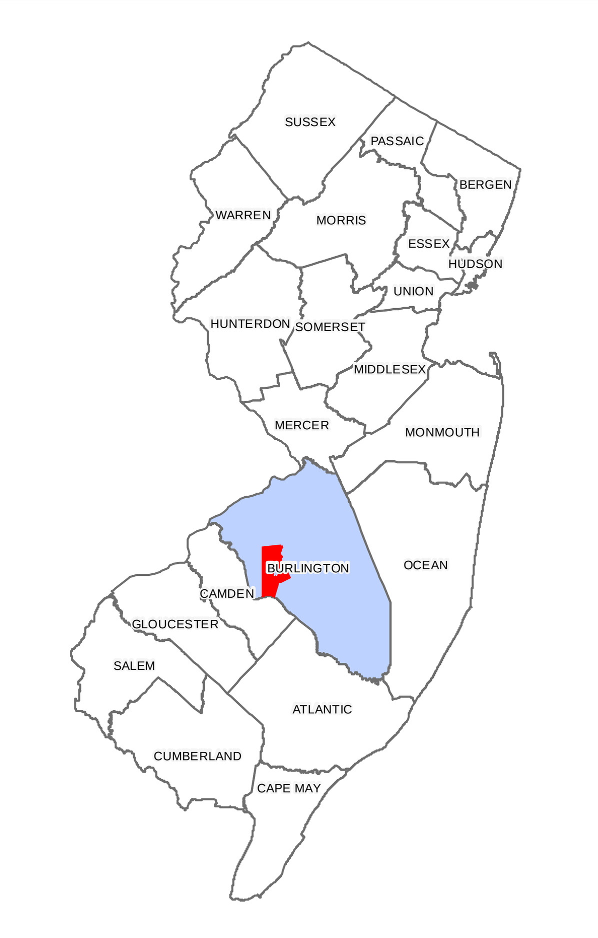


NEW JERSEY COUNTY MAP



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2. Bathymetric study conducted by Princeton Hydro on January 4 and January 17, 20213. Study conducted with a Trimble Pro XH GPS unit and a calibrated sounding pole.
3. Detritus areas accessed and delineated while on site by Princeton Hydro. This is a characterization of these areas through observations made in the field.

MAP PROJECTION: STATE PLANE NEW JERSEY (FEET) NAD83

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BATHYMETRIC STUDY

TARGETED DETRITUS AREAS

Legend

- Study Area Boundary
- Detritus Areas