Inventory and Analysis of Little Sturgeon Bay, Door County

Prepared by the Door County Soil and Water Conservation Department

Index

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Project Purpose

The long-term overall project goal is to establish stakeholder involvement and an organizational process to strengthen citizen support and watershed advocacy within the Little Sturgeon Bay area. It is envisioned that involving volunteers with the implementation efforts will promote a sense of ownership in both the natural resource base and the solutions to management issues.

This lake management planning goal centered on considering minimal to no chemical aquatic plant management applications and collecting data according to WDNR Long-Term Trend Lake Monitoring Protocol as recommended in the *Twin-Door-Kewaunee Basin Water Quality Management Plan* (Watermolen and Bougie 1995). The lake management planning grant project was also consistent with the goals outlined in the *Door County Land and Water Resource Management Plan* (Schuster et al. 1999).

Introduction

Little Sturgeon Bay is a partially bounded coastal water located on the west shore of the Door County Peninsula (Figure 1). Little Sturgeon Bay is associated with Green Bay, but the morphology and sheltered nature of Little Sturgeon Bay (i.e., shallow and extending almost two miles inland) produce ecological and recreational use issues that are similar to inland lakes. Five access points on the west shore and two on the east shore make Little Sturgeon Bay readily accessible to the public.

Little Sturgeon Bay has many characteristics that make it similar to an inland lake system. As a result, the management issues associated with Little Sturgeon Bay are common in many ways to Wisconsin inland lakes. For example, aquatic vegetation management and water quality have been an on-going concern for Little Sturgeon Bay riparian landowners. Specific issues (e.g., recreational opportunity, fishery health, etc.) have historically driven management initiatives for Little Sturgeon Bay.

Little Sturgeon Bay has a very significant presence in the Bay of Green Bay system in that it provides critical habitat for small mouth bass, yellow perch, walleye and muskie in addition to other various pan and sport fish. The inner portions of Little Sturgeon Bay provide prime spawning and rearing habitat for fish and is one of the few remaining intact prime fish rearing habitats for Green Bay. The shallow areas and marsh habitat also provide critical areas for shore birds and waterfowl. Areas of Little Sturgeon Bay are so critical that sensitive area designation(s) are pending for specific areas within the bay.

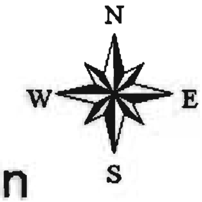
This report addresses the need for creating a baseline characterization of the bay for a comprehensive management effort that focuses on both in-lake and tributary watershed influences that to date, have been absent. Although Little Sturgeon Bay is similar to an inland lake in many aspects, it is a very dynamic water body when considering the interface with Green Bay, recreational use and wave/wind activity. One must realize that the importance and value of different habitats within Little Sturgeon Bay will change over time and shift in location as water levels fluctuate.

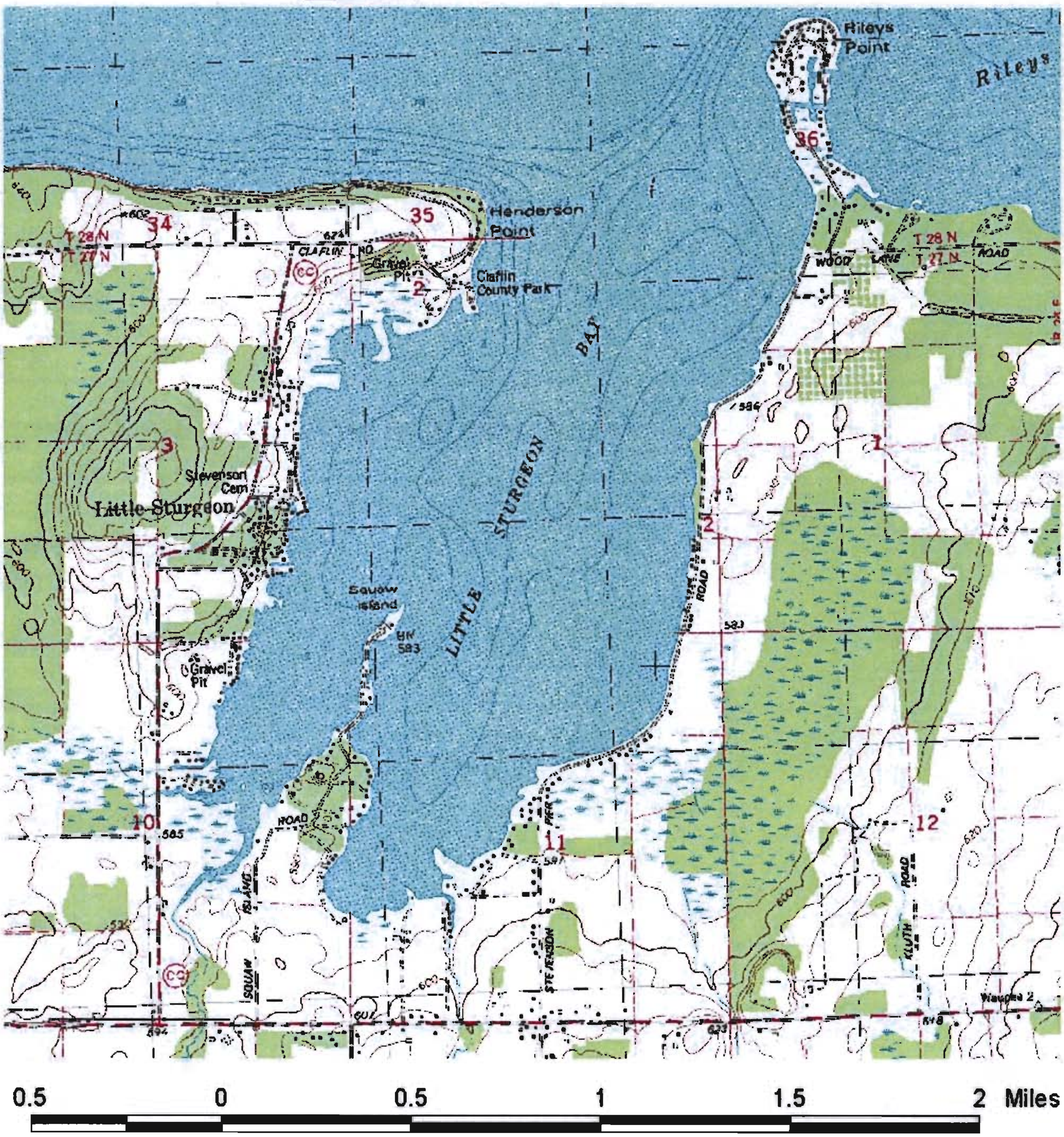
This report contains the inventoried information, an interpretation of the data and potential topics to address in phase II, the management plan.

The inventory process or phase I of the project and study included:

- Delineation of watershed drainage basins and collection of watershed inventory data,
- Identification of watershed land cover and land uses,
- An aquatic vegetation survey,
- Phosphorous and sediment load modeling based upon the inventoried land cover data,
- Water quality examination through inorganic chemical water analysis, and
- Involvement of the Little Sturgeon Area Property Owners Association and other public to continue monitoring efforts in the future.

Figure 1
Overview and Location of Little Sturgeon Bay, Door County, Wisconsin





Resource Overview

A description of the surface water resources in the Little Sturgeon Bay Watershed is provided below. The descriptions include Little Sturgeon Bay and the four streams that are tributary to the bay. All descriptions were taken from the *Surface Water Inventory of Door County* report that was completed by the Door County Soil and Water Conservation Department in 2000.

Little Sturgeon Bay

This is one of the more highly used bays because of the variety of opportunities it provides and the general nature of the local population surrounding it. Four small streams feed this bay, one of which also drains the Gardner Swamp (Gardner State Wildlife Area). The bay is partially segmented into two smaller basins at the South by Squaw Island Point. This point provides a reef habitat for various fish and is a popular fishing spot. A large portion of the shoreline is marshland that may reach inland to some extent. The shoreline areas that are not developed are gravel beaches but can consist of mud, muck and sediment in the lower bay to gravel and cobble along the east shoreline. Impacts from potential future development on the surrounding wetlands can have serious effects on the fish populations that utilize the area as spawning grounds. The sought after fish in this bay include smallmouth bass, yellow perch, northern pike, muskellunge, and walleye, although other panfish are present. Five access points on the west shore and two on the east shore makes this bay readily available to the public by either a boat launch, small marina or ending road.

Keyes Creek

Although officially named Keyes Creek, the locally used spelling is Kayes Creek after a family that resides in the area. This 7-mile long perennial stream originates in a network of springs. It has an approximate width of 4 feet with an 8ft/mile gradient and flows through the Gardener Swamp Wildlife Area before emptying into Little Sturgeon Bay. Three different soil associations surround the stream as it drains a portion of the Keyes Creek subwatershed of 30.4 square miles. The lower reaches of the stream are classified as WWSF (warm water sport fishery) and WWFF (warm water forage fishery) classified while the upper reaches are class I and class II. The stream earned a good to fair stream habitat ranking, but biotic index sampling values demonstrate that water quality is poor with significant organic pollution. It does support spring runs and suckers, northerns and walleyes have all been documented. It also has been known to contain large bowfin. Portions of this stream have been ditched or are pastured. On numerous occasions dissolved oxygen monitoring showed violations in water quality. Runoff samples in 1993 showed high levels of bacteria in the stream. The rural agricultural landscape contributes to the degradation of the stream's health through sedimentation, nutrient input and stream bank erosion.

Twin Harbor Creek

This small creek in the Keyes Creek subwatershed has a one-mile route before emptying into Little Sturgeon Bay. It is intermittent and WWFF classified. Suckers frequent the area, but yellow perch are known to use the stream, especially near it's mouth during spawning season. This stream provides many fishing opportunities. Silt and sediment are not a problem in the rocky substrate of this stream, but the Summerville-Longrie-Omena soil association that surrounds this stream could supply sediment to the stream if eroded. Dense algae growth and minimal flow are limiting factors for this creek.

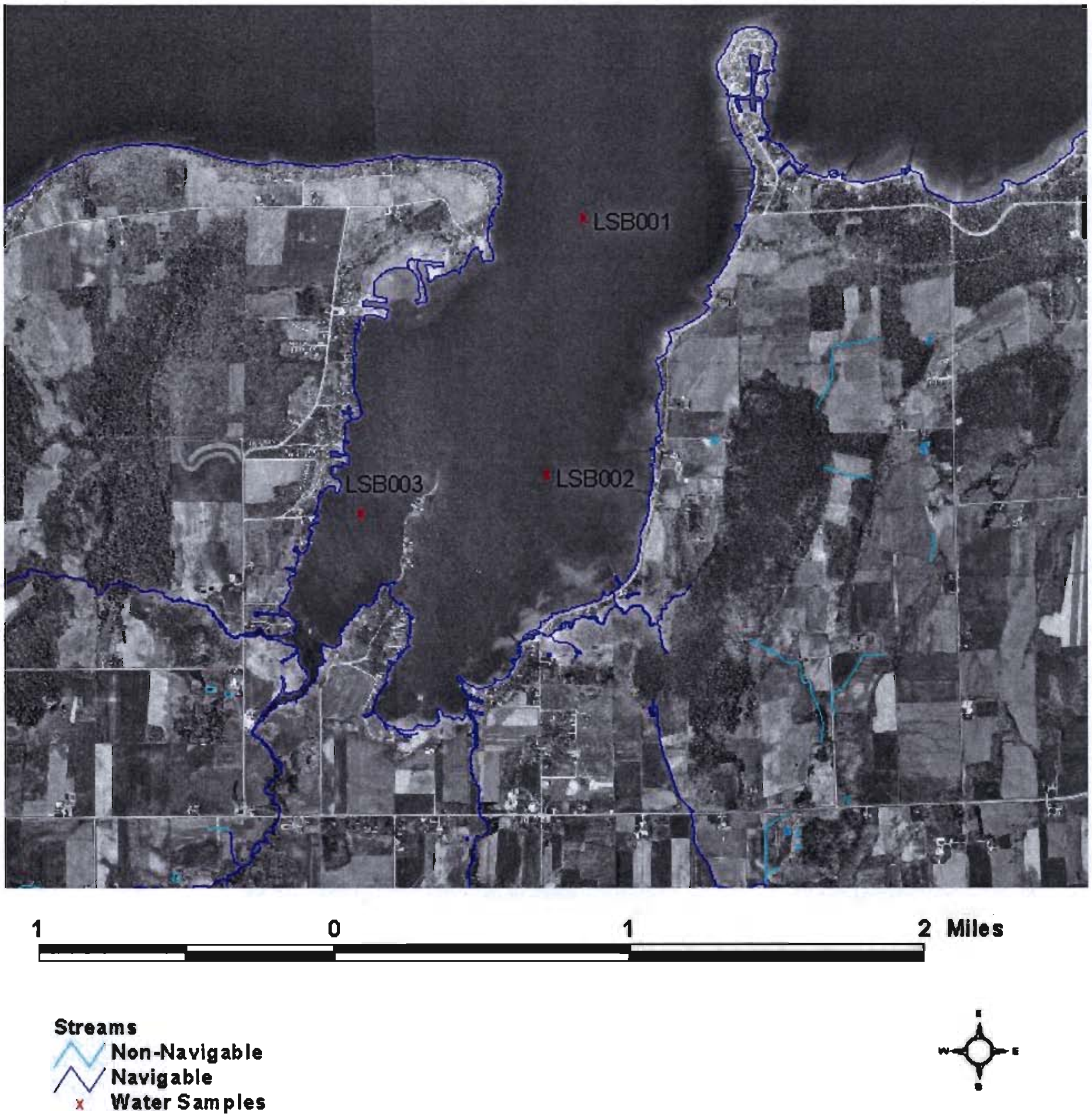
Malvitz Creek

The small one-mile stream is intermittent and classified as WWFF and LFF (limited forage fishery). The stream habitat ranking is fair. Carp, longnose and white suckers and walleye are known to use the stream. Large bowfin have been seen here as well. It drains soils of the Emmet-Solona-Angelica association through rural lands in the Keyes Creek subwateshed, but sedimentation does not appear to be a significant problem here yet.

Krueger Creek

This stream is another small, one-mile stream in the Keyes Creek subwatershed. The stream received a fair ranking for habitat and is classified as LFF. Filamentous algae can be rather abundant on its rocky substrate. This intermittent stream has white suckers in spring. Summerville-Longrie-Omena is the soil association that surrounds the stream.

Figure Two:
Water Quality Sample Points



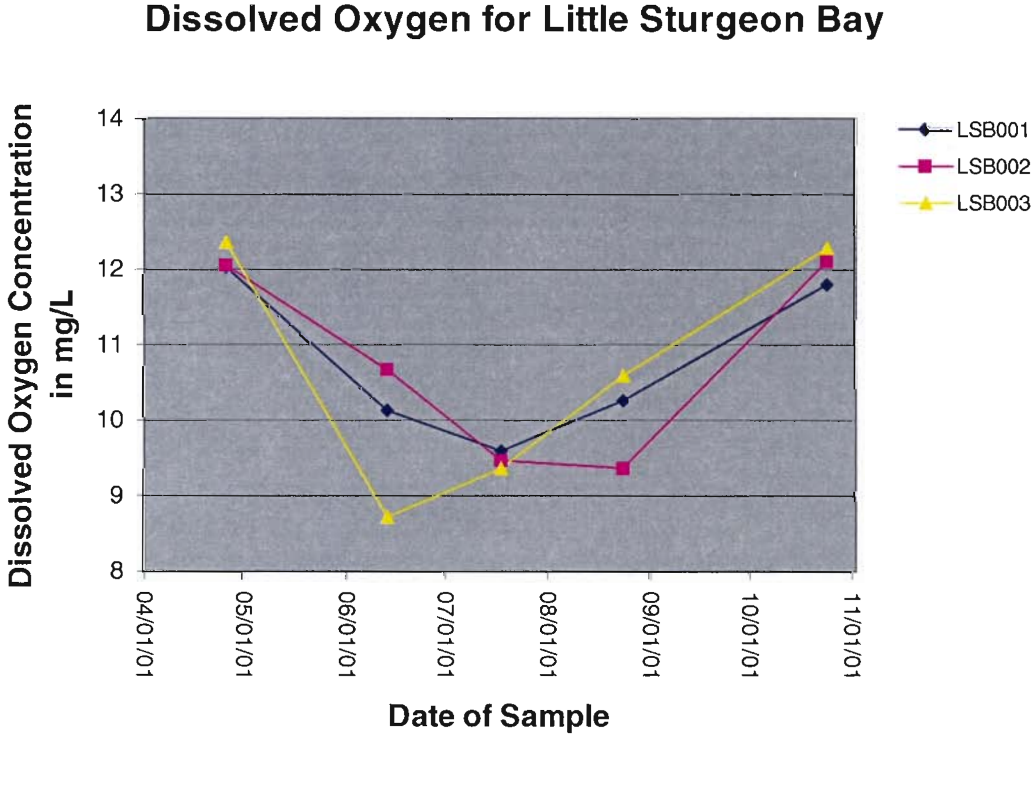
Water Quality Monitoring

Water quality samples were collected by an SWCD staff member and the UW-Extension Lakeshore Basin Educator on April 25 , June 13, July 17, August 23 and October 24, 2001. Water sample depths varied by location. At the outer bay sampling point, water was collected at six feet and in the inner bays, water was collected between two and three feet due to the shallow nature of the inner bays. Water quality parameters analyzed in the first spring sample set and the last fall sample set include chlorophyll *a* (uncorrected and lab filtered), conductivity, pH, alkalinity, ammonia, nitrate-nitrite, total kjeldahl nitrogen, total phosphorous and dissolved reactive phosphorous. Field tests included recording dissolved oxygen and temperature with a YSI 55 handheld model probe along with conductivity and temperature readings using a YSI salinity, temperature and conductivity probe. A field pH reading was also taken using a hand held probe. Weather conditions were recorded as well as secchi depth readings. Figure 2 shows the locations of the sampling sites.

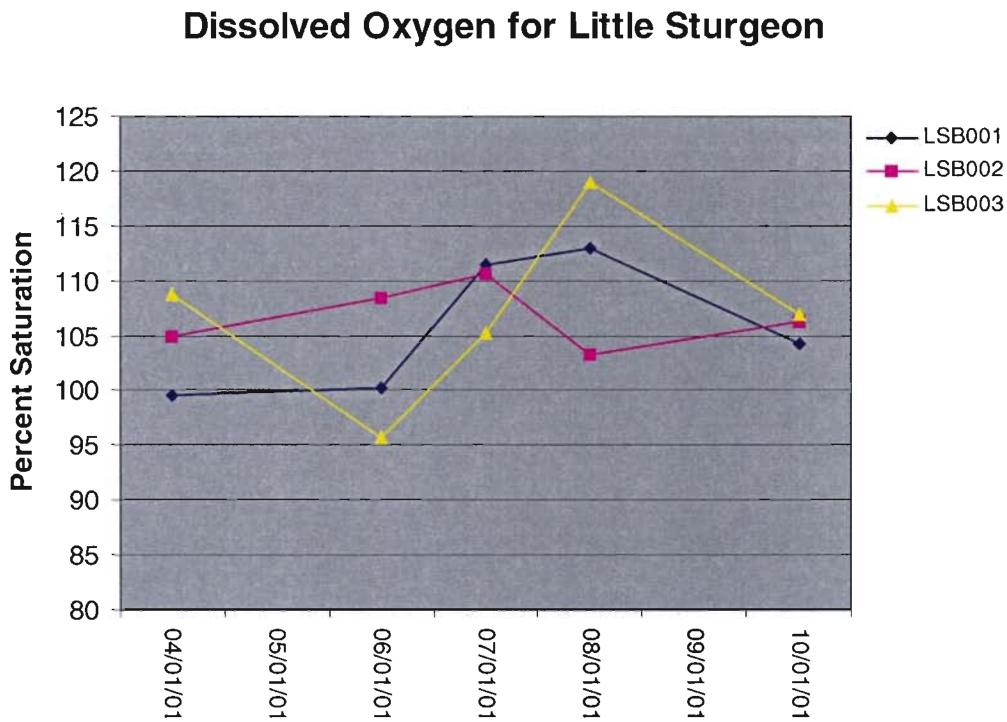
Dissolved Oxygen and Temperature

Temperature and dissolved oxygen data is used to help determine the zone of biological activity for a lake. Dissolved oxygen plays a significant role in chemical and biological processes in lakes, therefore the amount found in lake waters is of great importance. Dissolved oxygen is an especially critical factor affecting aquatic biota such as fish and aquatic insects.

Lakes in Wisconsin typically stratify, which means that a clear separation develops whereby warm, oxygen-rich surface water rests upon a layer of colder, oxygen poor water. Stratification is dependent upon several physical features including maximum depth, geographic area, retention time, basin shape, water color, orientation to the prevailing winds and surrounding topographical features. Whether or not a lake stratifies is important in determining how it responds to the influx of nutrients (DNR 1983). Sample results indicated that Little Sturgeon Bay is a mixed water system with no clear stratification, most likely a result of shallow water depths and a long fetch. The graph below shows the dissolved oxygen readings from spring to fall for all three sample locations. The readings for dissolved oxygen were taken at the same depth as sample collection at each sample site. As one would expect, dissolved oxygen concentrations decreased in summer during times of increased biological production and water temperature.



However, if one examines the percent saturation of oxygen, a large peak appears in the shallow, warm water site. This may be a result of aquatic vegetation producing oxygen as a byproduct of photosynthesis. In either case, percent saturation or ppm (mg/L), Little Sturgeon Bay is oxygen rich throughout the seasons.



Trophic State Index

Lakes are most often classified based on origin or trophic category. Trophic state is used primarily as an indicator of lake productivity. Oligotrophic lakes are generally clear, deep and free of aquatic plants or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. Mesotrophic lakes lie between oligotrophic and eutrophic. Often devoid of oxygen in late summer and the hypolimnion in late summer, their lower most layer limits cold water fish and causes phosphorus cycling from sediments. Swimming and boating can usually be enjoyed on this type of lake without limitations. Eutrophic lakes are high in nutrients and support a large plant biomass. They usually have abundant aquatic vegetation and are subject to frequent algae blooms. In addition, they often support large fish populations, but are also susceptible to oxygen depletion. Table One presents trophic category description in relation to a corresponding range of Trophic State Index (TSI) values. Geologically, all lakes naturally age in a progression from oligotrophic to eutrophic.

Table One: Trophic Categories

Category	*TSI*	*Lake Characteristic*
Oligotrophic	1-40	Clear water, oxygen rich at all depths, except if close to Mesotrophic border; then may have low or no oxygen; cold-water fish likely in deeper lakes
Mesotrophic	41-50	Moderately clear; increasing probability of low to no oxygen in bottom waters.
Eutrophic	51-70	Decreased water clarity; probably no oxygen in bottom water during summer; warm-water fisheries only; blue-green algae likely in summer in upper range; plants also excessive
Hypereutrophic	70-100	Heavy algae blooms throughout the summer; if>80, fish kills likely in summer and rough fish dominate

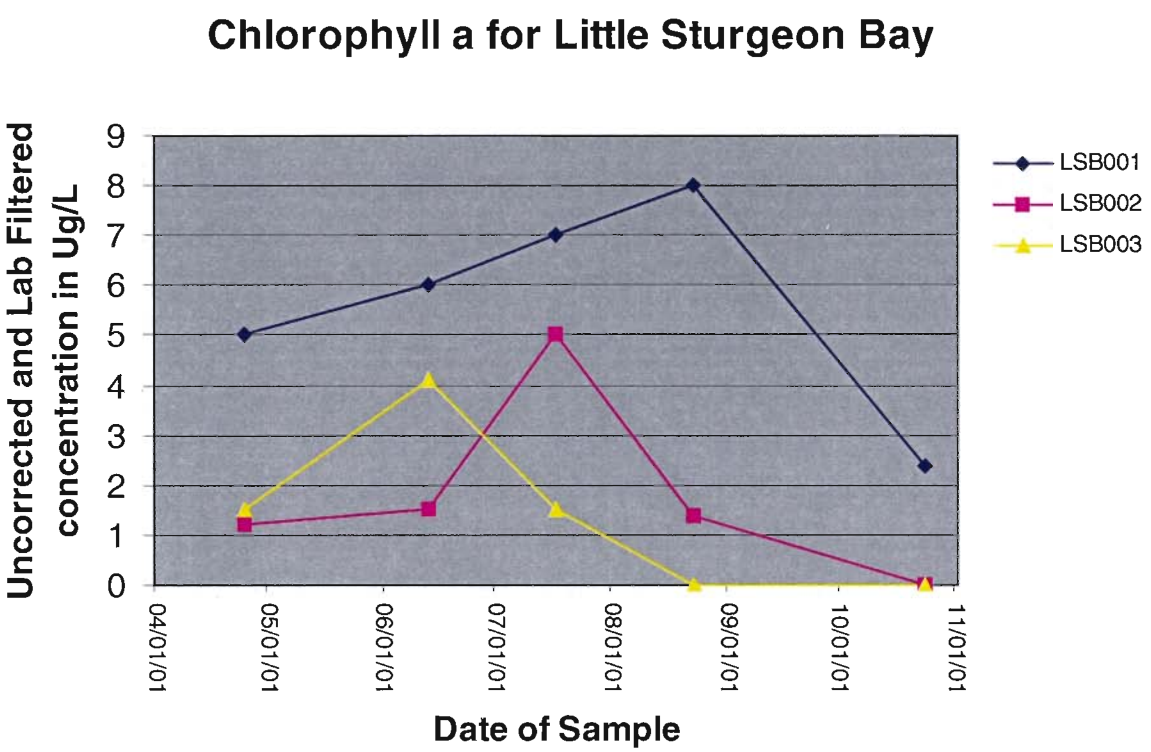
TSI's are indicators of the trophic state and are calculated based upon three parameters: total phosphorous, chlorophyll a, and Secchi disk. Total phosphorous (TP) serves as an indicator of the amount of nutrients available for algae growth in lakes, chlorophyll a (Chlor) is a measurement of the amount of algae present, and Secchi depth, is a simple measurement to gauge water clarity by recording the depth at which a black and white disk disappears. Table Two shows the calculated TSI values for each sample point and parameter in Little Sturgeon Bay.

Table Two: Trophic State Index Value for each Sample Site and Parameter

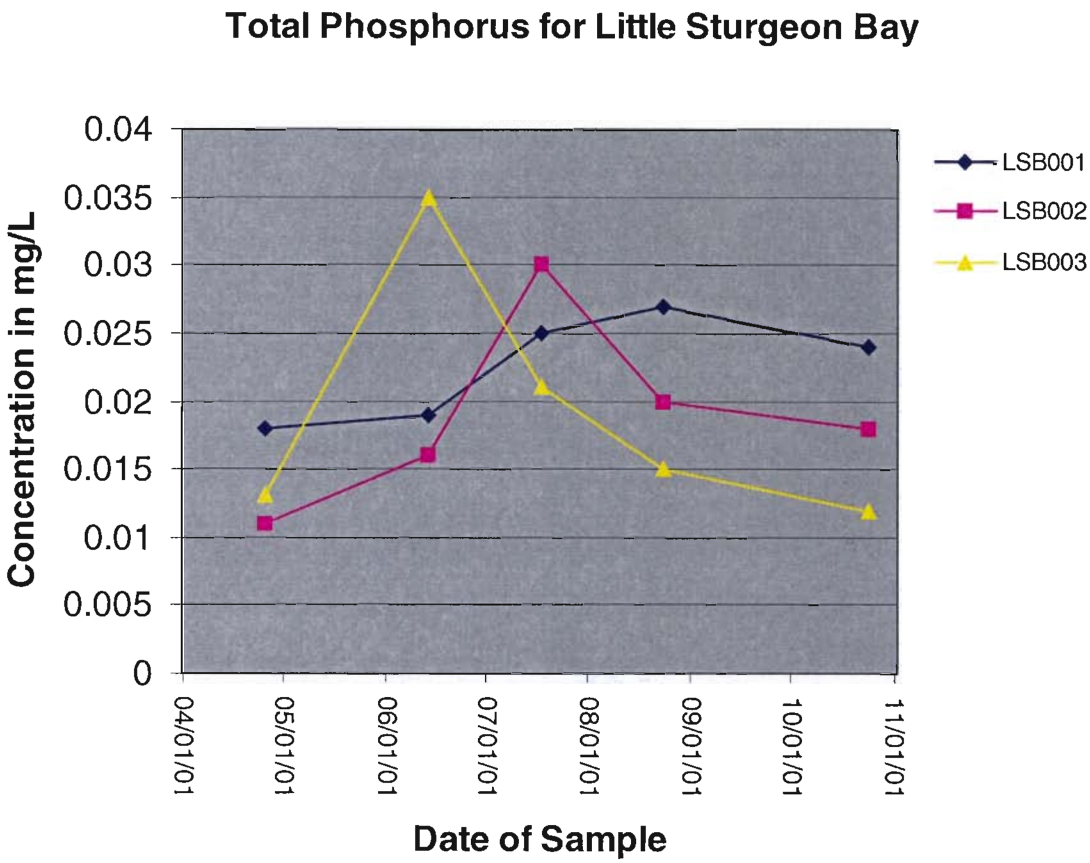
	4/25/2001	*6/13/2001*	*7/17/2001*	*8/23/2001*	*10/24/2001*
LSB001					
Chlor	46.39	48.18	49.69	50.99	39.19
TP	45.83	46.6	50.57	51.68	49.98
Secchi	47.15	43.1	44.66	46.4	42.58
LSB002					
Chlor	32.39	34.58	46.39	33.9	30
TP	38.73	44.13	53.2	47.35	45.83
*Secchi **	NA	NA	NA	NA	NA
LSB003					
Chlor	34.58	44.44	34.58	30	30
TP	41.14	55.42	48.1	43.2	39.98
*Secchi **	NA	NA	NA	NA	NA

* NA   Not applicable due to Secchi depth being equal to substrate at these locations.

Trophic classification of a macrophyte-dominated lake based on water clarity or chlorophyll a concentration alone generally results in underestimating the lake's productivity and trophic status (DNR, 1983). In Little Sturgeon Bay, it appears that most of the available plant nutrients are being used by the macrophyte population, thus limiting algal growth during the summer period. The limited algal growth contributes to the increased water clarity.



Total phosphorous is the most used and often preferred parameter to investigate trophic state. Phosphorous is an essential element in the nutrition of aquatic plants (both macrophyte and algae) and is generally correlated to the biological production of a lake. Using phosphorous to calculate TSI, Little Sturgeon Bay is classified overall as mesotrophic tending towards eutrophic.



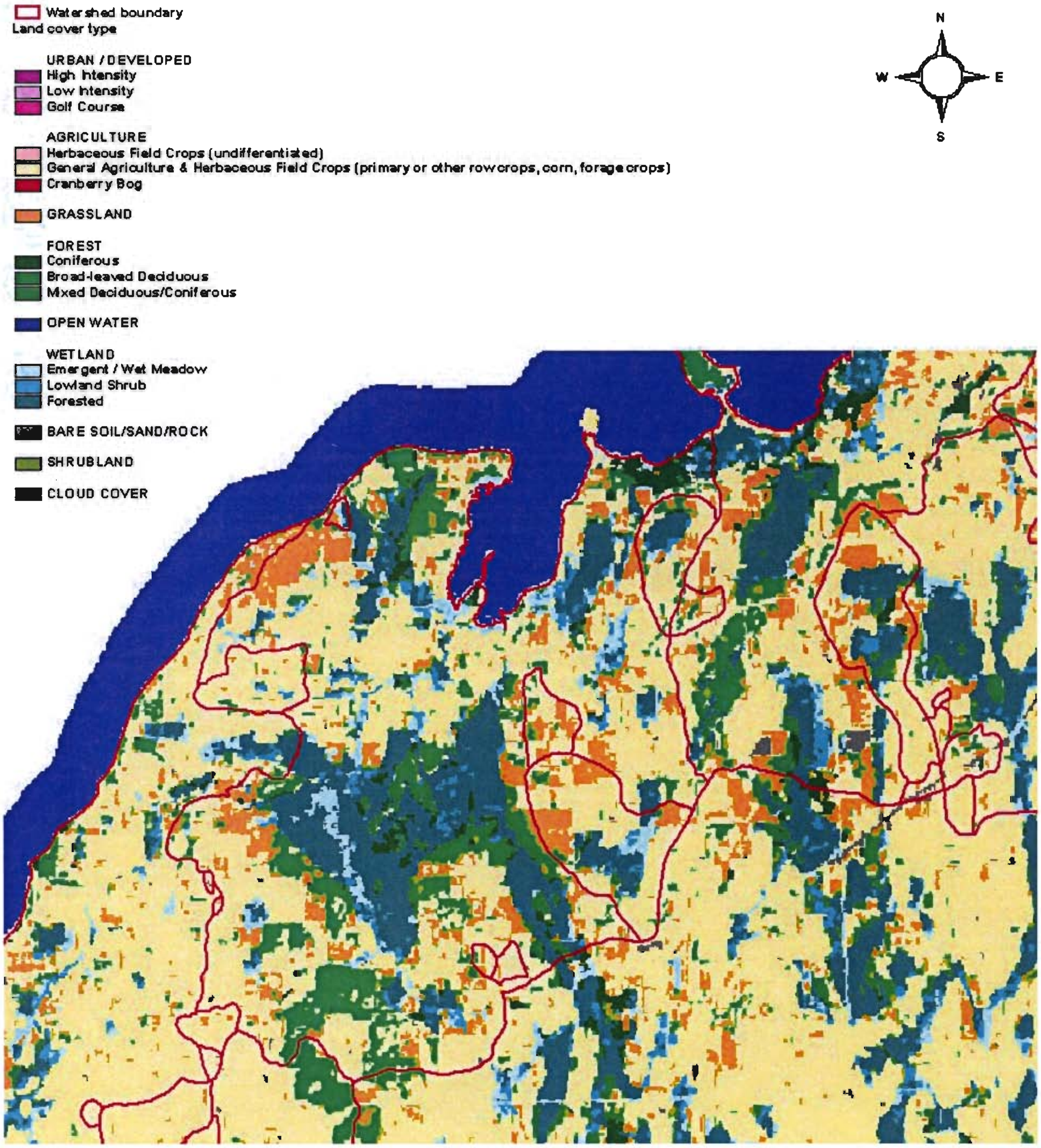
A major strength of TSI is that the interrelationships between variables can be used to identify certain conditions in the lake that are related to factors that affect the measured variables. A different way of looking at deviations is reported in Carlson (1992). If both of the deviations TSI(Chlor)-TSI(TP) and TSI(Chlor)- TSI(Secchi) are simultaneously plotted on a single graph, it is possible to identify some of these systematic deviations. The calculations for Little Sturgeon Bay are shown in Table Three. The inner two sampling areas of Little Sturgeon Bay could not be used for analysis because the secchi disk reading were to the bottom substrate and therefore, do not reflect actual water clarity. The outer sampling point data suggests the bay is most likely phosphorous limited.

Table Three: Value Differences in Trophic State Index Values

	4/25/2001	*6/13/2001*	*7/17/2001*	*8/23/2001*	*10/24/2001*
LSB001					
Chlor-TP	0.56	1.58	-0.88	-0.69	-10.79
Chlor –Secchi	-0.76	5.08	5.03	4.59	-3.39

Nitrogen to phosphorous ratios are also calculated to determine what the limiting nutrient may be. In general, when the nitrogen to phosphorous ratios are greater than 15:1, phosphorous is the limiting nutrient in the system (Krenkel and Novotny, 1980). The nitrogen to phosphorous ratio for Little Sturgeon Bay for all three sampling sites is greater than the 15:1 ratio. The values range from 32:1 to 55:1 which is consistent with the TSI deviations that support that phosphorous is the limiting nutrient.

Figure Three:
Watershed Delineations and Land Cover Types



Watershed Inventory

The watershed for Little Sturgeon Bay is relatively large (approximately 15,000 acres or 23.5 square miles) and consists of four stream subwatersheds and interspersed closed depressions. For this report, all data referring to watersheds or subwatersheds does not include closed depression. Closed depressions were not considered part of the overall watershed for Little Sturgeon Bay; however, those subwatersheds that drained directly to Little Sturgeon Bay and do not have a principle outlet such as the shoreline areas near the mouth of Little Sturgeon Bay (i.e. Portions of Henderson's Point and Riley's Point) are considered part of the overall watershed. Figure Three displays the watershed delineations and the land cover types.

Impacts

Little Sturgeon Bay is considered those waters within the confines of an arbitrary delineation from the tip of Riley's Point to the most northeasterly corner of Henderson's Point. Information concerning the levels of phosphorus and sediment delivery from the entire watershed of Little Sturgeon Bay and its tributaries is discussed below. Impacts of sediment entering the bay are considered because soil particles can degrade and/or eliminate habitat for fish and other aquatic life. High sediment concentrations can abrade fish gills and make fish more susceptible to disease (NPSRSB). Sediment can also fill pools that fish use for spawning, increase water temperature and consequently decrease oxygen concentrations. Phosphorus is one of the most important nutrients to plant growth and the key nutrient affecting the amount of aquatic plants and algae growth in water. Phosphorus is analyzed because it is a good indicator of overall nutrient status (SWI).

Methodology for Nonpoint Source Loading Analysis

Detailed information was collected and entered into the Computer Assisted Management and Planning System Program often referred to as the CAMPS database. CAMPS is used primarily for recording farm inventories, plans and practices. The database includes information on the operator, crop rotation, soil type, slope and tillage type. The database represents the agricultural practices for inventoried and non-inventoried fields. The accumulation of this data was then analyzed by hydrological unit using the WINHUSLE model.

WINHUSLE is a distributed parameter empirical water quality model that is used for the analysis and planning of land use impacts on surface water quality in predominately agricultural watersheds. WINHUSLE estimates the sediment yield from each inventoried field to the outlet of the hydrological area that it's in, the sediment and total phosphorous yield out of each area, and the in-stream sediment deposition rate within each area. WINHUSLE is calibrated by statistically regressing monitored sediment and phosphorous loads on monitored runoff volume, peak flow rates, and the average soil loss rate from the monitored watershed.

Much of the data required to run the WINHUSLE model existed within the Door County Soil and Water Conservation Department. Alterations to the input of the hydrological units were made. The CAMPS database was briefly reviewed and updated as well. The CAMPS database was then linked to the WINHUSLE model and run. Table Four contains the results of the model as of November 28, 2001 for the planned inventory (current field conditions) as opposed to the benchmark inventory (conditions in which fields have out-dated operation practices or rotations).

WINHULSE uses the Water Erosion Prediction Projects Climate Generator or CLIGEN (Nicks and Lane, 1989). The weather generator will produce statistically derived rainfall files for any of 1000 locations across the United States. For the Little Sturgeon Bay model, ten years of rainfall data from the station in Kewaunee, WI were used. The ten-year data total averaged 28.6 inches of which 1.8 inches were snow and 26.8 were rain.

Phosphorous deliveries and concentrations are rough estimates based on the concentration data at the calibration station. There are several significant sources of phosphorus that will affect the phosphorus concentration in the stream that are not evaluated. Most notably, these include barnyards and manure spreading. Because of the uncertainties associated with the phosphorus estimates, the phosphorus loads are not proportioned back to the source fields, nor are in-stream phosphorus delivery ratios calculated when using this model.

Table Four: Characteristics and Delivery of Little Sturgeon Bay Sub-Watersheds

	Twin Harbors Creek	*Kayes Creek*	*Malvitz Creek*	*Krueger Creek*	*Henderson's Point*	*East Shoreline*
Drainage area	2,379 acres	7,404 acres	2,564 acres	2,379 acres	270 acres	80 acres
Time of Concentration	2.89 hours	5.37 hours	2.94 hours	2.23 hours	0.50 hours	0.37 hours
Annual sediment delivered from fields to streams	254 tons	620 tons	165 tons	319 tons	14 tons	37 tons
Annual sediment deposited in streams	186 tons	530 tons	108 tons	196 tons	0 tons	0 tons
Annual total sediment delivered from fields and streams to outflow	68 tons	91 tons	56 tons	123 tons	14 tons	37 tons
Flow weight average event concentration suspended sediment	497 mg/L	261 mg/L	475 mg/L	767 mg/L	1471 mg/L	5103 mg/L
Annual phosphorus delivered from fields & streams to outflow	167 pounds	419 pounds	152 pounds	227 pounds	13 pounds	20 pounds
Flow weight average event concentration total phosphorus	0.61 mg/L	0.60 mg/L	0.64 mg/L	0.71 mg/L	0.71 mg/L	1.38 mg/L

The Wisconsin Lake Modeling Suite or WiLMS uses empirical models and was developed as a lake-planning tool. WiLMS estimates annual nutrient loading and in-lake phosphorus concentration to be used for planning and goal setting purposes. WiLMS couples ten empirical lake response models with an export-driven watershed loading module, an uncertainty analysis module, parameter range module, watershed load back calculation module, a lake condition module and a phosphorus steady state response time module.

WiLMS was used in this study as a guideline for comparison of potential phosphorous loading by land cover type. WiLMS uses annual total phosphorus export coefficients by land cover type in kilograms per hectare per year (Kg/Ha/Yr) to calculate total phosphorous loading from overland runoff. Land cover information was obtained from data compiled by the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND). WISCLAND is a consortium of government and private organization formed in 1993 to acquire funding and resources to develop land cover data for the state. The land cover data was derived from Landsat Thermatic Mapper satellite imagery developed from 1991 through 1993. Unfortunately, because of resolution used for the WISCLAND data, rural and shoreline development were not mapped and therefore, could not be categorized in the WiLMS analysis. This analysis could be improved in future studies by a ground inventory of all land covers/land uses in the Little Sturgeon Bay watershed so that residential and shoreline development could be accounted for in the analysis.

The information below shows the breakdown of phosphorus loading data from WiLMS by land cover type for each subwatershed. Row crops are by far the leading contributor of non-point source phosphorus loading, although loading also occurs from grassland/pasture land and naturally from precipitation on the bay surface.

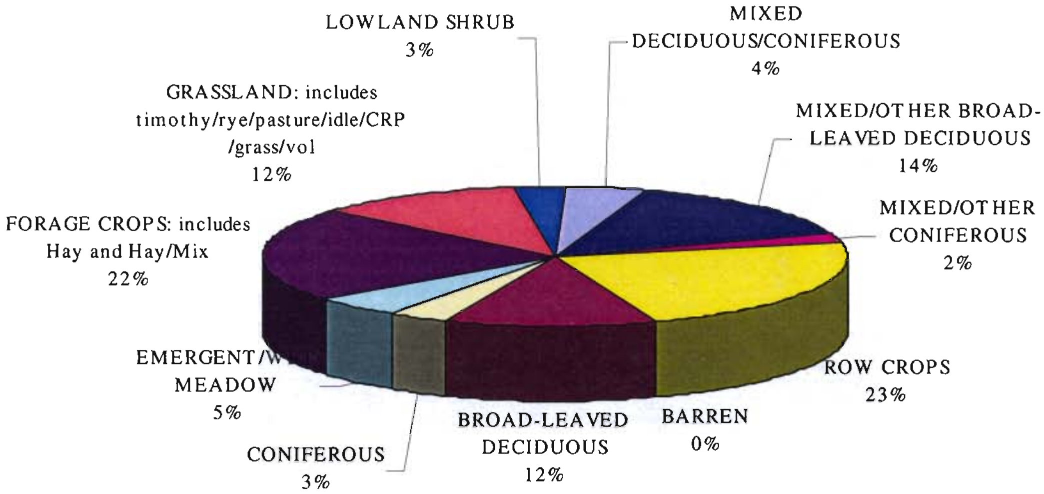


Figure Four: Total Land Cover for Little Sturgeon Bay Watershed (from 1993 WISCLAND data)

Table Five A: WiLMS Phosphorus Loading by Land Cover for Little Sturgeon Bay Sub-Watersheds

Twin Harbors
Tributary Drainage Area: 2,602.32 acres
Annual Runoff Volume: 1,951.7 acre-ft

Land Cover	*Acres*	*Most-Likely* Loading Coefficient (kg/ha/yr)*	*Loading Percent*
Row Crops	666.8	1.0	60.8
Pasture/Grass	1016.7	0.3	41
Wetlands	177.65	0.1	7
Forest	740.8	.09	15
Barren	.37	0.1	0
Other		0.1-0.3	48

* ***Most Likely is the term WiLMS uses for the median between low and high.***

Malvitz Creek
Tributary Drainage Area: 2,569.42 acres
Annual Runoff Volume: 1,927.1 acre-ft

Land Cover	*Acres*	*Most-Likely Loading Coefficient (kg/ha/yr)*	*Loading Percent*
Row Crops	420.69	1.0	54.4
Pasture/Grass	654.83	0.3	16.9
Wetlands	108.42	0.1	0.9
Forest	1384.45	0.09	0
Barren	1.0	0.1	0
Other		0.1-0.3	48

Krueger Creek
Tributary Drainage Area: 2,680.26 acres
Annual Runoff Volume: 2,010.2 acre-ft

Land Cover	*Acres*	*Most-Likely Loading Coefficient (kg/ha/yr)*	*Loading Percent*
Row Crops	694.75	1.0	60
Pasture/Grass	1141.92	0.3	19.7
Wetlands	312.75	0.1	1.8
Forest	529.42	0.09	0
Barren	1.4	0.1	0
Other		0.1-0.3	18.5

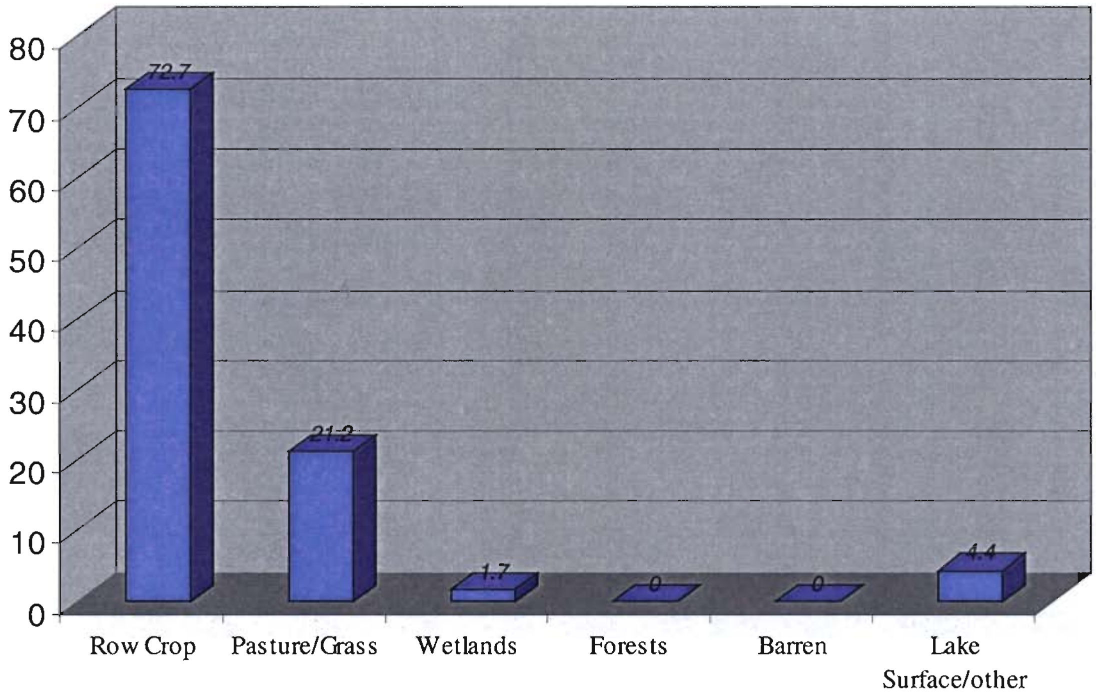
Keyes Creek
Tributary Drainage Area: 7,488.72 acres
Annual Runoff Volume: 5,616.5 acre-ft

Land Cover	*Acres*	*Most-Likely Loading Coefficient (kg/ha/yr)*	*Loading Percent*
Row Crops	1701.35	1.0	70.4
Pasture/Grass	2294.38	0.3	19.0
Wetlands	601.85	0.1	1.7
Forest	2877.97	0.09	0
Barren	13	0.1	0
Other			8.9

Henderson's Point
Tributary Drainage Area: 187.11 acres
Annual Runoff Volume: 140.3 acre-ft

Land Cover	*Acres*	*Most-Likely Loading Coefficient (kg/ha/yr)*	*Loading Percent*
Row Crops	59.21	1.0	20.7
Pasture/Grass	57.28	0.3	4.0
Wetlands	16.8	0.1	.4
Forest	52.93	0.09	0
Barren	0.9	0.1	0
Other			48

Figure Five: Total Phosphorus Loading by Land Cover for Little Sturgeon Bay



Point Source and Sanitary Review

An analysis of potential point discharges was not a component of the initial proposed project. Concerns about point sources were raised by citizens at the informational and educational meetings. Information regarding the status of septic systems was obtained from the Door County Sanitarian Department. In 1991, a sanitarian survey of Shunel Point (generally referred to as Riley's Point) in the Town of Gardner examined 93 sites. Of the 93 sites surveyed, 30 systems passed and 63 failed which results in 67% failing. An official sanitarian survey for the remainder of Little Sturgeon Bay has not been performed, but is tentatively scheduled for 2003. Using historic and current sanitarian records, an area within 1000 feet of the shoreline of Little Sturgeon Bay was examined by the Door County Sanitarian Department. Of the 360 properties identified, 115 properties were noted as properties without sanitary permits after 1974, 242 were properties with sanitary permits issued after 1974, one property was vacant and there were two affidavits of non-use. Some properties contain multiple systems with or without permits after 1974. Of the 242 properties with sanitary permits issued after 1974, 214 are holding tanks, 13 are mound systems, two are at-grade systems, three are in-ground pressure systems and ten are conventional systems.

Other point sources of pollution and discharge into Little Sturgeon Bay have not been identified.

Table Five B: Land Cover Information by Sub-Watershed

Land Cover Type Description	KAYES CREEK	TWIN HARBORS	MALVITZ CREEK	KRUEGER CREEK	HENDERSONS POINT	TOTALS
BARREN	13.17	0.37	1.03	1.42	0.89	16.88
BROAD-LEAVED DECIDUOUS	870.18	272.7	369.55	287.53	1.29	1801.25
CONIFEROUS	240.31	22.9	235.86	20.1	0	519.17
EMERGENT/WET MEADOW	405.37	105.45	49.06	189.2	16.8	765.88
FORAGE CROPS: includes Hay and Hay/Mix	1562.51	596.9	392.69	790.82	31.06	3373.98
GRASSLAND: includes timothy/rye/pasture/idle/CRP/grass/vol	731.87	419.8	262.14	351.1	26.22	1791.13
LOWLAND SHRUB	196.48	72.2	59.36	123.55	0	451.59
MIXED DECIDUOUS/CONIFEROUS	317.88	60.9	258.81	50.94	0	688.53
MIXED/OTHER BROAD-LEAVED DECIDUOUS	1291.65	308.1	441.21	139	49.84	2229.8
MIXED/OTHER CONIFEROUS	157.95	76.200	79.02	31.85	1.8	346.82
ROW CROPS	1701.35	666.800	420.69	694.75	59.21	3542.8
TOTAL ACRES MINUS OPEN WATER	7488.72	2602.320	2569.42	2680.26	187.11	15527.83

Aquatic Vegetation Sampling

Transect Survey

A quantitative aquatic vegetation survey was conducted by sampling two north-south transects located on the east and west side of Squaw Island, and one east-west transect located approximately midway between the south and north end of Little Sturgeon Bay (Figure Four). The location of the transects provide an overall dissection of the shallow areas of Little Sturgeon Bay. The latitude and longitude coordinates for each sample point were recorded using a Garmin GPS 12 Personal Navigator™ with a position accuracy of 15 meters (49 ft.). Each sample point corresponds to a ten-foot diameter circle within one of five different depth ranges located along each transect (Table Six).

Table Six: Depth Ranges for Transect Sampling of Aquatic Vegetation

Depth Code	Depth Range (feet)
1	0.0-1.5
2	1.5-3.0
3	3.0-5.0
4	5.0-10.0
5	10.0+

The substrate type and aquatic vegetation species composition were recorded at each sample point. The coordinates and depth code for each sample point are shown in Appendix A.

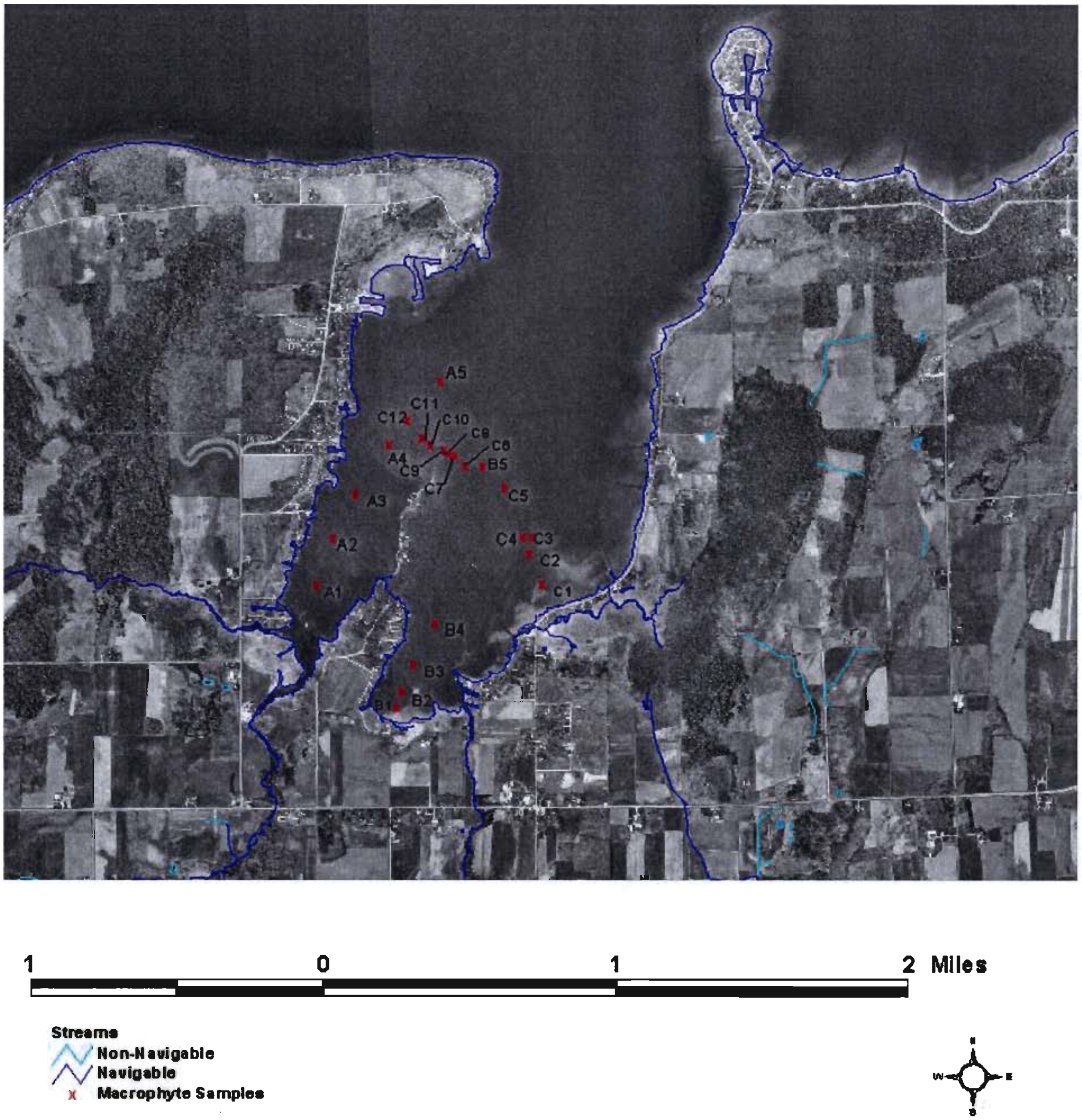
A visual estimate of percent foliage cover for each species was also recorded at the sampling locations. Coverage is determined as the perpendicular projection to the ground from the outline of the aerial parts of the plant species and is typically reported as the percent of total area (e.g., substrate or water surface) covered (Brower et al. 1990). For emergent and floating-leaved vegetation, the percent of water surface covered was used in the visual estimate, and for submergent vegetation the percent of substrate covered was used. After collection of the field data, the Daubenmire Classification Scheme (Mueller-Dumbois and Ellenberg 1994) was used to rank each species according to estimated foliage cover (Table Eight). By providing a range of percent foliage cover for each rank, the Daubenmire Classification Scheme helps to minimize errors associated with visual estimation.

Table Seven: Daubenmire Classification Scheme for Ranking Based Upon Estimated Foliage Cover

Percent Foliage Cover	Rank
0-5	1
5-25	2
25-50	3
50-75	4
75-95	5
95-100	6

The aquatic vegetation species composition data collected at the sample points was used to estimate *frequency of occurrence* for each species observed. The *frequency of occurrence* is defined as the number of times a given species occurred on the 22 observed sample points (Brower et al. 1990). Aquatic vegetation species that were observed in Little Sturgeon Bay but not recorded in one of the sample plots during the transect surveys were also noted. In addition, a cursory list of the shoreline vegetation observed was compiled, with particular attention given to the location of observed purple loosestrife (*Lythrum salicaria*) populations.

Figure Six:
Aquatic Plant Sample Transect Points



Floristic Quality Assessment Methodology

A Floristic Quality Assessment (FQA) was applied to the aquatic vegetation species list generated for Little Sturgeon Bay using the methodology of Nichols (1998). FQA is a rapid assessment metric used to assist in determining the floristic and natural significance of a given area. The assessment system is not intended to be a stand-alone tool, but is valuable as a complementary and corroborative method of evaluating the natural quality of a site.

The primary concept in FQA is species conservatism. Each aquatic vegetation species for Little Sturgeon Bay was assigned a coefficient of conservatism (*C*) ranging from 0 to 10. The coefficient of conservatism estimates the probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-settlement condition. A *C* of 0 indicates little fidelity to a natural community, and a *C* of 10 is indicative of restriction to high quality natural areas. The FQA was applied by calculating a mean coefficient of conservatism for all species observed in Little Sturgeon Bay. The mean C was then multiplied by the square root of the total number of plants to yield a floristic quality index. Non-native taxa were not used to calculate the floristic quality index. Examination of the floristic quality index within the context of statewide and regional trends was used to provide an overall evaluation of the floristic quality of Little Sturgeon Bay.

Species Abundance and Distribution

A total of 23 vascular aquatic plant species were observed in Little Sturgeon Bay (Table Nine). Relative abundance of each species in the bay was qualitatively estimated as rare, infrequent, common, or abundant based upon general observations made during the sampling effort. For comparison purposes, the relative abundance of each species in inland lakes in Wisconsin (Nichols and Vennie 1991) is also shown. Several interesting observations can be made when comparing the relative abundance in the bay versus the relative abundance in Wisconsin inland lakes. First, Eurasian water milfoil was abundant in the bay, but according to Nichols and Vennie was still infrequent statewide in 1991. While Eurasian water-milfoil prevalence statewide has undoubtedly increased since 1991, it is worth noting that Little Sturgeon Bay has a Eurasian water-milfoil population that is well established relative to most inland lakes in Wisconsin. Another interesting observation can be made in relation to white water crowfoot and wild celery. Both species were common in the bay, but are rare and infrequent, respectively, in Wisconsin inland lakes. The prevalence of these two species in the bay can probably be interpreted as in indication that some relatively intact, healthy native assemblages of aquatic vegetation exist in Little Sturgeon Bay. In fact, the subsequent section of this report will illustrate that the nearshore areas (i.e., <5 feet) tend to have harder substrates (e.g., sand or cobble) and a less disturbed aquatic plant community, while the deeper areas had softer substrate and a higher prevalence of exotic and invasive species.

Table Eight: Aquatic Vegetation Observed in Little Sturgeon Bay and Relative Abundance At the Bay and State Level

Common Name	Scientific Name[2]	Nativity	Relative Abundance in Bay	Relative Abundance in Wisconsin[1]
		Emergent Vegetation		
Bald spike-rush	*Eleocharis palstirs*	Native	Infrequent	Common
Arum-leaved arrowhead	*Sagittaria cuneata*	Native	Infrequent	Infrequent
Hardstem bulrush	*Scirpus acutus*	Native	Infrequent	Common
Softstem bulrush	*Scirpus validus*	Native	Infrequent	Common
Common bur-reed	*Sparganium eurycarpum*	Native	Infrequent	Infrequent
Broad-leaved cattail	*Typha latifolia*	Native	Infrequent	Common
		Floating-leaved Vegetation		
Small duckweed	*Lemna minor*	Native	Infrequent	Infrequent
Bullhead pond lily	*Nuphar variegata*	Native	Infrequent	Abundant
White water lily	*Nymphaea odorata*	Native	Infrequent	Infrequent
		Submergent Vegetation		
Coontail	*Ceratophyllum demersum*	Native	Abundant	Abundant

Common Name	Scientific Name[2]	Nativity	Relative Abundance in Bay	Relative Abundance in Wisconsin[1]
Muskgrass	*Chara spp.*	Native	Common	Abundant
Common waterweed	*Elodea canadensis*	Native	Abundant	Abundant
Spiked water-milfoil	*Myriophyllum sibiricum*	Native	Infrequent	Common
Eurasian water-milfoil	*Myriophyllum spicatum*	Exotic	Abundant	Infrequent
Slender naiad	*Najas flexilis*	Native	Infrequent	Abundant
Curly-leaf pondweed	*Potamogeton crispus*	Exotic	Infrequent	Common
Illinois pondweed	*Potamogeton illinoensis*	Native	Infrequent	Infrequent
Sago pondweed	*Potamogeton pectinatus*	Native	Infrequent	Abundant
Small pondweed	*Potamogeton pusillus*	Native	Infrequent	Common
Clasping-leaf pondweed	*Potamogeton richardsonii*	Native	Common	Common
Flat-stem pondweed	*Potamogeton zosteriformis*	Native	Common	Abundant
White water crowfoot	*Ranunculus longirostris*	Native	Common	Rare
Wild celery	*Vallisneria americana*	Native	Common	Infrequent
Water star-grass	*Zosterella dubia*	Native	Common	Common

1. Source: *Attributes of Wisconsin Lake Plants*, S. Nichols and J. Vennie, 1991
2. Nomenclature follows Gleason and Cronquist, 1991.

To assist in quantifying the abundance and distribution of the aquatic vegetation in Little Sturgeon Bay, three transects were sampled. The data from the transect sampling can be found in Appendix B. Table Nine shows the maximum observed rooting depth, frequency of occurrence, and mean Daubenmire classification ranking for each aquatic species observed at the sample points; those species observed in the bay but not observed at a sample point were not included in Table Nine.

The species with the highest frequency of occurrence percentages included common waterweed (*E. canadensis*), Eurasian water milfoil (*M. spicatum*), coontail (*C. demersum*), and wild celery (*V. americana*). Eurasian water milfoil is an exotic, invasive species, and both common waterweed and coontail are native species that are considered invasive. Invasive species are defined as species that have the potential to grow at nuisance levels which can impede navigation and recreation. Wild celery is a desirable native species that provides an excellent source of food for waterfowl and marsh birds.

In general, wild celery is most abundant in nearshore areas with sandy or rocky substrate. Common waterweed, Eurasian water milfoil, and coontail become increasingly abundant in deeper water with softer substrate, and these three species are at potential nuisance levels in some areas. However, their abundant growth can also provide valuable habitat for fish and other aquatic species. For example, the dense stands of vegetation can provide important refuge areas for young-of-the-year fish that are susceptible to predation and can be important habitat for aquatic macroinvertebrates that are a vital source of food for fish and waterfowl. Little Sturgeon Bay is also a relatively unique and productive shallow waterbody in the Green Bay ecosystem.. As a result, it is probably an important fish production area for Green Bay, and the dense stands of vegetation found in Little Sturgeon Bay may provide important habitat needed to support the Green Bay fishery. Although historically this importance may have been shared with other bays along the Green Bay coast, given the loss of the lower Green Bay ecosystem today certainly makes Little Sturgeon Bay all the more ecologically important. Management of nuisance aquatic vegetation in Little Sturgeon Bay needs to be carefully considered and done in a manner that is sensitive to protecting the habitat value that these aquatic vegetation stands may provide.

Curly-leaf pondweed (*P. crispus*) and Eurasian water milfoil were the only two aquatic exotic species found growing in Little Sturgeon Bay. Purple loosestrife is an exotic species that was found growing in some shoreline habitats, and it will be discussed in the *Shoreline Vegetation* section.

Curly-leaf pondweed was infrequently observed in Little Sturgeon Bay, but it is important to consider the life history of curly-leaf pondweed when interpreting the significance of its limited occurrence. Curly-leaf pondweed has cool water adaptations that it developed in its colder home ranges of Europe and Asia. During the spring, curly-leaf pondweed grows and produces foliage, but by mid-July the plant begins to enter a summer dormancy period that is unique for Wisconsin aquatic plants. In mid-July when most aquatic vegetation is reaching its peak growth, curly-leaf pondweed is decaying and dying back. The Little

Sturgeon Bay aquatic vegetation survey was conducted during the first week of August to capture aquatic vegetation near its peak growth; however, the unique growth patterns of curly-leaf pondweed may have made it harder to observe during this time period. As a result, the abundance of curly-leaf pondweed in the bay may have actually been underestimated.

Table Nine: Aquatic Vegetation Distribution and Abundance Data for Little Sturgeon Bay[1]

Species	Maximum Observed Rooting Depth (feet)	Frequency of Occurrence (Percent)	Mean Daubenmire Classification Ranking (Approximate Percent Aerial Cover Shown in Parentheses)[2]	Notes
Elodea canadensis	15.0	82	2.2 (30%)	Very common; abundance increased in deeper water with softer substrate
Myriophyllum spicatum	15.0	77	1.9 (23%)	Very common and not observed with spiked water milfoil
Ceratophyllum demersum	15.0	68	1.9 (23%)	Common; abundance increased in deeper water with softer substrate
Vallisneria americana	7.5	64	1.8 (21%)	Common; associated with areas of sandy substrate
Chara spp.	15.0	27	3.2 (54%)	Abundance greatest in water depth of 0.0 to 2.5 feet with sandy, hard substrate
Potamogeton zosteriformis	12.0	27	1.3 (11%)	Localized populations found throughout the bay.
Ranunculus longirostris	7.0	27	1.2 (9%)	Localized populations found throughout areas less than approximately 7.0 feet deep
Zosterella dubia	15.0	27	1.3 (11%)	Localized populations found throughout the bay
Potamogeton richardsonii	7.0	23	1.0 (5%)	Localized populations found throughout areas less than approximately 7.0 feet deep
Potamogeton pusillus	5.0	14	1.3 (11%)	Restricted to shallow, protected areas; often found with sago pondweed.
Myriophyllum sibiricum	2.5	9	1.0 (5%)	Uncommon, restricted to shallow areas, and not observed with Eurasian water milfoil
Najas flexilis	2.5	9	1.5 (15%)	Uncommon and restricted to shallow areas
Potamogeton crispus	15.0	9	1.0 (5%)	Uncommon
Potamogeton pectinatus	1.5	9	1.5 (15%)	Restricted to shallow, protected areas; often found with small pondweed

1. *Eleocharis erythropoda*, *Lemna minor*, *Nuphar variegata*, *Nymphaea odorata*, *Potamogeton illinoensis*, *Sagittaria cuneata*, *Scirpus acutus*, *Scirpus validus*, *Sparganium eurycarpum*, and *Typha latifolia* were observed in Little Sturgeon Bay but not recorded in any of the sample plots. As a result, they are not included in the analyses shown in the table. 2. Mean is only for those sample plots where a particular species was found.

Floristic Quality Assessment Results

The FQA completed for the Little Sturgeon Bay native vascular aquatic vegetation indicated a mean coefficient of conservatism of 5.05. Nichols (1998) found that the median *C* for inland lakes in this region of the state is 5.6. The number of species observed in Little Sturgeon Bay was 23, and the median for inland lakes in the region is 14. It is important to note that the data from Nichols may not be directly applicable because it applies to inland lakes, but it can be useful in providing some relative comparisons.

The floristic quality index for Little Sturgeon Bay was 23.13, while the median floristic quality index for inland lakes in this region is 20.9 (Nichols 1998). Overall, the floristic quality assessment suggests that the aquatic vegetation of Little Sturgeon Bay is indicative of an aquatic environment of average to above average quality. When the two exotic species, Eurasian water milfoil and curly leaf pondweed, are assigned a *C* value of 0 and included in the FQA evaluation, the floristic quality index becomes 22.10; however, this value is still above the regional median reported for inland lakes.

Table Ten: Coefficients of Conservatism for Little Sturgeon Bay Vascular Aquatic Vegetation

Common Name	Scientific Name	Coefficient of Conservatism[1]
Coontail	*Ceratophyllum demersum*	3
Common waterweed	*Elodea canadensis*	3
Small duckweed	*Lemna minor*	5
Spiked water-milfoil	*Myriophyllum sibiricum*	7
Eurasian water-milfoil	*Myriophyllum spicatum*	Exotic species
Slender naiad	*Najas flexilis*	6
Bullhead pond lily	*Nuphar variegata*	6
White water lily	*Nymphaea odorata*	6
Curly-leaf pondweed	*Potamogeton crispus*	Exotic species
Illinois pondweed	*Potamogeton illinoensis*	6
Sago pondweed	*Potamogeton pectinatus*	3
Small pondweed	*Potamogeton pusillus*	7
Clasping-leaf pondweed	*Potamogeton richardsonii*	5
Flat-stem pondweed	*Potamogeton zosteriformis*	6
White water crowfoot	*Ranunculus longirostris*	6
Arum-leaved arrowhead	*Sagittaria cuneata*	7
Hardstem bulrush	*Scirpus acutus*	5
Softstem bulrush	*Scirpus validus*	4
Common bur-reed	*Sparganium eurycarpum*	5
Broad-leaved cattail	*Typha latifolia*	1
Wild celery	*Vallisneria americana*	6
Water star-grass	*Zosterella dubia*	6
Mean *C*		5.05

1. Source: *Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications*, S. Nichols, 1998

Shoreline Vegetation

A list of the shoreline vegetation observed during the aquatic vegetation survey is shown in Table Twelve. The shoreline vegetation list is not comprehensive and is only intended to give an indication of the type of shoreline vegetation present.

Table Eleven: Shoreland Vegetation Observed During the Aquatic Vegetation Survey

Common Name	Scientific Name[2]
Sedge	*Carex spp.*
Fox sedge	*Carex vulpinoidea*
Bull thistle	*Cirsium vulgare*
Red-osier dogwood	*Cornus sericea*
Few-flowered spike rush[1]	*Eleocharis quinqueflora*
Fireweed	*Epilobium angustifolium*
Boneset	*Eupatorium perfoliatum*
Grass-leaved goldenrod	*Euthamia graminifolia*
Green ash	*Fraxinus pennsylvanica*
Jewelweed	*Impatiens capensis*
Dudley's rush	*Juncus tenuis var. dudleyi*
Jointed rush	*Juncus nodosus*
Purple loosestrife	*Lythrum salicaria*
White sweet-clover	*Melilotus alba*
Common evening primrose	*Oenothera biennis*
Reed canary grass	*Phalaris arundinacea*
Ninebark	*Physocarpus opulifolius*
Dock-leaved smartweed	*Polygonum lapathifolium*
Smartweed	*Polygonum sp.*
Cottonwood	*Populus deltoides*
Silver-weed	*Potentilla anserina*
Dock sorrel	*Rumex sp.*
Sandbar willow	*Salix exigua*
Crack willow	*Salix fragilis*
Stinging nettle	*Urtica dioica*
Blue vervain	*Verbena hastata*
Water speedwell	*Veronica anagallis-aquatica*
River bank grape	*Vitis riparia*

1. State of Wisconsin Special Concern species
2. Nomenclature follows Gleason and Cronquist, 1991

Shoreline communities can be broadly characterized into three types consisting of:

1. Upland shoreline habitat characterized by a relatively abrupt transition from the ordinary high water mark into upland conditions. The majority of the upland habitat has been developed for residential, commercial, or agricultural use.
2. Emergent/wet meadow habitat. This habitat type is primarily concentrated in the southern end of the bay at the mouth's of Kayes, Malvitz, Twin Harbor, and Krueger Creeks.
3. Exposed sand/mud flats resulting from low water levels during recent years.

One of the species identified on the exposed mud flats was few-flowered spike rush (*E. quinqueflora*). Few-flowered spike rush is a State of Wisconsin Special Concern species. Special Concern species are those about which some problem of abundance or distribution is suspected but not yet proven. The main purpose of this category is to focus attention on certain species before they become Endangered or Threatened. Few-flowered spike rush is categorized as imperiled in Wisconsin because of rarity (i.e., 6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state. Populations of few-flowered spike rush were abundant on the exposed sand flats in Little

Sturgeon Bay. This spike rush is typically associated with calcareous shores and flats, and the dolomite bedrock that underlies and surrounds Little Sturgeon Bay provides an ideal habitat for this species, especially during low-water periods that produce exposed flats.

Not all shoreline species observed, however, were as desirable as the few-flowered spike rush. Established populations of the exotic species purple loosestrife (*L. salicaria*) were observed throughout the southern end of the bay near the mouth's of Kayes and Twin Harbor Creeks (see Figure Five for location of creeks and established Purple Loosestrife sites). Purple Loosestrife colonies were primarily confined to wet meadow habitats associated with the bay and creeks, and were relatively well established with hundreds of flowering individuals observed.

Project Summary

Little Sturgeon Bay parallels a mesotrophic inland lake system in production and recreational use. Overall, the waters of Little Sturgeon Bay are plentiful in dissolved oxygen and have above average water clarity. The watershed for Little Sturgeon Bay is 23% row crops, 53% woody vegetation and 34% grass based cover. The majority of sediment loading and 73% of the phosphorus loading is due to agricultural practices in the watershed. Phosphorus is the limiting nutrient in the bay. Point source pollution was not apparent, however, of the area surveyed for sanitation, 214 of 242 sanitary systems are holding tanks. One may extrapolate that of the 88% of homes in the Little Sturgeon Bay area with holding tanks, a significant portion will fail a system review. Aquatic vegetation in Little Sturgeon Bay has high species diversity and high species abundance which was greater than expected. The aquatic plant community is average to above average when compared to similar inland lake systems.

Inventory Analysis

The inventory and collection of base line data for Little Sturgeon Bay are to be used to establish trend-monitoring data. This initial step and future collections of data should be used in a "phase two" process to develop a comprehensive management plan for the bay. The recommendations that follow can be used as management guidelines for phase two. These recommendations are intended to be a baseline for the management plan and do not represent a specific implementation plan, or an exhaustive study of public input. The recommendations are derived from observations, historic and current uses and collected quantitative and qualitative data. The recommendations or future tasks may include:

1. The potential to pursue nearshore sensitive area designation for all or portions of the Bay
2. Long term control of Purple Loosestrife in lower bays.
3. Control of non-point source discharge of nutrients and sediment into tributaries and bay.
4. Address and explore options for shoreline protection and alteration issues.

Concern or Issue 1: The Significance of Little Sturgeon Bay to Provide High Quality Spawning Habitat for a Variety of Species

Little Sturgeon Bay is an important spawning and rearing area for many species of fish. The nearshore areas which are rich in aquatic plant diversity and density represent prime habitat for a variety of fish. One area in particular is the lower bay east of Squaw Island Point. Walleye, northern pike, dogfish, and long and white nose sucker use the bay and associated creeks for spawning and rearing as well as centrarchids, forage minnows and yellow perch. Beds of hard stem and soft stem bulrush are located here as well as other emergent and submergent aquatic vegetation necessary for fish and wildlife. Bulrush is especially important for small mouth bass spawning.

The importance of Little Sturgeon Bay serves as spawning and nursery grounds for a variety of fish is perhaps unparalleled on Green Bay. The species present, their abundance and the importance of the east lower bay is supported by DNR fish assessments during the past decade. Due to the intact, favorable and successful spawning area, the LSAPOA is encouraged to explore protection efforts for the east lower bay in phase II (the management plan). The various aquatic cover and substrate types are critical in successful spawning. It is a crucial habitat to protect for the future of fish and wildlife using the area.

Concern or Issue 2: Aquatic Plants Impeding Navigation and Recreational Activities
Aquatic plants provide a source of food for shorebirds, waterfowl, insects and amphibians which are all critical components of Little Sturgeon Bay. Both lower bays of Little Sturgeon Bay have near shore areas with relatively intact aquatic vegetation. At times, however, the amount of aquatic vegetation may reach nuisance levels, especially in waters less than four feet deep. The assemblage of aquatic plants consists of a variety of native species and of invasive non-natives such as Eurasian water milfoil and curly leaf pondweed. Coontail, common waterweed and Eurasian water milfoil cause the greatest recreational use restrictions and nuisance populations.

Concern or Issue 3: Detrimental Impacts of Non-native Aggressive Species, More Specifically, Purple Loosestrife and Eurasian Water Milfoil.
Invasive aggressive plants and animals are an apparent threat to the Little Sturgeon Bay area. Purple Loosestrife, a wetland plant species found in Little Sturgeon Bay and neighboring areas, can quickly become an epidemic. It is established on Riley's Point and in the west lower bay. It is critical that the existing plants be controlled or eradicated when possible. Purple Loosestrife threatens the entire near shore communities around Little Sturgeon Bay that have been identified as important habitat. It also threatens the special concern species, few-flowered spike rush, by smothering and out-competing this rare species.

Concern or Issue 4: Non-point Source Input of Sediment and Phosphorous
Nearshore vegetation acts as a trap for sediment flowing from the shoreland and streams. This vegetation is key in protecting water quality and taking up nutrients to reduce the availability of those nutrients to stimulate algae blooms. Plants also anchor bottom sediment, which reduces turbidity. This is most noticeable in the west lower bay where deposited sediment is plentiful and aquatic plants are diverse.

Upstream and upland property owners should be made aware of the state and local programs available to help reduce nutrient and sediment run-off.

Concern or Issue 5: Habitat Alterations and Impacts to Shoreline or Near Shore Areas
All municipalities have the authority to pass ordinances. Pier ordinances have the ability to protect some of the nearshore resources valued by controlling pier density and location, setting forth dimensional standards, and designating areas within the bay, which due to ecological significance, require greater protection. Surface use ordinances can impose surface use controls as well. Water level fluctuations significantly affect conditions in the bay. Low levels may cause stressful conditions for fish and increase the number of nuisance aquatic plants. High water levels can boost the amount of nutrients from runoff and flooded lakeshore soils. Older septic systems, located near the shore, may flood when groundwater levels are high. Yet another consequence of fluctuating water levels is shoreline erosion. Currently, with low lake levels, surface use in the lower bays and nearshore areas are already limited, however, as lake levels rebound the nearshore areas will become accessible again.

Exposed shoreline areas due to decreased water levels creates a unique habitat of exposed lakebed. The exposed bed gives way to more emergent vegetation and a larger transitional zone to upland areas. Shore birds are often attracted to such areas. It also provides a larger beach increasing access interests. However, operation of any motor vehicle on exposed lakebeds is against the law according to Wisconsin State Statute 30.29. Property owners are also prohibited from mowing beach vegetation without a permit. Removal of some vegetation less than 30% for every 100' of shoreline using only hand tools is permissible in most cases but may require permission through the county shoreland zoning ordinance.

Vegetation in the exposed lakebed and transitional zone is very important to the health of the bay. It protects against erosion and provides great habitat. In years of extremely high lake levels, many landowners chose to place dimension stone, rock or other riprap along their properties. This rock barrier can provide protection from erosion, but provides little or poor quality habitat for aquatic organisms. It actually may be detrimental in some areas because it allows property owners to have manicured lawns directly adjacent to the lake edge, which can increase nutrient run-off and create habitat for aquatic invasive aggressive species like zebra mussels and round goby.

Public Education and Awareness Building

The initial project began as an effort stemming from the Little Sturgeon Area Property Owner's Association (LSAPOA). Most of the management concerns of the property owners and recreationists in Little Sturgeon Bay have historically focused on the topic of aquatic nuisance weeds. The initial idea for the grant project was to develop a management tool for aquatic plants, however, the grant project went far beyond just nuisance weeds.

Informational Meetings
On February 20th, 2001, an introductory meeting was held in the Little Sturgeon area for invited community residents. The attendees consisted of about 14 individuals and included of property owners, business owners and individuals in government office. The proposed project was presented to the group for comments and discussion.

The annual meeting of the LSAPOA was held September 15, 2001. Information was presented at the meeting concerning the status of and upcoming developments regarding the Little Sturgeon Bay ecosystem. Informational handouts were made available ranging from shoreline landscaping and vegetative buffers to aquatic exotic species. The group was also briefly informed about a recent discovery of an invasive aggressive species of fish, the round goby (*Neogobius melanostomus*).

Newsletter
In March 2001, a newsletter titled *Bay Connections* was released and mailed directly to 450 property owners around Little Sturgeon Bay including Riley's Point. The newsletter discussed the grant project, a purple loosestrife control efforts on Riley's Point and shoreline/stream habitat threats. The second edition of *Bay Connections* was released in March 2002 to the same direct mailing group. This newsletter focused on the findings of the grant project and the next steps property owners can take to continue the efforts. (see Appendix A)

Little Sturgeon Days
Each year, an event entitled "Little Sturgeon Days" is held in the Town of Gardner. This event brings out the local community and neighboring rural communities to take part in a parade, food and music. A large informational display booth for the Little Sturgeon Bay grant project was located on the event grounds during the June, 2001 and 2002 celebrations. The display included live samples of aquatic nuisance weeds, all the water collecting and measuring instruments, the water chemistry check out kit and information on habitat and frog surveys.

Public Workshops
Public workshops were held on August 19, 2001 and ran consecutively throughout the morning. The first workshop was held on Riley's Point in the parking lot of Sunset Bar and Grill. Participants saw first hand the populations of purple loosestrife and were educated on its lifecycle. The group took a brief walk around the area to the cobble shoreline. At the cobble shoreline, a brief presentation on control techniques was demonstrated.

The group then moved onto the second workshop which was held in the Town of Gardner fire station. The UW- Extension Basin Educator presented the preliminary results of the aquatic vegetation survey and shared vouchers of all the samples taken during the survey.

The group remained at this location for the remainder of the workshop which was a discussion session facilitated by the DNR Water Quality Biologist.. The presentation focused on sensitive area designation, the habitat quality of Little Sturgeon Bay and the importance of Little Sturgeon Bay habitats to the entire Green Bay system.

The workshop series ended with a small social and lunch. The workshop series had approximately 40 participants.

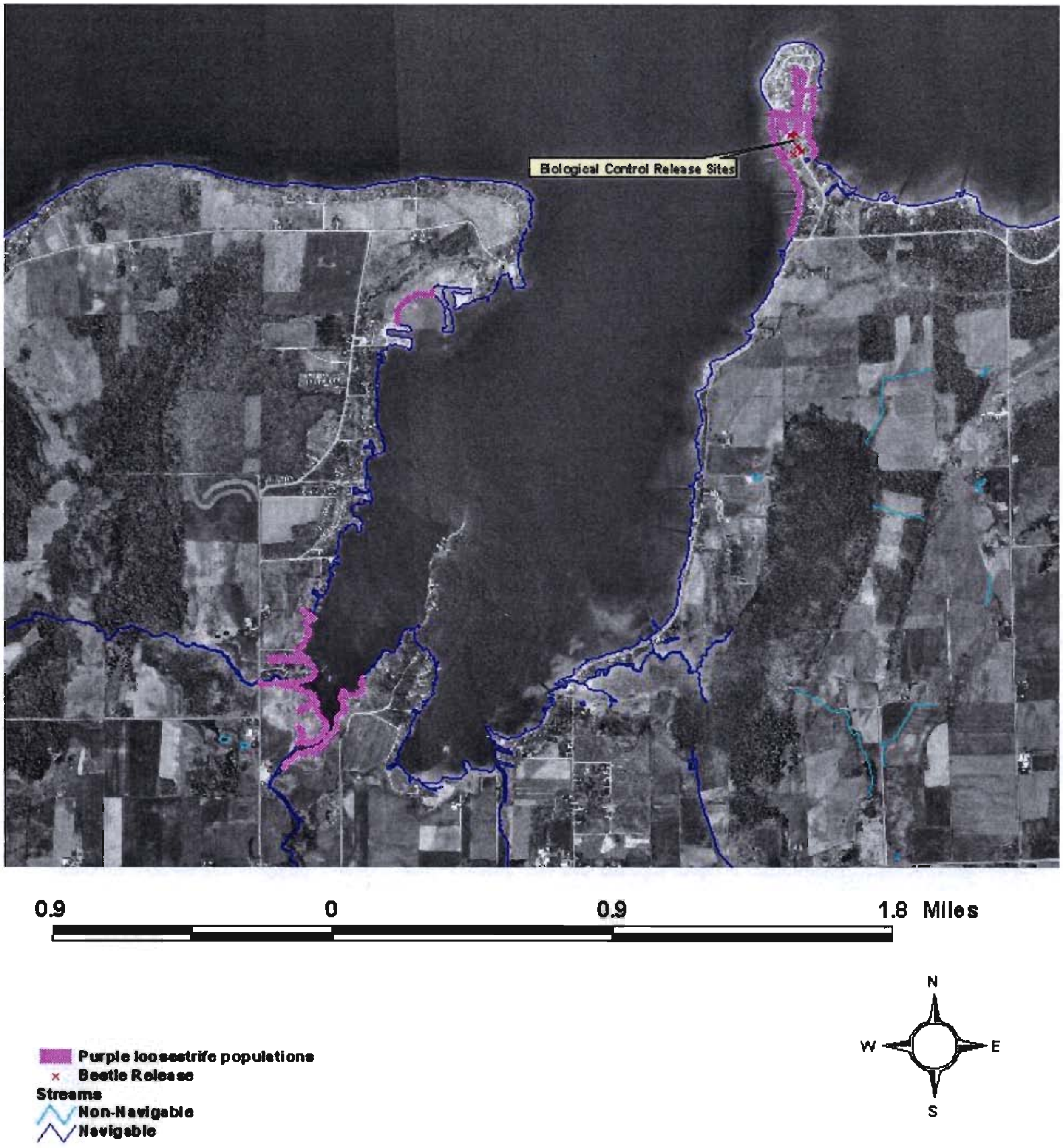
In May of 2002, an Adopt-the-Bay (water chemistry sampling) public workshop portion was conducted. Interested individuals participated in a spring hands on demonstration where the sampling equipment and kit were available. The participants were instructed on sampling procedures, protocol and overall importance of monitoring as part of a training effort to continue water quality monitoring long-term.

Citizen Advocacy

A strong part of the success of the Lake Planning Grant project was due to public involvement. The increase in public involvement and citizen advocacy at the local, level was the baseline for establishing future stewardship. Key local individuals advanced the projects efforts by identifying local routes for dispersal of information as well as local obstacles that the project may encounter. By having local support and citizen advocacy from the residents of the Little Sturgeon Area, the project established itself within the people and will, hopefully, begin to create a renewed sense of ownership.

Over the next two years, the SWCD will be available to assist the Little Sturgeon Bay Property Owners Association and other local interested individuals in fostering that sense of ownership through habitat monitoring, water quality monitoring and environmental education. By investing in projects or events that tie local residents to their local resources, this initial project will ultimately build community camaraderie and environmental husbandry.

Figure Seven:
Purple Loosestrife Areas of Establishment



Purple Loosestrife Control Plan

An apparent threat to the ecological significance of Little Sturgeon Bay and the surrounding wetlands is the invasive aggressive plant purple loosestrife (*Lythrum salicaria*). Purple loosestrife is an invader that arrived in eastern North America through seed dispersal by settlers. It is a very hardy perennial that can produce 2.7 million seeds annually per flowering head and also spreads through perennial rootstocks. These rootstocks are extensive and can send out 30-50 shoots which create a dense mat choking out other plants.

Purple loosestrife degrades habitat in numerous ways, but is most noted for rapidly degrading wetlands and diminishing their value to wildlife. Wetlands are the most biologically diverse and productive components of ecosystems in general. Little Sturgeon Bay is not an exception. Little Sturgeon Bay is noted as being one of the most significant wetland and riparian areas for wildlife and fish production in the Green Bay system (Wisconsin DNR Staff). The threat of monotypic stands of purple loosestrife poses a threat to habitat quality throughout Little Sturgeon Bay and neighboring bays and harbors.

Population Targets and Occurrences

Purple Loosestrife in Little Sturgeon Bay appears to be currently confined to two areas of dense to semi-dense populations at Riley's Point and Twin Harbors (Figure Seven). Although an official inventory and plant count has not been conducted, plants in bloom were recorded and noted in the aquatic and shoreline vegetation inventory for Little Sturgeon Bay.

<u>Twin Harbors:</u>
The *Twin Harbors* area refers to the wetland area along the southwest shoreline of Little Sturgeon Bay, the outlet of Twin Harbors Creek, and the small island/outcrops within the lower bay and extending to the mouth to Keyes Creek. A significant population of purple loosestrife was noted along the west shoreline slightly north of Polish Lane and extending south past Twin Harbors Road. No mature plants were seen along the banks of Twin Harbors Creek. Mature plant establishment also occurs along the shores of the small outcrop islands in the bay. A few sporadic plants have been identified along the southwest shore of Squaw Island Point (east shoreline of the lower west bay), but the most significant concentration of plants is found on the southwest shore.

Purple Loosestrife at the Twin Harbors location has the potential to outcompete the native vegetation and create a monotypic stand of loosestrife. Purple loosestrife may be able to colonize the banks and near shore areas as well as much of the area of standing water since the maximum depth of the lower bay is less than three feet. This area of Little Sturgeon is a critical wetland habitat for fish, waterfowl and other wildlife. Purple loosestrife control is necessary and imperative to protect from further infestation.

<u>Riley's Point:</u>
Riley's Point is a small peninsula that compromises the north east shore of Little Sturgeon Bay and the northwest shore of Riley's Bay. The peninsula historically was wooded wetland, but since the late 1930's has undergone significant anthropogenic alterations. The point is now nearly all small homes and seasonal cottages. A town road dissects the peninsula and aides in creating small wetland pockets between the raised bank of the road and the raised or filled area directly adjacent to the shoreline where most houses were constructed. These small pockets of remnant wetlands are infested with dense populations of adult purple loosestrife. At the north end of Riley's Point is a small boat launch and mooring area. Individual plants occur along the shoreline where lawn is not maintained.

It is believed that the Riley's Point populations have existed prior to 1997 and were first officially recorded in 1999. As of 2000, the populations seemed well contained in part due to their segregation from the waters of the bay. However, in 2001, the rock and cobble shoreline area near the culvert that connects the mooring and boat launch area to the bay had numerous individual plants.

In 2000, the Door County Soil and Water Conservation Department (SWCD) in cooperation with the Wisconsin Department of Natural Resources (WDNR) released the biological control beetle *Galurecella sp.* At the time of release, landowners were notified of the beetle as well as the resource threat purple loosestrife causes. The beetle was released in three of the concentrated pocket areas for long term control and as a potential beetle rearing nursery and education component. These efforts are greatly expanding.

<u>Henderson's Marsh/ The Marina and Other Suitable Habitat:</u>
A large and significant coastal wetland exists along the inner reaches of the bay located along the the interior of Little Sturgeon Bay's north west shore between the southern stretch of Henderson's Point and the boat slips and parking lot associated with the marina located on the shoreline. No populations were found to be established, but this important wetland area should be monitored closely. Other significant areas include Squaw Island point, Squaw Island reef, the lower inner bay east of Squaw Island, the mouth of Malvitz creek and the mouth of Krueger Creek.

<u>Individual Plants:</u>
Individual plants are beginning to occur throughout the bay. Each plant will continue to spread seed and increase the core area of infestation. These individual plants may soon establish satellite populations that will develop into dense seas of purple flowering heads. Control efforts should be extended to include eradication plans that can be enacted when individual plants or small populations are observed.

Levels of Concern

The purple loosestrife populations found at Twin Harbors and Riley's Point serve as a viable seed source for the remaining portions of the bay as well as adjacent coastal and inland wetland areas. The spread of purple loosestife via any of the four stream channels to reach upland sites and the Gardner Wildlife Area is very possible and may have already occurred in some instances. These populations also pose a threat to other wetlands around the Door Peninsula.

The two identified infested sites previously stated should be treated with equal priority. However, no control efforts exist or have been conducted to date at Twin Harbors.

Control Techniques

Controlling the spread of purple loosestrife is crucial to protecting and maintaining vital fish, wildlife and native plant habitat, while people can help control the natural spread of the aggressive plant, improper control efforts may sometimes assist in the spread. Four major techniques exist for controlling purple loosestrife. The control techniques are digging and hand pulling, cutting and disposing of flowering heads, chemical application and biological control species. An effective control plan will incorporate a combination of control techniques based on the conditions and concerns of a given infestation.

Explanation of Control Techniques:

Digging and Hand Pulling:
Pulling is easiest when the plants are young (under 2 years) or when in sand or loose soils. Older plants have larger roots that can be eased out with a garden fork. Remove as much of the root as possible. Small pieces broken off may sprout new plants. It is very important to disturb as little soil as possible. Disturbed and disrupted habitat or soil is a prime area for new seeds to start! This effort is time intensive and burdensome; use it near the edge of a young population or on stray plants popping up in inconvenient areas.

Cutting:
Removing flowering spikes will prevent this year's seed from producing more plants in future years since each plant can produce over 2 million seeds in one season. Remove last year's dry heads also because they still may contain seeds. Cut the entire plant stems at ground level to inhibit growth. Dispose of properly! Do not

compost, mulch or bring to the landfill because the seeds can still remain viable. Let plants decay in a plastic bag or burn.

Chemical Control:
If an infestation is in a dry upland area and on private property, the property owner may use an approved herbicide by applying it directly to individual plants. Broadcast spraying is not advised without supervision from a qualified management agency because broadcast spray kills all broad-leaved plants. This leaves the area being sprayed open to further invasion from nearby remaining sources of purple loosestrife. This also gives the seeds left in the soil a chance to germinate.

Biological Control:
In areas of dense and/or extensive populations, mechanical and chemical controls can be ineffective. Biological controls for purple loosestrife utilize a plant specific insect that feeds naturally on the purple loosestrife. The insects, like purple loosestrife, are also from Eurasia. The insects have gone through rigorous isolation and research projects to ensure that after the purple loosestrife is under control, the insects themselves won't become a problem. The insects are a long-term solution (10-20 years) and can reduce plant abundance by as much as 80%. One of these insects, the *Galerucella* beetle was released on Riley's Point in 2000. (The beetle was originally raised on potted host plants, then transplanted to the Riley's Point location. The beetles, once established, can also be collected in the field and transplanted to new sites.)

Control efforts are based on the extent and density of the target populations and the size of the area that is infected or at risk. Chemical treatment is typically not a good long-term solution, but is often the beginning step to get a dense or large population to a size that can be managed using mechanical control. Table Thirteen describes recommended control practices to be implemented in Little Sturgeon Bay from 2002-2007. It is recommended that the control techniques be revisited in 2004 to ensure that a manageable and proper effort is being maintained throughout the implementation. These control techniques and implementation schedule must be reviewed prior to 2008 to ensure proper results.

Table Twelve : Suggested Control Plan for Little Sturgeon Bay

	2002	*2003*	*2004*	*2005 and beyond*
Henderson's Marsh & Marina	Monitor and Record	Monitor and Record	Monitor and Record	Monitor and Record
Individual Plants L only	Cut head and stems of individual plants. Spot herbicide application to individual plants in all localities. *	Pull and/or dig isolated adult plants. Cut heads and stems of other individuals. Treat with herbicide if small populations are dense in nature. *	Pull and/or dig isolated adult plants. Cut heads and stems of other individuals.	Pull and/or dig isolated adult plants. Cut heads and stems of other individuals.
Mouth of Krueger Creek	Monitor and Record	Monitor and Record	Monitor and Record	Monitor and Record
Mouth of Malvitz Creek & Inner Bay East	Monitor and Record	Monitor and Record	Monitor and Record	Monitor and Record
Riley's Point H, M & L	Pocket areas treated with biological control. Pull individual plants with shallow roots in cobble shoreline. Spot application of herbicide to individual plants along boat launch and slip area as well as ditch ways. *	Pocket areas treated with biological control. Cut head and stems of individual plants. Spot herbicide application to individual plants in all localities. *	Pocket areas treated with biological control. Cut heads and stems of individual plants. If large adult plants still present, reapply herbicide and/or reassess site.	Pocket areas treated with biological control. Cut remnant plants only.
Squaw Island Shores	Monitor and Record	Monitor and Record	Monitor and Record	Monitor and Record
Twin Harbors H, M & L	Cut flowering heads and stems at ground level of outer population and spot apply herbicide. Carefully spray herbicide application to	Treat again with herbicide by cutting heads and spot application to specific plant. Target remaining core	Treat again with herbicide spot application to each specific plant. * (Less than 40%)	Continue plant distress by cutting stems at ground to inhibit growth. Cut prior to flowering (late June through

	2002	2003	2004	2005 and beyond
	spikes of core population on calm day (try to avoid any overspray.) Remove individual sporadic plants on outer edge of population. * (Greater than 60%)	populations and island outcrop shoreline. * (Remaining plants unaffected in previous year; 45-60%)		July). If population still at medium to large density, treat again with herbicide. If population less than 30%, treat individual plants by cutting only.

*Note: Herbicide applications over water or near wet areas requires consent from the WDNR Water Quality Biologist and may require a permit.

L: Low Density	1 to 50 plants	or 1-25% of given area
M: Medium Density	50 to 1,000 plants	or 26-75% of given area
H: High Density	more than 1,000 plants	or greater than 76% of given area

Monitoring and Recording

The best approach to controlling invasive aggressive species is to prevent the plant from ever becoming established. Prevention requires a given amount of monitoring to realize when and where a problem is or may start. One simple and effective approach is to establish one to two weekends out of the year to visit each of the seven areas identified above to look for plants. The ideal time to monitor the site is when the flowers are in bloom before seed production, typically late June through August. By dedicating one to three hours only two days out of the summer, new population's can be quickly identified and prevented from establishing or spreading.

Interested community groups, volunteers, clubs or school groups are great candidates for monitoring. Below is a suggested chart to use for planning the monitoring efforts for Little Sturgeon Bay. Since monitoring efforts are most effective long term, it is best if groups or individuals give a 2-3 year commitment which may total 18 –20 hours. When interested people choose a route, they should also choose a date. By committing to a specific date or series of dates, the work is more likely to become an outing or an event that is part of a schedule rather than a chore that has to be squeezed in to someone's life.

Table Thirteen: Example of Monitoring Assignment Strategy

Route or Area	Late June (6/20-6/30)	July (throughout month)	Early August 8/1-8/11)
Henderson's Marsh & Marina	Wild Ones 6/23	Wild Ones 7/23	Local resident A 8/1
Individual Plants	LSBPOA members	LSBPOA members	LSBPOA members
Mouth of Krueger Creek	Local resident B 6/29	Master Gardeners 7/14	Local resident B 8/4
Mouth of Malvitz Creek & Inner Bay East	Boy Scouts 6/27	Master Gardeners 7/14	Master Gardeners 8/11
Riley's Point	Local resident C 6/30	Southern Door 5th graders	Ecology club 8/5
Squaw Island Shores	Local resident D 6/29	Local resident E 7/27	Local resident F 8/7
Twin Harbors	Local resident G 6/29	Rotary Club 7/10	Rotary Club 8/10

Monitoring data is very useful, even if no plants are detected. Results should be reported to a management agency to track the spread and/or control. Indications of the habitat composition can give insight into other habitat conditions and trends in biological integrity. Below is a list of individuals or agencies to contact which will be able to store and use the information collected.

Little Sturgeon Area Property Owners Association

Door County Soil and Water Conservation Dept.
P O Box 670
421 Nebraska Street
Sturgeon Bay, WI 54235
(920)746-2214
(920)746-2369 fax
jcorbisi@co.door.wi.us

Derek Strohl
Program Director
Wisconsin Wetlands Association
222 S. Hamilton St., Ste. 1
Madison, WI 53703
(608) 250-9971
derek@wiscwetlands.org
www.wiscwetlands.org

While purple loosestrife is the primary species being addressed in the control plan, other invasive aggressive plants can cause detrimental impacts in similar ways. When groups or individuals are monitoring purple loosestrife, they should also watch for species like leafy spurge and giant reed grass. Leafy spurge has been recorded in Door County at the Peninsula Park in Fish Creek and Whitefish Dunes State Park. It was located near boat launch and walk way areas. Giant reed grass is also in Door County along wet roadways. People are most familiar with the expansive infestation in Green Bay under the West Side of Tower Drive Bridge. Other invasive aggressive plants should be recorded or noted so efforts can be taken to prevent their establishment. Prevention is always the cheapest and easiest form of control!

Education

A key component to an efficient and effective effort is education. Individuals must first realize the resource threat to give support to the effort. It also takes a certain amount of training to properly identify purple loosestrife and also to properly administer the correct control technique.

Many information and education materials already exist. It is recommended that the Little Sturgeon Area Property Owners Association act as the source for individuals to obtain the information needed. The Door County Soil and Water Conservation Department in cooperation with the UW Extension Lakeshore Basin Educator will be able to offer a one-day training session each year if needed as well as direct the LSAPOA on obtaining current and accurate education materials to disseminate.

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Appendix D: Water Chemistry Data

Water Body Identification Number 0000092
Little Sturgeon Bay

Results for Sample Location LSB001

Lab Tests	4/25/01	6/13/01	7/17/01	8/23/01	10/24/01
Chlorophyll A Uncorrected and lab filtered Ug/L	5	6	7	8	2.4 low absorbance result approximate
Conductivity Umhos/cm	355				300
PH	8.28				8.22
Alkalinity mg/L	122				108
Ammonia mg/L	.038				
Nitrate-nitrite mg/L	.151				0.124
Total Kjeldahl nitrogen mg/L	.54		.513 Matrix exceeded		0.39
Total Phosphorous mg/L	.018	.019	.025	.027	0.024
Dissolved reactive phosphorous (ortho-p in mg/L)	.005	ND	.003		0.010
Field Tests					
Sample Depth	6	8	6	6	6
Dissolved Oxygen mg/L	12.03	10.13	9.6	10.25	11.8
Temperature C	7	15.6	21.7	20	10
PH	9.3	8.7		8.9	8.9
Secchi Depth	8	10.7	9.4	8.5	11
Cloud Cover %	20		100	70	100
Conductivity	250	272	298	?261	?230

Results for sample location LSB002

Lab Tests	4/25/01	6/13/01	7/17/01	8/23/01	10/24/01
Chlorophyll A Uncorrected and lab filtered Ug/L	1.2 low absorbance result approximate	1.5 low absorbance result approximate	5.0	1.4 low absorbance result approximate	<1.0 low absorbance result approximate
Conductivity Umhos/cm	344				308
PH	8.9				8.27
Alkalinity mg/L	126				109
Ammonia mg/L	.030				
Nitrate-nitrite mg/L	.117				0.077
Total Kjeldahl nitrogen mg/L	.90		.540 matrix exceeded	0.42	0.46
Total Phosphorous mg/L	.011	.016	.030	0.020	0.018
Dissolved reactive phosphorous (ortho-p in mg/L)	ND	ND	.003		0.008
Field Tests					
Sample Depth		2.5			
Dissolved Oxygen mg/L	12.05	10.67	9.45	9.36	12.11
Temperature C		16.3	23.5	20.0	
PH	9.4	8.7		8.5	

Lab Tests	4/25/01	6/13/01	7/17/01	8/23/01	10/24/01
Secchi Depth	6.0 bottom	5.5 bottom	5.0 bottom	5.5 bottom	
Cloud Cover %	20		100	70	100
Conductivity	262	272	310	256	

Results for Sample Location LSB003

Lab Tests	4/25/01	6/13/01	7/17/01	8/23/01	10/24/01
Chlorophyll A Uncorrected and lab filtered Ug/L	1.5 low absorbance result approximate	4.1 low absorbance result approximate	1.5 low absorbance result approximate	<1.0 low absorbance result approximate	<1.0 low absorbance result approximate
Conductivity Umhos/cm	349				348
PH	8.44				8.34
Alkalinity mg/L	131				128
Ammonia mg/L	.032				
Nitrate-nitrite mg/L	.091				ND
Total Kjeldahl nitrogen mg/L	.54		.590 matrix exceeded	0.44	0.53
Total Phosphorus mg/L	.013	.035	.021	0.015	0.012
Dissolved reactive phosphorous (ortho-p in mg/L)	.002	ND	.002		0.002
Field Tests					
Sample Depth	2	2.5			
Dissolved Oxygen mg/L	12.36	8.71	9.36	10.6	12.28
Temperature C	10.1	20.4	21.6	21.5	
PH	9.4	8.5	9.36	9.3	
Secchi Depth	4.2 bottom	5.0 bottom	5.2 bottom	5.0 bottom	
Cloud Cover %	20		100	70	100
Conductivity	273	461	288	222	