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Indian Lake Plant Survey

Alan Jeffrey Gribble  
*Worcester Polytechnic Institute*

Charles Steele Cheston  
*Worcester Polytechnic Institute*

Eric Walter Plante  
*Worcester Polytechnic Institute*

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Indian Lake Plant Survey

An Interactive Qualifying Project Report
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

Submitted to:

Project Advisors:  Professor Chickery Kasouf, WPI
                     Professor Reeta Prusty Rao, WPI

Project Sponsor:   Beth Proko, Indian Lake Watershed Association

Submitted by:

Charles Cheston

Alan Gribble

Eric Plante

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Abstract

Indian Lake is addressing the problem of aquatic plant overgrowth. The Indian Lake Watershed Association asked our team to determine the cause and severity of the issue. The team developed protocols to survey the Lake, collected data, created a website to report information regarding the overgrowth within the lake, and updates regarding the project, including interactive maps displaying the data to keep the public informed about the situation. Future teams can use these protocols to collect data in a systematic manner, and develop a longitudinal database. The project concluded with a presentation to the Association, and members of the press.
Acknowledgements

The group would like to thank a few individuals without whom we would not have been able to undertake this project:

Thank you professors Chickery Kasouf and Reeta Prusty Rao, our advisors, for their guidance and wisdom while reviewing our report drafts and for their willingness to help us surpass our limitations throughout the entirety of this project.

Thank you Beth Proko, our project sponsor, for all of the assistance and resources she provided us throughout this project. Also, thank you to members of the Indian Lake Watershed Association that assisted in our data collection, specifically Bob gates, Lee Dematos and Ed Proko.
Executive summary

To better understand the state of the aquatic plant overgrowth in Indian Lake, a survey was done in affiliation with the ILWA. Previous surveys revealed the lake to be eutrophic. This suggests that pollution, littering or other human activities led to the buildup of excess nutrients in the lake, resulting in weed overgrowth. Previous surveys however, did not focus on developing a GPS coordinate database. The team developed a set of protocols to guide future data collection.

Data were collected from pre-mapped points and catalogued. The spreadsheet was then programmed into a format suitable to integrate with “Google Earth” for easy user interface and visualization. These maps are comprehensive and report all data collected at the transect points. Multiple maps of varying data collections were created in a way that could be laid over top of one another to determine any potential correlations between two or more conditions.

A website was also created which will be handed over to the ILWA for maintenance upon completion of the project. This website allows easy access for interested citizens to attain information about the situation as well as contact those in charge to report areas of overgrowth or other concerns on the lake. It will also be used in future projects to notify the public of the progress of each project during the collection process.
Summary of Methodology

To collect data, a GPS data logger was used with a recording system that provided a precise and accurate location as well as any data that may need to be analyzed. The data logger allowed the group to match the GPS coordinates with the collection time rather than struggling to match precision coordinates with a handheld GPS before taking a collection. The collection points were organized into transects, designed to cover the most area and provide accurate and thorough data for the state of the lake. At each point, relative abundance (percent cover) of each weed was taken, as well as bio-volume, depth, and a time stamp. The time stamp was then cross referenced against information picked up by the data logger to determine our coordinates within 3 feet of any collection. Any plant collected was classified by species and density and bagged to dispose of at a later time. The perimeter of the lake was then scouted and any area of the shoreline possessing any emergent plants was also marked with a collection point.

Summary of Results

Data collection identified six plants with notable presence. Of these six, the nuisance plants that exist in the middle of the lake, known as submerged plants, were Eurasian Watermilfoil and Small Pondweed. They were found in approximately equal and sizable quantities. As this collection was done in late fall it is important to note that collections in spring or summer will see much higher density readings. This is due to the plants in-season extension towards the surface as well as increasing surface area to
gather as much light as possible. Of the shoreline emergent plants, the two most frequent were common reed and cattail. Both of these were found in approximately equal quantities. In 2004 small pondweed was not identified at all on Indian Lake and cattail had only a slight presence, however in 2012 they are both abundant in certain areas of the lake and should therefore be watched carefully.

Certain conditions were also observed during collections that have proven to help the growth of these plants. No plants were identified in any area of the lake deeper than eight feet. It was also identified that most areas affected by plant overgrowth were areas of the lake cut off from current flow.

**Summary of Recommendations**

Increasing current flow is essential to the area, especially around Sears Island. Increasing current flow will pick up debris and carry it towards the outlet, eventually removing it from the lake. By replacing the causeway connecting Sears Island to the shore with a bridge, water will be able to flow to around the island much easier. This would help increase current flow in that area of the lake, carrying away some of the silt deposits that these plants grow in.

Another option the group considered was the partial dredging of the lake. Though the situation seems severe, the issue is most prevalent along the shorelines and in shallow areas with silt layered bottoms. Dredging the shallow areas to the south of Sears Island would solve the majority of the problem, leaving only a few additional growth areas.
Reinstating the former draw down depth would be effective in preventing revival of these invasive plants every spring. Forcing the Eurasian milfoil to recede further every winter to survive hinders it from growing more in the growth season. Additionally, a cleanup day could be instituted, asking for help from local volunteers to cleanup and remove any plants left out of the water by the drawdown.

As Eurasian milfoil is one of the largest issues faced, one technique that has been used to reverse its aggressive growth patterns is the use of the water veneer moth. This moth feeds on Eurasian milfoil and is consumed by local predators so it does not interfere with the local ecosystem.
Table of Authorship

Each of the three group members contributed to the completion of the project with varying responsibilities. The portions of the project that each person was accountable for are listed below.

**Chase Cheston** - Chase’s most critical task was revising and formatting the final document. Every time a section of the paper was completed, Chase would edit the paper until it was clear and concise. Chase was also responsible for creating the maps used by the survey. During data collections, Chase was operating the boat used to reach each survey point.

**Alan Gribble** - Alan’s principal responsibility was writing, creating the bulk of the text that would then be trimmed and edited into final form by Chase. Alan was also responsible for the research that led to our list of possible solutions. During the data collection process, Alan was responsible for doing the actual collections, both of the survey data and the depth recordings.

**Eric Plante** - Eric’s main tasks involved the creation of the website to integrate all of our information and the maps created. He coordinated this process with the vice president of the ILWA, so that the website could be handed over to them upon completion of the project. Eric also created a manual that instructs future WPI project teams how to manage and expand the website, allowing it to be used for many future. When the data collections were being done, Eric was responsible for tracking our GPS coordinates and recording the data for each collection point.
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1. Introduction

Indian lake is the largest body of water fully contained within the City of Worcester. It was originally known as North Pond, and provided an outlet for Mill Brook, one of the Blackstone River’s main water sources. In 1828, the pond was dammed at its outlet as part of a water-control system for the Blackstone Canal. The area has undergone continuous development, and now includes numerous lakeshore properties along with three public access beaches. The lake community, both those who live near it and those who frequent it for recreation in the summer, have observed a dramatic increase in the growth of aquatic plants in recent years. During the last decade these invasive aquatic plant species have been adversely affecting water clarity and swimming areas, as well as suffocating the fish that populate the lake. In its shallowest areas, the lake bottom is not visible and a strong green color masks the entire lake body. This project aims to identify and help control these plants.

1.1 Past Monitoring of the Lake

The Indian Lake Watershed Association (ILWA) was formed in 1985 to monitor the water conditions and weed overgrowth. It was formed with the purpose of monitoring and reviving the lake. Indian Lake exhibits characteristics that mark it as an eutrophic lake. Eutrophication of a body of water is a form of pollution that can result in the removal of higher order organisms such as fish from an ecosystem. Since 1986 the ILWA has implemented a winter drawdown to control weed growth. This drawdown specifically targets areas around the shoreline, near residential properties and recreational areas. The drawdown strategy had proven effective in
the control of Eurasian Watermilfoil until recently when the depth was changed from 6 feet to 4 feet. By reducing the drawdown, the coverage of the plant has been to increase. As this species becomes further established in the lake it spreads into the deeper waters, where the drawdown proves less effective. The ILWA approached WPI for an in-depth survey of the lake to re-address the problem. The information collected by this survey is important for examining why these species have such a strong presence in the lake and determining how to reduce their growth. This project also provides a baseline for future surveys that will continue to form an informed description of Indian Lake’s weed growth.

1.2 Objectives

The main focus of this project was to identify species of aquatic vegetation within Indian Lake, and to assess the extent to which they hinder recreational use of the lake. By establishing a robust protocol, our methods of sample collection can be replicated by future groups, allowing the data points to be compared on a timeline. This is essential to monitoring the ecological health of the lake. Based on the data collected our group created suggestions for the ILWA on how to manage the current overgrowth. To make this project and its results accessible to concerned citizens, an interactive website was created containing details regarding the project, educational information about the plants found, and the ecological state of the lake. Interactive maps were also created for the website to show the public the state of the lake in a way that is easy to understand. The website was given a contact feature to solicit suggestions or report on substantive changes, such as a new weed or a new location for a known weed. The
website will be hosted and managed by the ILWA and edited by future groups to keep the interactive data current.
2. **Background**

This chapter includes Indian Lake’s history through the last 200 years, an explanation of the problems currently facing the lake and a description of the plants found during our survey.

### 2.1 History of Indian Lake

#### 2.1.1 The Creation Of Indian lake

Indian Lake didn’t exist 200 years ago. It began as North Pond and was roughly 40 acres in size. In the early 1800s, plans for the creation of a canal stretching from Worcester to Providence, RI were developed. Construction of the Blackstone Canal began in 1825, and opened for use in the fall of 1828. It was created to increase trade between the two cities, allowing Worcester to improve its economic status. To control water flow though the canal, a dam was built at the outlet of North Pond, turning it into a reservoir. As a result, North Pond grew to more than four times its size, now totaling 193 acres. The rising water created Sears Island, which had previously been a hill on the shoreline (Coombs, 1935). The advent of railroads soon rendered the canal impractical and it ceased use as a commercial trade. The dam stayed, leaving behind the area now known as Indian lake.

#### 2.1.2 Commercial Use

The earliest documented commercial use of the lake was as a power source for the watermills that lined its outlet, Mill Brook (Coombs, 1935). These mills provided power for some of Worcester’s factories. Indian Lake also served as the home of the Walker Coal and Ice
Company. Harvesting 15,000 tons or more of ice every year, the Walker Coal and Ice Company provided employment for many of Worcester’s residents (Costa et al., 2010). A warehouse fire, combined with the growing popularity of electric refrigeration, shut down the company in 1935.

2.1.3 Recent History

In the 1970’s, a highway was designed to connect Worcester to local cities and towns. The original blueprints had the highway cut straight across Indian Lake, atop a gravel causeway. This proposal was not well received by the residents because of the environmental damage it would cause to the lake, both from construction and eventually passing vehicles. The original plan also called for the demolition of the West Boylston Street School. A revised path, now Route 190, was proposed by a concerned citizen, which both saved the school and skirted around the lake. Additionally, the new plan saved the city a considerable sum, as there was no longer a need for the thousands of tons of gravel the causeway would’ve needed (Noonan, 1974).

2.1.4 Present Day

Presently Indian Lake has no real commercial significance for the surrounding community. In the past it was home to a yacht club that has since shut down. The lake still serves as a popular venue for recreation for the city of Worcester. In addition to the waterfront properties owned by the residents of the lake, there are two public access beaches and a small park with a boat ramp. In the summer, due to its ease of access and usability, it plays host to
many swimmers, boaters, fishers, and, beachgoers. This in fact provides the motivation and rationale for this survey - preserving the beauty of the lake and maintaining its functionality as a recreation destination.

2.2 Ecological State of Indian Lake

2.2.1 Eutrophication

One general issue plaguing lakes in the New England area is eutrophication. Eutrophication is when excess nitrates and phosphates are introduced into the ecosystem of a lake, typically by human activity. These added chemicals make the water very nutrient rich, benefiting the growth of certain plants more than others. Aggressive growth of certain species can overtake and choke out other plants and aquatic wildlife. This effect can cause an ecosystem to alter drastically. Many of these changes affect recreational use of the lake and impair its aesthetics (Maitland, 1984). The introduction of nitrates and phosphates into Indian Lake was likely caused by runoff from a local street or storm drain, along with debris and dirt particles from the bordering highway.

Lake eutrophication triggers a chain of events. The excess nitrates and phosphates create ideal conditions for the growth of select plants. These plants begin to grow excessively, spreading and becoming denser every year. As they take over water clarity decrease along with the levels of dissolved oxygen in the water. Decreased light and oxygen levels together result in death of many aquatic animals. Fish and other gilled animals that rely on filtering oxygen out of the water suffocate. As these animals perish, they don’t feed on the aquatic plants that caused the problem, allowing them to grow even more aggressively. The decline in the lake’s fish
population also results in the relocation of other local animals, including waterfowl like ducks and herons, to new food sources (Eutrophication, 2007). In addition to the destruction of the local ecosystem, as the excess nitrates and phosphates build up, algae blooms will begin to form. Some of these algae blooms can be poisonous to humans and other animals.

The effect of eutrophication on recreation is a growing nuisance. As plants continue to grow more aggressively, they begin to take up more of any particular water column. Swimmers have a hard time swimming through dense aquatic plants. Boats are more likely to get entangled in the plants as they move, becoming stuck and ruining their engines. Though Indian Lake is already suffering the effects of eutrophication and is infested with invasive weeds, it is not beyond recovery. This study recommends simple measures that aim to prevent further devastation of the local ecosystem.

2.2.2 Silt Levels in Indian Lake

A survey of Indian Lake indicated that the areas affected by weed overgrowth contained high silt levels (ESS, 2004). Placement of local vegetation and the direction of current flows allow silt buildup in certain locations of the lake. The silt sequesters nutrients for these plants allowing them to grow bigger. This is one possible explanation for the direct correlation between silt levels and amount of overgrowth in the lake in certain areas.
2.3 Aquatic Plant Distribution

With a survey like this it is necessary to understand the relationship between the presence of certain plants and the depth at which they are found. Most aquatic plants only grow in one depth region of a lake. Because sunlight can only penetrate so far into water, a plants need for light limits the depth to which it can grow. The portion of a lake deep enough that the sun does not reach the bottom is known as the Limnetic Zone (NSF, 2004). This zone usually lacks any aquatic vegetation due to this lack of sunlight. As seen in previous surveys and confirmed during our survey, the center of Indian Lake is a Limnetic Zone. The zone most important to this survey was the Littoral zone. This zone is far enough from shore that submerged, emergent, and floating plants grow but also shallow enough that light reaches the bottom and all plants are able to receive proper nutrition.

![Figure 2.7 - Lake Zones (NSF, 2010)]
2.4 Invasive Plants Present in Indian Lake

The aggressive growth of certain non-native plants poses a major threat to the health of the ecosystem around Indian lake. Invasive plant species usually grow unencumbered by predators because animals in the native ecosystem are unlikely to eat them (ESS, 2006). As invasive plants subvert the native plants, they remove a large part of the food source for the fish population. This, combined with the decrease in dissolved oxygen caused by eutrophication, the survival rate for local fish decreases severely. For this survey, we identified several native and invasive plants that we further sub divided into three categories: submerged, floating, and emergent plants.

2.4.1 Submerged Plants

The majority of the nuisance plants in Indian Lake are submerged plants, or plants that grow up from the bed of the lake. Though other species of submerged plants have been found in the past, we only collected two species of plants.

2.4.1.1 Eurasian Watermilfoil

Eurasian watermilfoil (*Myriophyllum spicatum*) is a species of submerged aquatic plant found naturally throughout Europe and Asia. It first appeared in North American during the 1940’s and has been a steadily growing problem ever since. Eurasian watermilfoil is known as a subversive perennial plant, meaning that the plant continues to live during the winter, re-growing and expanding as it does (Bortman, 2003).
The growth pattern suggests that Eurasian Watermilfoil is among the first plants to fully establish itself in the springtime. Because it is available so early in the breeding season, fish are more likely to use it as food, even though it contains significantly less nutritional value than the native plants it displaces. At the same time, the density of the cover it provides means that the survival rate of young small fish increase to well beyond their normal values (Ricciardi, 2009).

Compound these two problems and the result is a steady starvation of the lake’s animal population. As the small fish grow larger, their overabundance quickly outstrips the nutrition that the watermilfoil can provide. Because there are too many fish and not enough food, the population begins to starve. This starvation also heavily affects the bird populations that depend on the fish as a food source, as their prey rapidly begins to dwindle (Smith, 1990). Eurasian Watermilfoil was first of two submerged plant populations found during our survey of Indian Lake.

Figure 2.2 – Eurasian Watermilfoil, Eric Plante
2.4.1.2 Small Pond Weed

The second submerged plant we found was Small Pond Weed (*Potamogeton pusillus*).

![Small Pond Weed](image)

*Figure 2.3 – Small Pond Weed, Eric Plante*

This is a plant is native to the entire North American continent (USDA, 2012), therefore not alarming by itself. What does worry us is that when surveyed in 2004, it was not found anywhere in Indian Lake (ESS, 2004). It was found in Little Indian Lake, so it has likely come from there, and has grown rapidly. Similar to Eurasian Watermilfoil, it is a perennial species, although its growth is nowhere near as rapid or expansive as an invasive weed.

2.4.2 Floating Plants

Only one floating plant was found on Indian Lake – Yellow Pond Lilly, which is neither invasive nor harmful.

2.4.2.1 Yellow Pond Lily

The only floating plant found during our survey was the Yellow Pond Lily (*Nuphar Luteum*). It is commonly found all across North America and is classed as a beneficial native
plant. Its stems and leaves provide food and shelter to a large number of species. They are a perennial plant; this means that colonies of Yellow Pond Lily grow in the same place every year (USDA, 2012).

![Figure 2.4 - Yellow Pond Lily](http://www.fcps.edu/islandcreekes/ecology/yellow_pond_lily.htm)

**2.4.3 Emergent Plants**

Emergent plants are species that grow in the water near the shoreline but extend up past its surface for sunlight and air. We identified three different species of emergent plants.

**2.4.3.1 Cattail**

Primary among these emergent plants is Cattail (*Typha latifolia*). Cattail is native to this area and other members of its genus can be found all over the world. Cattail is a “dominant competitor” in wetland areas, which can lead to its classification as a nuisance plant. It grows
rapidly, can survive long periods of unfavorable conditions, and spreads its seed easily. This rapid and widespread growth can cause it to push out other local species, damaging the biodiversity of ecosystems it inhabits. The spread of Cattail can be attributed to its seed heads, each of which may contain as many as 200,000 seeds (Turner, 2009). In addition to their prolific seeding, cattails are incredibly hardy. Their seeds can survive buried underground for extended periods of time, sprouting when conditions improve. Thanks to an adaptation called Aerenchyma, even dead stalks can still feed air to the roots. (Sculthorpe, 1967).

2.4.3.2 Common Reed

One of the Indian Lake species in competition with Cattail is the Common Reed (Phragmites australis). It is found around the world, although there are marked differences between subspecies. The European variation is labeled as an invasive species, and can be found
mixed in with other subspecies. Similar to Cattail, if allowed to overrun it can heavily damage an ecosystem’s biodiversity. It can grow to approximately 6-7 feet in height and can spread by as much as 15ft in a year (Gucker, 2008).

2.4.3.3 Poa

The third emergent species we observed was *Poa spp*. Poa is the genus for nearly 500 species of grasses. It is closely related to a household lawn grass and poses little to no threat to the lake. However, it can be used as a biomarker because its presence may provide insight into changes occurring in and around the lake.

2.5 Technology

This project involves two major pieces of technology. These are the use of a GPS Data Logger and the creation of a website to display our results.

Figure 2.6 Common Reed

2.5.1 GPS Data logger

The data logger was USB powered, and came with basic instructions for its use. When connected to a computer running the correct software, it could record data at variable intervals until it ran out of storage space. During the collections, our data logger was set to record latitude and longitude data every 10 seconds. By matching up the time of our collections with the input of the GPS, we were able to accurately record our location at every collection.

2.5.2 Website

The most efficient way to relay information about the project to the community is through a public website. Web pages are becoming an important part of the organization of information in modern culture. It is an excellent tool that has many advantages.

First, it is much more convenient to find information on a website than in a report while also less time consuming. The information would otherwise be difficult to find or the person interested may not know it exists (Simms, 2005). Another advantage is that websites are easy to promote and are always accessible. There is a sense of locality to a web page because it is available at any time and is no farther than a person’s computer. The user experiences consistency in that the information will always be there and in the same format (Web’s Advantages, 2013).

A successful informative website has a clear intent and purpose. Ultimately the website should be user friendly and do so by directing the reader to the information they looking for. Well-planned navigation is essentially invisible when it’s working (Barnum, 2011). The layout of
each page should facilitate the user’s movement through the website to the information they are looking for with little effort. When designing the layout of a website, much like a newspaper, the most important information goes at the top of the page because it is the first thing a reader sees. A common strategy is to put the page titles and major links at the top of the page where they are easily accessible and immediately seen. The reader should be able to decide relatively quickly if the page has the information they want and if not, where to find it (Brinck et al., 2002).

When designing the layout it is important to consider that all the elements on a screen are competing for the user’s attention. Simplicity in a layout allows for quick and easy navigation. Each page layout should direct the user individually as if it is the first time they are seeing it, even if it isn’t (Pipes, 2011). The best way to do this is with the strong use of links.

Links are a crucial part of the functionality of any site because they are the mode in which a user navigates. There are two aspects to the success of links: the user’s ability to predict where a link will lead them; and how well users can differentiate one link from other, nearby links (Lawrence & Tavakol, 2007). Text links are the most effective in describing its purpose because they are direct. Using pictures and figures often complicates the information and introduces ambiguity when interpreting images. The link itself does not have to include the full description. The link can include some short text with a longer description nearby. The objective is to make the links as clear as possible to a user that may not be knowledgeable in the subject (Brinck et al., 2002). Of course, simplicity is important. Having too many links on a web page complicates it. However, having too few links makes them too generic. This is to be
avoided because it becomes easy to pick the wrong one. A common problem is that users are often looking in the wrong place for information without even knowing it.

Organizing these links in a way that makes them easy to find and sort through is the next step in designing a user friendly website. A table of contents or a navigation bar is the best way to do this. Horizontally organized links have proven to be the most effective. Specifically, the top or the bottom of the page is the area where a user is most likely to look if searching for more information. Vertical lists are effective from an organizational standpoint, but do not hold the same success. It is simply more convenient when navigation buttons are at the top of the page and staring the user in the face (Lawrence & Tavakol, 2007).

When organizing information on a web page it is important to consider that the text format on a website is different than other sources and offers a different dimension of reading. Generally information is concise and direct, only including the necessary information. This keeps the text clear and prevents a page from being overwhelming. If the reader wants more, the information is available in another page of the website or through a link to another source. The reader is essentially in control of what they want to read and can efficiently navigate themselves directly to the information they want (Evaluating Websites, 2012)
3. Methodology

3.1 Introduction

This survey was conducted to assess the current ecological state of aquatic plant overgrowth in Indian Lake. The goals of this project are to establish the first set of collection data and to create the protocols for future groups to follow. This first set of data points provides the critical baseline that is required for comparison during future collections. As the results of this survey represent only one set of data points, future project groups will be responsible for additional collections. By combining multiple sets of collection data, the growth rates and population of plants in Indian Lake can be monitored. The methods and techniques used during this experiment were based on those of the ESS Plant Replacement Program (ESS Group, 2004), in conjunction with the ILWA.

3.2 Planning the Survey

To ensure a comprehensive survey of the weeds present in the lake and a thorough sample collection, we created a guide map highlighting areas we intended to survey. A tour was taken of Indian Lake to observe problem areas and map out the collection points. The density of collection points was directly proportional to the density of plant life and this was made by visual inspection of the areas during the tour. Finally input from local residents on areas with a problematic lakebed was taken into account and superimposed onto the survey map. The final survey map was comprised of 117 collection points distributed through 27 different transect
lines. These lines used prominent shoreline features such as inlets or outcroppings as reference points. A perimeter survey of Indian Lake was also performed to determine the percent of the shoreline covered by emergent plants. As GPS data was need to remain accurate in our collection. We tried different options including smartphone and in-car systems, but settled on a USB data logger. It was chosen over the other options due to its ability to catalog data directly to a computer, as well as having a higher degree of accuracy.

### 3.3 Data Collection and Analysis

In order to better understand the condition of Indian Lake, it is important to know certain pieces of information relevant to the collection. At each collection point six pieces of data were recorded: date and time, depth, percent cover, bio-volume, and the species of plant collected by the percent cover sample and by the bio-volume sample.

#### 3.3.1 Coverage Area of Weeds at Transect Point

We modified an aluminum gravel rake to evaluate the area covered by a particular weed. The rake was heavily weighted and had a long synthetic line attached to the handle. The weight ensured that the rake would drop quickly to the bottom every time, landing tines down for consistent collections. At each collection point the rake was submerged into the water, dragged slightly across the bottom, and then raised back into the boat to catalog the samples collected.

Cataloguing coverage area provided useful insight into growth patterns and densities in areas of interest and the lake as a whole. This collection method is especially significant for a
survey performed in the fall, as most plants have receded towards the lakebed to survive the winter. Percent cover allowed us quantify how much of each plant type was present. After dropping, dragging, and pulling up the rake, the density of the collected sample was catalogued using the relative abundance scale below. It was developed by the U.S. Army Corps of Engineers and modified by Cornell (ILWA, 2011).

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z (zero)</td>
<td>No Plant Life Collected</td>
</tr>
<tr>
<td>T (trace)</td>
<td>Finger-full on rake</td>
</tr>
<tr>
<td>S (sparse)</td>
<td>Handful on rake</td>
</tr>
<tr>
<td>M (moderate)</td>
<td>Rake-full of plants</td>
</tr>
<tr>
<td>D (dense)</td>
<td>Difficult to bring into Boat</td>
</tr>
</tbody>
</table>

This data was then recorded alongside the correct transect point, along with the other survey information.

### 3.3.2 Bio-volume of Weeds Recovered at Transect Point

To collect bio-volume samples we modified a gallon jug to form a suitable water column. The jug was submerged and pulled back from the water. Its contents were then catalogued. Bio-volume is a measurement of the presence of biologic material in the water column. Due to the late season of our collection, most of the plants had receded back down to the lakebed. Despite the cold temperatures emptying out much of the water column, bio-volume was
recorded in this survey to keep protocols consistent. Collections taken by future groups (in the summer or early fall) will likely yield much higher percentages of bio-volume. A modified gallon jug was used as a water column and bio-volume density was taken at every collection point. The bio-volume relative abundance scale below was also developed by the U.S. Army Corps of Engineers and modified by Cornell.

Table 3.2 Bio-volume Scale

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - No Biomass</td>
<td>No plants</td>
</tr>
<tr>
<td>1 - Low Biomass</td>
<td>Very low growth</td>
</tr>
<tr>
<td>2 - Moderate Biomass</td>
<td>Growth extending up into water column</td>
</tr>
<tr>
<td>3 - High Biomass</td>
<td>Growth in water column and possibly to surface, may be considered a recreational or habitat nuisance</td>
</tr>
<tr>
<td>4 - Very High Biomass</td>
<td>Growth filling the water column and covering the surface</td>
</tr>
</tbody>
</table>

3.3.3 Identification of Invasive and Non-Invasive Species

Based on the ESS survey (ESS, 2006) we had familiarized ourselves with the species we expected to find in the lake. These species are detailed in Chapter 2, Section 4. We were able to identify Eurasian Watermilfoil as we brought it up, and kept samples to confirm once we were back off of the boat. Small Pondweed was initially unknown to us, but we quickly identified it as we researched plants that were likely to be present in this region. Plants that we were unable to be identified or were unsure of were placed in plastic bags marked with the date, time, and
location. Common Reed was one of these, and was easily identified because we had brought a sample back with us.

### 3.3.4 Depth at Transect Point

We made a depth measurement tool by connecting two 10ft pieces of plastic pipe, marked in ½ foot increments. Depth measurements were used to confirm the Aquatic Plant Distribution from Chapter 2.3. When taking these measurements, we were also able to determine what the bottom composition of the lake was. If the pipe got stuck or came back up dirty, we could tell we were in an area of high silt and mud. Conversely, in the pipe bounced off the bottom it was probably of rocky composition.

### 3.3.5 Date and Time

The date and time were recorded at every collection so they could be matched against the GPS data logger, providing us with exact coordinates for each collection point. There are multiple time stamps through certain transect lines because wind and current pushed our boat, causing the lines to diverge from where we wanted to take them. These mistakes were corrected on subsequent visits by resampling along those transect lines and combining the collected points to make a straighter line.
3.4 Interactive Data Mapping

In order to offer an interpretive output of our survey, the data collected from each point was recorded into a Microsoft Excel file. This file was then structured so it could be converted into .KML file. The .KML format allows large accumulations of data to be uploaded to Google Maps in an organized manner. Each species was given its own color to make identification easier. These interactive maps allow concerned citizens to easily understand the state of the lake’s ecosystem and view the supporting data. Three maps highlight the main focus of the survey. These maps are the presence of submerged plants, coastal presence of emergent and floating plants, and points of current flow. In addition other maps also recorded. The use of these maps greatly increases the impact of our data analysis as it illustrates the recorded data in a way that can be easily laid over another set of data to discover any correlation between the two.
4. Results

In order to identify the current state of plant overgrowth within Indian Lake, the ILWA requested an ecological survey. Here we present all data acquired during our survey to be interpreted to help decide a way to help restore Indian Lake.

4.1 Aquatic Plant Distribution Associated with Depth

Using a set number of transect lines with varying number of collection points, coverage area, bio-volume, and depth were recorded. Coverage area and bio volume were recorded on a relative abundance scale adopted by the US Army Corps of Engineers. Table 4.1 is a comparison chart that couples the abundance of a collection with a given percentage to help illustrate the density of each plant. All collections were done between the dates of October 12th and October 23rd, 2012. The plants collected consisted of three types of submerged plants, three types of shoreline emergent plants and one type of floating pond lily.

Table 4.1 Relative Abundance – Coverage Area Scale

<table>
<thead>
<tr>
<th>Abundance</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero</td>
<td>0%</td>
</tr>
<tr>
<td>Trace</td>
<td>1% -20%</td>
</tr>
<tr>
<td>Sparse</td>
<td>21% -40%</td>
</tr>
<tr>
<td>Moderate</td>
<td>41% -60%</td>
</tr>
<tr>
<td>Dense</td>
<td>61% -80%</td>
</tr>
<tr>
<td>Very Dense</td>
<td>81% -100%</td>
</tr>
</tbody>
</table>

A bathymetric survey was also conducted and recorded alongside coverage area and bio volume to allow for simpler connections between depth and plant growth. The depth chart shows that the area surrounding Sears Island maintains a relatively consistent depth while the
main body of Indian Lake is broken into four depth zones. The southeastern quadrant of the main body gets deeper off the shore very rapidly and reaches depths of approximately 20 feet. The southwestern quadrant contains a very steadily increasing depth, again reaching approximately 20 feet. While both the northeastern and northwestern quadrants are on average much deeper than the area around Sear’s Island, both experience similar maximum depths.

4.2 Google Earth Mapping

With the data collected during the survey, a Google Earth interactive map was created to indicate each plant’s presence within the lake. Each plant was assigned a unique color; a collection point without plant life was recorded as a white dot. This information was separated into multiple maps to make each one easier to understand. For initial analysis all of the data was layered over one map to discover any relationships between different data points. Using the Google Earth maps we created, a few notable relations were found. Though the lake extends beyond 20 feet deep in some, no plants were found in water deeper than 7 feet. We also found that areas cut off from constant current flow, such as the area south of Sear’s Island, were prime locations for invasive weed overgrowth. The lack of current flow in areas affected by overgrowth suggests that stray current flow may deposit silt and other nitrogenous soil particles in these areas of the lake. Because there is no steady flow there to remove the silt this results in a buildup of soil that promotes plant growth.
4.2.1 Submerged Plants

Three submerged plants were found during our collections and were recorded into the interactive map. From our data, Eurasian milfoil was identified as an invasive species. The two most present plants, Eurasian Watermilfoil and Small Pondweed, were found in relatively equal quantities. One of these plants, Najas, was only found in one location. Of the 116 points that were taken only 22 collections yielded any plants. It should also be noted that those points where more than one plant was collected were recorded twice, once for each plant that was collected. These plants were all located in relatively shallow areas with little current flow and high floor level silt content. While the locations of plant growth should stay consistent, summer collections will reveal much denser collections of both Eurasian Watermilfoil as well as Small Pondweed. As the water becomes warm enough, the plants will grow back up into the water column to attain nourishment, resulting in much denser collections.

Figure 4.1 Submerged Plant Distribution
4.2.2 Emergent and Floating Plants

The two most prevalent emergent plants were Common Reed and Cattail, as visible in the Distribution Map (Figure 4.2). Yellow Pond lilies were present in a few locations, and a large bunch Poa spp. was seen in one area. Much of the shoreline of Indian Lake is covered by emergent plants and this map helps to identify the extent of the growth of these plant as well as which plants are present in which locations. Some plants that were noted as present in previous surveys were not located, such as smartweed and pickerelweed. Their absence may be from one or both of following reasons. These are both budding plants that bloom in the summer time and wilt in the fall in order to grow back again next spring, meaning that we may not have been able to see them. They may also have been pushed out by cattail or common reed, as these two now cover for a large portion of Indian Lake’s shoreline.
4.3 Restricted Water Flow Around Indian Lake

A map with points of current flow was created along with the plant distribution and bathymetric survey interactive maps. Using this map to highlight all inlets and outlets allowed correlations to be made between current flow and areas of overgrowth. The Lake has two main inlets, a large storm-drain that runs from Shoreham Street and the connecting streets and Anarat Brook, a small underground creek. Depending on their respective water levels, water can flow through the connection between Indian Lake and Little Indian Lake. The Lake also has one outlet, located on the shoreline near where the lake touches up against Route 190. These points were evaluated to determine whether or not their flow had any impact on the state of excessive vegetation growth in Indian Lake.

Two points of flow, the connection to Little Indian Lake and the pipes below the Sears Island causeway, are blocked, either through lack of preventive cleaning or through poor implementation and design. These points are important to note, as they are adjacent to areas greatly affected by overgrowth. Additionally, though they may seem insignificant, many smaller storm drains flow directly into Indian Lake. These can collect debris from local roads on rainy days and dump whatever they are carrying into the lake. This debris may include lawn and garden fertilizers that can stimulate an overgrowth of weeds all on their own.

Figure 4.3 Areas of Current Flow
5. Discussion

5.1 State of Indian Lake

Our observations of the lake during the survey indicate that since all three significant points of current flow are in the northern half of the lake the areas affected are mostly in the southern half of the lake. These observations conform to the suggestion that the lack of current flow to the southern end is one of the contributing factors in Indian Lake’s weed overgrowth. This is likely because the lack of flow causes the water to become more stagnant and allow silt particulates to fall out of colloidal suspension to the lakebed. This in turn provides nutritious soil for plants like Eurasian Milfoil to lay roots in. In 2004, the ESS Group performed a full survey of Indian Lake, which identified seven different species of plant. These plants were Eurasian watermilfoil, stonewort, pickerelweed, common reed, common grass, smartweed, and cattail. This survey identified much lower quantities of Eurasian milfoil and cattail when compared to the data collected from our survey.

This survey identified small pondweed as a much more prevalent species; in contrast small pondweed was not identified at all in 2004 (ESS, 2006). In the last eight years, Eurasian watermilfoil and small pondweed have spread to the extent that these plants were found in most regions of the lake shallower than seven feet. Cattail and common reed have also seen significant growth along the lakes shorelines. Other plants that were identified in this survey were yellow pond lily and Poa spp. (common grass). The eutrophic nature of the lake creates a niche environment for the overgrowth of the naturally aggressive Eurasian Milfoil by accumulating phosphates and nitrates that are essential nutrients for plant growth.
5.2. Dead Lake Phenomena

Eutrophication in lakes triggers a chain of events that can have drastic effects to both the health of the lake as well as social and economic aspects of the lake. If left unattended the lake may continue into the final stages of eutrophication, which will render it nearly unusable. Once the chain is complete the lake is then what’s known as a “dead lake”, or a lake in which no animals (aquatic or avian) inhabit.

5.2.1 Effects on the Ecosystem

This chain of events can be detrimental to biodiversity in an aquatic ecosystem. The addition of foreign particles or other debris (i.e. gravel, garbage), can lead to excess nitrates and phosphates in the water, which in turn provides an excess nutrient supply for aquatic plant growth. While all plants use these nutrients to grow, Eurasian Milfoil begins to grow earlier and more aggressively than native plants. It is also capable of spreading much faster than any other plant identified in Indian Lake. As Eurasian milfoil grows, the amount of average dissolved oxygen in the water decreases resulting in the death of a large percentage of the local fish population. As the fish population dies off local birds will move to other lakes in search of food.

5.2.2 Effects on Recreation

Indian lake is presently used for fishing and year round water sports. Eutrophication can interfere with recreation or leisure activities. In general, overgrowth of aquatic vegetation makes boating or swimming hard. Excess dissolved nitrates and phosphates cause a foul smell
and discoloration, diminishing the aesthetic appeal of the lake and discouraging visitors. Loss of the fish population not only hurts the ecosystem but also deters fishermen. Algae blooms that form due to excess nitrates and phosphates are typically harmful to swimmers (Bartram et al., 1999). This would have a profound effect on the local use of the lake, as well as decrease values of waterfront property.

5.3 Invasive and Aggressive Plant Growth

It is necessary to understand which plants exhibit aggressive or invasive characteristics in order to determine which plants must be monitored in future years compared to those with stagnant growth patterns.

The two plants identified that present the largest issue are Eurasian Milfoil (invasive) as well as small pondweed (native). Both plants exhibit aggressive growth patterns and present recreational as well as ecological problems that could have long term complications. One particularly concerning trait of Eurasian Milfoil is its ability to begin growing in the spring a few weeks before other plants allowing it extra time to grow and expand (Bole, Allan, 1978). In 2004 small pondweed was not identified in Indian Lake and is now common. In eight years it has gone through a large growth period and should be watched for further expansion.

Along the shoreline, cattail has also experienced aggressive growth over the last 8 years. Though usually considered invasive, there are two subspecies of common reed, one of which is native to the area and grows much less aggressively. In the last 8 years, common reed has shown little growth, which may suggest that the species present on Indian Lake is the native subspecies (Catling, Mitrow, 2011).
5.4 Indian Lake Website

A significant result of this project is the creation of a website dedicated to it. A large part of this project is in communicating to the community of Indian Lake. It offers a way to organize the data collected during this project in the public domain and further establish the project for future surveys. The website contains a number of features that without it would not be possible.

The most important feature is the inclusion of a series of interactive Google maps. These maps display each collection point, showing exactly where it was taken and what was found including the date, time, depth, density and plant species found. There are five maps included; the first displays every collection point taken. Next, each point where plants were found is color coded, by species, to show the general growth distribution. Then each submerged plant has its own map, showing individual plant growth patterns. The last map displays the distribution of emergent plants, also color coded by plant species. The maps visually organize the collection data and display plant distributions. They provide clarity and transparency to the survey, allowing members of the community to see and interpret collection data themselves.

The website has a number of features that makes it useful for this project which without it would not be possible. The most important feature is the inclusion of a series of interactive Google maps. These maps display each collection point, showing exactly where it was taken and what was found including the date, time, depth, density and plant species found. There are five maps included; the first displays every collection point taken. Next, each point where plants were found is color coded, by species, to show the general growth distribution. Then each
submerged plant has its own map, showing individual plant growth patterns. The last map displays the distribution of emergent plants, also color coded by plant species. The maps visually organize the collection data and display plant distributions. They provide clarity and transparency to the survey, allowing members of the community to see and interpret collection data themselves.

The website also offers information about the project in the “Project Info” section. This section is dedicated to explaining key information about the survey and results. It includes information on eutrophication, common plant species present in freshwater lakes, and the results of the collection data. This section summarizes the information put together in the report but will not include everything. The full project report will be available by a link on this page. A large advantage to having this information on the web is that it offers a consistent source that can be referenced by the community. During the expansion of this project in later years, the website can easily be updated to include new information and improvements. Members of the community will already know where to find information about the project and can easily be kept up to date.

The website also serves as a medium between project members and the lake community. Contact information is provided on the websites “Contact Us” page. This makes it easy to contact the entire project team at once, which may otherwise be hard to do. Any questions or input about the project can be received and considered. It is important to have a means of contact with the community because it is their concerns that drive this project. It also allows project members to post information about the project and the lake publically. On the home page is a column titled “Lake News” where any new information relevant to the project can be
posted, and reported to the community. Screen shots of all of these pages are included in Appendix G.

5.5 Conclusion and Recommendations

In its current state, with eutrophication and plant overgrowth the stability of the lake is below the desired conditions. The following is potential suggestions that may be used to help the lake both short term and long term. While short term methods seem helpful due to the removal of plants in ways listed below, if the problem is not though of long term as well these problems may return. The key to improving the state of Indian Lake is to not only remove the plants but also remove the ideal growing conditions for these plants. Then they will not be able to grow so aggressively. There are a few key factors regarding Indian Lake that if addressed might significantly help the current situation. Therefore the process of beginning to attempt to resolve the issues faced in Indian Lake must acknowledge methods that will not only alleviate the situation now but help to prevent future complications as well.

Using the data collected and further research into the topic we decided on three potential solutions to solve the immediate problem in Indian Lake. Using the maps created after the collection it is evident that no plants grow past 9 feet in depth. This means that if dredging were an option dredging only the areas shallower than 9 feet what drastically cut costs. Another method that has been used before in similar situations by other communities is a summer draw down event. This event involves drawing the water down a variable depth at the discretion of those in charge in order to organize a community clearing of any aquatic plants are revealed by the decrease in depth. As Eurasian Milfoil is a growing problem in Indian Lake, one
method that has been used with some success in the Finger Lakes region of Northern New York is the use of the water veneer moth, an insect which lives most of its lifespan in water and feeds exclusively on Eurasian Milfoil but is also fed on by local predator fish which reduces the likelihood of another invasive species (WSDE, 2012).

Once the immediate problem is addressed it is necessary to consider methods to prevent future overgrowth. In the last year the winter draw down depth of Indian Lake was decreased from 6 feet to 4 feet. It may be beneficial to reinstate the 6 feet draw down depth. Lowering the draw down depth could potentially begin a harmful chain of events. Reduction of the draw down depth means that in winter month’s Eurasian milfoil will have to recede less to survive and will be able to grow much more aggressively in the spring when the growth season begins. Though this decision was made to protect the lakes local fish population it is possible that reducing the draw down depth may allow very aggressive growth of Eurasian Milfoil in future years further reducing the levels of dissolved oxygen in the water resulting in the death of the fish population. Another factor to consider long term is the lack of current flow in certain areas of the lake. Our survey shows that the area most affected by plant overgrowth is the area surrounding Sear’s Island. This area lacks any current flow points and remains relatively stagnant allowing for the deposition and buildup of silt particles. One possible solution may be to replace the causeway with an open bottomed bridge allowing for current flow between those two sections of the lake.

In a broad view, Indian Lake is only in the first few stages of eutrophication and plant overgrowth. If aggressive and invasive plants were removed and these factors addressed the lake may stabilize and regain much of its beauty and recreational attraction.
5.6 Limitations of the Project and Implications in the Future

This survey was conducted in late October, when temperatures had begun to drop. Because of this, the small pondweed had receded and the nettle-like leaves of the Eurasian Milfoil had fallen off. The plants had retracted closer to the bottom of the lake to survive the winter. Their presence is much different in spring and summer, when they expand and bloom to the surface to harness as much sunlight as possible. Therefore a collection done between spring and summer should yield much higher density and biomass readings. Multiple samplings are needed during various seasons to fully evaluate the seasonal effects on eutrophication and plant growth in Indian Lake. Over the years, this should provide a detailed analysis of the growth rate of invasive and aggressive species in Indian Lake. There were also a few plants that had been identified in 2004 but not during this collection. These species not identified were smartweed and pickerelweed. These plants bloom primarily in the spring and it is possible that the two species had lost any flowering and may have blended in with other emergent plants due to the lack of distinguishing characteristics or if the species are a perennial plant and receded below the soil level and will regrow in the spring. As these plants may be present and were not identified in a fall collection due to different patterns exhibited by the species, collections done in other seasons may identify these plants as still present.
### Appendix A - Aquatic Plant Life and Bathymetric Survey Data

<table>
<thead>
<tr>
<th>Transect Point (line #.point #)</th>
<th>Depth (ft.)</th>
<th>Coverage Area</th>
<th>Collected Plant</th>
<th>Bio-volume Plant Collected</th>
<th>Bio-volume Density rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.2</td>
<td>4.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.3</td>
<td>4.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1.4</td>
<td>2.5</td>
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<td>-</td>
<td>-</td>
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</tr>
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<td>4.1</td>
<td>3.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.2</td>
<td>5.5</td>
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<td>Eurasian Milfoil</td>
<td>Moderate Biomass</td>
<td></td>
</tr>
<tr>
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<td>5.0</td>
<td>Trace Eurasian Milfoil</td>
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</tr>
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<td>3.5</td>
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<td>Trace Small Pond Weed</td>
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<td>4.0</td>
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<td>-</td>
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<td>Very Dense Small Pond Weed</td>
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<td>-</td>
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<td>6.4</td>
<td>5.0</td>
<td>Moderate Small Pond Weed</td>
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<td>6.5</td>
<td>6.0</td>
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</tr>
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<td>6.0</td>
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Appendix B – GPS Points Map
Appendix C – GPS Points Coded Map
Appendix D – Eurasian Watermilfoil Distribution
Appendix E – Small Pond Weed Distribution
Appendix F – Emergent Plant Distribution
Appendix G – Website Screen Shots

Overview

The main focus of this project was to identify species of aquatic vegetation within Indian Lake and to then assess the extent to which they hinder recreational use of the lake. By establishing a solid methodology, our methods of collection can be replicated by future groups, allowing the data points to be compared on a timeline. This is essential to monitoring the ecological health of the lake. Based on the data collected our group presented the ILWA with suggestions on how to manage the current overgrowth.

Key Features:

- A series of interactive Google maps is organized in the ‘Maps’ section. They display each lake collection point, showing exactly where it was taken and what was found including the date, time, depth, density and plant species found.
- The ‘Project Info’ sections includes information collected in the project report that is useful for understanding plant growth in freshwater lakes and interpreting the results of this survey. Topics include in this section include eutrophication, common plant species present in freshwater lakes, and the results of the collection data.
- The ‘Contact Us’ page is open for any one with questions or suggestions about the project.

Purpose of this web-page

This website’s purpose and design allows easy access for those of the public interested in Indian Lake to obtain information about the survey as well as contact those in charge to report areas of overgrowth or other concerns about the lake. Communication with project members and ILWA representatives is encouraged and can be done through the Contact Us page. This website includes details about the entire project including the collection results. The most important feature is the inclusion of a series of interactive maps that display the distribution of plants collected from the lake. This feature allows for a simple way to view the survey results and visualize growth distributions. These maps will be permanently accessible as long as this website exists and viewable by anybody who is interested.
Maps Home

| Total Collection | Displays all points that were collected. |
| Color Coded Distribution | Displays all collection points organized by a separate color for each plant found. |
| Milfoil Distribution | Displays only the collection points where Eurasian Milfoil was found, each marked by a number representing the density found. |
| Small Pond Weed Distribution | Displays only the collection points where Small Pond Weed was found, each marked by a number representing the density found. |
| Emergent Plant Distribution | Displays only the collection points where Emergent plants were found color coded to each type of plant. |
| Current Flow | Marks where the inlets and outlets of the lake are located along the amount of flow each provides. |

Each collection point has been organized in a series of maps:
- There is a series of 6 interactive maps accessible by the menu to the right.
- Each map describes a distribution found in the lake.
- These maps provide a simple way to display the data collected from the lake while making it easy to analyze.
- By clicking each point on the map you can display the actual point coordinates, the water depth, and a description of the sample collected.
Total Collection Map:

Maps
Maps Home Page
Total Collection
Color Coded Distribution
Milfoil Distribution
Small Pond Weed Distribution
Emergent Plant Distribution
Current Flow

- Each collection point has been organized on the map below.
- There are a total of 6 maps describing distributions found in the lake.
- By clicking each Point on the map you can display the actual point coordinates, the water depth, and a description of the sample collected.
Submerged Plant Growth

Three species of submerged plants were found during our collections. From our data, Eurasian milfoil was identified as an invasive species. The two most present plants, Eurasian Watermilfoil and Small Pondweed were found in relatively equal quantities. One of these plants, Najas, was only found in one location. Of the 116 points that were taken only 22 collections yielded any plants. It should also be noted that those points where more than one plant was collected were recorded twice, once for each plant that was collected. These plants were all located in relatively shallow areas with little current flow and high floor level silt content. While the locations of plant growth should stay consistent, summer collections will reveal much denser collections of both Eurasian Watermilfoil as well as Small Pondweed. As the water becomes warm enough, the plants will grow back up into the water column to attain nourishment, resulting in much denser collections.
Eurasian Milfoil Density Distribution:

- The collection points have been numbered to represent the density of Eurasian Milfoil that was found.
- There is a total of 13 points where Milfoil was found.
- The Milfoil density is concentrated in areas that water flow is very poor, and the amount of runoff from the surrounding hills is high.
- The cove south of Sear's Island is where the largest growth has been observed.
- This area has the poorest water circulation due to the inlets and outlets being on the other side of Sear's Island around the main body of water.
Small Pond Weed Density Distribution:

Maps
- Maps Home Page
- Total Collection
- Color Coded Distribution
- Milfoil Distribution
- Small Pond Weed Distribution
- Emergent Plant Distribution
- Current Flow

The collection points have been numbered to represent the density of Small Pond Weed that was found. Milfoil and Small Pond Weed were the two most common submerged plants collected. Note the density of submerged plants is concentrated in areas that have poor water circulation. The cove south of Scar's Island is where the largest growth has been observed. This area has the poorest water circulation due to the inlets and outlets being on the other side of Scar's Island around the main body of water.
Emergent and Floating Plants

The two most prevalent emergent plants were Common Reed and Cattail, as visible in the Distribution Map (Figure 4.2). Yellow Pond lilies were present in a few locations, and a large bunch Poa spp. was seen in one area. Much of the shoreline of Indian Lake is covered by emergent plants and this map helps to identify the extent of the growth of these plants as well as which plants are present in which locations. Some plants that were noted as present in previous surveys were not located, such as smartweed and pickerelweed. Their absence may be from one or both of following reasons. These are both bolting plants that bloom in the summer time and wilt in the fall in order to grow back again next spring, meaning that we may not have been able to see them. They may also have been pushed out by cattail or common reed, as these two now cover for a large portion of Indian Lake’s shoreline.
Current Flow:

Restricted Water Flow
A map with points of current flow was created along with the plant distribution and bathymetric survey interactive maps. Using this map to highlight all inlets and outlets allowed correlations to be made between current flow and areas of overgrowth. The Lake has two main inlets; a large storm drain that runs from Shoreham Street and the connecting streets and Anarat Brook, a small underground creek. Depending on their respective water levels, water can flow through the connection between Indian Lake and Little Indian Lake. The lake also has one outlet, located on the shoreline near where the lake touches up against Route 190. These points were evaluated to determine whether or not their flow had any impact on the state of excessive vegetation growth in Indian Lake. Two points of flow, the connection to Little Indian Lake and the ones below the Sears Island causeway, are blocked. Either through lack of preventive cleaning or through poor implementation and design. These points are important to note, as they are adjacent to areas greatly affected by overgrowth. Additionally, though they may seem insignificant, many smaller storm drains flow directly into Indian Lake. These can collect debris from local roads on rainy days and dump whatever they are carrying into the lake. This debris may include lawn and garden fertilizers that can stimulate an overgrowth of weeds all their own.
Project Overview

Indian Lake is the largest body of water fully contained within the City of Worcester. The lake as seen today has grown significantly from its original size. It was originally known as North Pond and provided an outlet for Mill Brook, one of the Blackstone River's main water sources. In 1828, the pond was dammed at its outlet as part of a water-control system for the Blackstone Canal. The area has undergone continuous development and now boasts numerous lakeshore properties along with three public access beaches. The lake community, both those who live near it and those who frequent it for recreation in the summer, have observed a dramatic increase in the growth of aquatic plants in recent years. During the last decade these invasive aquatic plant species have been adversely affecting water clarity and swimming areas, as well as choking out the fish that populate the lake. In its shallowest areas, the lake bottom is not visible and a strong green color masks the entire lake body.

Executive Summary

In an attempt to better understand the state of overgrowth in aquatic plant life within Indian Lake, a survey was done in affiliation with the ILWA. Previous surveys have been done within the same topic however none have been taken by any corporation in collaboration with any other conducted survey. In order to get a thorough analysis this survey was conducted in a way to set protocols for future teams to take more collections and compare data to organize solid empirical evidence to judge whether the lake must be treated or not.

Project Goals

- First identify what the aquatic vegetation is present in Indian Lake.
- Assess how growth density effects recreational use of the lake and biological conditions.
- Form recommendations regarding plant management as well as prepare for future surveys projects.
- Inform the lake community through this website.
About Indian Lake

History

Indian Lake didn’t exist 200 years ago. It began as North Pond and was roughly 40 acres in size. In the early 1800s, plans for the creation of a canal stretching from Worcester to Providence, RI were developed. Construction of the Blackstone Canal began in 1825, and opened for use in the fall of 1828. It was created to increase trade between the two cities, allowing Worcester to increase its economic status. To control water flow through the canal, a dam was built at the outlet of North Pond, turning it into a reservoir. As a result, North Pond grew to more than four times its size, now totaling 193 acres. The rising water created Sears Island, which had previously been a hill on the shoreline (Coombs, 1935). The advent of railroads soon rendered the canal impractical and it ceased use as a commercial trade. The dam stayed, leaving behind the area now known as Indian Lake.

Commercial Use

The earliest documented commercial use of the lake was as a power source for the watermills that lined its outlet, Mill Brook (Coombs, 1932). These mills provided power for some of Worcester’s factories. Indian Lake also served as the home of the Walker Coal and Ice Company. Harvesting 15,000 tons or more of ice every year, the Walker Coal and Ice Company provided employment for many of Worcester’s residents (Costa, 2010). After 90 years on Indian Lake, a warehouse fire shut down the company, as the development of electric refrigeration had made ice harvesting obsolete.

Recent History

In the 1970’s, a highway was designed intending to connect Worcester to local cities and towns. The original blueprints had the highway cut straight across Indian Lake, atop a gravel causeway. This proposal was not well received by the residents because of the environmental damage it would cause to the lake, both from construction and eventually passing vehicles. The original plan also called for the demolition of the West Boylston Street School. A revised path, now Route 190, was proposed by a concerned citizen, which both saved the school and skirted around the lake. Additionally, the new plan saved the city a considerable sum, as there was no longer a need for the thousands of tons of gravel the causeway would’ve needed (Noelans, 1974).

Present Day

Presently Indian Lake has no real commercial significance for the surrounding community. In the past it was home to a yacht club that has since shut down. The lake still serves as a popular venue for recreation for the city of Worcester. In addition to the waterfront properties owned by the residents of the lake, there are two public access beaches and a small park with a boat ramp. In the summer, due to its ease of access and usability, it plays host to many swimmers, boaters, fishers, and, beach goers. This in fact provides the motivation and rationale for this survey - preserving the beauty of the lake and maintaining its functionality as a recreation destination.
Eutrophication In Indian Lake

A Common Problem
One general issue plaguing lakes in the New England area is eutrophication. Eutrophication is when excess nitrates and phosphates are introduced into the ecosystem of a lake, typically by human activity. These added chemicals make the water very nutrient rich, benefiting the growth of certain plants more than others. Aggressive growth of certain species can overtake and choke out other plants and aquatic wildlife. This effect can cause an ecosystem to alter drastically. Many of these changes affect recreational use of the lake and impair its aesthetics (Mattland, 1984). The introduction of nitrates and phosphates into Indian Lake was likely caused by runoff from a local street or storm drain, along with debris and dirt particles from the bordering highway.

Ecological Effects
Lake eutrophication triggers a chain of events. The excess nitrates and phosphates create ideal conditions for the growth of select plants. These plants begin to grow excessively, spreading and becoming denser every year. As they take over water clarity decrease along with the levels of dissolved oxygen in the water. Decreased light and oxygen levels together result in death of many aquatic animals. Fish and other gilled animals that rely on filtering oxygen out of the water suffocate. As these animals perish, they don’t feed on the aquatic plants that caused the problem, allowing them to grow even more aggressively. The decline in the lake’s fish population also results in the relocation of other local animals, including waterfowl like ducks and herons, to new food sources (Eutrophication, 2007). In addition to the destruction of the local ecosystem, as the excess nitrates and phosphates build up, algae blooms will begin to form. Some of these algae blooms can be poisonous to humans and other animals.

Recreational Problems
The effect of eutrophication on recreation is a growing nuisance. As plants continue to grow more aggressively, they begin to take up more of any particular water column. Swimmers have a hard time swimming through dense aquatic plants. Boats are more likely to get entangled in the plants as they move, becoming stuck and ruining their engines.

Indian Lake
Though Indian Lake is already suffering the effects of eutrophication and is infested with invasive weeds, it is not beyond recovery. This study recommends simple measures that aim to prevent further devastation of the local ecosystem.
Collection Process

Planning the Survey

To ensure a comprehensive survey of the weeds present in the lake and a thorough sample collection, we created a guide map highlighting areas we intended to survey. A tour was taken of Indian Lake to observe problem areas and map out the collection points. The density of collection points was directly proportional to the density of plant life and this was made by visual inspection of the areas during the tour. Finally input from local residents on areas with a problematic lakebed was taken into account and superimposed onto the survey map. The final survey map comprised of 117 collection points distributed through 27 different transect lines. These lines used prominent shoreline features such as inlets or outcroppings as reference points. A perimeter survey of Indian Lake was also performed to determine the percent of the shoreline covered by emergent plants. As GPS data was used to remain accurate in our collection. We tried different options including smartphones and in-car systems, but settled on a USB data logger. It was chosen over the other options due to its ability to catalog data directly to a computer, as well as having a higher degree of accuracy.

Weed Coverage Area

At each collection point six pieces of data were recorded: date and time, depth, percent cover, bio-volume, and the species of plant collected by the percent cover sample and by the bio-volume sample. A modified aluminum grooved rake was used to evaluate the area covered by a particular weed. The rake was heavily weighted and had a long rope attached to the handle. A weight was attached to ensure that the rake would drop quickly to the bottom every time, landing lines down for consistent collections. At each collection point the rake was submersed into the water, dragged slightly across the bottom, and then raised back into the boat to catalog the samples collected.

After dropping, dragging, and pulling up the rake, the density of the collected sample was catalogued using the relative abundance scale below. It was developed by the U.S. Army Corps of Engineers and modified by Cornell (ILWA, 2011). This data was then recorded alongside the correct transect point, along with the other survey information.

<table>
<thead>
<tr>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (zero)</td>
<td>No Plant Life Collected</td>
</tr>
<tr>
<td>T (trace)</td>
<td>Finger-full on rake</td>
</tr>
<tr>
<td>S (sparse)</td>
<td>Handful on rake</td>
</tr>
<tr>
<td>M (moderate)</td>
<td>Rake-full of plants</td>
</tr>
<tr>
<td>D (dense)</td>
<td>Difficult to bring into boat</td>
</tr>
</tbody>
</table>

Identification of Invasive and Non-Invasive Species

Based on the ESS survey (ESS, 2006) we had familiarized ourselves with the species we expected to find in the lake. These species are detailed in Chapter 2, Section 4. We were able to identify Eurasian Watermilfoil as we brought it up, and kept samples to confirm once we were back off of the boat. Small Pond weed was initially unknown to us, but we quickly identified it as we rechecked plants that were likely to be present in this region. Plants that we were unable to be identified or were unsure of were placed in plastic bags marked with the date, time, and location. Common Reed was one of these, and was easily identified because we had brought a sample back with us.
Aquatic Plant Life

Overview

In addition to the detrimental growth caused by eutrophication, the overgrowth of aquatic plants in Indian Lake is a result of the introduction of invasive and non-native plants into the local ecosystem. The danger brought by invasive plants is that they will edge out and replace the native species, either by being more resilient to changes in the water or by not becoming part of the food chain. If a plant is not eaten by the local wildlife it can grow unchecked, quickly crowding out and removing the native plants as a food source (ESS, 2006). This means that if the fish and invertebrates can’t adapt they will starve, decimating the upper levels of the food chain. During our survey we identified three categories of aquatic plants, submerged, floating, and emergent, as documented in the following pages.

Invasive Plants

The aggressive growth of certain non-native plants poses a major threat to the health of the ecosystem around Indian lake. Invasive plant species usually grow unencumbered by predators because animals in the native ecosystem are unlikely to eat them (ESS, 2006). As invasive plants subvert the native plants, they remove a large part of the food source for the fish population. This, combined with the decrease in dissolved oxygen caused by eutrophication, the survival rate for local fish decreases severely.

Growth Distributions

With a survey like this it is necessary to understand the relationship between the presence of certain plants and the depth at which they are found. Most aquatic plants only grow in one depth region of a lake. Because sunlight can only penetrate so far into water, a plant needs for light limits the depth to which it can grow. The portion of a lake deep enough that the sun does not reach the bottom is known as the Limnetic zone (NSF, 2004). This zone usually lacks any aquatic vegetation due to this lack of sunlight. As seen in previous surveys and confirmed during our survey, the center of Indian Lake is a Limnetic zone. The zone most important to this survey was the Littoral zone. This zone is far enough from shore that submerged, emergent, and floating plants grow but also shallow enough that light reaches the bottom and all plants are able to receive proper nutrition.
Submerged Plants

Overview
The majority of the nuisance plants in Indian Lake are submerged plants, or plants that grow up from the bed of the lake. Though other species of submerged plants have been found in the past, we only collected two species of plants.

Eurasian Water Milfoil
Eurasian watermilfoil (Myriophyllum spicatum) is a species of submerged aquatic plant found naturally throughout Europe and Asia. It first appeared in North America during the 1940s and has been a steadily growing problem ever since. Eurasian watermilfoil is known as a submergent perennial plant, meaning that the plant continues to live during the winter, re-growing and expanding as it does (Boothman, 2003).

The growth pattern suggests that Eurasian Watermilfoil is among the first plants to fully establish itself in the springtime. Because it is available so early in the breeding season, fish are more likely to use it as food, even though it contains significantly less nutritional value than the native plants it displaces. At the same time, the density of the cover it provides means that the survival rate of young small fish increase to well beyond their normal values (Ricciardi, 2009). Compound these two problems and the result is a steady starvation of the lake's animal population. As the small fish grow larger, their overabundance quickly outstrips the nutrition that the watermilfoil can provide. Because there are too many fish and not enough food, the population begins to starve. This starvation also heavily affects the bird populations that depend on the fish as a food source, in their prey rapidly begins to dwindle (Smith, C.S., 1990). Eurasian Watermilfoil was first of two submerged plant populations found during our survey of Indian Lake.

Small Pond Weed
The second submerged plant we found was Small Pond Weed (Potamogeton pusillus). This is a plant is native to the entire North American continent (USDA, 2012), therefore not alarming by itself. What does worry us is that when surveyed in 2004, it was not found anywhere in Indian Lake (ESS, 2004). It was found in Little Indian Lake, so it has likely come from there, and has grown rapidly. Similar to Eurasian Watermilfoil, it is a perennial species, although its growth is nowhere near as rapid or expansive as an invasive weed.
Emergent Plants

Overview
Emergent plants are species that grow in the water near the shoreline but extend up past its surface for sunlight and air. We identified three different species of emergent plants.

Cattail
Primary among these emergent plants is Cattail (Typha latifolia). Cattail is native to this area and other members of its genus can be found all over the world. Cattail is a "dominant competitor" in wetland areas, which can lead to its classification as a nuisance plant. It grows rapidly, can survive long periods of unfavorable conditions, and spreads its seed easily. This rapid and widespread growth can cause it to push out other local species, damaging the biodiversity of ecosystems it inhabits. The spread of Cattail can be attributed to its seed heads, each of which may contain as many as 200,000 seeds (Turner, 2009). In addition to their prolific seeding, cattails are incredibly hardy. Their seeds can survive buried underground for extended periods of time, spreading when conditions improve. Thanks to an adaptation called Aerithyma, even dead stalks can still feed air to the roots (Sculthorpe, 1967).

Common Reed
One of the Indian Lake species in competition with Cattail is the Common Reed (Phragmites australis). It is found around the world, although there are marked differences between subspecies. The European variation is labeled as an invasive species, and can be found mixed in with other subspecies. Similar to Cattail, if allowed to overrun it can heavily damage an ecosystem's biodiversity. It can grow to approximately 6-7 feet in height and can spread by as much as 15 ft in a year (Gasker, 2008).

Poa
The third emergent species we observed was Poa, the genus for nearly 500 species of grasses. It is closely related to a household lawn grass and poses little to no threat to the lake. However, it can be used as a biomarker because its presence may provide insight into changes occurring in and around the lake.
Results

Using a set number of transect lines with varying number of collection points, coverage area, bio-volume, and depth were recorded. Coverage area and bio-volume were recorded on a relative abundance scale adopted by the US Army Corps of Engineers. Table 4.1 presents a comparison chart that relates collections made on relative abundance into percentages to help give a more comprehensible understanding of plant density. This table allows for a simple analysis of the collected data to be presented with little required explanation. All collections were done between the dates of October 12th and October 25th, 2012. The plants collected consisted of three types of submerged plants, three types of shoreline emergent plants and one type of floating pond lily.

A bathymetric survey was also conducted and recorded alongside coverage area and bio-volume to allow for simpler correlations between depth and plant growth. The depth chart shows that the area surrounding Sear’s Island maintains a relatively consistent depth while the main body of Indian Lake is broken into four depth zones. The southeastern quadrant of the main body gets deeper off the shore very rapidly and reaches depths of approximately 20 feet. The southwestern quadrant contains a very steadily increasing depth, again reaching approximately 20 feet. While both the northeastern and northwestern quadrants are on average much deeper than the area around Sear’s Island, both experience similar max depths.

Data Mapping

With the data collected during the survey, a Google Earth interactive map was created to indicate each plant’s presence within the lake. Each plant was assigned a unique color, a collection point without plant life was recorded as a white dot. This information was separated into multiple maps to make each one easier to understand. For initial analysis all of the data was layered over one map to discover any relationships between different data points. Using the Google Earth maps we created, a few notable correlations were found. Though the lake extends beyond 20 feet deep in some, no plants were found in water deeper than 7 feet. We also found that areas cut off from constant current flow, such as the area south of Sear’s Island, were prime locations for invasive weed overgrowth. The lack of current flow in areas affected by overgrowth suggests that stray current flow may deposit silt and other nutrientous soil particles in these areas of the lake. Because there is no steady flow there to remove the silt this results in a buildup of soil that promotes plant growth. These maps can be found in the Maps section, or through the links under results on the left side of the page.
Conclusions

State of Indian Lake

Our observations of the lake during the survey indicate that since all three significant points of current flow are in the northern half of the lake the areas affected are mostly in the southern half of the lake. These observations conform to the suggestion that the lack of current flow to the southern end is one of the contributing factors in Indian Lake’s weed overgrowth. This is likely because the lack of flow causes the water to become more stagnant and allow silt particulates to fall out of colloidal suspension to the lakebed. This in turn provides nutritious soil for plants like Eurasian Milfoil to lay roots in. In 2004, the ISNS Group performed a fall survey of Indian Lake, which identified seven different species of plant. These plants were Eurasian watermilfoil, stonewort, pickerelweed, common reed, common grass, smartweed, and cattail. This survey identified much lower quantities of Eurasian milfoil and cattail when compared to the data collected from our survey. This survey has identified small pondweed as a much more prevalent species; in contrast small pondweed was not identified at all in 2004 (ISNS, 2006). In the last eight years, Eurasian watermilfoil and small pondweed have spread to the extent that these plants were found in most regions of the lake shallower than seven feet. Cattail and common reed have also seen significant growth along the lakeshorelines. Other plants that were identified in this survey were yellow pond lily and Potamogeton (common grass). The estrophic nature of the lake creates a niche environment for the overgrowth of the naturally aggressive Eurasian Milfoil by accumulating phosphates and nitrates that are essential nutrients for plant growth.

Invasive and Aggressive Plant Growth

The two plants identified that present the largest issue are Eurasian Milfoil (invasive) as well as small pondweed (native). Both plants exhibit aggressive growth patterns and present recreational as well as ecological problems that could have long term complications. One particularly concerning trait of Eurasian Milfoil is its ability to begin growing in the spring a few weeks before other plants allowing it extra time to grow and expand (Boile, Allan, 1978). In 2004 small pondweed was not identified in Indian Lake and is now common. In eight years it has gone through a large growth period and should be watched for further expansion.

Along the shoreline, cattail has also experienced aggressive growth over the last 8 years. Though usually considered invasive, there are two subspecies of common reed, one of which is native to the area and grows much less aggressively. In the last 8 years, common reed has shown little growth, which may suggest that the species present on Indian Lake is the native subspecies (Cutting, Mitrow, 2011).
CONTACT US

Please Contact:
Beth Proko
Phone: 508-856-9598
Email: bproko@charter.net

For more information about the ILWA visit www.ILWA.org

Feedback, questions, or important information
Any feedback about the website or project, any questions about the project along with any information about the lake that could be helpful is appreciated. This website serves as a medium between the Indian Lake community and our project group. Any helpful information will be utilized and if applicable can be posted on the website for all members of the community to see.

To submit feedback please email the group at IndianLakeigp@wpi.edu
Appendix H – Website Manual

Indian Lake Plant Survey

Website Manual

Part of An Interactive Qualifying Project Report
Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In partial fulfillment of the requirements for the
Degree of Bachelor of Science

Submitted to:

Project Advisors: Professor Chickery Kasouf, WPI
Professor Reeta Prusty Rao, WPI

Project Sponsor: Beth Proko, Indian Lake Watershed Association

Submitted by: Eric Plante

Project Code: CJK-1301
Submitted: March 12, 2013
Introduction

The following manual describes the methods used to write the documents of the website and how to edit them in the future. The format for all documents of this
website is html which was chosen because it is universal to any browser and easy to read or edit. The documents of this website were primarily created using Dreamweaver, but can be edited with any text editor and saved as an html file extension. This manual assumes the reader has a basic understanding of html, which if not, can be found at these resources: http://www.w3schools.com/ or http://www.html.net/. The first sections describe the most important and basic features of html: the Div element, Style sheets and how to use links. These topics are important to any html document. The proceeding sections describe the background behind page layout, navigation and how to edit individual pages of the documents that contain unique strategies of web design. The last sections describe the process of accessing, managing and organizing files on the server.

Html strategies in use

This section includes a description of important strategies used in the development of this website which are common to html webpages. These strategies rely heavily on the use of divisions and a separate style sheet to control the content of each page. This is the preferred way to organize content on a web page in html 5, the latest version of html code, and the method that receives the best support across various browsers. When adding links to different documents there are various considerations to be made that are described below.

Div Element

• The div element creates divisions in the webpage that are areas of the webpage that can be controlled individually. Divisions can be any specified size and position.
• Almost all content of the website is part of a division that can be easily controlled by a style sheet.
• To define a division the element is written as: <div id="sample"> content </div> Where <div> opens the element. Here the id of the division is defined as “sample” so it can be referenced later in the style sheet. The end of the content within the division is marked by the closing tag </div>.

Style Sheets

• This website relies heavily on the use of divisions and a separate cascading style sheet to control all content.
• The style sheet designates properties such as an element’s size, position, background color, border, and styles for elements inside of the division. This is the predominant method of organizing the website.
• Each page includes a reference to the style sheet and a single sheet is used to control all pages, making universal changes simple.
• Any element can be referenced by the style sheet using a specific id or class.
• An element that is referenced in the sheet must be acknowledged by an id specified in the line of the element code. The style sheet then recognizes an id in the format of #idname. A class is noted by a period #, for example: .blue references the blue class
This website uses the external style sheet filename: LAKE_STYLE.css which is referenced on each page using the link: <link href="LAKE_STYLE.css" rel="stylesheet" type="text/css">. This link is inserted in the heading of the document, shown in figure 2.

**Using Links**

- Each link has to specify exactly where the destination file is. When linking to other files within the website, the proper domain and folder name must be specified.
- Each page has a base reference that directs it to the head of the file directory. The base reference is specified in the head of the file above the style sheet reference.
- If the base reference is not set correctly then it would be impossible to access files in any other folder of the file tree.
- When the current document is in a sub folder of the main folder it is necessary to reference the main folder before referencing a document in it. Figure 1 shows an example file tree and how to reference from within it.

**Page Layout**

The layout of each html webpage is different depending on the purpose and design of the website. A webpage can have any size or orientation desired. Most commonly pages are designed to fit well on a generic screen size. This section describes the parameters and features used in the design of this website’s page layout needed in when editing features of the webpage.

**Body Division**

- The main content of the page is within the body division (not to be confused with the body of the html document), which separates a 1000 pixel wide page from the background image. Height and width are defined in pixels to ensure that the page loads consistently in any size window.
- The division gives the web page visual depth and context on the screen while providing a standard width compatible with almost any screen. The body of the document contains a separate background image.
- It also controls page length using several different class types applied to the body division. The page length varies based on page content.
- When creating a new page it is important to consider page length which can be designated by the classes: long2, long, full, short1, and short2 (in order of longest to shortest respectively) ranging from a page height of 1300 pixels to 1900 pixels.

**Header**

- The header of each page is an inline frame with the filename: HEADER_ALT.html which is referenced using the link <iframe src="HEADER.html" id="headframe" frameborder="0" scrolling="no"></iframe> also shown in figure 2.
• As seen in the reference above the inline frame is defined by the id headframe that is referenced by the style sheet. It is also controlled by two inline styles, one defining the border width to be 0 (so no border appears) and the other turning scrolling off so that the frame will appear seamlessly on the page as if it were not a separate document. Note there is no content in the header.

• An inline frame is used to create the header on each page that references a separate html file and loads it as part of the current page. The advantage of this over simply writing the header into each file is that changes can be made to the one html file and applied universally.

• The frame is 1000 pixels wide and 500 pixels tall.

• The header file uses an internal style sheet that is separate from the universal style sheet. HEADER_ALT.html is the only file where LAKE_STYLE.css is not applicable.

Navigation

The navigation of the website uses a number of strategically placed links to guide the user through the pages. This section describes how these links are organized and how to edit them.

Main Navigation Bar

• The main navigation buttons are at the top of each page in the header and include: Home, Maps, Project Info, and Contact Us. Each is a standard link using the <a> element.

• The links in the header document are part of the top most file folder and therefore do not require a specific base reference.

• When inserting a link be sure to define the target window as the parent or the link will navigate from within the header inline frame instead of the full window.

Side Menus

• The Maps and Project Info pages have separate side menus for navigation through their content separate of main navigation links.

• These menus are a constant when navigating through the Maps or Project info pages but do not appear outside of them.

• Each is part of specific division structure that applies a border, text formatting, proper spacing and alignment on the page.

• To add a new menu box use <div id="box" class="maps" > altering the class designation to the desired page. The maps and info classes use different size boxes and page alignment.

Website Information Links

• At the bottom of each page is a horizontal rule, under which are links to the site plan and site map.
The site map outlines the organization of information on the entire website with links to every page. Next to it is a file directory describing the organization of files in the website folders. Both the site map and file directory are shown below.

To add this stamp use a division with the id “stamp” and the appropriate class for length, corresponding to the same classes used for page length.

Each individual link must be in a separate division “bar” to maintain spacing and text formatting.

Google Maps

This website features a series of Google Maps that display collection information. These maps are interactive, allowing for users to select points of interest and view them on the map. The maps are hosted by Google and must be edited through their website using an account controlled by the ILWA. Below describes the process of creating and editing these maps.

Creating a New Map

- To create a new map log into the Google website and select the maps page.
- On the left side under the Google logo are the options “get directions” and “my places”. Select “my places”.
- A red button should appear labeled create map.
- After selecting “create map” text boxes will appear allowing you to insert the map title and a short description is desired.
- On the map displayed in the center of the page you can add a point by selecting the marker in the right hand corner of the map.
- Place the marker in the desired location. A box should appear when the marker is placed allowing you to add information about that point.
- When the desired number of markers has been added select “done” on the left side of the page next to the map.

Editing an Existing Map

- To edit an existing map log into the Google account and select maps.
- The select “my places”, and the “maps” tab on the left side of the page.
- Select the desired map to edit and the red “edit” button should appear.

Linking Maps to the Webpage

- To add a map to the webpage simply copy and paste the link provided by google.
- This link can be found by selecting the desired map and selecting the link icon next to the print button in the upper right hand corner of the left column, under the Google logo.
Editing Individual Page Content

Editing basic html pages can be done quite easily using any text editor although Adobe Dreamweaver is recommended. Although the documents of this website are similar and contain the same shell, individual pages contain unique features and content organization that requires specific attention when editing. This section describes these features and how they differ from other pages.

Header

- The header is controlled by a single html document (HEADER.html) with an internal style sheet.
- This is the only document not controlled by LAKE_STYLE.css.
- Any changes to this document will be universal to every page as it appears on every page as an inline frame. The iframe itself is controlled by LAKE_STYLE.css.
- The tabs section controls the links on the main menu bar. To add links simply add a reference. For example: `<a href="SITEMAP.html"> SITE MAP </a>` references the sitemap file and displays the reference as the text SITE MAP.

Home Page (index)

- The main content of the home page is in the info division which contains text in paragraphs.
- The home page also features a news column on the left hand side. This column is the division #box. home.
- To add an entry, create a new division #data.home and reference it to the LAKE_NEWS.html file and appropriate anchor number, specified by #news6 for example. The reference url should look like this: “LAKE_NEWS.html#news4”.

Lake News Page

- To add an entry to the news page, create a new division with the #ndata.fullpage.
- Add anchor within the division with an id name with the number corresponding to the home page link. These numbers should just go in order to differentiate between links. This way the page will load centered on this entry when it is chosen. The anchor should look like so: `<a id="news2"> </a>`

Maps Home Page

- The title of the maps home page is designated by the division id “left”.
- A list of the individual map pages is the center of the page. These links are in the #arrows division. Each individual map is in the subdivision the id “single” for separate styling.
- Towards the bottom of the page is a series of bullets in the #bullets division.

Individual Map Pages

- The heading is again in the division with id “left”.
- Each page has a left side menu with a link to each map.
The links are in the division id "box" class "maps". Each link is a simple anchor and font style is controlled by the .maps class in the style sheet.

The text content appears below the map division id “centertext”, which uses paragraph attributes.

If a legend appears to the right of the map it is added as an image using the <img> attribute.

The map appears as an iframe in a link that is provided by Google maps. The position and border of the map is controlled using the id “MAP”.

The maps can be edited through a Google account made specifically for this project.

Project Info Pages

- The main content of the project info pages lies within the division id “INFO”. This division uses the paragraph attribute to organize text.
- On the left side is a menu of all project pages. This menu is in the division id “box” class “info”.
- To make sub-links of an info page stand out visually in the menu the #drop division is used to decrease the font size and indent the text.

Contact Us

- The main content of the contact us page features two divisions:
  - #names contains the contact information for individual people.
  - #feedback contains a paragraph about feedback and contact information for the group as a whole.

Site Map/ File Directory

- This page contains the division id “sitemap” that sits on the left side of the page. It lists a link to every page in the website. To add a link use the traditional <a> reference.
- On the right side is the file directory in the form of an image. This image can be edited separately of the website to include changes and the updated in the server files.

File Management

This section describes how to access, organize and upload files to the server. Files can be edited locally, separate of the server, and then uploaded to the server to update them.

Accessing Files

- This website is part of the ILWA’s official website ILWA.org and is hosted on their server.
- The ILWA home page is designated by the filename index.html, the same this homepage, but the folder directory is different.
- The base file directory is “http://ilwa.org/plant survey/” and all files pertaining to the survey website are in the "plant survey" folder.
• The files can be accessed and edited from the server using the program FileZilla. This allows you to edit and transfer files to and from the server.

Using FileZilla
• To access files you must first connect to the server by entering the required credentials in the menu bar at the top of the window. It requires the host, username, password and port number. Then click quickconnect to connect to the server.
• Once connected files can be transferred to and from the server by dragging them into the file queue at the bottom of the window. The left side of the window is local files and the right server files. Select the server side folder that you want to transfer files to and select transfer- process queue at the top of the navigation bar or keys (CTRL+P).
• To update files simply edit them locally and then transfer them onto the server. If the file is pre-existing you will need to overwrite the file.

File organization
• The main file folder includes a separate folder for the subsections Maps and Project Info of the website. There is also a separate folder for all images.
• The style sheet is in the top most folder with the home page.
• File folders are named in all capital text to make recognition easy in links.
• Files found in subfolders are named in all lower case font.
• The file directory is shown below
Site Map

▼ Home:

▼ Maps Home
  ► Total Collection Map
  ► Color Coded Distribution Map
  ► Milfoil Distribution Map
  ► Small Pond Weed Distribution Map
  ► Emergent Plant Distribution Map
  ► Flow Distribution Map
  ► Depth Distribution Map

▼ Project Overview
  ► About Indian Lake
  ► Eutrophication
  ► Collection Process
  ▼ Aquatic Plant Life
  ► Submergent Plants
  ► Emergent Plants
  ► Survey Results
  ► Submarginal Plants
  ► Emergent and Floating Plants
  ► Current Flow
  ► Effect of Depth
  ► Conclusions
  ► Full Report

► Lake News

▼ Contact Us
  ► Site Plan
  ► Site Map

File Directory

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Figures

Figure 1: An example file tree and how to reference within it.

Consider for example you are currently in file 2. If you want to access the home page you must first reference the file tree folder. The proper reference would be: C:\Example file tree\ home page for the home page or C:\Example file tree\Folder 1\ File 1 for file 1. If the base folder is not referenced then the browser will search for: Folder 2\ Home Page which does not exist.

Figure 2: An example of the beginning of an html document.
The side menus are defined by a series of divisions, the uppermost being the box id. Different classes are used to define variations in placement and size.

Each page has a "stamp" division which is the information on the bottom of each page including links to the site plan, site map, and contact us page.

All tags must be closed. This is defined with forward slash. For example <html> opens the document and <html> closes it.

Figure 3: An example of the end of an html document
References


Costa, E., Mason, V., Waller, C. "Little Indian Lake: Diagnostic Study." 2010. Print


http://www.waterontheweb.org


