8.8 BIG STONE LAKE

8.8.1 An Introduction to Big Stone Lake

Big Stone Lake, Oneida County, is a drainage lake with a maximum depth of 57 feet and a surface area of 548 acres. This lake has a relatively large watershed when compared to the size of the lake. Big Stone Lake contains 33 native plant species, of which wild celery was the most common plant. Purple loosestrife, an invasive wetland plant, was observed during the 2011 lake surveys.

Field Survey Notes

Much purple loosestrife observed in the southeastern wetland area of lake. Another colony spotted near Hwy 32.

Lake is quite deep. The littoral region is dominated by a sandy substrate.

Photo 8.8.1-1 Big Stone Lake, Oneida County

Lake at a Glance – Big Stone Lake

Morphology	
Acreage	548
Maximum Depth (ft)	57
Mean Depth (ft)	21
Volume (acre-feet)	11,701
Shoreline Complexity	4.4
Vegetation	
Curly-leaf Survey Date	June 21, 2011
Comprehensive Survey Date	August 10, 2011
Number of Native Species	33
Threatened/Special Concern Species	-
Exotic Plant Species	Purple loosestrife
Simpson's Diversity	0.65
Average Conservatism	7.1
Water Quality	
Wisconsin Lake Classification	Deep, lowland drainage
Trophic State	Eutrophic / mesotrophic
Limiting Nutrient	Phosphorus
Watershed to Lake Area Ratio	99:1

8.8.2 Big Stone Lake Watershed Assessment

Big Stone Lake's watershed is 55,027 acres in size. Compared to Big Stone Lake's size of 548 acres, this makes for an incredibly large watershed to lake area ratio of 99:1.

Exact land cover calculation and modeling of nutrient input to Big Stone 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 2011, Big Stone Lake's immediate shoreline was assessed in terms of its development. Big Stone Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 1.8 miles of natural/undeveloped and developed-natural shoreline (26% of the entire shoreline) were observed during the survey (Figure 8.8.2-1). 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, 2.1 miles of urbanized and developed–unnatural shoreline (30% of the total shoreline) was observed. If restoration of the Big Stone 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 Stone Lake Map 1 displays the location of these shoreline lengths around the entire lake.

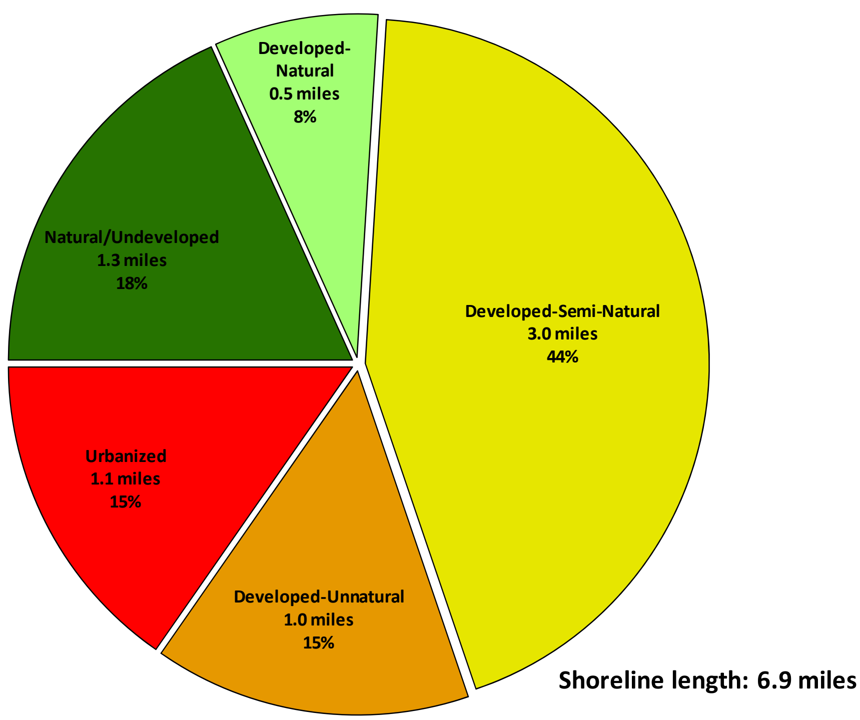

Figure 8.8.2-1. Big Stone Lake shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on the Big Stone Lake Map 1.

8.8.3 Big Stone Lake Water Quality

During 2011/2012, water quality data was collected from Big Stone Lake on six occasions. 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 Secchi disk clarity since 2006, with advanced monitoring (total phosphorus and chlorophyll-*a*) beginning in 2007. These efforts provide consistent, reliable data on which a comparable database may be built. Monitoring should be continued in order to understand trends in the water quality of Big Stone Lake for years to come.

During this time, summer average total phosphorus concentrations have fluctuated little, ranging between 18.8 and 26.7 µg/L (Figure 8.8.3-1). These average values rank within the TSI category of *Good*. A weighted value across all years is nearly equal to the median for deep, lowland drainage lakes in the state of Wisconsin. As with the total phosphorus values, average chlorophyll-*a* concentrations also rank in the *Good* category, and a weighted average is nearly equal to the median concentration for similar lakes across the state (Figure 8.8.3-2). Very little fluctuation is seen in this small dataset.

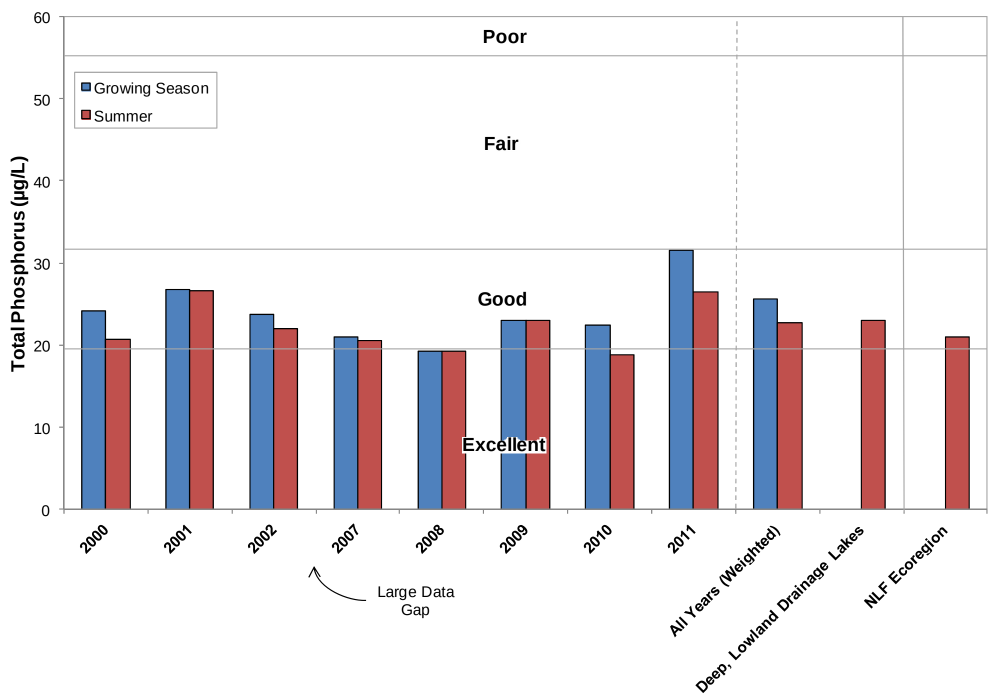

Figure 8.8.3-1. Big Stone Lake, state-wide deep, lowland drainage lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

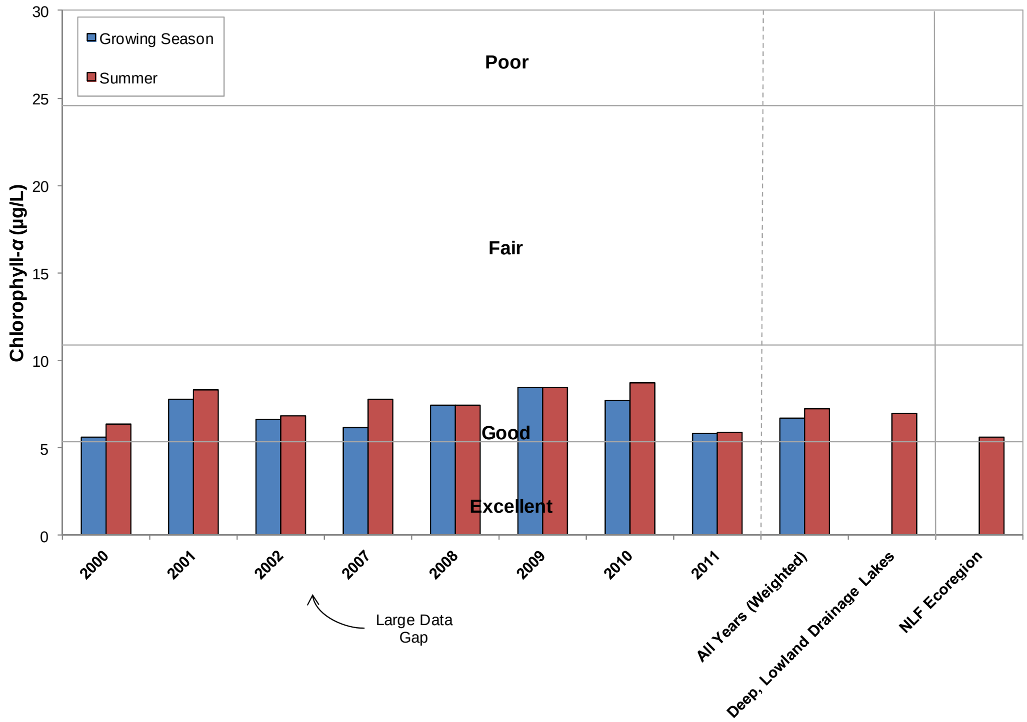

Figure 8.8.3-2. Big Stone Lake, state-wide deep, lowland drainage lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Measurements of Secchi disk clarity span a similar timeframe as the other two primary water quality parameters, and show a little annual variance as well (Figure 8.8.3-3). All summer averages range between categories of *Fair* and *Good*, though a weighted average across all years is less than the median for deep, 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. However, other factors may influence the clarity of a lake's water as well. For example, in 2011 Onterra ecologists noted exceptionally dark water – more so than in previous years when studies had been completed on the Three Lakes Chain of lakes. As seen in Figure 8.8.3-1, nutrient levels were slightly higher in 2011, but chlorophyll-*a* concentrations were not elevated; in fact, they were slightly lower than in previous years (Figure 8.8.3-2). In that same year, the Secchi disk depth summer average was roughly 2.5 feet lower than in previous years (Figure 8.8.3-3). Clearly, presence or absence of algae is not the cause of the reduced water clarity in 2011.

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 Stone 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. It is possible that wetlands flushed the Three Lakes Chain with these organic acids in 2011. Even with higher-than-normal nutrients in the water column, the natural staining of the water reduced visibility as well as light penetration, which is likely the cause for relatively limited algal production in that year.

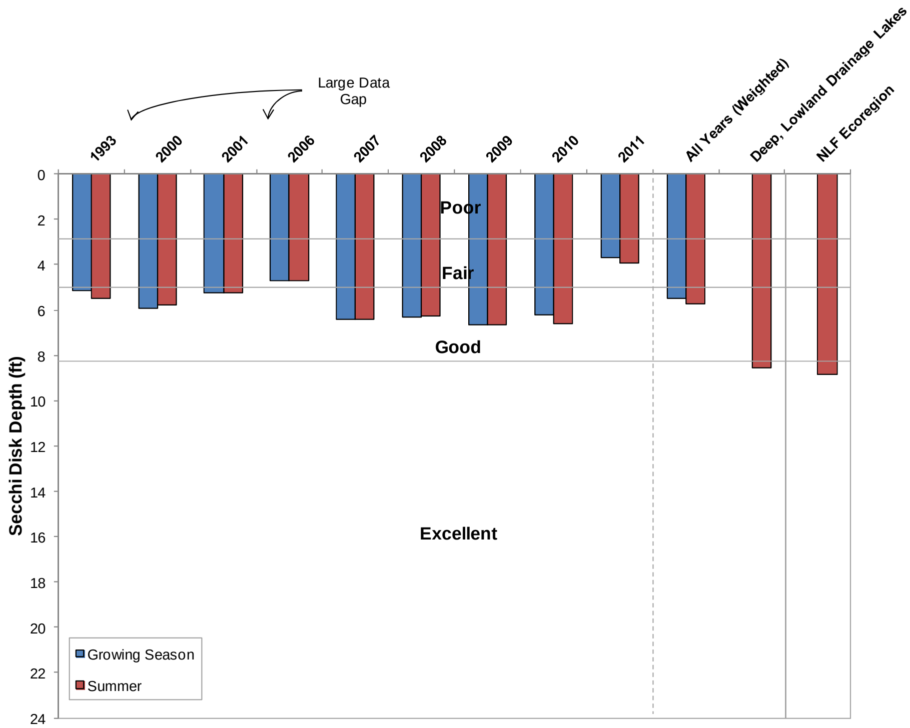

Figure 8.8.3-3. Big Stone Lake, state-wide deep, lowland drainage lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Big Stone Lake Trophic State

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to eutrophic (Figure 8.8.3-4). 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 Stone Lake is in a borderline eutrophic/mesotrophic state.

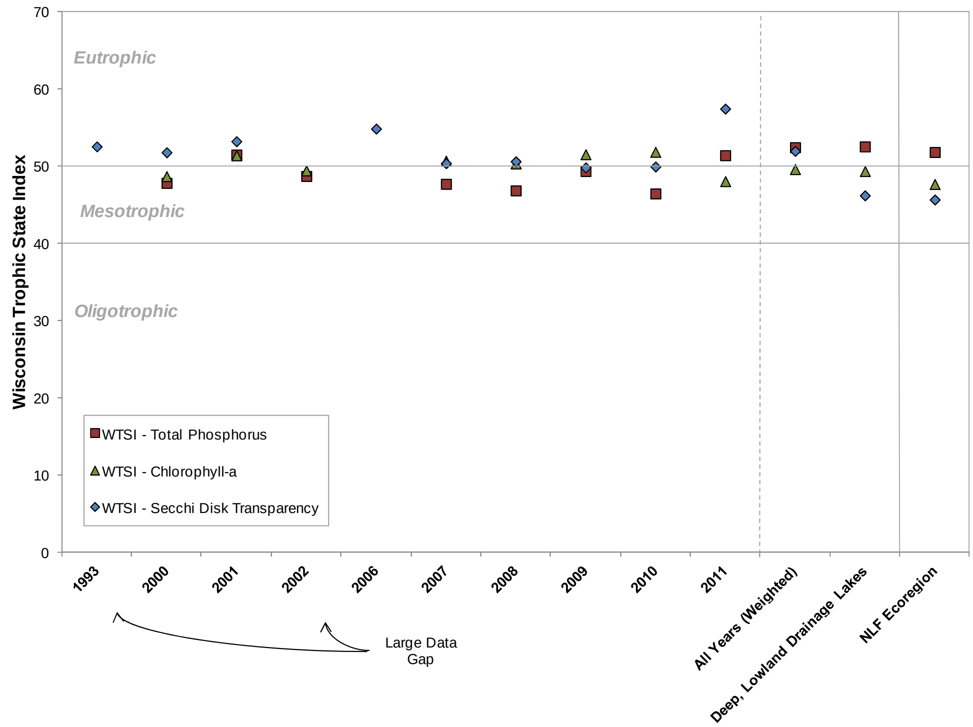

Figure 8.8.3-4. Big Stone Lake, state-wide deep, lowland drainage lakes, and regional Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Big Stone Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Big Stone Lake by Onterra staff. Graphs of those data are displayed in Figure 8.8.3-5 for all sampling events.

Big Stone Lake mixed thoroughly during the spring (May) and fall (October) of 2011. This is the case in many Wisconsin lakes, as high winds and changing air temperatures during this time mix the water column up and distribute temperatures and oxygen throughout the lake. In the early summer months, the lake begins to stratify as temperatures increase in the top of the water column and remain constant towards the bottom. Dissolved oxygen is used by bacteria near the bottom of the lake to breakdown organic matter. As the decomposition occurs, oxygen is depleted and not replenished from the overlying water, which becomes stratified by June and continues through August. Once the fall winds begin, the lake mixes completely and oxygen is restored to the bottom of Big Stone Lake. Despite the late summer dip, dissolved oxygen levels remained sufficient in the upper 20 feet of the water column to support most aquatic life found in northern Wisconsin lakes. Ample oxygen concentrations were also present within the winter months of 2012 as well, when dissolved oxygen is of most concern.

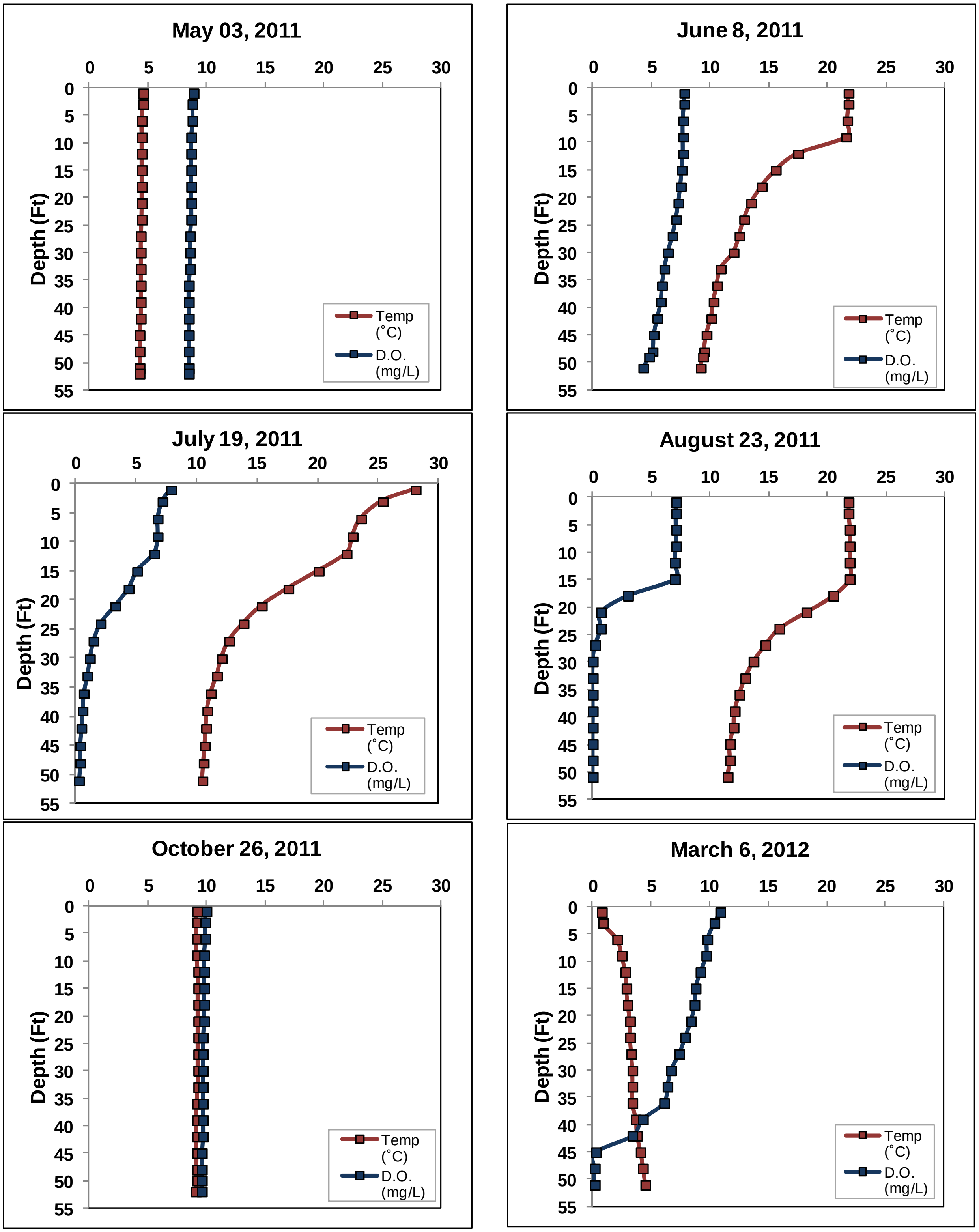

Figure 8.8.3-5. Big Stone Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Big Stone 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 Stone 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 Stone Lake's pH was measured at 7.0 during the summer months of 2011. This value is neutral and falls 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 Stone Lake was measured at 21.3 (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 Stone Lake during the summer of 2011. 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 Stone Lake's pH of 7.0 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 Stone Lake was found to be 7.8 mg/L, falling well below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2011 and these samples were processed by the WDNR for larval zebra mussels. Results to be included in next draft.

8.8.4 Big Stone Lake Aquatic Vegetation

The curly-leaf pondweed survey was conducted on Big Stone Lake on June 21, 2011. This meander-based survey did not locate any occurrences of this exotic plant, and it is believed that this species either does not exist in Big Stone Lake or is present at an undetectable level.

The aquatic plant point-intercept survey was conducted on Big Stone Lake on August 10, 2011 by Onterra. The floating-leaf and emergent plant community mapping survey was completed on that same day to create the aquatic plant community map (Big Stone Lake Map 2). During all surveys, 33 species of native aquatic plants were located in Big Stone Lake (Table 8.8.4-1). 22 of these species were sampled directly during the point-intercept survey and are used in the analysis that follows. Aquatic plants were found growing to a depth of seven feet, which is comparable to the maximum depth of plant growth within the other Three Lakes Chain of lakes. As discussed later on within this section, many of the plants found in these surveys indicate that the overall aquatic plant community is healthy and fairly diverse.

Of the 170 point-intercept locations sampled within the littoral zone, approximately 66% contained aquatic vegetation. Approximately 92% of the point-intercept sampling locations where sediment data was collected at were sand, 4% consisted of a fine, organic substrate (muck) and 5% were determined to be rocky (Chain-wide Fisheries Section, Figure 3.4-5).

Table 8.8.4-1. Aquatic plant species located in the Big Stone Lake during the 2011 aquatic plant surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2011 (Onterra)
Emergent	*Calla palustris*	Water arum	9	*I*
	Dulichium arundinaceum	Three-way sedge	9	*I*
	Decodon verticillatus	Water-willow	7	*I*
	Eleocharis palustris	Creeping spikerush	6	*I*
	Iris versicolor	Northern blue flag	5	*I*
	Lythrum salicaria	Purple loosestrife	Exotic	*I*
	Pontederia cordata	Pickerelweed	9	*X*
	Sagittaria latifolia	Common arrowhead	3	*I*
	Scirpus cyperinus	Wool grass	4	*I*
	Typha spp.	Cattail spp.	1	*I*
	Zizania palustris	Northern wild rice	8	*X*
FL	*Brasenia schreberi*	Watershield	7	*X*
	Nymphaea odorata	White water lily	6	*X*
	Nuphar variegata	Spatterdock	6	*X*
FL/E	*Sparganium emersum*	Short-stemmed bur-reed	8	*I*
	Sparganium eurycarpum	Common bur-reed	5	*I*
	Sparganium fluctuans	Floating-leaf bur-reed	10	*X*
Submergent	*Callitriche palustris*	Common water starwort	8	*X*
	Ceratophyllum demersum	Coontail	3	*X*
	Myriophyllum sibiricum	Northern water milfoil	7	*I*
	Najas flexilis	Slender naiad	6	*X*
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	*X*
	Potamogeton obtusifolius	Blunt-leaf pondweed	9	*X*
	Potamogeton amplifolius	Large-leaf pondweed	7	*X*
	Potamogeton pusillus	Small pondweed	7	*X*
	Potamogeton robbinsii	Fern pondweed	8	*X*
	Potamogeton zosteriformis	Flat-stem pondweed	6	*X*
	Potamogeton vaseyi	Vasey's pondweed	10	*X*
	Potamogeton spirillus	Spiral-fruited pondweed	8	*X*
	Potamogeton richardsonii	Clasping-leaf pondweed	5	*X*
	Potamogeton gramineus	Variable pondweed	7	*X*
	Utricularia vulgaris	Common bladderwort	7	*X*
	Vallisneria americana	Wild celery	6	*X*
SE	*Eleocharis acicularis*	Needle spikerush	5	*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

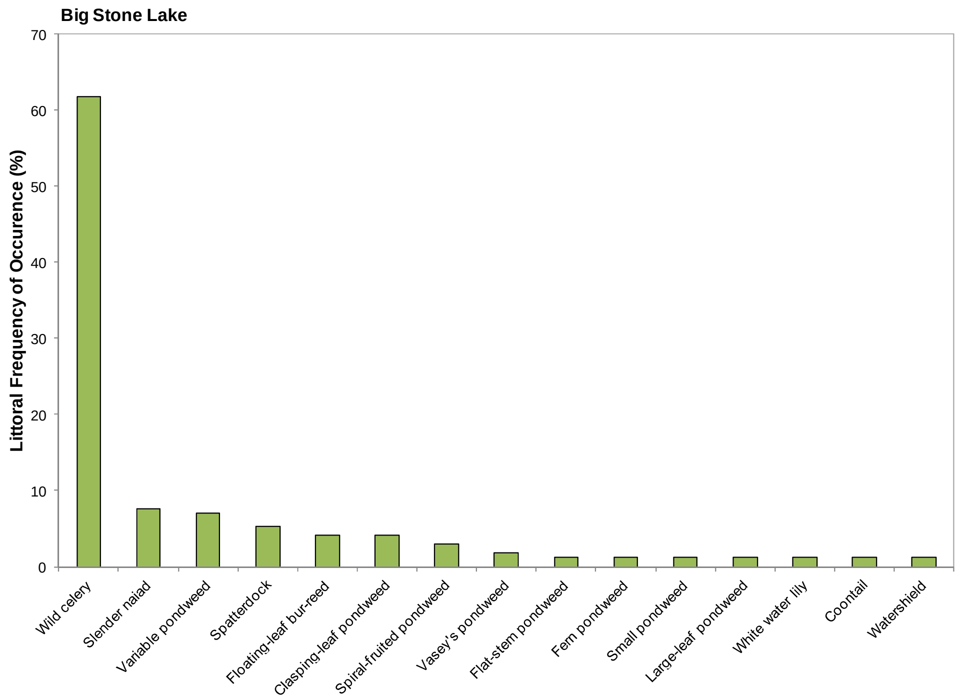

Figure 8.8.4-1 Big Stone Lake aquatic plant littoral frequency of occurrence analysis. Chart includes species with a frequency occurrence greater than 1.0% only. Created using data from a 2011 point-intercept survey.

Figure 8.8.4-1 (above) shows that wild celery, slender naiad and variable pondweed were the most frequently encountered plants within Big Stone Lake. Wild celery is a long, limp, ribbon-leaved turbidity-tolerant species that is a premiere food source for ducks, marsh birds, shore birds and muskrats. Animals may eat the entire plant, including the tubers that reside within the sediment. 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 a food source of waterfowl. Variable pondweed, is a submersed plant that produces a thin, cylindrical stem that has numerous branches. These branches produce linear leaves that grow anywhere from four to eleven centimeters long, and may produce three to seven veins per leaf. The floating leaves this plant produces are much more oval in shape, and may have 11 to 19 veins per leaf. This plant also hybridizes easily with other pondweed (*Potamogeton*) species; thus, this plant can appear quite variable in size and shape and is named appropriately.

Of the seven milfoil species (genus *Myriophyllum*) found in Wisconsin, only northern water milfoil were located from Big Stone Lake. Northern water milfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and higher water clarity. It was found only incidentally on Big Stone Lake; the presence of much hard substrate may be keeping this plant from establishing itself to a larger level. 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.

33 species of aquatic plants (including incidentals) were found in Big Stone Lake, which is more than the regional and state median value. 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 Stone Lake's plant community (0.65) lies above the Northern Lakes and Forests Lakes ecoregion median value (0.86), indicating the lake's plant community holds low 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 62% of the sampling locations, its relative frequency of occurrence is 58%. Explained another way, if 100 plants were randomly sampled from Big Stone Lake, 58 of them would be wild celery. This distribution can be observed in Figure 8.8.4-2, where together seven species account for 87% of the population of plants within Big Stone Lake, while the other 15 species account for the remaining 13%. Wild celery dominates the plan community, with a relative frequency of 58%. Eleven additional species were located from the lake but not from of the point-intercept survey, and are indicated in Table 8.8.4-1 as incidentals.

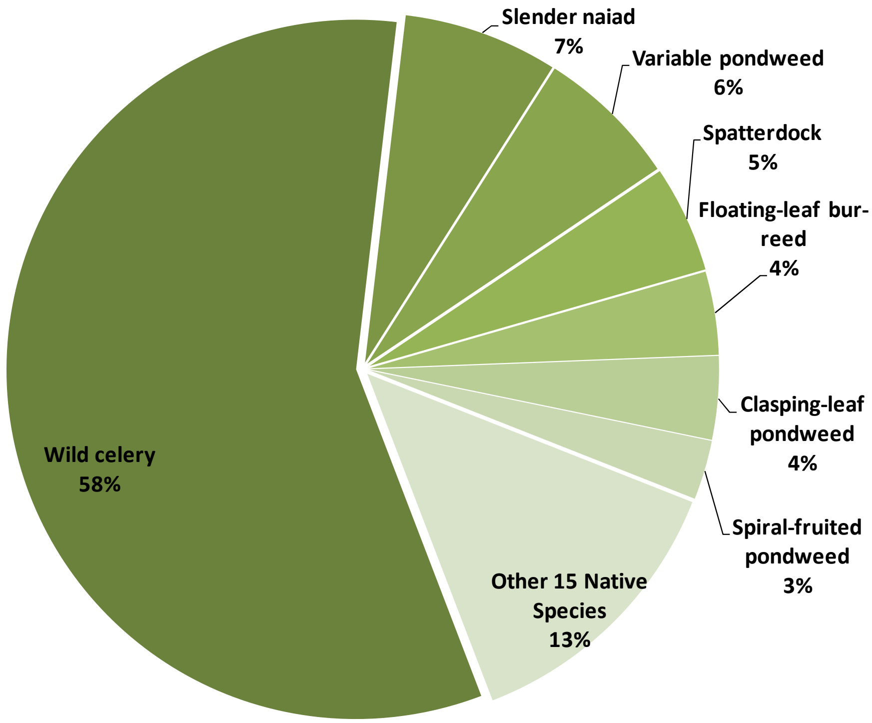

Figure 8.8.4-2 Big Stone Lake aquatic plant relative frequency of occurrence analysis. Created using data from 2011 point-intercept survey.

Big Stone Lake's average conservatism value (7.1) is higher than both the state and ecoregion median. This indicates that the plant community of Big Stone Lake is indicative of an undisturbed system. This is not surprising considering Big Stone Lake's plant community has moderate diversity but high species richness. Combining Big Stone Lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 33.3 which is above the median values of the ecoregion and state.

The quality of Big Stone Lake is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in many areas. The 2011 community map indicates that approximately 27.5 acres of the lake contains these types of plant communities (Big Stone Lake Map 2, Table 8.8.4-2). Eleven floating-leaf and emergent species were located on Big Stone Lake (Table 8.2.4-1), all of which provide valuable wildlife habitat.

Table 8.8.4-2. Big Stone Lake acres of emergent and floating-leaf plant communities from the 2011 community mapping survey.

Plant Community	Acres
Emergent	8.2
Floating-leaf	19.3
Mixed Floating-leaf and Emergent	0.1
Total	27.5

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 Stone 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 Stone Lake

During the 2011 community mapping survey, numerous occurrences of purple loosestrife were located along the shorelines of Big Stone Lake and within shallow emergent plant communities (Big Stone Lake Map 2, Table 8.8.4-2). 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.

Purple loosestrife has likely been present in and around Big Stone Lake for some time. 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. Additional purple loosestrife monitoring during periods of control efforts would be required to ensure the eradication of the plant from the shorelines of Big Stone Lake. Detailed discussion regarding this control effort will be discussed in the Implementation Plan.

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