8.4 BIG LAKE

8.4.1 An Introduction to Big Lake

Big Lake, Oneida County, is a drainage lake with a maximum depth of 27 feet and a surface area of 865 acres. This eutrophic lake has a relatively large watershed when compared to the size of the lake. Big Lake contains 32 native plant species, of which wild celery was the most common plant. Two wetland exotic plants were observed during the 2010 lake surveys.

Field Survey Notes

Rough water conditions experienced during survey on August 5th. Several otters spotted near island – very playful critters!

Purple loosestrife plant located along shoreline. Plant was hand-pulled entirely, location marked with GPS coordinates.

Photo 8.4.1-1 Big Lake, Oneida County

Lake at a Glance – Big Lake

Morphology	
Acreage	865
Maximum Depth (ft)	27
Mean Depth (ft)	12
Volume (acre-feet)	10,810
Shoreline Complexity	2.6
Vegetation	
Curly-leaf Survey Date	June 18, 2010
Comprehensive Survey Date	August 5 & 9, 2010
Number of Native Species	32
Threatened/Special Concern Species	-
Exotic Plant Species	Amur silver grass & Purple loosestrife
Simpson's Diversity	0.89
Average Conservatism	6.6
Water Quality	
Wisconsin Lake Classification	Deep, lowland drainage lake
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	52:1

8.4.2 Big Lake Watershed Assessment

Big Lake's watershed is 45,504 acres in size. Compared to Big Lake's size of 865 acres, this makes for a large watershed to lake area ratio of 52:1.

Exact land cover calculation and modeling of nutrient input to Big Lake will be completed towards the end of this project (in 2015-2016). By this time, the latest satellite imagery (and thus the most accurate land cover delineation) will be available. Additionally, when water quality sampling of the upper reaches of the chain is completed, these results will be input to predictive models and thus make the modeling of nutrient input to the entire chain more accurate.

As mentioned previously in the Chain-wide Watershed Section, one of the most sensitive areas of the watershed is the immediate shoreland area. This area of land is the last source of protection for a lake against surface water runoff, and is also a critical area for wildlife habitat. In late summer of 2010, Big Lake's immediate shoreline was assessed in terms of its development. Big Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 3.7 miles of natural/undeveloped and developed-natural shoreline (52% of the shoreline) were observed during the survey (Figure 8.4.2-1). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.2 miles of urbanized and developed–unnatural shoreline (17% of the total shoreline) was observed. If restoration of the Big Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Big Lake Map 1 displays the location of these shoreline lengths around the entire lake.

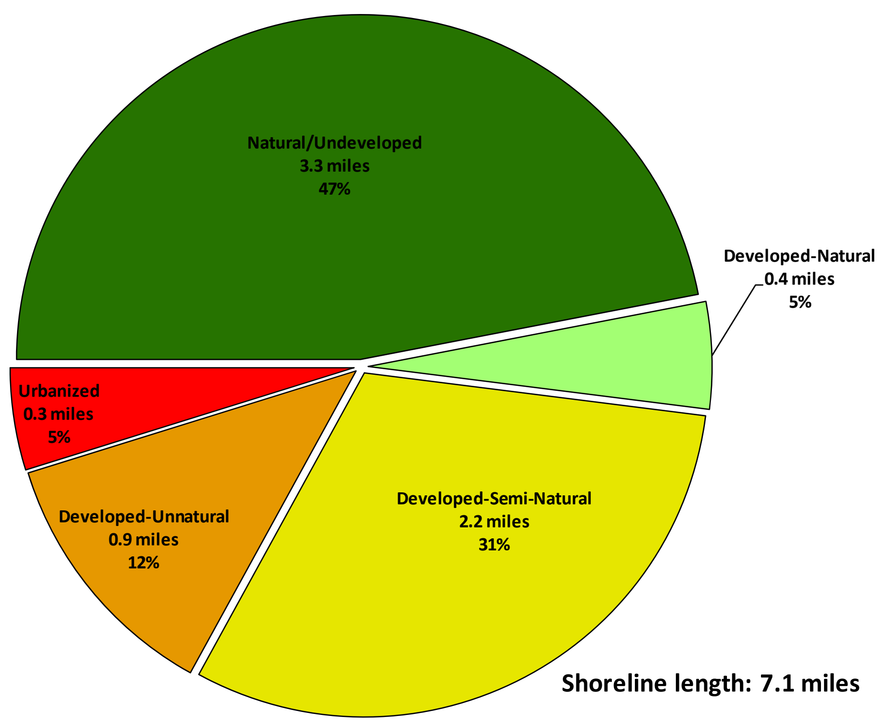

Figure 8.4.2-1. Big Lake shoreland categories and total lengths. Based upon a late summer 2010 survey. Locations of these categorized shorelands can be found on Big Lake Map 1.

8.4.3 Big Lake Water Quality

Water quality data was collected from Big Lake on three occasions in summer of 2010. Onterra staff sampled the lake for a variety of water quality parameters including total phosphorus, chlorophyll-*a*, Secchi disk clarity, temperature, and dissolved oxygen.

Citizens Lake Monitoring Network (CLMN) volunteers have monitored water quality through an advanced monitoring program since 2006. These efforts provide a considerable amount of data which may be compared against recent data in an effort to detect any trends that may be occurring in the water quality of the lake. These efforts should be continued in order to understand trends in the water quality of Big Lake.

During this time, summer average total phosphorus concentrations have fluctuated slightly, ranging between 25.0 and 37.0 μg/L (Figure 8.4.3-1). These average values rank within the TSI categories of *Good* and *Excellent*, and a weighted value across all years is slightly lower than the median value for shallow, lowland drainage lakes in the state of Wisconsin. Average chlorophyll-*a* concentrations have shown some variation within the dataset (Figure 8.4.3-2). Most values fall within the TSI *Excellent* category, though some rank as *Good*. The weighted average across all years is similar to the median for other shallow, lowland drainage lakes statewide.

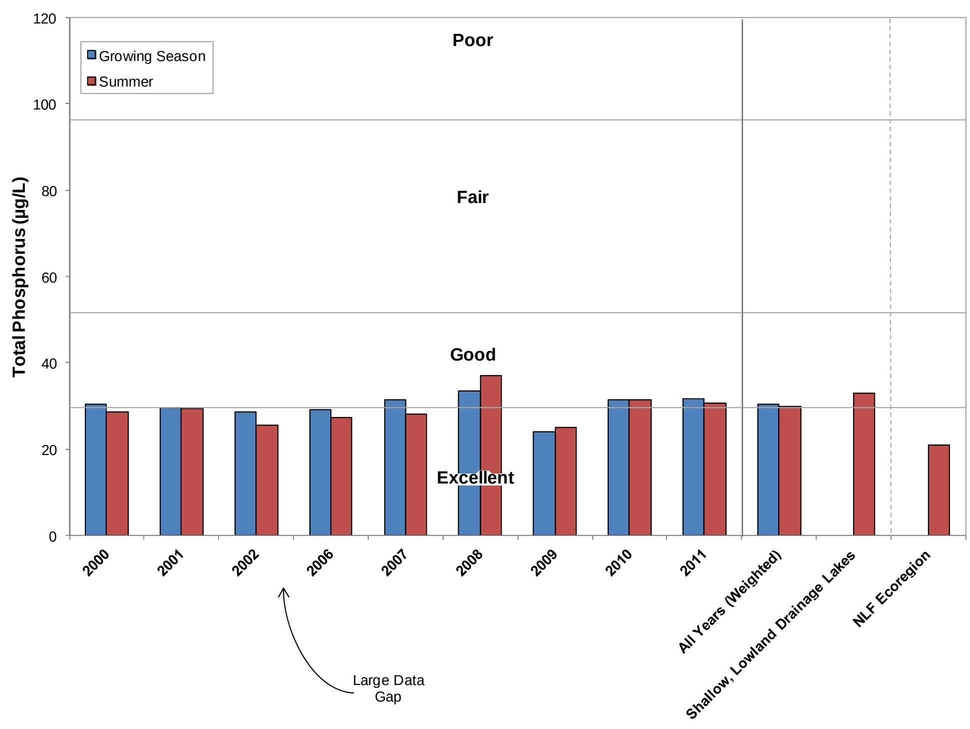

Figure 8.4.3-1. Big Lake, state-wide shallow, lowland drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

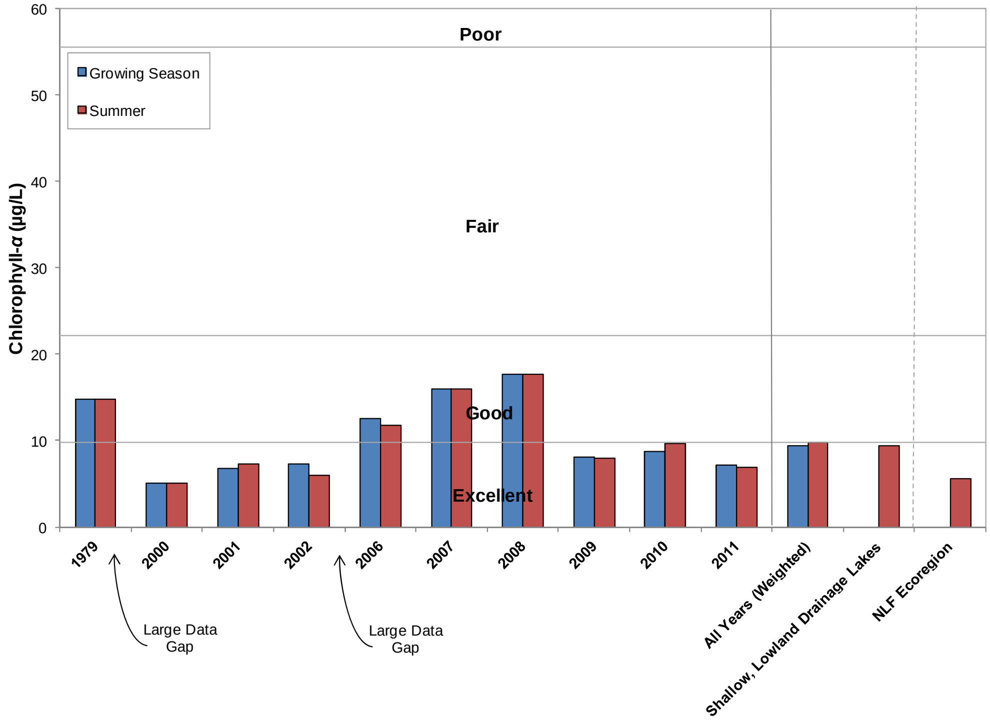

Figure 8.4.3-2. Big Lake, state-wide shallow, lowland drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Measurements of Secchi disk clarity span a longer timeframe than the other two primary water quality parameters, and show little annual variance (Figure 8.4.3-3). All summer averages range between categories of *Fair* and *Good*, and a weighted average across all years is less than the median for shallow, lowland drainage lakes statewide. Secchi disk clarity is often tied to algal abundance – the more algae in the water column, the less clear the water will be. It is likely, however, that another factor is limiting the water clarity in Big Lake.

Secchi disk clarity is influenced by many factors, including plankton production and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. In lakes such as the Three Lakes Chain of lakes, a natural staining of the water plays a role in light penetration, and thus water clarity, as well. The darker waters of Big Lake contain many organic acids that are washed into the lake from nearby wetlands. The acids are not harmful to humans or aquatic species; they are by-products of decomposing wetland plant species. This natural staining reduces light penetration into the water column, which reduces visibility but also reduces the growing depth of aquatic vegetation within the lake. Indeed, during the point-intercept aquatic vegetation survey that took place on Big Lake in 2010, aquatic plants were found growing to a maximum depth of seven feet.

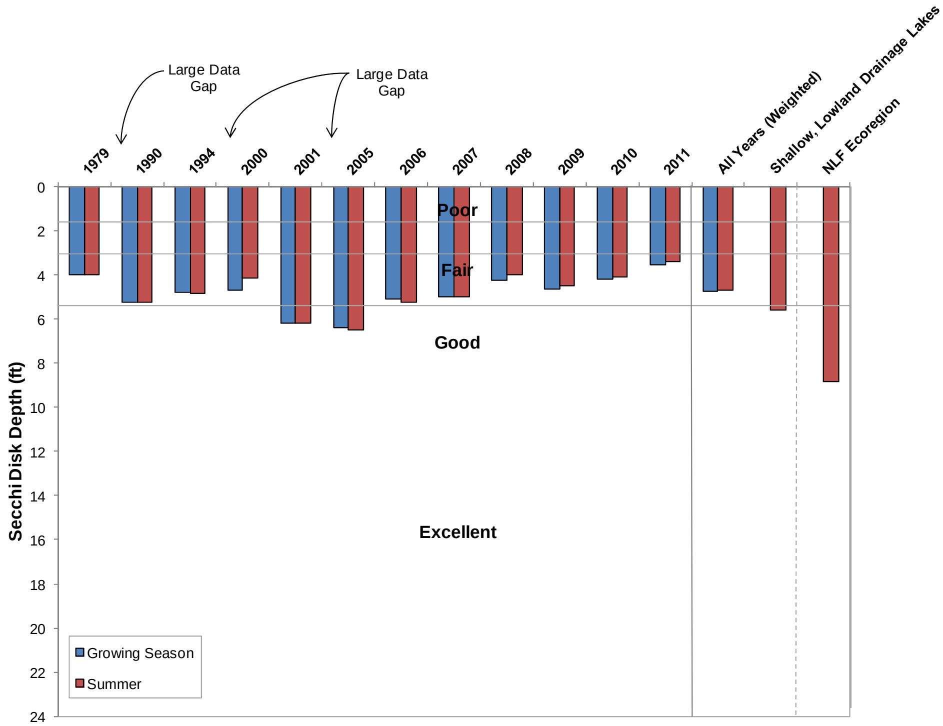

Figure 8.4.3-3. Big Lake, state-wide shallow, lowland drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Big Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper mesotrophic to eutrophic (Figure 8.4.3-4). In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Big Lake is in a eutrophic state.

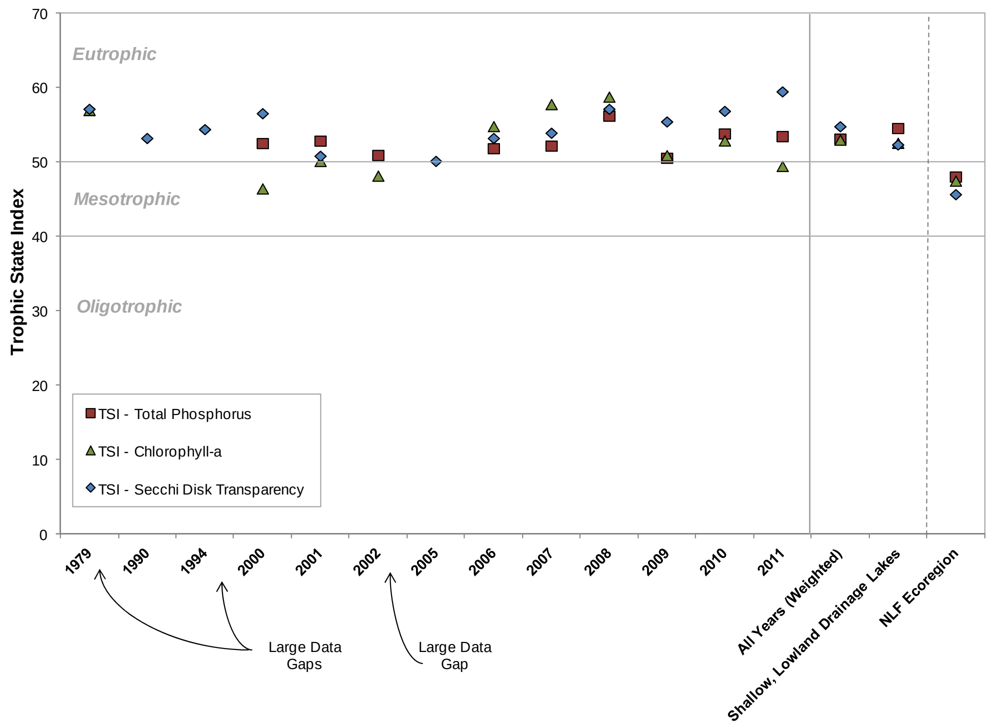

Figure 8.4.3-4. Big Lake, state-wide deep, lowland drainage lakes, and regional Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Big Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Big Lake by Onterra staff. Graphs of those data are displayed in Figure 8.4.3-5 for all sampling events.

Big Lake remained thoroughly mixed throughout most of the summer months in 2010, though a small amount of stratification likely occurs periodically in the deeper portions of the lake as seen in the August profile. This is not uncommon in lakes that are large in size and moderately deep. Energy from the wind is sufficient to mix the lake from top to bottom, distributing oxygen throughout the epilimnion and hypolimnion and keeping water temperatures fairly constant within the water column.

Decomposition of organic matter along the lake bottom is likely the cause of the slight decrease in dissolved oxygen observed in the summer and winter months. Despite this decrease in oxygen near the bottom of the lake, levels remained sufficient to support most aquatic life found in northern Wisconsin lakes. Dissolved oxygen was also ample during the winter months of 2011, when oxygen may decrease due to ice cover on the lake and lack of oxygen production from plants and algae.

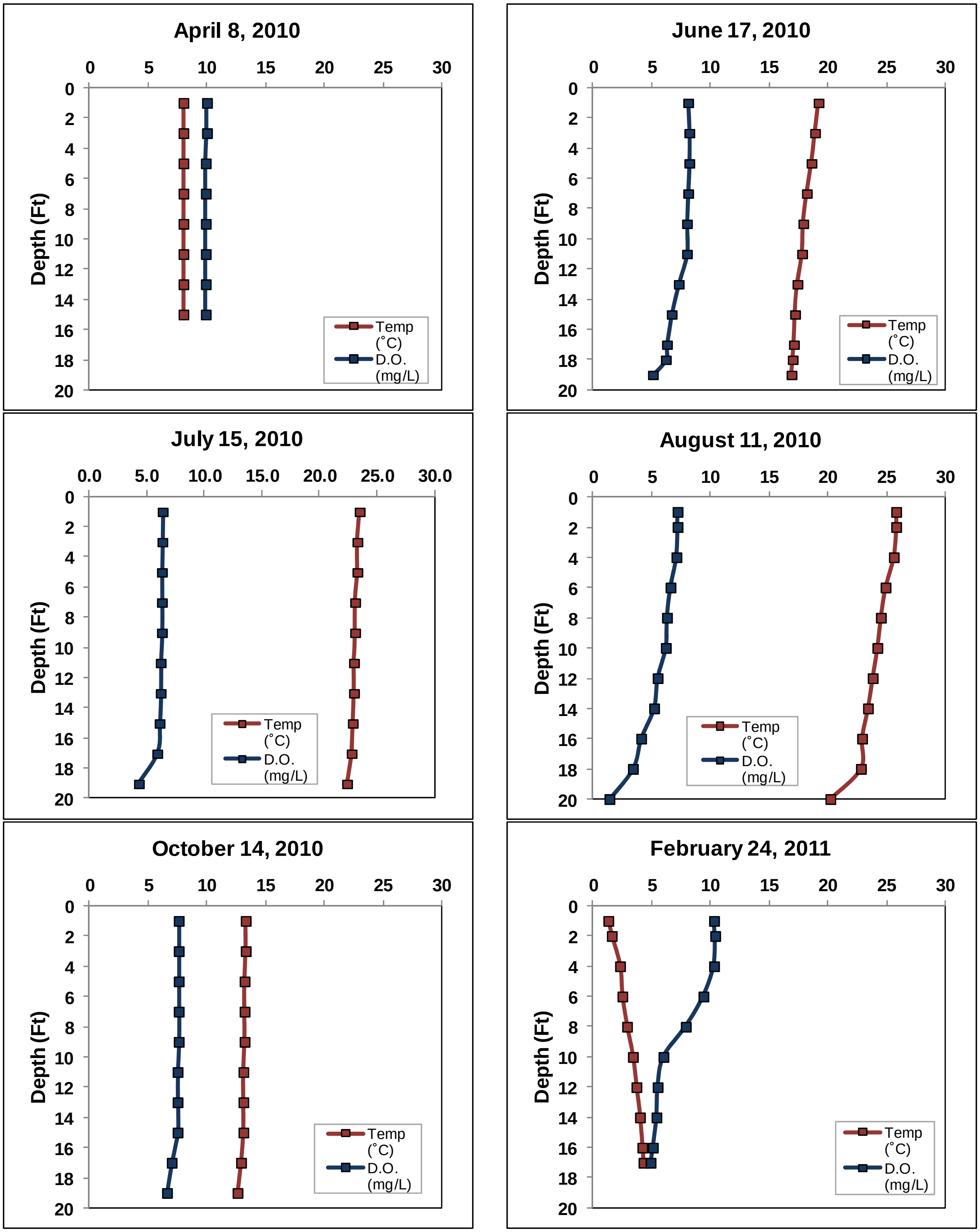

Figure 8.4.3-5. Big Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Big Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Big Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

As the Chainwide Water Quality Section explains, the pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is thus an index of the lake's acidity. Big Lake's pH was measured at roughly 7.3 in the summer months of 2010. This value is near neutral and fall within the normal range for Wisconsin lakes.

A lake's pH is primarily determined by the amount of alkalinity that is held within the water. Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. Lakes with low alkalinity have higher amounts of the bicarbonate compound (HCO_3^-) while lakes with a higher alkalinity have more of the carbonate compound of alkalinity ($CO_3^=$). The bicarbonate form is better at buffering acidity, so lakes with higher alkalinity are less resistant to acid rain than those with lower alkalinity. The alkalinity in Big Lake was measured at 24.0 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Samples of calcium were also collected from Big Lake during the summer of 2010. Calcium is commonly examined because invasive and native mussels use the element to build shells and in reproduction. Invasive mussels typically require higher calcium concentrations than native mussels. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Big Lake's pH of 7.3 falls slightly outside of this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Big Lake was found to be 8.0 mg/L, falling below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2010 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval mussels) were found within these samples.

8.4.4 Big Lake Aquatic Vegetation

The curly-leaf pondweed survey was conducted on Big Lake on June 18, 2010. This meander-based survey did not locate any occurrences of this exotic plant, and it is believed that this species either does not currently exist in Big Lake or is present at an undetectable level.

The aquatic plant point-intercept survey was conducted on Big Lake on August 5 & 9, 2010 by Onterra. The floating-leaf and emergent plant community mapping survey was completed on August 11 to create the aquatic plant community map (Big Lake Map 2). During all surveys, 32 species of native aquatic plants were located in Big Lake (Table 8.4.4-1). 23 of these species were sampled directly during the point-intercept survey and are used in the analysis that follows. Additionally, two species of emergent exotic plants were found on the Big Lake shoreline – amur silver grass and purple loosestrife. Submergent aquatic plants were found growing to a depth of seven feet, which is not uncommon for lakes as heavily stained as Big Lake (see the Big Lake Water Quality Section for discussion on Big Lake's water clarity). As discussed later on within this section, many of the species found in this survey indicate that the overall aquatic plant community is healthy and diverse.

Of the 236 point-intercept locations sampled within the littoral zone, approximately 56% contained aquatic vegetation. Approximately 59% of the point-intercept sampling locations where sediment data was collected at were sand, 37% consisted of a fine, organic substrate (muck) and 4% were determined to be rocky (Chain-wide Fisheries Section, Figure 3.4-5).

Table 8.4.4-1. Aquatic plant species located in the Big Lake during the 2010 aquatic plant surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2010 (Onterra)
Emergent	*Carex crinita*	Fringed sedge	6	I
	Carex utriculata	Common yellow lake sedge	7	I
	Calla palustris	Water arum	9	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Equisetum fluviatile	Water horsetail	7	X
	Eleocharis palustris	Creeping spikerush	6	X
	Glyceria canadensis	Rattlesnake grass	7	I
	Lythrum salicaria	Purple loosestrife	Exotic	I
	Miscanthus sacchariflorus	Amur silver grass	Exotic	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Scirpus cyperinus	Wool-grass	4	I
	Zizania palustris	Northern wild rice	8	X
FL	*Nymphaea odorata*	White water lily	6	X
	Nuphar variegata	Spatterdock	6	X
FL/E	*Sparganium eurycarpum*	Common bur-reed	5	X
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
Submergent	*Ceratophyllum demersum*	Coontail	3	X
	Elodea canadensis	Common waterweed	3	X
	Isoetes echinospora	Spiny-spored quilwort	8	X
	Myriophyllum sibiricum	Northern water milfoil	7	X
	Megalodonta beckii	Water marigold	8	X
	Nitella sp.	Stoneworts	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton natans	Floating-leaf pondweed	5	I
	Potamogeton strictifolius	Stiff pondweed	8	X
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Utricularia intermedia	Flat-leaf bladderwort	9	I
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
SE	*Eleocharis acicularis*	Needle spikerush	5	X
FF	*Lemna trisulca*	Forked duckweed	6	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free-Floating
X = Located on rake during point-intercept survey; I = Incidental Species

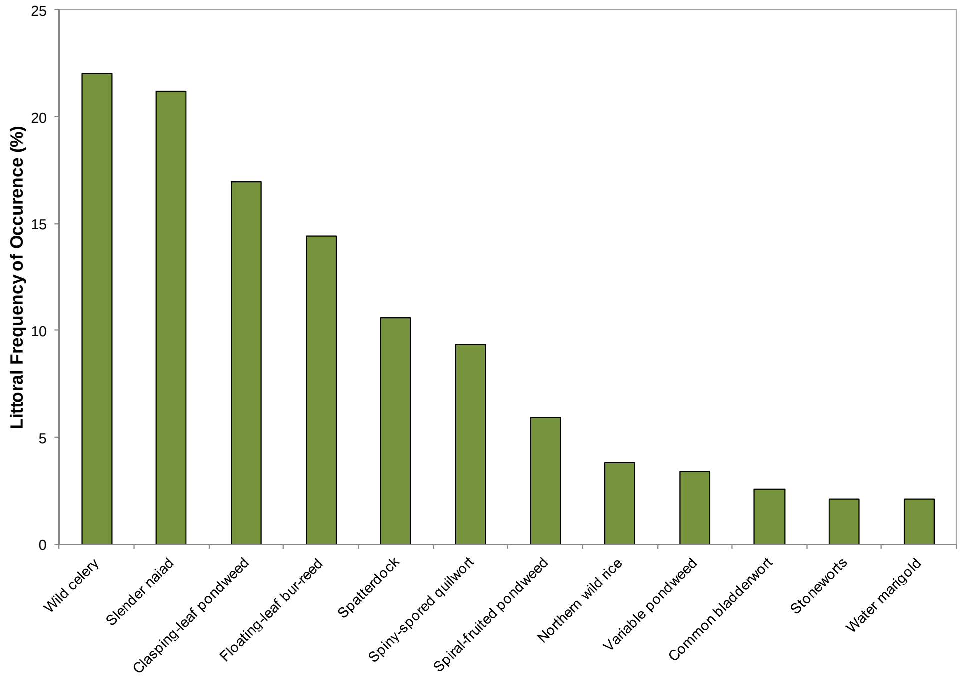

Figure 8.4.4-1 Big Lake aquatic plant littoral frequency of occurrence analysis. Chart includes species with a frequency occurrence greater than 1.0% only. Created using data from a 2010 point-intercept survey.

Figure 8.4.4-1 (above) shows that wild celery, slender naiad and clasping-leaf pondweed were the most frequently encountered plants within Big Lake. Wild celery is a submerged aquatic plant with ribbon-shaped floating leaves that may grow to as long as two meters, depending on water depth. It is a preferred food choice by numerous species of waterfowl and aquatic invertebrates. As its name implies, slender naiad is a slender, low-growing species with narrow, short pale green leaves. This submerged plant provides habitat for small aquatic organisms and is also a food source of waterfowl. Clasping-leaf pondweed is a submergent plant that has oval to somewhat lance-shaped leaves that "clasp" around one-half to three-quarters of the stem circumference. Unlike many other pondweeds, this plant does not produce floating leaves.

Of the seven milfoil species (genus *Myriophyllum*) found in Wisconsin, one was located within Big Lake. Northern water milfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and higher water clarity. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the reddish appearance of Eurasian water milfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern water milfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

32 species of native aquatic plants (including incidentals) were found in Big Lake and because of this, one may assume that the system would also have a high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Big Lake's plant community (0.89) lies above the Northern Lakes and Forests Lakes ecoregion value (0.86), indicating the lake holds good diversity.

As explained earlier in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while wild celery was found at 22% of the sampling locations, its relative frequency of occurrence is 18%. Explained another way, if 100 plants were randomly sampled from Big Lake, 18 of them would be wild celery. This distribution can be observed in Figure 8.4.4-2, where together 10 species account for 88% of the population of plants within Big Lake, while the other 13 species account for the remaining 12%. Eleven additional species (native and non-native) were located from the lake but not from of the point-intercept survey, and are indicated in Table 8.4.4-1 as incidentals.

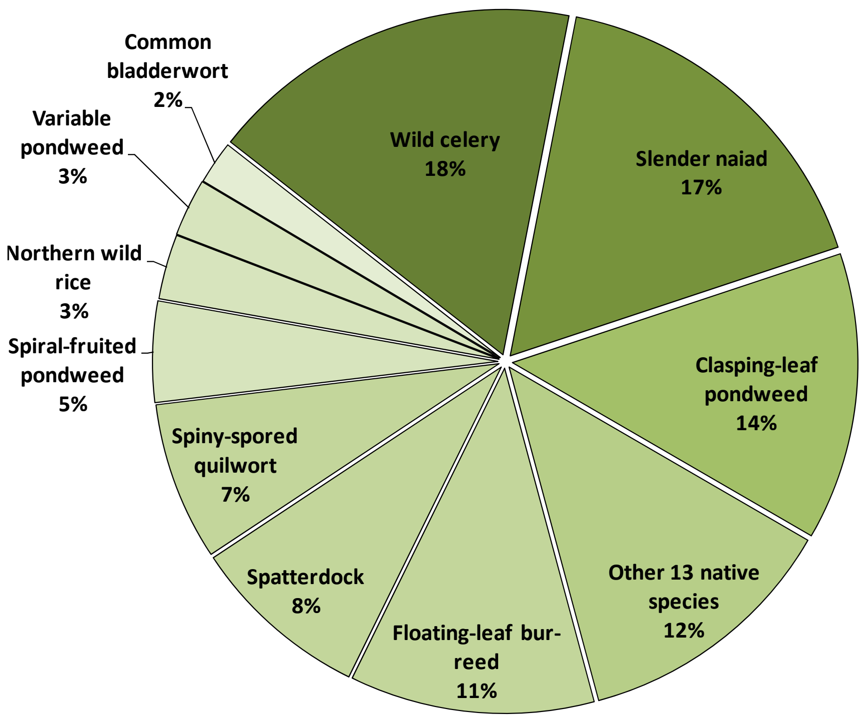

Figure 8.4.4-2 Big Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2010 point-intercept survey.

Big Lake's average conservatism value (6.6) is higher than the state median (6.0) but slightly under the ecoregion median (6.7). This indicates that the plant community of Big Lake is indicative of a moderately disturbed system. This is not surprising considering Big Lake's plant community has good diversity and fairly high species richness. Combining Big Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a high value of 31.5 which is above the median values of the ecoregion and state.

The quality of Big Lake is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in many areas. The 2010 community map indicates that approximately 15.6 acres of the lake contains these types of plant communities (Big Lake Map 2,

Table 8.4.4-2). Fifteen floating-leaf and emergent species were located on Big Lake (Table 8.4.4-1), all of which provide valuable wildlife habitat.

Table 8.4.4-2. Big Lake acres of emergent and floating-leaf plant communities from the 2010 community mapping survey.

Plant Community	Acres
Emergent	4.7
Floating-leaf	5.5
Mixed Floating-leaf and Emergent	114.9
Total	125.1

The community map represents a ‘snapshot’ of the emergent and floating-leaf plant communities, replications of this survey through time will provide a valuable understanding of the dynamics of these communities within Big Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also Lost a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Aquatic Invasive Species in Big Lake

During the 2011 community mapping survey, a single purple loosestrife plant was located on the shoreline of Big Lake (Big Lake Map 2). Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930’s, it has now spread to 70 of the state’s 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

The single plant that was found on Big Lake was carefully pulled by Onterra staff. Volunteer monitoring of this location and the Big Lake shoreline in general is recommended to spot any other occurrences of purple loosestrife. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal – all of which have proven to be successful with continued and aggressive effort. Detailed discussion regarding this control effort will be discussed in the Implementation Plan.

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