A LAKE PROTECTION PLAN FOR ANVIL LAKE

VILAS COUNTY, WISCONSIN

Prepared By:

Environmental Horizons, Incorporated

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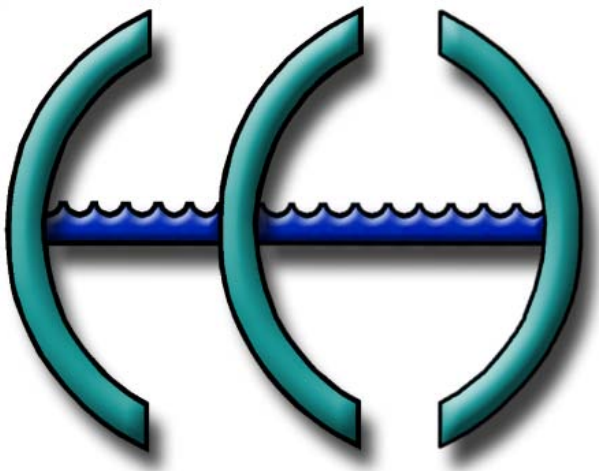

Final Report

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CHAPTER I

INTRODUCTION

Anvil Lake is located in the Town of Washington in Vilas County, Wisconsin. The Lake is an internally-drained, seepage Lake, as shown on Map 1. Anvil Lake is a valuable natural resource offering a unique setting and variety of recreational and related-use opportunities to the small residential community and their visitors using the Lake.

Anvil Lake is an integral part of this lake-oriented community. Much of the land surrounding the lake forms part of the Chequamegon-Nicolet National Forest, which provides opportunities for residents and visitors to access the Lake and its amenities. Recreational boating access is provided through three recreational boating access sites, one located within the National Forest land, a second owned by the Town of Washington, and one privately-owned access site.

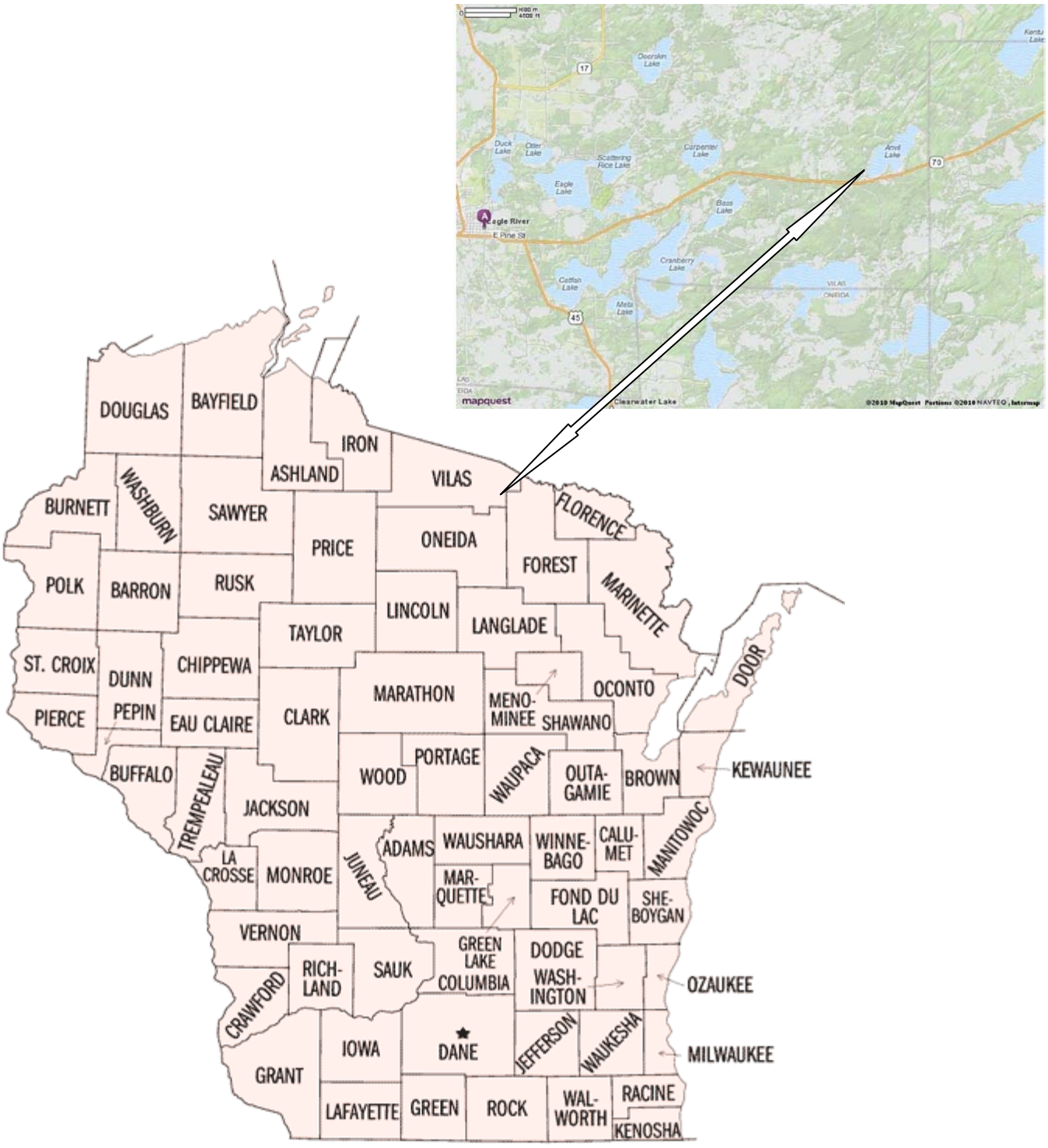
The Anvil Lake Association is the primary mechanism whereby residents of the Anvil Lake community collectively manage the natural resources of their community. The Association seeks to undertake, among other activities, a lake-oriented program of community involvement, education, and management. The changing lake surface elevation conditions within the Lake, likely to adversely affect the recreational and aesthetic values of the Lake, caused the community to seek planning assistance in the development of a lake protection plan for the Lake. Pursuant to this mandate, and seeking to improve the usability and prevent the deterioration of the natural assets and recreation potential of Anvil Lake, the Town of Washington, in cooperation with the Association, has contracted with Environmental Horizons, Incorporated, for the preparation of a lake protection plan for Anvil Lake.

This report summarizes available data on land uses within the drainage area tributary to Anvil Lake, water quality data, and related information, and sets forth an inventory of the aquatic plant communities present within Anvil Lake. In this regard, this Lake protection plan represents part of the ongoing commitment of the Anvil Lake Association, in cooperation with the Town of Washington, to sound planning with respect to the Lake. Since its inception, the Anvil Lake Association has acquired a significant amount of data and information on Anvil Lake. This knowledge is summarized herein, and provides the foundation upon which the interpretation of the inventory data collected under the auspices of the current project is based.

The inventory data presented herein were collected during 2010 by Environmental Horizons, Inc., with the assistance of the Anvil Lake Association, University of Wisconsin Center for Limnology Trout Lake Station, and U.S. Geological Survey. The aquatic plant survey of Anvil Lake was conducted by Dr. Susan Knight of the University of Wisconsin Center for Limnology Trout Lake Station staff. The survey was completed using the “point-intercept,” grid-based aquatic plant survey method employed by the Wisconsin Department of Natural Resources (WDNR) for aquatic plant surveys throughout the State. Water quality data were collected both by the U.S. Geological Survey using their Trophic State Index (TSI) water quality sampling protocol and by a volunteer monitor using the Citizen Lake Monitoring Network protocol. Environmental Horizons, Inc., staff completed the recreational use and shoreline

Map 1

LOCATION OF ANVIL LAKE, VILAS COUNTY, WISCONSIN



Source: Environmental Horizons, Inc and Mapquest.

structure surveys and recreational watercraft counts, and coordinated the community questionnaire survey on lake use and water quality.

The scope of this report is limited primarily to consideration of the factors affecting water quality, aquatic plant communities, and recreational uses of Anvil Lake. However, this plan will form an integral part of a future comprehensive lake management plan for Anvil Lake. The preparation of a comprehensive lake management plan for Anvil Lake will require additional water quality and biological data collection and analysis, as well as data on the water budget and role of groundwater inflows to the Lake.

This plan is intended to address the recreational lake use goals and objectives for Anvil Lake, developed in consultation with the Anvil Lake Association and Town of Washington. These goals and objectives are:

1. To protect and maintain public health, and to promote public comfort, convenience, necessity, and welfare, through the environmentally sound management of vegetation, fishery, and wildlife populations, in and around Anvil Lake;

2. To provide for high-quality, water-oriented recreational and aesthetic opportunities for residents and visitors to Anvil Lake, and manage the Lake in an environmentally sound manner; and,

3. To effectively manage the water quality of Anvil Lake to maintain healthy aquatic and riparian wetland plant communities and, thereby, better facilitate the conduct of water-related recreation, improve the aesthetic value of the resource to the community, and enhance the resource value of the waterbody.

This inventory and plan element, which conforms to the requirements and standards set forth in the relevant Wisconsin public law and State guidance documents,[1] should serve as an initial step in achieving these objectives over time.

[1]*This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 40, "Invasive Species Identification, Classification and Control;" Chapter NR 103,"Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual Removal and Mechanical Control Regulations."*

CHAPTER II

INVENTORY FINDINGS

INTRODUCTION

Anvil Lake is located within the Town of Washington in Vilas County, Wisconsin. The lake is located approximately 10 miles east of Eagle River, just to the north of Highway 70. Anvil Lake is an internally drained basin lying adjacent to the West Branch of the Blackjack Creek, a tributary stream to the Eagle River, which then drains to the Wisconsin River. The Wisconsin River System is part of the Mississippi River Drainage System.

WATERSHED CHARACTERISTICS

Anvil Lake lies within the Chequamegon-Nicolet National Forest, which comprises the majority of the drainage area tributary to Anvil Lake. The drainage area tributary to Anvil Lake, shown on Map 2, encompasses about 1,216 acres of lands that drain directly to the Lake without passing through any upstream waterbodies. A substantial portion of this drainage area is comprised of woodlands, although the immediate shorelands of the Lake are occupied by residential lands. Most of the riparian property is in private ownership. However, one public access and the campgrounds are located on National Forest lands. This and an unimproved landing owned by the Town of Washington provide public recreational boating access, while the National Forest campground, provides additional land- and water-oriented recreational opportunities for the public.

Table 1

HYDROGRAPHIC CHARACTERISTICS OF ANVIL LAKE

Parameter	Measurement
Surface Area.....	377 acres
Volume	7,382 acre-feet
Shoreline Length.....	4.84 miles
Maximum Depth.....	32 feet
Mean Depth	19 feet
Direct Drainage Area	1,216 acres

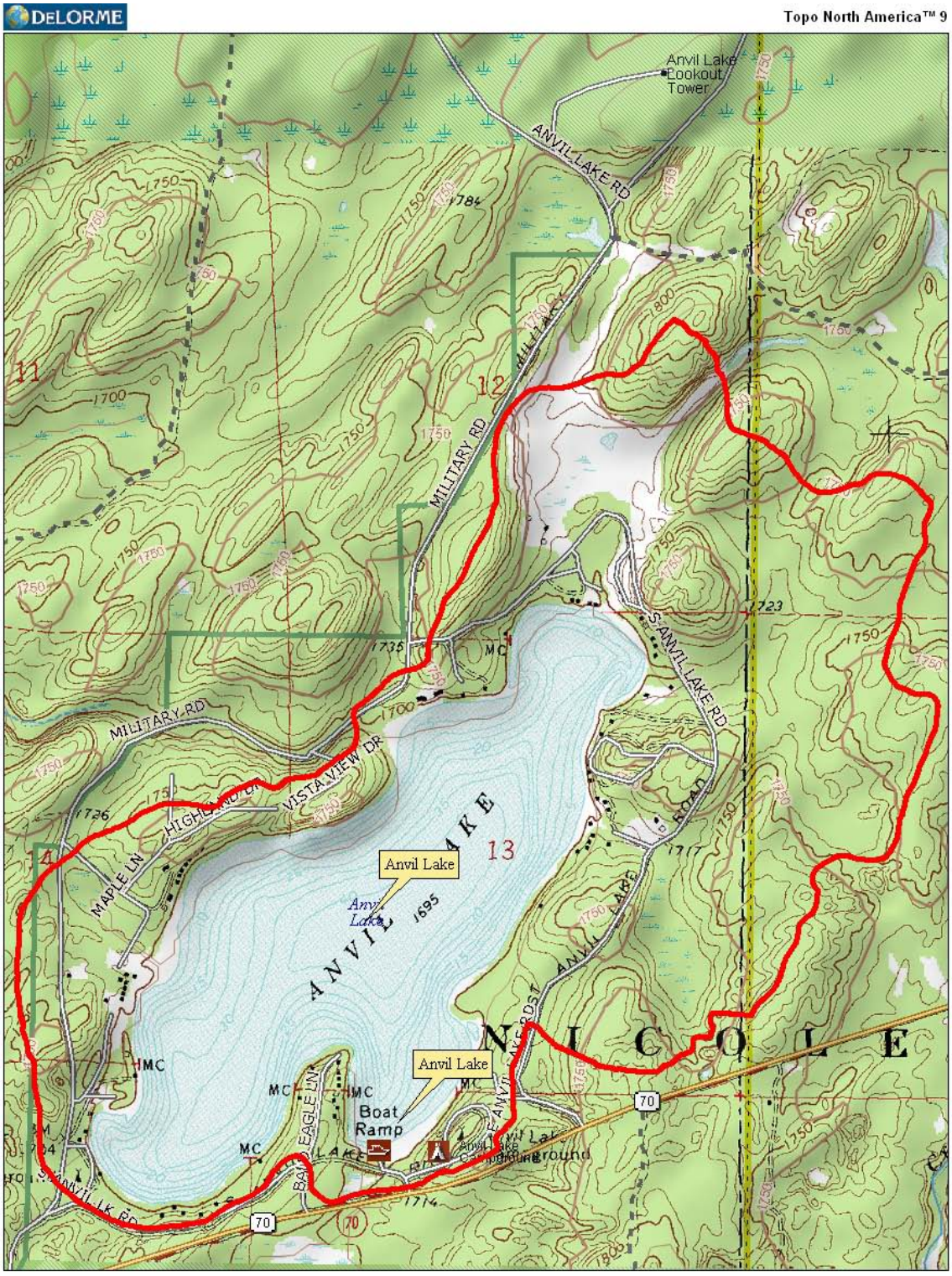
Source: Wisconsin Department of Natural Resources and Environmental Horizons, Inc.

WATERBODY CHARACTERISTICS

Anvil Lake is a 377-acre internally-drained, groundwater-fed waterbody, the hydrographical characteristics of which are set forth in Table 1. The Wisconsin Department of Natural Resources (WDNR) documented the hydrographic characteristics of the Lake in 1970, when the Lake stage was approximately 4.5 feet higher than that in the summer of 2010. As of 1970, Anvil Lake had a maximum depth of approximately 32 feet, a mean depth of about 19 feet, and a volume of about 7,382 acre-feet. Approximately 5 percent of the

MAP 2

ANVIL LAKE WATERSHED AND TOPOGRAPHIC MAP



Source: Environmental Horizons, Inc.

lake basin is less than 3 feet in depth, while about 52 percent of the Lake has a depth of more than 20 feet. Anvil Lake is comprised of a single deep basin. The bathymetry of the Lake, during 1970, is shown on Map 3. The topographic features and landscape relief of the area surrounding Anvil Lake are also illustrated on Map 2.

POPULATION AND LAND USE CHARACTERISTICS

Population and Land Use

As of 2000, there were approximately 67 persons residing within the area surrounding Anvil Lake in the Town of Washington in Vilas County. There were approximately 117 housing units located within this area. Of these housing units 31 were reported as being occupied, with the balance being comprised of seasonal (or unoccupied) housing units.

Development in the drainage area directly tributary to Anvil Lake is comprised of high to moderate density residential development in the immediate shoreland area of Anvil Lake, as shown on Map 2. The eastern portions of the drainage area of Anvil Lake, shown on Map 3, are relatively undeveloped at present, some being part of the National Forest. A small portion of the northern area of the drainage area remains in pastoral use. A significant portion of the drainage area of the watershed remains in woodland. The existing 2007 land use pattern within the drainage area tributary to Anvil Lake is quantified in Table 2. Few changes in land use within the drainage area tributary to Anvil Lake are anticipated. Such changes are expected to be limited to infilling of already platted lots and the possible redevelopment of existing properties.

Recreational Boating Access

Recreational boating access to the Lake is provided through three sites located along the lake shore: one is privately owned and associated with a resort and two are publicly owned. One, located in the National Forest, is improved and includes a parking area. The second is owned by the Town of Washington and is primitive. The resort has a concrete boat ramp. These access sites are shown later in this chapter on Map 10.

TABLE 2

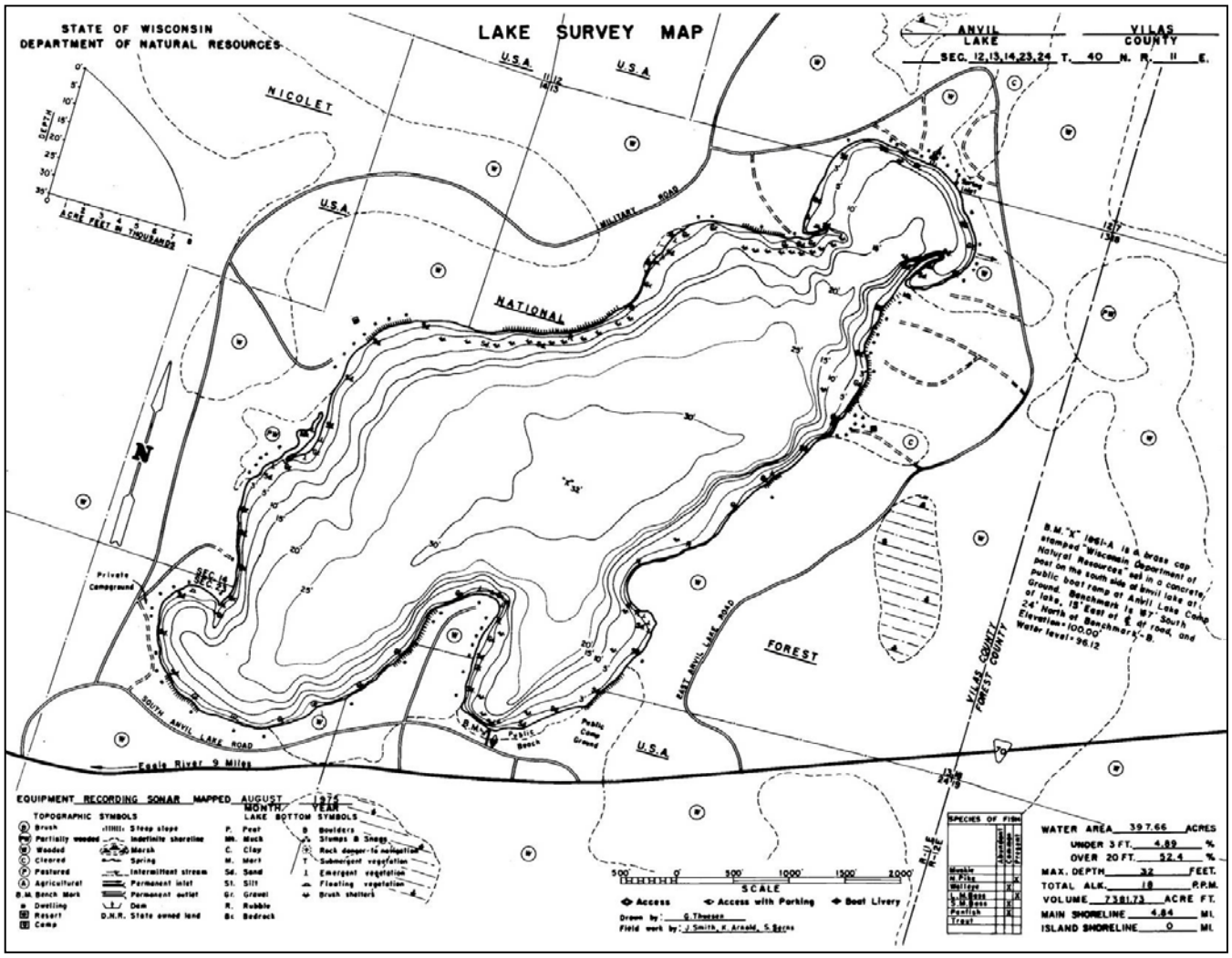
EXISTING LAND USE WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO ANVIL LAKE

Land Use Categories	Direct Drainage Area	
	Acres	Percent of Total Drainage Area
Urban		
Rural Residential	237	19
Subtotal	237	19
Rural		
Woodlands	602	50
Surface Water	377	31
Subtotal	979	81
Total	1,216	100

Source: Environmental Horizons, Inc.

MAP 3

BATHYMETRIC FEATURES OF ANVIL LAKE



Source: Wisconsin Department of Natural Resources.

Future Conditions

Limited growth of the Anvil Lake community in the Town of Washington is forecast. Minor infilling of currently platted lots could be anticipated, although the opportunities to divide lands for residential use are limited by the presence of the National Forest lands and Vilas County Shoreland Zoning. Any such lands may be expected to be developed at densities similar to those elsewhere in the lakeshore area, although the creation of additional resorts is expected to be limited by the current economic downturn (*circa* 2010). However, some redevelopment of existing properties may occur, as seasonal accommodations are transformed into year-round housing units. Thus, it can be anticipated that additional demands for water-based recreational opportunities may be generated.

WATER QUALITY

Water quality data have been acquired from Anvil Lake under the auspices of the Wisconsin Self-Help Monitoring Program (now the Citizen Lake Monitoring Program) since 1986. Anvil Lake is a mesotrophic or moderately-enriched waterbody, with a summer total phosphorus concentration of about 15 micrograms per liter (µg/l). Water quality parameters are summarized in Table 3. This phosphorus concentration is generally similar to those measured in other natural lakes in the County. Mesotrophic lakes are relatively fertile, supporting a diverse aquatic plant community and productive fisheries. At times, mesotrophic lakes may exhibit abundant growths of algae and aquatic plants. At the time of the conduct of the 2010 aquatic plant survey of Anvil Lake, some filamentous algae were observed. However, aquatic plant growth in the Lake, generally, was moderately abundant.

Water quality data on Anvil Lake suggest that the Lake can have a higher total phosphorus concentration at autumnal turnover, approaching 20 µg/l at times. Above this level of 20 µg/l, the lake could be considered eutrophic or slightly enriched. This concentration would suggest: (i) the influence of drought and the decrease in lake volume associated with the lack of inflow to the system, and/or (ii) the occurrence of internal loading, or mixing of this phosphorus-rich water with the surface waters of the Lake at the time of fall overturn. In the former case, the reduced water flow through the Lake results in the evaporative concentration of conservation elements such as phosphorus. In the latter case, phosphorus-rich hypolimnetic water is mixed into the surface waters of the Lake providing nutrients that can support and sustain a late season algal bloom. As water depth decreases, the likelihood of multiple mixing events increases. Figure 1 shows the relationship between total phosphorus and chlorophyll-a concentrations, in micrograms per liter, for the data series generated under the auspices of the Citizen Lake Monitoring Program (CLMN) program. This Figure shows that there is a strong likelihood of the Lake having increased chlorophyll-a levels during periods when the Lake also has high total phosphorus concentrations. This relationship is well-known in Lakes, as shown in Figure 2, and supports the empirical modeling suite developed by the Organization for Economic Cooperation and Development (OECD) among others. It also supports the likelihood that algal growth in the Lake is limited or controlled by the availability of phosphorus in the system. This, in turn, supports the recent action by the Wisconsin Legislature to moderate the anthropogenic input of phosphorus to Lakes in the State by restricting the applications of phosphorus-containing fertilizers to turf in urban areas—see *2009 Wisconsin Act 9*, which created Section 94.643 of the *Wisconsin Statutes*, relating to restrictions on the use and sale of fertilizer containing phosphorus.

Table 3

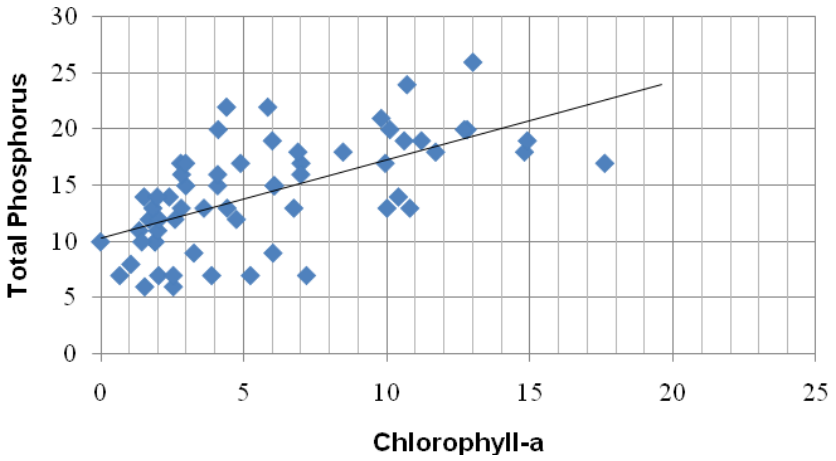
SURFACE WATER QUALITY CONDITIONS IN ANVIL LAKE: 1986 - 2010

Parameter	Mean	Maximum	Minimum
Physical Properties			
Dissolved Oxygen (mg/l)	8.1	14.8	0.0
Secchi Depth (feet)	11.6	25.5	3.2
Temperature (°F)	61.0	79.5	45.0
Nutrients			
Total Phosphorus (µg/l)	15	26	4
Biological			
Chlorophyll-*a* (µg/l)	5.6	17.6	0.0

Source: Environmental Horizons, Inc.

FIGURE 1

ANVIL LAKE PHOSPHORUS-CHLOROPHYLL RELATIONSHIP (concentrations in µg/l)



Source: Anvil Lake Association and Environmental Horizons, Inc.

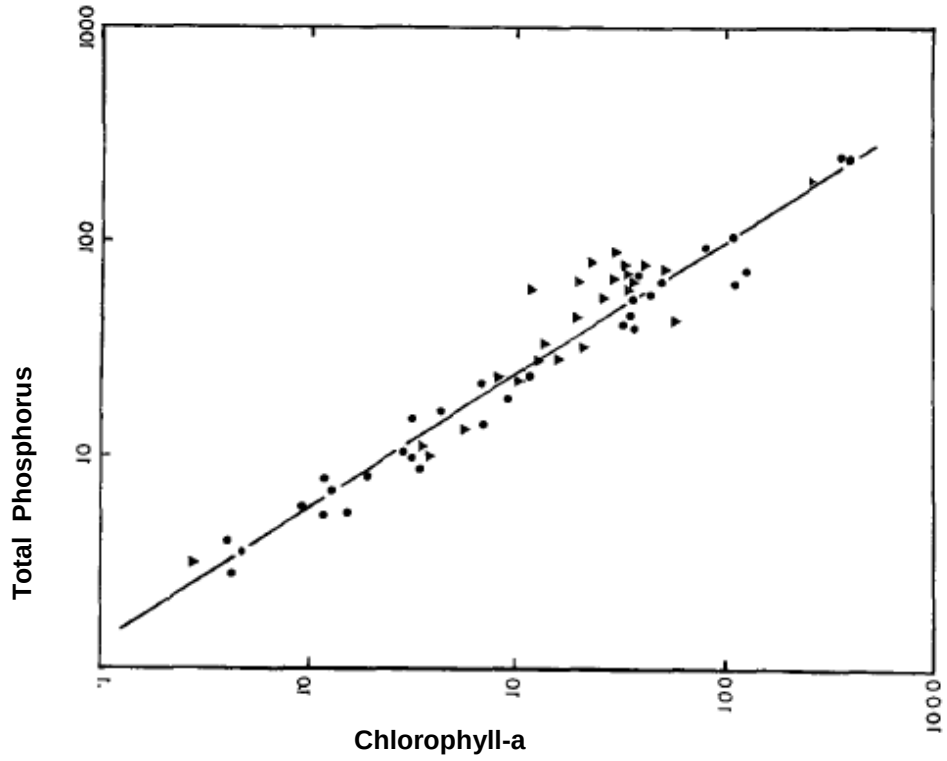
The surface water total phosphorus concentration in the Lake was consistently less than approximately 20 µg/l, which is the value above which algal blooms could be expected to occur. The observed total phosphorus concentrations are indicative of marginally impaired water quality, or borderline eutrophic conditions. This was consistent with mean Secchi-disc transparency values of about 12 feet.

The depletion of dissolved oxygen in the hypolimnion or bottom waters of a lake is common in mesotrophic and eutrophic waterbodies.[1] Dissolved oxygen concentrations were measured as part 5 of the CLMN volunteer monitoring program. These data show that the Lake typically stratifies during the summer months with respect to both temperature and dissolved oxygen concentration. Such summer (and periodic winter) stratification is typical of most larger waterbodies within the northern hemisphere.

[1] *R.G. Wetzel,* Limnology*, Saunders, Philadelphia, 1975.*

FIGURE 2

DILLON & RIGLER PHOSPHORUS-CHLOROPHYLL RELATIONSHIP (concentrations in µg/l)



Source: P.J. Dillon and F.H. Rigler, "The Phosphorus-Chlorophyll Relationship in Lakes," Limnology and Oceanography, volume 19, pages 767-773, 1974.

Associated with these periods of hypolimnetic anoxia is the likelihood of internal loading occurring within the Lake. Internal loading is the result of the release of phosphorus and other elements from the lake sediments as a result of changes in oxidation state of the multivalent cations such as iron, calcium, and aluminum which releases previously-bound elements back into the water column.[2] The impact of this internal loading on lake trophic state is related to the rate at which the lake mixes from top to bottom during the spring and fall overturn events. In spring and fall, differential warming and cooling of the lake surface waters, respectively, alters the density of the lake waters in such a manner as to promote the mixing of lake water. When the mixing process is relatively slow, on the order of days to weeks, minerals and nutrients released from the lake sediments into the hypolimnion of the lake tend to recombine with the multivalent cations in the lake sediments and precipitate out of the water column. Conversely, if the mixing process is relatively rapid, on the order of hours or days, as may occur due to

[2]*Werner Stumm and James J. Morgan,* Aquatic Chemistry: An Introduction Emphasizing Chemical Equilibria in Natural Waters*, Wiley-Interscience, New York, 1970.*

the passage of an intense storm, the minerals and nutrients may be mixed upward into the epilimnion or surface waters where they are available for plant growth. In Anvil Lake, the former process could be assumed to be the dominant process; namely, that the phosphorus released into the bottom waters of Anvil Lake is re-precipitated during the overturn process. This hypothesis is supported by the fact that the predicted total phosphorus concentration of about 20 µg/l equaled the observed total phosphorus concentration in the Lake.[3]

Based on the total phosphorus data, Anvil Lake has a Carlson Trophic State Index (TSI) value of 48, indicating that the Lake is a meso-eutrophic waterbody.[4] Eutrophic lakes are fertile lakes that support abundant aquatic plant growths and may support productive, but limited, fisheries, frequently dominated by rough fish such as carp. Mesotrophic lakes, on the other hand, have productive fisheries and support moderate growths of aquatic plants. Nuisance growths of algae and plants may be exhibited by eutrophic lakes, but are infrequent in mesotrophic lakes. The Carlson TSI value based on Secchi disc transparency was about 42, which is within the mesotrophic, or moderately enriched, range, while the Carlson TSI value based upon chlorophyll-a concentration was approximately 46, also indicative of a mesotrophic state. All three TSI values—based upon phosphorus and chlorophyll-a concentrations and Secchi disc transparency—ranged from about 30 to about 60, and has remained relatively consistent over the years. This range in TSI values most likely represents the range of seasonal variation within the Lake rather than any change in the actual water quality.

POLLUTANT LOADINGS

Pollutant loads to a lake are generated by various natural processes and human activities that take place in the drainage area tributary to a lake. These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation, while pollutants loadings transported across the land surface directly tributary to the lake enter the lake directly as stormwater runoff and surface overflow as well as indirectly as groundwater inflow. Pollutants transported by streams also can enter a lake as surface water inflows; however, in a seepage lake like Anvil Lake, this route does not exist.. In the absence of identifiable or point source discharges from industries or wastewater treatment facilities, direct runoff from the land surface into the Lake and direct deposition onto the Lake surface are the principal routes by which contaminants enter a waterbody.[5] There are no known point sources of water pollutants within the Anvil Lake direct tributary drainage area. All of the residential lands within the tributary drainage area are served by onsite sewage disposal systems; hence, the discussion that follows is based upon nonpoint source pollutant loadings.

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[3]*Estimates of the long-term annual average total phosphorus concentration Anvil Lake were derived from the WILMS model, described in Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-96 REV,* Wisconsin Lake Model Spreadsheet, Version 2.00, User's Manual*, June 1994; in-lake total phosphorus concentrations were estimated from the model output using the Vollenweider phosphorus loading model: OECD,* Eutrophication of Waters: Monitoring, Assessment and Control*, Organization for Economic Cooperation and Development, 1982.*

[4]*Carlson, R.E. "A trophic state index for lakes,"* Limnology and Oceanography*. 22:361-369, 1977.*

[5]*S.-O. Ryding and W. Rast,* The Control of Eutrophication in Lake and Reservoirs, *Unesco Man and the Biosphere Series Vol. 1, 1989.*

drainage area. All of the residential lands within the tributary drainage area are served by onsite sewage disposal systems; hence, the discussion that follows is based upon nonpoint source pollutant loadings.

The nonpoint source pollutant loads to Anvil Lake were estimated on the basis of land use inventory data. Based upon the Wisconsin Lake Model Spreadsheet (WILMS) mathematical model, annual phosphorus loads entering Anvil Lake were calculated to be approximately 290 pounds of phosphorus, while the annual loads of sediment and heavy metals entering the lake were estimated using unit area loading coefficients for specific land use types, as shown in Table 4. Table 4 also shows the relative percentage contributions of the various land uses to the pollutant loads to Anvil Lake.

Table 4

ESTIMATED EXTERNAL CONTAMINANT LOADS TO ANVIL LAKE

Source	P-lbs[a]	P - %[a]	Sediment-lbs[b]	Sediment-%[b]	Cu - lbs[b]	Cu-%[b]	Zn-lbs[b]	Zn- %[b]
Low Density Residential	47.4	39	4,621.5	6	0	100	1.5	100
Woodlands	24.1	20	2,227.4	3	NA	NA	NA	NA
Water	49.0	41	70,876.0	91	NA	NA	NA	NA
Subtotal	73.1	61	73,103.4	94	NA	NA	NA	NA
Total	120.5	100.0	77,724.9	100.0	0	100	1.5	100

[a]*Values computed using the Wisconsin Lake Model Spreadsheet model (WILMS); low density residential loading includes 3.3 pounds of phosphorus per year from onsite sewage disposal systems.*

[b]*Values computed using the Unit Area Load Model.*

Source: Environmental Horizons, Inc.

The data indicate that, based on existing land use conditions in the Anvil Lake watershed, approximately one-third of the total phosphorus load to Anvil Lake is estimated to be contributed each from residential lands, woodlands, and direct deposition onto surface waters. Onsite wastewater treatment systems are estimated to contribute about 3 pounds of phosphorus to the Lake, or about 1 percent of the total phosphorus load.

To validate the estimated phosphorus load to Anvil Lake, Environmental Horizons staff applied the estimated phosphorus load of about 120 pounds in the Vollenweider-type OECD phosphorus budget model to estimate an in-lake total phosphorus concentration. This calculation resulted in an estimated annual average phosphorus concentration of about 12 µg/l. This concentration corresponds well to the observed in-lake total phosphorus concentration of about 15 µg/l reported from the Lake during the period of record, 1986 to 2010. This agreement would suggest that the estimated phosphorus load is a reasonable representation of the loads entering Anvil Lake, and that other pollution sources, such as internal loading from the lake sediments is small compared to the loading from external sources.

A unit area load (UAL) model was used to estimate the loadings of sediment and selected heavy metals to the Lake. Metals are generated from urban land uses; hence, no contributions of copper or zinc were estimated from rural land sources. The unit area load model was developed using data from a large number of lakes across the United States, and represents an average mass of specific contaminants being generated from specific types of land use.

Based on the UAL modeling, it is estimated that approximately 80,000 pounds of sediment are contributed annually to Anvil Lake, primarily through deposition directly onto the Lake surface from the atmosphere as precipitation and dry (dust) fallout. The balance of the sediment load entered the Lake from other rural land use sources.

As noted, metals are assumed to be contributed to the Lake from urban sources such as construction materials, roofing materials, automobile systems and exhausts, etc. Based upon the UAL modeling, it is estimated that about 1.5 pounds of zinc enter the Lake annually. Copper inputs from land use activities were estimated to be less than the sensitivity of the model to determine. It should be noted that copper sources, such as the application of copper-based algicides directly to the Lake to control algal growth, are not included in this estimate. The use of copper-based algicides is discussed further below.

While the specific contaminant loads to Anvil Lake will require detailed field measurements of both flow—comprised of direct rainfall, surface runoff, and groundwater inflow—and concentrations of specific contaminants, the foregoing estimates do provide an initial basis for identifying controllable pollutant sources. Of the pollutant sources suggested in Table 4, the most significant controllable sources under existing land use conditions are residential lands, which generate the largest percentage of the controllable nutrient loading. Control of contaminants from these various sources can be affected through a variety of measures, as set forth in Chapter IV.

GEOLOGY AND SOILS SURROUNDING ANVIL LAKE

Geology

The visual land surface of Wisconsin is largely the result of extensive glaciation. The soils and surface sediments were laid down by a series of glacial advances and retreats. The last major glacial period was the Wisconsinan which began about 26,000 years ago and ended roughly 10,000 years ago. Glaciation is responsible for a majority of the soil properties and surface features present such as wetlands, and natural lakes.

The glacial sediments in the vicinity of Anvil Lake are chiefly comprised of two major types: pitted outwash and coarse glacial till. Pitted outwash is comprised of water worked, sandy deposits that are characterized by numerous lakes, kettles, and depressions. The glacial till is comprised of coarse sandier sediments, but was deposited by the glacier itself. Glacial till is a denser and compact material than outwash, and can create a confining layer underneath the soil surface.

In addition to this glaciation, the region is characterized by a complicated geological history. Underlying these glacial sediments is the bedrock geological formation called the Quinnesec Formation. This formation is chiefly characterized by mafic metavolcanic rocks illustrated on Map 4. These rocks are comprised largely of basalts and andesite and are approximately 1,800 million years old,[1] and form one of the oldest geological formations in northeastern Wisconsin.[2] This formation is part of a larger geological region called the Penokean belt, which is an ancient mountain range that resulted from the collision of two of the earliest existing continents. The Penokean belt is rich in mineral formations to include copper and to a lesser extent zinc, silver, and gold.[3]

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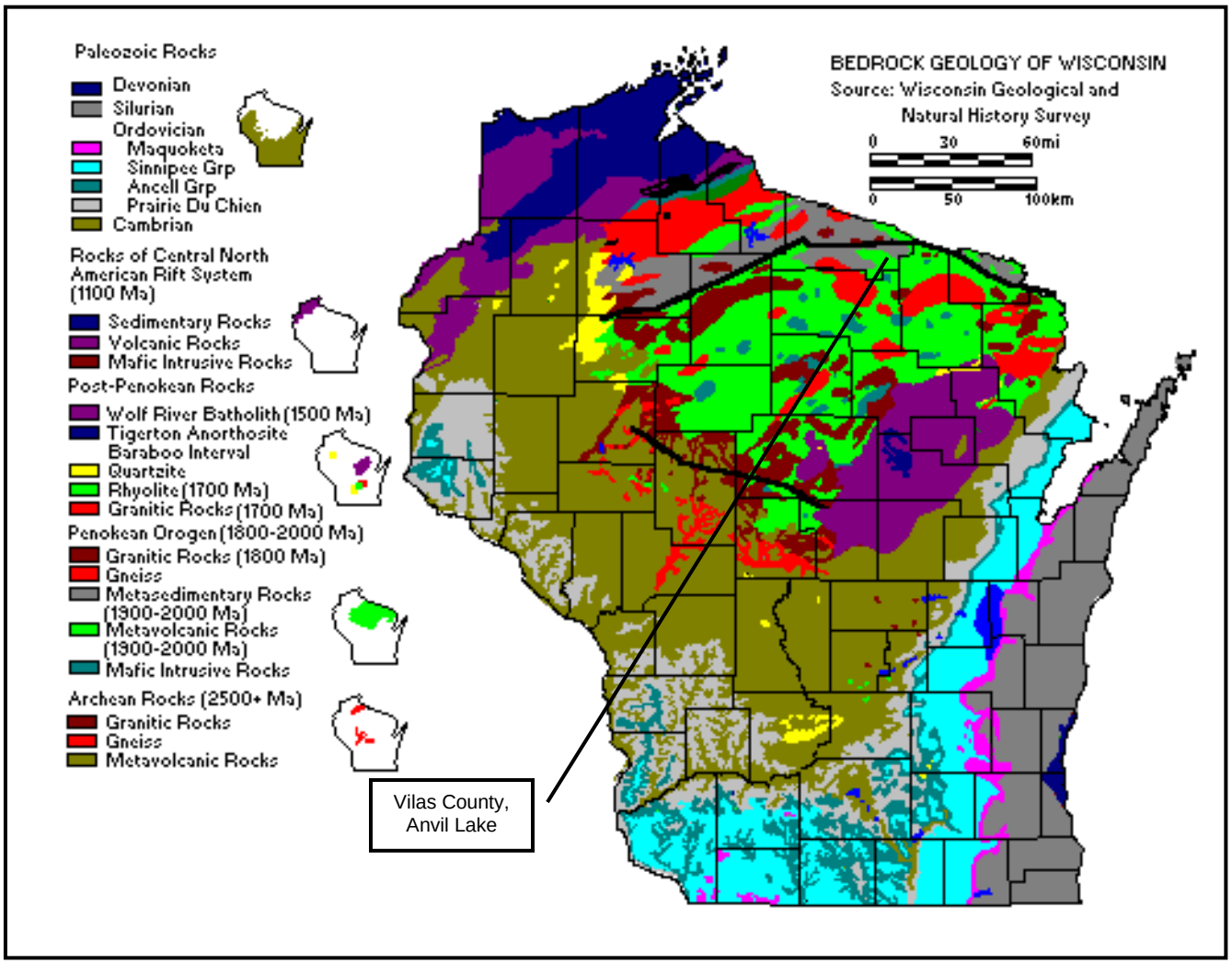
[1] *United States Geological Survey.*

[2] *Cain, Allan J., and Beckman, Walter A. Jr., Preliminary Report on the Precambrian Geology of the Athelstane Area, Northeastern Wisconsin,* The Ohio Journal of Science*, 64(1): 57.*

[3] *Dott, Robert H. and Attig, John W.,* Roadside Geology of Wisconsin*, Mountain Press Publishing Company, 2004.*

MAP 4

BEDROCK GEOLOGY OF WISCONSIN



Source: Wisconsin Geological and Natural History Survey.

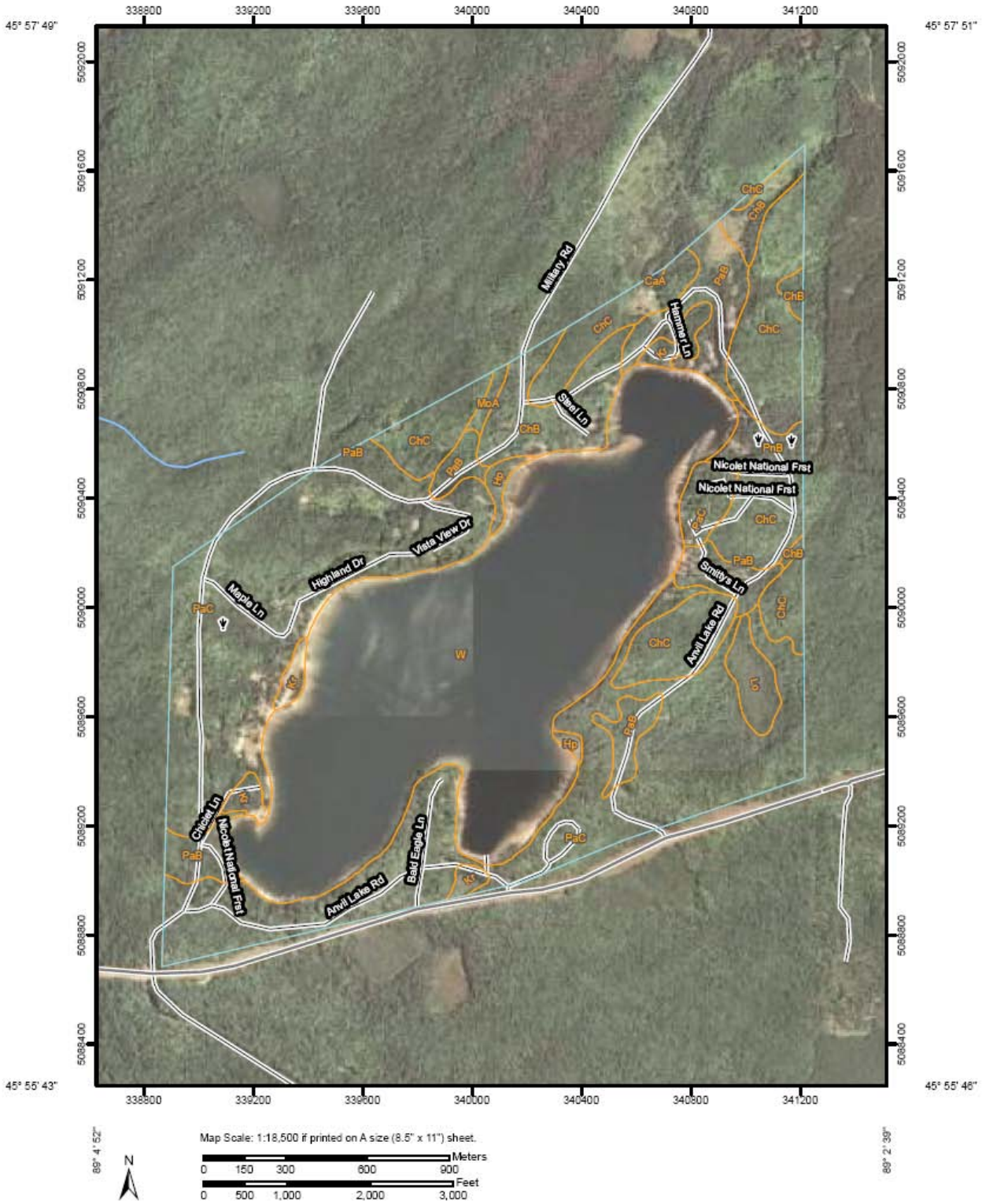
Soils

Soils and their management are one of the most important contributing factors to water quality within a given watershed. In 1988, the U.S. Department of Agriculture (USDA), Soil Conservation Service (SCS; now Natural Resources Conservation Service, NRCS) completed a soil survey report for Vilas County. The report included comprehensive information on individual soil types within the county and aerial photographs and interpretations of those soils. Since then, more information has been updated and further refinements have been made. To view the most current information on Vilas County soils, the information is available online by accessing the USDA's website at: http://websoilsurvey.nrcs.usda.gov/app/.

Each soil type has its own unique set of characteristics such as land slope, permeability or infiltration rate, chemical properties, vegetation, susceptibility to erosion, among others which all affect the suitability of a soil in terms of onsite sewage systems, buildings and foundations and vegetation management. The soils within the direct drainage area of Anvil Lake are illustrated on Map 5, with some of their major properties to include soil drainage classification, onsite sewage system suitability,

MAP 5

GENERAL SOILS WITHIN THE ANVIL LAKE DIRECT DRAINAGE WATERSHED



USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

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TABLE 5

SOIL CHARACTERISTICS IN THE VICINITY OF ANVIL LAKE

Map Unit Symbol	Map Unit Name	Soil Drainage Classification	Onsite Sewage System Suitability	Hydric Soils Rating
CaA	Cable silt loam, 0 to 3 percent slopes	Very poorly drained	Very Limited	All Hydric
ChB	Champion silt loam, 1 to 6 percent slopes	Moderately well drained	Very Limited	Not Hydric
ChC	Champion silt loam, 6 to 20 percent slopes	Moderately well drained	Very Limited	Not Hydric
Hp	Histosols, ponded	Very Poorly Drained	Not Rated	All Hydric
Kr	Kinross mucky sand, 0 to 2 percent slopes	Very poorly drained	Very Limited	All Hydric
Lo	Loxley and Dawson peats, 0 to 1 percent slopes	Very poorly drained	Very Limited	All Hydric
MoA	Monico silt loam, 0 to 3 percent slopes	Somewhat poorly drained	Very Limited	Partially Hydric
PaB	Padus fine sandy loam, 0 to 6 percent slopes	Well drained	Very Limited	Not Hydric
PaC	Padus fine sandy loam, 6 to 15 percent slopes	Well drained	Very Limited	Not Hydric
PnB	Pence sandy loam, 0 to 6 percent slopes	Well drained	Very Limited	Not Hydric
W	Water	- - *a*	- -	- -

[a]Not applicable.

Source: USDA – Natural Resources Conservation Service: National Cooperative Soil Survey and Environmental Horizons, Inc.

MAP 6

SOIL SLOPE CLASSIFICATIONS SURROUNDING ANVIL LAKE

Virtually all of the soils in the direct drainage area to Anvil Lake are unsuitable for onsite sewage disposal systems; this is illustrated above in Map 7. The USDA NRCS uses a variety of soil

characteristics to evaluate whether a soil between the depths of 24 and 60 inches is suitable for effluent attenuation, installation, and functionality and maintenance of the system, and public health. These properties include but are not limited to proximity to groundwater, slope, permeability, presence of gravel and boulders, and depth to bedrock. The soils surrounding Anvil Lake are virtually all rated as very limited for septic tank absorption fields. From a management standpoint, septic systems installed in this area, especially those in close proximity to Anvil Lake should be evaluated on a frequent and regular basis to ensure that the system is functioning properly. Reasons for this rating include the following: proximity to the saturated zone, slow water movement, seepage of the bottom layer and limited filtering capacity.

Hydric Soils

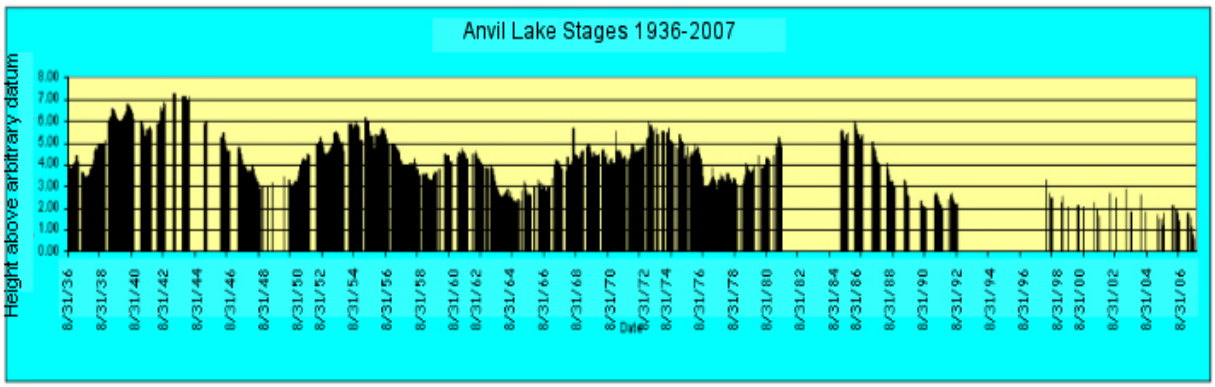
A hyric soil is defined as "is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part."[9] The soils in area surrounding Anvil Lake have three hydric ratings: not hydric, partially hydric, and all hydric. The soils considered partially hydric will provide issues with foundations and onsite sewage systems. Those soils considered hydric should not be developed as septic systems will not work and home foundations without extreme engineering will not have suitable support and will always have wetness problems. The hydric soil classifications surrounding Anvil Lake are illustrated above on Map 8.

WATER BUDGET

Anvil Lake is a groundwater-fed Lake, whose lake surface elevation is dependent largely upon the inflow of groundwater to maintain lake levels. While few data exist on the water budget of Anvil Lake, the diminution of Lake levels in recent years would suggest that there has been a lack of inflow to the Lake from the surrounding groundwater aquifer, and from rainfall onto the Lake surface. The effect of this period of drought can be clearly seen in Figure 3. Based upon the period of record, recent lake surface elevations are the lowest recorded since 1936, when records were first being kept.

FIGURE 3

DECLINING LAKE SURFACE ELEVATIONS REPORTED FROM ANVIL LAKE, VILAS COUNTY: 1936 - 2009

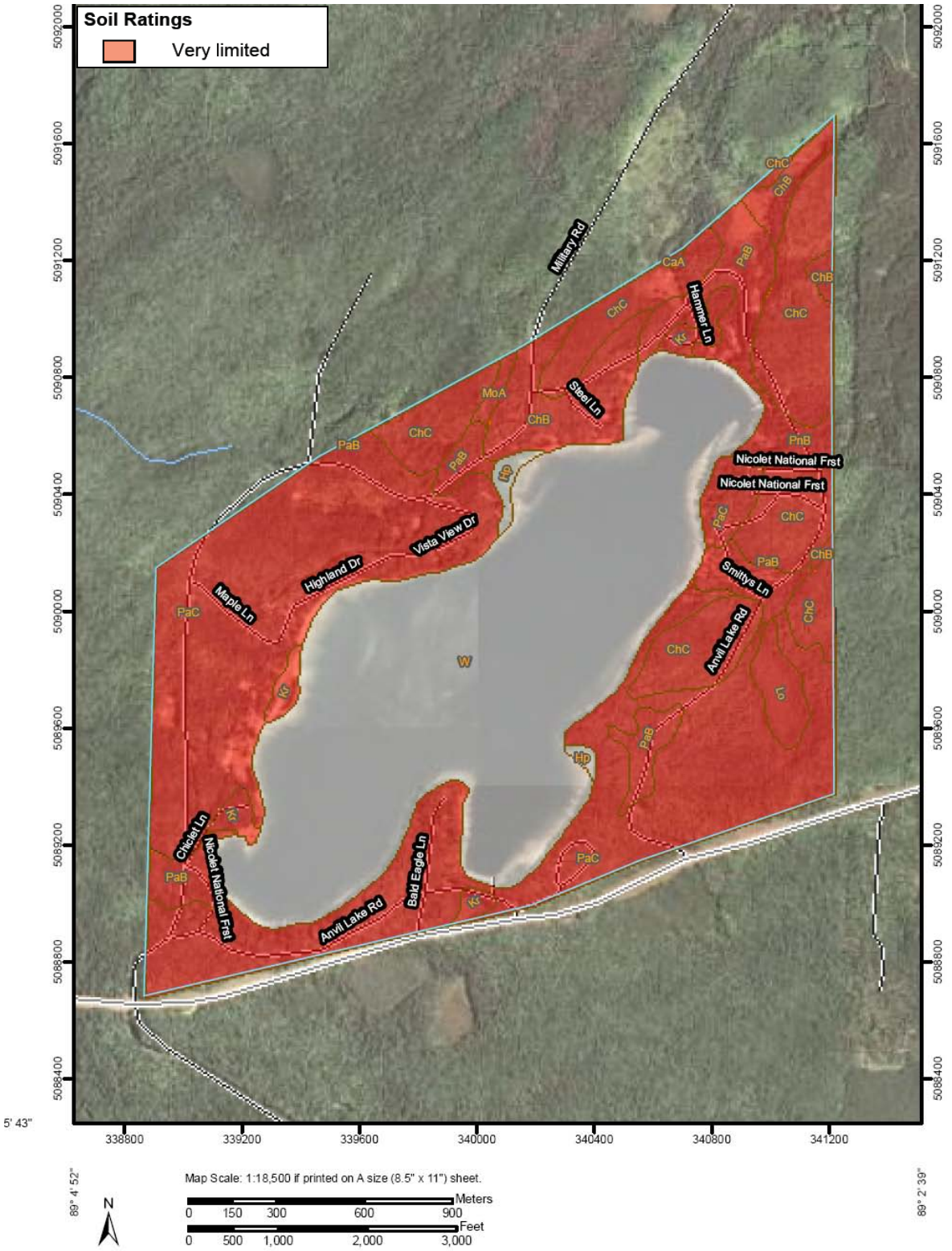


Source: Anvil Lake Association.

[9] *USDA- Natural Resources Conservation Service.*

Map 7

SOIL CHARACTERISTICS FOR ONSITE SEWAGE DISPOSAL SURROUNDING ANVIL LAKE



USDA Natural Resources Conservation Service

Web Soil Survey
National Cooperative Soil Survey

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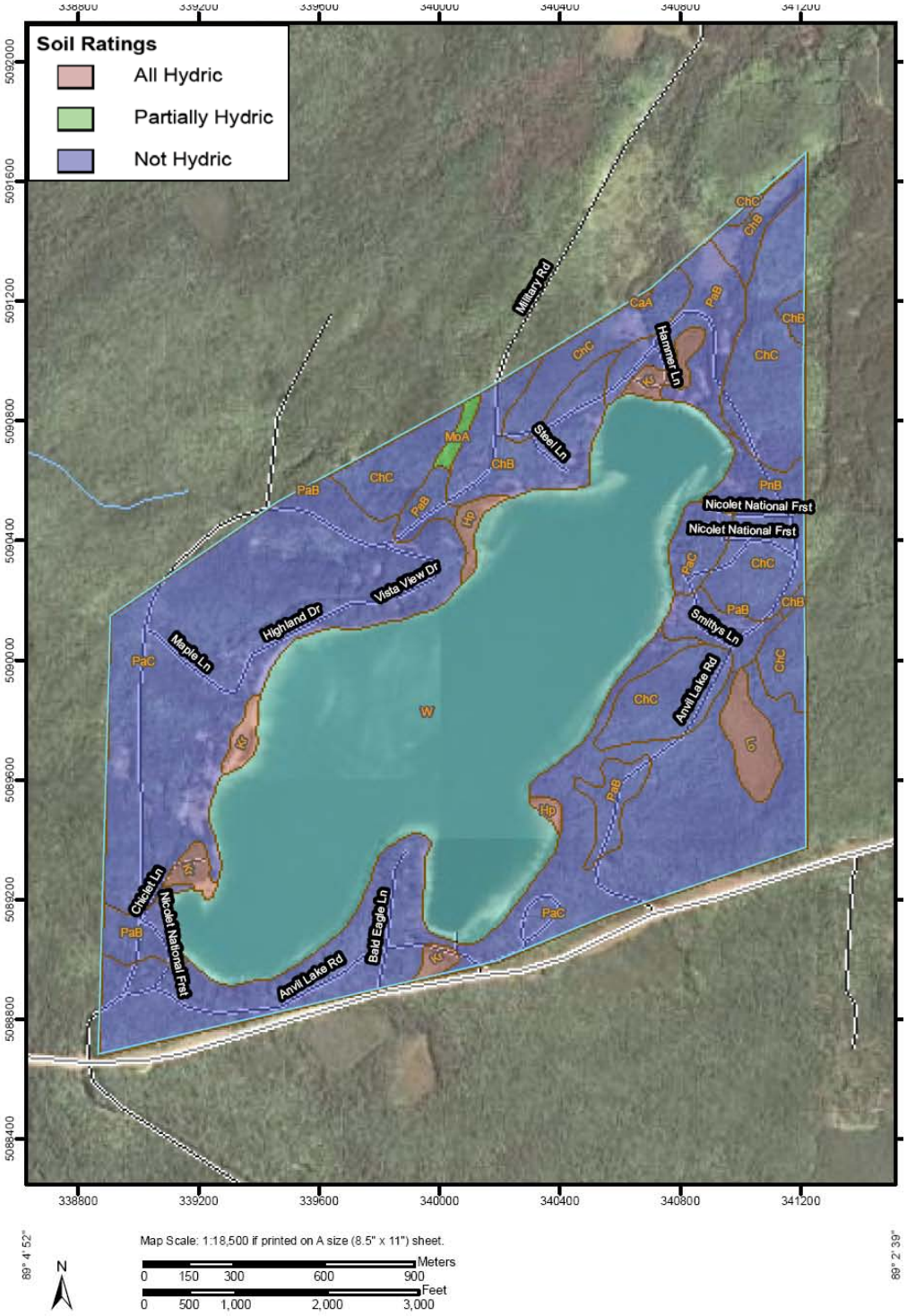
MAP 8

HYDRIC SOIL CLASSIFICATIONS SURROUNDING ANVIL LAKE



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Web Soil Survey
National Cooperative Soil Survey

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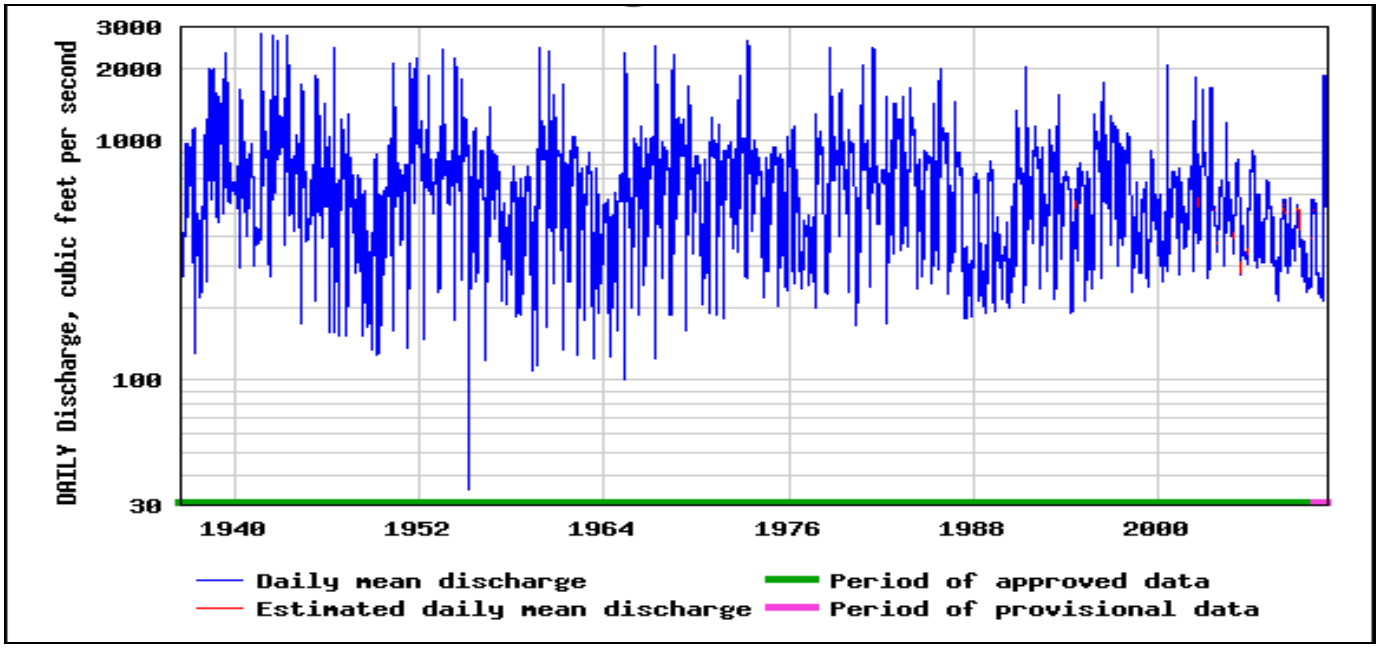
The trend observed in Anvil Lake with respect to lake surface elevations is reflected also in the regional runoff patterns, as shown in Figure 4. These data from the Wisconsin River reflect the same decrease in runoff that is reflected in the lake surface elevation records from Anvil Lake. Again, these levels are approaching the lowest recorded during the period of record.

Notwithstanding, for the purposes of estimating the nutrient and contaminant loads to Anvil Lake, the annual water budget to the Lake was estimated based upon long term average precipitation, evaporation, and runoff values. These estimates, calculated as the sum of the volume of water falling directly onto the Lake surface plus the volume of water falling onto the land surface presumed to enter the Lake as stormwater runoff and the estimated evaporative loss from the Lake surface, result in a potential water load to the Lake of about 1,025 acre-feet annually, which results in the estimated long term water residence time of about seven years. It should be noted that these values reflect the long term condition of the Lake, and do not necessarily reflect the conditions observed under the recent drought. More detailed assessment of the water load to Anvil Lake would be required to construct the water budget for the Lake, taking into account groundwater inflows and outflows, and the relative balance between groundwater and precipitation.

FIGURE 4

DECLINING SURFACE RUNOFF IN THE WISCONSIN RIVER: 1936 - 2009



Source: U.S. Geological Survey.

AQUATIC PLANTS, DISTRIBUTION, AND MANAGEMENT AREAS

Rooted Aquatic Macrophytes

An aquatic plant survey was conducted in Anvil Lake by University of Wisconsin-Madison Center for Limnology Trout Lake Station staff during July 2010.[10] The observed plant species documented during the survey and their ecological significance are presented in Table 6, and graphically depicted on Map 9. Illustrations of the most common aquatic plants found in Anvil Lake are included in Appendix A.

TABLE 6

AQUATIC PLANT SPECIES AND THEIR ECOLOGICAL SIGNIFICANCE IN ANVIL LAKE

Aquatic Plant Species Present	Ecological Significance
Chara sp., Muskgrass	Provides shelter for young fish and food for fishes, especially bass; food for wildfowl
Elatine minima, Waterwort	Provides general habitat, especially for ducks
Eleocharis acicularis, Needle spikerush	Provides spawning area for fishes, especially largemouth bass; stems and roots eaten by wildfowl and muskrat
Elodea canadensis, Common waterweed	Provides shelter and support for insects which are valuable as food for fish, muskrat, and waterfowl
Elodea nuttallii, Slender waterweed	Provides shelter and support for insects which are valuable as fish food
Isoetes echinospora, Spiny spored-quillwort	Provides limited food, especially for waterfowl and grouse
Juncus pelocarpus f. submersus, Brown-fruited rush	Provides spawning area for fishes, especially rock bass, bluegill and sunfish; attractive to wildfowl, upland game birds, marsh birds, and song birds; bases and roots eaten by muskrat
Myriophyllum tenellum, Dwarf water-milfoil	Provides shelter and support for insects which are valuable as fish food; wildfowl eat the fruits
Najas gracillima, Northern naiad	Provides food and shelter for fishes and ducks
Nitella sp., Nitella	Provides food and shelter for fishes and ducks
Potamogeton amplifolius, Large-leaf pondweed	Offers shade, shelter and foraging for fish; valuable food for waterfowl
Potamogeton epihydrus, Ribbon-leaf pondweed	Provides valuable food for waterfowl and muskrat
Potamogeton foliosus, Leafy pondweed	Provides food for geese and ducks; food for muskrat, beaver and deer; good surface area for insects and cover for juvenile fish
Potamogeton friesii, Fries' pondweed	Provides valuable food for waterfowl
Potamogeton gramineus, Variable pondweed	Provides food and shelter for fishes and ducks; rootstock contains starch
Potamogeton pusillus, Small pondweed	Provides food for ducks, geese, muskrat, beaver, and deer; provides food and shelter for fish
Potamogeton spirillus, Spiral-fruited pondweed	Provides habitat for fish and invertebrates; provides food for ducks and geese; stabilizes

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[10] *Susan Knight, John Yadro, Tom Ewing, Melissa Simpson, David Schmidt and Matt Wagner participated in a point-intercept aquatic plant survey on Anvil Lake (WBIC 968800) on July 5-8, 2010; See University of Wisconsin Center of Limnology for Report entitled "Anvil Lake Aquatic Plant Survey, October 2010."*

Aquatic Plant Species Present	Ecological Significance
	lake bottom sediments
Potamogeton strictifolius, Stiff pondweed	Provides food for ducks; may be grazed by muskrat, deer, and beaver; provides cover for fishes
Potamogeton vaseyi, Vasey's pondweed	Provides food for ducks, muskrat, and some fishes*
Potamogeton zosteriformis, Flat-stem pondweed	Provides food for ducks, muskrat, beaver, and deer; provides cover for fish
Sagittaria latifolia, Common arrowhead	Provides food for ducks, muskrats, porcupines, beavers and fish; provides shelter for young fish; attracts marsh birds, wildfowl, and songbirds
Sparganium angustifolium, Narrow-leaved bur-reed	Provides cover for wildfowl; nutlets eaten by waterfowl, especially ducks and muskrat; provides shelter for marsh birds and waterfowl
Vallisneria americana, Wild celery	Provides good shade and shelter, supports insects, and is valuable fish food; excellent food for wildfowl; provides shelter for muskrat; attractive to marsh birds, shore birds, and waterfowl

**Designated Wisconsin Species of Special Concern*

NOTE: Information obtained from A Manual of Aquatic Plants by Norman C. Fassett, University of Wisconsin Press, 1957; and, Through the Looking Glass…A Field Guide to Aquatic Plants, University of Wisconsin-Extension, 1997.

Source: University of Wisconsin Center for Limnology and Environmental Horizons, Inc.

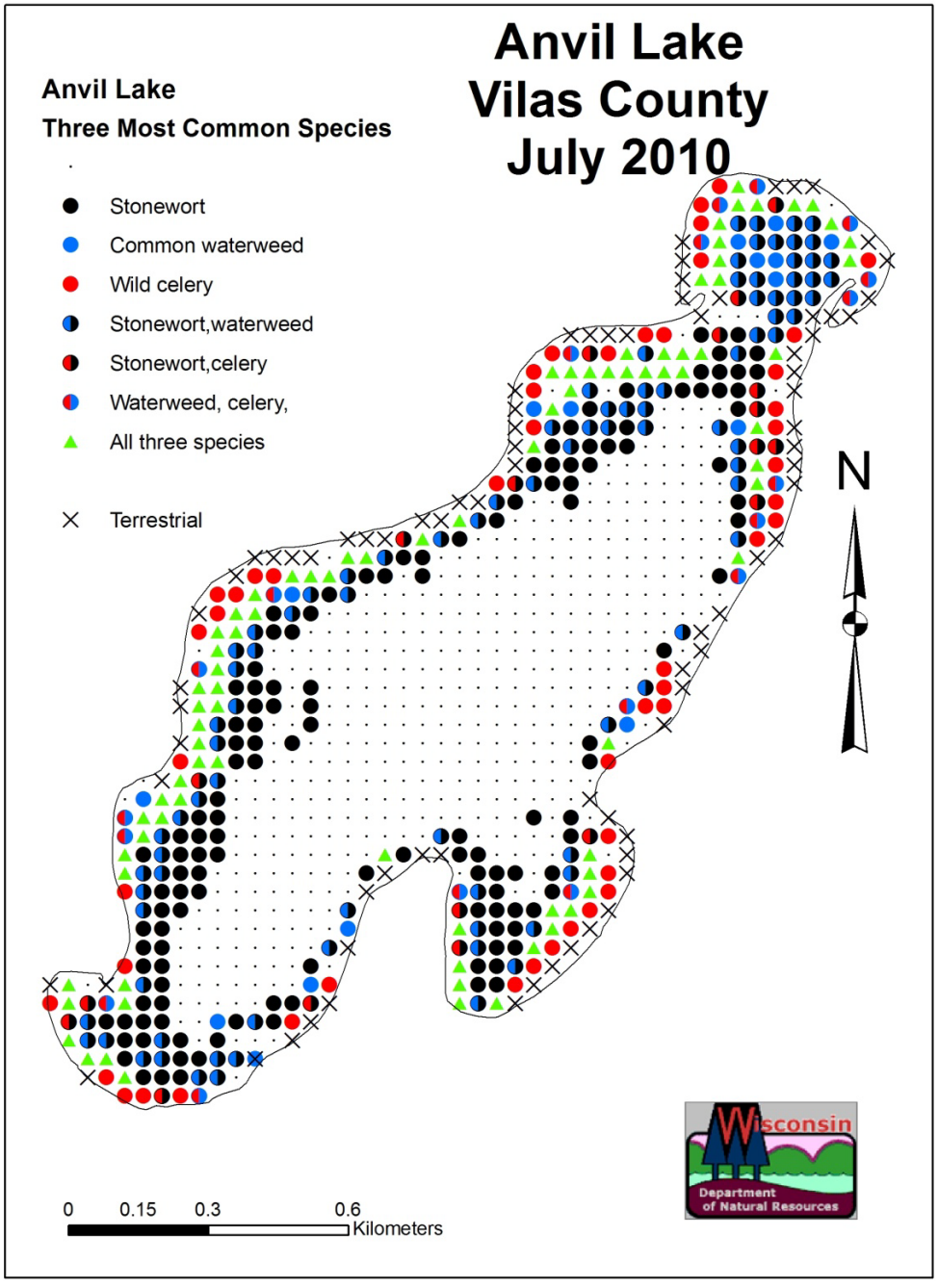
The survey was conducted using the grid-based, point intercept sampling technique. A rake on a pole was used to sample the aquatic plant species present in water depths of up to 15 feet, and a rake on a rope was used for sites deeper than 15 feet. The sampling grid included 953 points, of which 423 sites had vegetation. Many sites along the shore were not sampled because of low water. At each site, water depth and bottom substrate composition was recorded (substrate was described using a narrative substrate texture scale as muck, sand, or rock). Total rake fullness was estimated on a four-point scale as 0 (no plants), 1 (a few plants on the rake), 2 (rake approximately half full), or 3 (rake overflowing with plants). The abundance of each species found at a point also was estimated using a scale of 1 to 3. The rake hauls were supplemented at each site by a visual inspection. Species within 6 feet of the boat, but not actually collected on the rake, were reported as “visuals.” Shoreline condition and shoreline vegetation were also recorded.

Seventeen species of aquatic plants (18 including plants seen but not collected) were collected, including floating and submersed species growing to a maximum water depth of 23.9 feet. There was a diversity of plant growth types and no invasive species.[11] A smaller-scale plant survey done in 2005 found a substantially different flora, possibly due to changes in water level and/or possibly coincident changes in water quality. Together these results indicate Anvil Lake has a healthy aquatic plant community.

[11] *The Floristic Quality Index (FQI) was 30.6 and the Aquatic Macrophyte Community Index (AMCI) was 52.*

MAP 9

COMMON SPECIES OF AQUATIC PLANTS FOUND IN ANVIL LAKE



Source: University of Wisconsin - Madison

The aquatic plant community included many aquatic plant species designated as having important ecological value, as shown in Table 6.

Using the data collected in the survey, the Floristic Quality Index (FQI),[12] and Aquatic Macrophyte Community Index,[13] were calculated. These indices provide a basis for assessing the floristic integrity of Anvil Lake and comparing it to other nearby lakes. The FQI is based on species recognized as native aquatics. The FQI is computed using two parameters: the number of species present, and a coefficient of conservatism (C) for each species. Values of C range from 1 to 10 and indicate how "pristine" an environment a particular species requires. The C values were assigned to each aquatic plant species found in Wisconsin by a panel of botanists. Some species collected are not included in this measure for several reasons: not all aquatic/wetland transition species are included (e.g., *Lysimachia terrestris*), identification is uncertain (e.g., moss or *Sparganium* sp.), or the plant is an introduced species (although none were found in this study). Also, "visuals" were not included in the FQI. Hence, the total number of plants identified may be greater than the number of species contributing to the FQI. The C value of each species is averaged to compute an average C value for the lake and this value is multiplied by the square root of the number of species seen on the lake to derive the FQI.

The FQI for Anvil Lake was 30.6, which is greater than the Indices reported from other lakes in the Northern Lakes and Forests Region. The FQI scores for several nearby waterbodies ranged from 23.0 to 28.8, with an average score for the Northern Lakes and Forests Region of 24.3. The FQI score can be high because of a high average coefficient of conservatism and/or a high number of species being present. In Anvil Lake, both the species diversity and the average coefficient of conservatism were slightly higher than those of other nearby lakes.

The AMCI is a sum of seven parameters, each scaled from 1 to 10 (for a maximum total of 70). The AMCI is another index used to assess lake quality using aquatic plant data.

The AMCI was 52 out of the maximum of 70. Three factors—the percent littoral area vegetated, the maximum depth of rooted plants, and the lack of exotic species—rated the maximum score of 10. The Simpson diversity index, measuring diversity and evenness of species distributions, was 0.78, corresponding to a score of 4 on the AMCI scale. This is probably low because three species—*Eleocharis acicularis*, *Elodea canadensis*, and *Myriophyllum tenellum*—dominated at many sites. A lake with the same number of species but with a more even distribution would have a higher Simpson Diversity score.

The total AMCI score of 52 is lower than lakes in the northern lakes and forest region, because of the relatively low Simpson's Diversity Index, few sensitive species, and very few floating or emergent species.

No Threatened or Endangered species of aquatic plant were found, but Vasey's pondweed (*Potamogeton vaseyi*), a species of Special Concern, was found well distributed at 31 sites in Anvil Lake.

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[12] *Nichols, S.A.,"Floristic quality assessment of Wisconsin lake plant communities with example applications,"* Journal of Lake and Reservoir Management*, 15(2):133-141, 1999.*

[13] *Nichols, S., S. Weber, and B. Shaw. "A proposed aquatic plant community biotic index for Wisconsin lakes,"* Environmental Management*, 26(5):491-502, 2000.*

A 2005 aquatic plant survey conducted by Bryan Pierce, Scott Nordin, Tim Nordin, Don Gillum, Mike Hinz, and Fred Young, utilized a smaller grid (151 points). Eight species of aquatic plants were found, fewer than half the number found in the 2010 study. Six of the species found in 2005 were also found in 2010, as shown in Table 7. One of the species found during 2005, creeping spikerush, a species restricted to shallow water, found in 2005 was not found in 2010, and was very likely locally extirpated, because of the extraordinarily low water levels in the lake in 2010. Two different species of bur-reed were found in the two surveys, although this may be due to the misidentification of the species within this genus, which are extremely difficult to identify. The most significant difference between the two studies is the appearance of stonewort (*Nitella* sp., a macroscopic alga) since 2005. In this study, *Nitella* was found growing at all but the shallowest sites, out to the maximum depth of plant growth. Observations reported by divers in Anvil Lake suggest that the lake bottom where *Nitella* is now abundant was empty of plants a few years ago (Sandy Gillum, personal communication).

It is unclear why *Nitella* has become such a dominant component of the aquatic plant flora of Anvil Lake. On one hand, the water level is very low, and the growth of plants in areas of the lake that were previously too deep when the water level was higher could be expected. On the other hand, since water levels have gone down, lake clarity has decreased. This loss of water clarity should limit the expansion of areas in the Lake where plant growth would be expected. Also, *Nitella* was not present in Anvil Lake during 2005, although given its current distribution it could have been expected to be growing out to the maximum depth of plant growth applicable in 2005. Possible changes in the light regime due to changes in lake level, frequency of mixing, nutrient availability, and algal levels might have limited the growth of *Nitella*, but these factors cannot explain why there was no *Nitella* observed in the lake a few years ago.

Overall, Anvil Lake has a healthy aquatic plant community, with good diversity throughout the littoral zone of the lake. Several factors, including good AMCI and FQI scores, the lack of any invasive species, and the presence of a Special Concern species contribute to this condition. The 2010 plant survey, together with the results of the 2005 aquatic plant survey, creates the basis for developing comparisons with future aquatic plant surveys and forming an understanding of the responses of the lake plant community to various and changeable environmental conditions.

Microscopic Aquatic Plants

In addition to the rooted aquatic plant (macrophyte) surveys conducted during 2005 and 2010, a survey of the algal flora of Anvil Lake was undertaken during 2008 and 2009. Samples were analyzed for the algal species present on approximately a bi-weekly basis. The results of these analyses are set forth in Table 8. Forty-nine species of algae were reported. These species ranged from cyanobacteria (blue-green algae) to a variety of green algae (chlorophyceae) and diatoms (bacillariophyceae). These species follow a pattern of seasonal abundance, with the specific distribution of species following a seasonal pattern defined by water temperature and turbulence. With the exception of the filamentous diatom, *Melosira* sp., most diatoms, with their siliceous shells, require turbulent waters to remain in the zone of light penetration, or euphotic zone, and hence occur in greatest number in spring and autumn when such turbulent conditions can be expected with greater frequency as these periods tend to be the windiest. In contrast, most blue green algae prefer less windy conditions. Species such as *Microcystis* sp. develop gas vacuoles within their cells which keep them buoyant and in the euphotic zone. As a result, they prefer the less windy conditions of summer, when they tend to dominate the algal flora of the lake. This periodicity can also be seen in Table 8.

TABLE 7

FREQUENCY OF OCCURRENCE OF AQUATIC PLANTS IN ANVIL LAKE: 2005 AND 2010

Aquatic Plant Species	2005 Survey	2010 Survey
Chara sp., Muskgrass	-	< 0.020
Elatine minima, Waterwort	-	< 0.020
Eleocharis acicularis, Needle spikerush	0.410	0.056
Eleocharis palustris, Creeping spikerush	0.005	< 0.020
Elodea canadensis, Common waterweed	0.270	0.232
Elodea nuttallii, Slender waterweed	-	0.027
Isoetes echinospora, Spiny spored-quillwort	-	< 0.020
Juncus pelocarpus f. submersus, Brown-fruited rush	-	< 0.020
Myriophyllum tenellum, Dwarf water-milfoil	0.090	< 0.020
Najas gracillima, Northern naiad	-	< 0.020
Nitella sp., Nitella	-	0.362
Potamogeton amplifolius, Large-leaf pondweed	0.005	< 0.020
Potamogeton epihydrus, Ribbon-leaf pondweed	0.010	< 0.020
Potamogeton foliosus, Leafy pondweed	-	< 0.020
Potamogeton friesii, Fries' pondweed	-	< 0.020
Potamogeton gramineus, Variable pondweed	-	< 0.020
Potamogeton pusillus, Small pondweed	-	0.054
Potamogeton spirillus, Spiral-fruited pondweed	-	< 0.020
Potamogeton strictifolius, Stiff pondweed	-	< 0.020
Potamogeton vaseyi, Vasey's pondweed	-	0.034
Potamogeton zosteriformis, Flat-stem pondweed	-	< 0.020
Sagittaria latifolia, Common arrowhead	-	< 0.020
Sparganium angustifolium, Narrow-leaved bur-reed	-	< 0.020
Sparganium emersum, Short-stemmed burr-reed	0.005	< 0.020
Vallisneria americana, Wild celery	0.210	0.167
Total	1.000	1.000

Source: Anvil Lake Association, University of Wisconsin Center for Limnology, and Environmental Horizons, Inc.

Blue green algae, or cyanobacteria, can develop toxic varietals, with alkaloid compounds being created by the cells during their growth period.[14] The algae themselves are visually identical to the non-toxic varietals of the same species. Potentially toxic species include *Microcystis* spp. The toxins produced by the algae have been known to cause illness and even death, primarily among domestic animals and wildlife, although a recent case reported from the Middleton area of Wisconsin included a human fatality who was exposed to the cyanotoxins as a result of prolonged skin contact while swimming in a highly eutrophic golf course pond.[15] One human and one canine incident were reported to UW-Oshkosh

[14] *Harding, W.R. and B.R. Paxton,* Cyanobacteria in South Africa: A Review*, Water Research Commission Report No. TT 153/01, July 2001.*

[15] *See Vilas County,* Vilas County Land and Water Resources Management Plan: 2010-2015*, September 2009; Vilas County,* Vilas County Lake and River Classification Study*, February 1999; Vilas County,* Vilas County Comprehensive Plan*, November 2009.*

occurring on Anvil Lake in 2009. Consequently, thoroughly rinsing off after exposure to possible blue-green algae is recommended by the WDNR; changing out of wet swim suits and showering as soon as possible after possible exposure will minimize the risk of exposure to blue-green algal toxins.

TABLE 8

SPECIES OF MICROSCOPIC ALGAE REPORTED FROM ANVIL LAKE: 2008-2009

Species	2008			2009										
	9/06	9/22	10/07	5/03	5/17	5/25	6/15	7/06	7/20	8/03	9/07	9/17	9/19	10/06
Blue Green														
Anabaena spiroides		X	X				X	X	X	X	X	X	X	X
Anabaena sp.	X	X	X		X	X	X	X	X	X	X	X	X	X
Aphanocapsa sp.						X	X							
Aphanothece sp.						X	X	X	X					
Aphanizomenon sp.										X		X	X	
Chroococcus sp.						X	X	X	X	X	X	X		
Coelosphaerium sp.		X	X	X	X	X	X	X	X	X	X	X	X	X
Gloeocapsa sp.					X	X	X	X	X					
Gloeotrichia sp.	X	X	X					X	X	X	X	X		
Gomphosphaeria sp.			X								X			
Merismopedia sp.										X				
Microcystis aeruginosa		X	X	X	X	X	X	X	X	X	X	X	X	X
Microcystis flos aquae	X	X	X			X	X	X	X	X	X	X		X
Oscillatoria/Planktothrix													X	
Cryptomonad														
Cryptomonas sp.			X	X		X								
Desmid (Green)														
Desmidium sp.		X												
Euastrum sp.												X		
Spondylosium sp.					X	X	X	X	X					
Diatom														
Asterionella formosa				X	X									
Cyclotella sp.				X	X				X					
Cymbella sp.									X					
Fragillaria crotonensis			X	X										
Melosira sp.		X	X	X	X	X		X	X	X	X	X	X	X
Melosira granulata			X											
Navicula sp.			X											
Pinnularia sp.					X									
Stauroneis sp.				X	X			X						
Tabellaria fenestrate				X	X	X	X	X	X	X	X			
Dinoflagellate														
Ceratium hirundinella			X			X		X	X	X	X			
Gymnodinium sp.					X		X	X	X					
Massartia sp.					X	X								
Peridinium sp.		X	X	X	X	X	X	X						
Golden Brown														
Dinobyron serularia				X		X	X	X	X					
Mallamonas sp.			X					X						

Species	2008			2009										
	9/06	9/22	10/07	5/03	5/17	5/25	6/15	7/06	7/20	8/03	9/07	9/17	9/19	10/06
Tribonema sp.				X	X	X				X				
Uroglenopsis sp.								X						
Green														
Botryococcus braunni			X	X	X	X	X	X	X	X	X	X	X	X
Coelastrum sp.			X		X									
Cosmarium sp.									X					
Crucigenia tetrapedia			X											
Dictyosphaerium pulchellum			X					X	X	X				
Pediastrum boryanum												X		
Quadrigula sp.									X		X			
Spirogyra sp.								X						
Sphaerocystis schroeteri					X		X							
Staurastrum paradoxum						X		X	X	X		X		
Tetredron sp.						X		X			X			
Ulothrix sp.												X		
Zygnema sp.								X						

Source: James Kreitlow (Anvil Lake Association), and Environmental Horizons, Inc.

WETLANDS AND WOODLANDS

Wetlands

Wetlands are defined by federal agencies as having “a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions.” Wisconsin defines a wetland based on "the presence of water at a frequency and duration sufficient to support, and that under normal circumstances does support, wetland vegetation or aquatic life, and is commonly referred to as a bog, swamp, or marsh."

Wetlands affect the quality of water by acting as a filter or a buffer zone allowing silt and sediments to settle out. They also influence the quality of water by providing water during periods of drought and holding it back during periods of floods. When located along shorelines of lake and streams, wetlands help protect those shorelines from erosion. Wetlands may also serve as groundwater discharge and recharge areas in addition to being important resources for overall ecological health and diversity by providing essential breeding and feeding grounds, shelter, and escape cover for many forms of fish and wildlife. However, wetlands are poorly suited to urban use. This is due to the high soil compressibility and instability, high water table, low load-bearing capacity, and high shrink-swell potential of wetland soils, and, in some cases, to the potential for flooding. In addition, metal conduits placed in some types of wetland soils may be subject to rapid corrosion. These constraints, if ignored, may result in flooding, wet basements and excessive operation of sump pumps, unstable foundations, failing pavements, broken sewer lines, and excessive infiltration of clear water into sanitary sewerage systems. In addition, there are significant onsite preparations and maintenance costs associated with the development of wetlands, particularly as they relate to roads, foundations, and public utilities.

Few areas of wetland are present in the vicinity of Anvil Lake, although some scattered wetland areas exist as isolated pockets surrounding the Lake. Specific note should be taken of the presence of these

wetlands, and especially of the characteristic hydric soils in portions of the lake basin, as shown previously on Map 8.

Woodlands

Woodlands and forests provide an attractive natural resource of immeasurable value. Under good management, woodlands can serve a variety of beneficial functions, contributing to clean air and water, regulating surface water runoff, and contributing to the maintenance of a diversity of plant and animal life. The drainage area to Anvil Lake contains a substantial amount of woodlands and forests. Woodlands are defined as ecosystems that contain widely spaced trees with their crowns not touching, while forests have closer spaced trees with full canopy coverage.[16] Typical trees present in the drainage area include aspen, white birch, red and sugar maple, black ash, yellow birch, northern red oak, tamarack, white and red pine, balsam, and black spruce among others.

WILDLIFE, WATERFOWL, AND FISHERIES

No data were obtained during the present study, and information on the fauna of Vilas County in general has been noted as being sparse.[17] However, the WDNR report walleye to be common in Anvil Lake, and northern pike, smallmouth bass, and panfish to be present.[18]

Given the moderate- to high-density, single-family residential nature of much of the Lake's shoreline, and the surrounding woodlands in the vicinity, it is likely that the wildlife community is comprised of small upland animals, such as rabbit, raccoon, skunk, and squirrel; predators, such as black bear, bobcat, coyote, fisher, American martin, and wolf; game birds, such as pheasant and ruffed grouse; marsh furbearers, such as beaver, muskrat, and otter; migratory and resident songbirds; marsh birds, such as red-winged blackbirds; and other species of waterfowl including loon, which are presented in Photo 1. In addition, deer are abundant in the watershed and it is likely that given the open grassland areas within the watershed, that songbirds would likely be present. The character of wildlife species, along with the nature of the habitat present in the planning area is likely to have undergone significant change since the time of European settlement and the subsequent clearing of forests, plowing of the prairie, and filling or draining of wetlands for agricultural purposes. Modern practices that adversely affect wildlife and wildlife habitat include: the excessive use of fertilizers and pesticides, road salting, heavy traffic, the introduction of domestic animals, and the fragmentation and isolation of remaining habitat areas for urban and agricultural uses.

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[16] *David Lindenmayer, Mason Crane, and Damian Michael,* Woodlands: a Disappearing Landscape, *CISRO Publishing, 2005.*

[17] *Vilas County,* Vilas County Lake and River Classification Study*, February 1999.*

[18] *Wisconsin Department of Natural Resources Publication No. PUB-FH-800 2009,* Wisconsin Lakes*, 2009.*

PHOTO 1

LOON ON ANVIL LAKE

Source: Environmental Horizons, Inc.

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RECREATIONAL USES AND FACILITIES

Anvil Lake is a multi-purpose use waterbody serving all forms of water-based and water-related recreation, including swimming, boating, and fishing during the summer months, and ice-skating, cross-country skiing, snowmobiling, and ice fishing during the winter months. The Lake is used year-round as a visual amenity, and for a variety of other outdoor activities including bird watching, walking, and grilling out.

Recreational use surveys were conducted by Environmental Horizons staff on Thursday, August 5th, and on Sunday, August 8th, 2010 and are summarized in Table 9. These inventories consisted to a morning and an afternoon survey of the Lake with the purpose of counting people making use of the Lake and documenting the purposes for which the Lake was being used. This study was purposefully during an “off-peak” weekend in order to assess how the Lake was being typically used—holiday weekends bring out significantly more boats and users than non-peak periods, but such intense use is not representative of the average level of use.

On the morning of August 5th, a partly sunny day with a brisk breeze blowing, 16 lake users were observed, the majority of whom were engaged in swimming or wading (5 persons). Scenic viewing and walking on the Lake shore, together, comprised the same number of individuals. Three fishing boats and three speedboats were also observed, one speed boat was towing a tuber.

TABLE 9

RECREATIONAL USE SURVEY ON ANVIL LAKE: AUGUST 2010

Date and Time	Weekday Participants							
	Fishing [a]	Pleasure Boating[b]	Skiing	Sailing	Jetskiing	Swimming	Other [c]	Total
June 18, 2007 10:30 a.m.to 10:45 a.m. 3:15 p.m. to 3:30 p. m.	0 1	0 3	1 0	0 0	0 0	0 0	0 1	1 5
Total	1	3	1	0	0	0	1	6
Percent	16.7	50.0	16.7	0	0	0	16.6	100.0

Date and Time	Weekend Participants							
	Fishing	Pleasure Boating[d]	Skiing	Sailing	Jetskiing	Swimming	Other [c]	Total
June 17, 2007 10:15 a.m. to 10:30 a.m. 3:00 p.m. to 3:15 p. m.	3 0	0 22	1 0	0 0	0 11	0 6	0 8	4 47
Total	3	22	1	0	11	6	8	51
Percent	5.8	43.1	2.0	0	21.6	11.8	15.7	100.0

[a]Two fishermen were observed at 8:30 a.m.

[b]Pleasure boaters consisted of 1 pontoon boat and 2 high speed boats.

[c]Other uses consisted of boats pulling tubers.

[d]Pleasure boaters consisted of 1 jet boat, 6 pontoon boats, and 15 high speed boats.

Source: Environmental Horizons, Inc.

In the afternoon, which became mostly sunny with gusty winds, 25 individuals were observed, 13 of whom were engaged in beach-related activities. Twelve persons were observed to be boating: 3 persons were fishing and 9 were engaged in higher speed recreational boating activities. There were 14 occupied campsites in the National Forest campground on Anvil Lake on this date.

The weekend was cloudy, but the winds had abated. On the morning of Sunday, August 8th, 34 persons were observed, the majority of whom (14 persons) were walking, fishing, or picnicking around the lakeshore. Five persons were swimming from the shore. The same number (5 persons) were observed to be fishing from boats, one pontooning, three kayaking, and four operating motor boats on the Lake.

In the afternoon, 16 persons were observed, of whom three were engaged in beach-related activities. Two individuals were observed to be tubing, one water-skiing, and four operating personal watercraft (PWCs or "jet skis"). One person was operating a pontoon boat and three were motoring around the Lake. There were two anglers. There were four occupied campsites in the National Forest campground.

In terms of recreational watercraft present on and around the Lake, there were 250 watercraft or various descriptions observed. This means that, on the weekday, between about 6 and 7 percent of watercraft were in operation; on the weekend, about 5 percent of watercraft were in operation. This latter percentage is typically on the higher end of the percentage of watercraft in operation on Wisconsin Lakes at any given time. As noted above, this percentage reflects a typical week day and weekend day and not peak usage; during holiday weekends, a significantly higher percentage of the 250 watercraft observed would be expected to be in operation. A summary of the boat count is presented in Table 10.

Of this total number of watercraft, the majority (almost 40 percent) were rowboats and canoes, with an additional 15 percent of the boat population being comprised of paddleboats and 10 percent of the boat population being comprised of kayaks, and which were counted separately. Thus, of the watercraft inventories during this summer 2010 census, two-thirds were vessels powered by humans. One sailing vessel and one sculling boat were also observed. The remaining one-third of the watercraft population was comprised of motorized vessels. Just over 15 percent of the watercraft (or about one-half of the motorized watercraft) were "bass" boats or watercraft capable of higher speeds on the Lake, about 10 percent were pontoon boats, and about 5 percent were PWCs.

These observations present a rather contradictory view of desired lake uses. Clearly, there is a significant segment of the lake population who wish to use the Lake for high speed boating, waterskiing, and, reportedly, wake-boarding; however, these data also suggest that there is a majority of the population who wish to use the Lake for other boating activities such as canoeing, kayaking and paddle-boating. Curiously, on the dates of the recreational use surveys, boating activities in general were limited relative to shore-based activities such a walking, fishing, and swimming. What is clear from the census data is that the Lake can be considered to be subjected to multiple and potentially conflicting recreational use demands, with operation of motorized watercraft potentially conflicting with the operation of non-motorized watercraft and scenic enjoyment, although, at the peak of observed usage, each motorized watercraft had in excess of 40 acres of nominal lake area in which to operate (nominal lake area is based on the lake being at its normal or ordinary high water level, which obviously is not currently the case). In any event, such usage is consistent with current State recreational boating standards for lakes of the size of Anvil Lake.

TABLE 10

WATERCRAFT ON, AND IN THE VICINITY OF ANVIL LAKE: AUGUST 8th, 2010

Type of Watercraft										
Pontoon	**Fishing Boat**	**Personal Watercraft**	**Sailboat**	**Jetboat**	**Skiboat**	**Paddle-boat**	**Canoe/ Kayak**	**Rowboat**	**Watertoys[a]**	**Cabin-cruiser**
282	134	103	9	7	75	53	43	14	29	1

[a] *Watertoys consist of water trampolines, swim rafts and water tubes.*

Source: Environmental Horizons, Inc.

A closing thought with regard to recreational water use of Anvil Lake is that Anvil Lake is a reasonably typical multiple use waterbody. Consequently, the management actions to be developed for this Lake should seek to provide for both water quantity and water quality that will support such use.

As previously mentioned, there are three access sites which provide recreational boating access to the Lake. Two public access sites on Anvil Lake are located on the southeastern and southwestern shores of the Lake, as shown on Map 6.The southeastern public recreational boating access is provided within the National Forest lands.

SHORELINE PROTECTION STRUCTURES

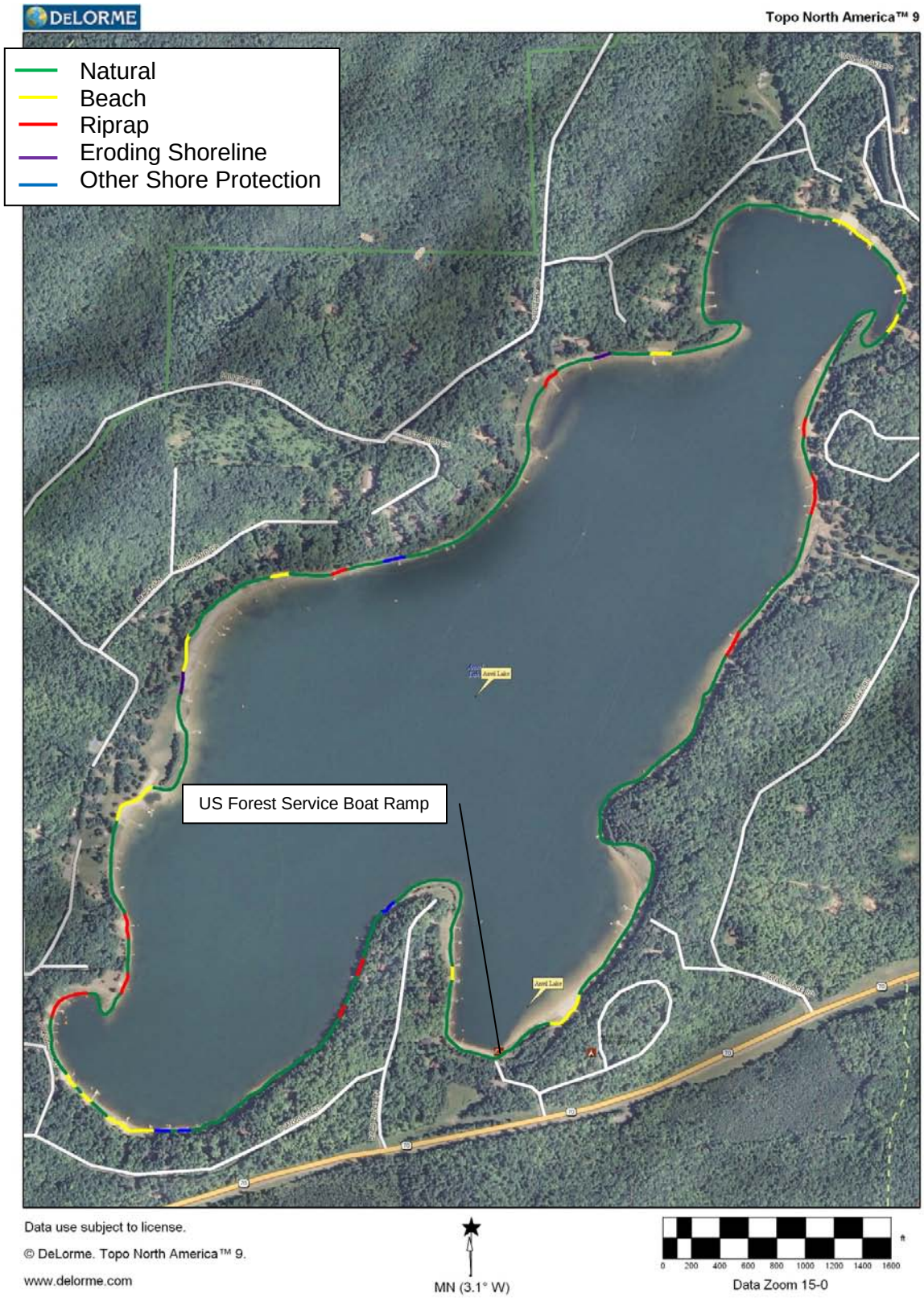
Shoreline protection structures are designed to minimize shoreland erosion and to protect the structure and functioning of the aquatic ecosystem, especially, in the nearshore areas. Such protection structures also can contribute to preserving and enhancing water quality and habitat for fishes and other aquatic life. Certain shoreland landscaping practices have been shown to be effective deterrents to resident waterfowl populations, as well as attractive means of preserving and providing habitat for desirable aquatic species. Environmental Horizons, Inc. staff conducted a survey of the Anvil Lake shoreline during August 2010. This survey identified the shoreline as being comprised primarily of natural vegetation, with a mixture of riprap, seawalls, and manicured beach, as shown on Map 10. Note should be taken of the reduced surface elevation of the Lake at the time of the survey. For this reason, the shoreline structure inventory reflects structures that are currently well above the current water surface elevation. Had this convention not been adopted, the exposed lake bed would have resulted in the lake shoreline being described totally as “beach”. While some small areas of manicured beach are present, the majority of areas noted as “beach” in the shoreline survey conducted by Environmental Horizons, Inc. staff, and shown on Map 10, reflect shoreland areas that appear to have been denuded of vegetation in order to promote water access during the current period of reduced lake levels. Nevertheless, despite the reduced water surface elevations, only two obvious areas with erosion-related problems were observed and that appeared to be related to wave action during periods when the lake surface elevation was at its “normal” elevation.

LOCAL ORDINANCES

Anvil Lake is subject to land use and shoreline regulations that are under jurisdictional control of the Vilas County and are regulated under Chapter 17, “Zoning Code,” of the *Vilas County Code of Ordinances*. Additional land use and recreational use ordinances are set forth in Chapter 15, “Private Sewage System;” Chapter 16, “Forest and Land” which included recreational use ordinances; and, Chapter 18, “Subdivision Control.” Recreational boating on Anvil Lake is regulated by the State of Wisconsin boating and water safety laws, set forth in Chapter 30 of the *Wisconsin Statutes*.

MAP 10

SHORELINE SURVEY OF ANVIL LAKE



Source: Environmental Horizons, Inc.

CHAPTER III

ISSUES OF CONCERN

INTRODUCTION

Anvil Lake is a waterbody that is capable of supporting a variety of recreational water uses. Based upon the inventory data set forth in Chapter II, the Lake has few problems or concerns, although water level variation remains a major concern of the community. In general, the major focus of the community is maintaining the Lake in its current condition, including maintaining water levels in the Lake that are conducive to supporting the variety of aesthetic and recreational uses to which the Lake is put. This concern also extends to keeping the Lake free of nonnative species and maintaining conditions in the lake and surrounding community that are conducive to harmonious relations.

One means of assessing the concerns of the community is through the conduct of a community, questionnaire-based survey. This survey forms and integral part of this lake protection plan. The survey was conducted during the autumn of 2010, and involved the distribution of questionnaires to each of the residential properties located around the Lake. The distribution list was based upon the Town of Washington tax parcel listing and the mailing list compiled and maintained by the Anvil Lake Association. The survey instrument is appended hereto as Appendix B.

Based upon these sources of information, this plan focuses on the protection of the Lake and its environs. Where concerns may exist, potential future problems and issues of concern are elaborated below and addressed in this plan.

OVERVIEW OF COMMUNITY CONCERNS

More than one-half of the community residents responded to the survey. Of these respondents, about three-quarters indicated that they were members of the Anvil Lake Association. The majority (60 percent) were seasonal residents who were more or less equally divided between weekend residents (45 percent of the seasonal residents) and seasonal summer residents (40 percent of seasonal residents). These respondents spent an average of 64 days a year at Anvil Lake, the majority (80 percent) of whom for more than 10 years. Most of these respondents (55 percent) used the Lake with their families.

More than one-half of the respondents (55 percent) were open water anglers, who reported fishing for an average of 16 days per year; about one-fifth of respondents also indicated that they were ice-anglers, who reported ice-fishing for an average of 12 days per year. Fish species caught during the open water season included panfish (reported by 26 percent of anglers), northern pike and smallmouth bass (20 percent), crappie (16 percent) and walleye (13 percent). During the winter, northern pike was the targeted species (reported by 40 percent of anglers). Respondents were divided about the quality of the fishery during the open water months, with about two-fifths each reporting that the fishery was fair

or poor. This was in contrast to the winter fishing season during which about three-fifths of respondents reported the fishery to be fair.

Respondents also noted that boating was a popular pastime, with an average of about three watercraft being owned by each respondent. Respondents reported operating high speed watercraft (speedboats and personal watercraft [PWCs]) for about 20 to 25 days per year; waterskiing and wakeboarding were engaged in an average for about 10 days per year. Powered watercraft ranged from an average of about 130 horsepower for high speed watercraft, such as ski boats and PWCs, and about 40 horsepower for other watercraft, such as fishing boats.

The most popular pastimes were bird watching (165 days per year) and walking/jogging (113 days per year).

Given the characteristics of the respondents, the four most significant issues of concern identified included water quality (identified by 61 percent of respondents), fishing quality (56 percent), water levels (53 percent) and lack of lake depth (50 percent of respondents). Four-fifths of respondents indicated that water quality had declined in recent years, with the largest percentage of the remainder suggesting that lake water quality has been unchanged. Nevertheless, two-thirds of respondents rated water quality as being good. Consequently, most respondents were satisfied with the levels of law enforcement (80 percent were satisfied or well-satisfied), enforcement of boating regulations (90 percent were satisfied or well-satisfied), levels of development (80 percent were satisfied or well-satisfied), and sanitation regulations (72 percent were satisfied or well-satisfied) applicable to Anvil Lake.

In summary, the major issues of concern identified by the respondents to the questionnaire survey were related to (1) maintenance of onsite sewage disposal systems, (2) development in the area of the Lake, and (3) boating. Additionally, from the perspective of the anglers, the quality of the fishery also was identified as an issue of concern. These four issues are elaborated further below.

LAND USE

Development Within the Drainage Area

The drainage area directly tributary to Anvil Lake is comprised of large portions of woodland that form the Chequamegon-Nicolet National Forest within the Town of Washington. While this limits the magnitude of potential future development within the area tributary to the Lake, ongoing redevelopment of existing platted lots is changing the landscape on portions of the Lake, especially on the western and eastern extremes that are occupied by a resort (western) and undeveloped land (eastern). Outside of this area, much of the immediate shoreline of the Lake has been developed for residential use. Virtually all of these lands are indicated to be poorly suited for residential development with onsite sewage disposal systems due to the poorly drained nature of the soils, as discussed in Chapter II.

Linked with development, and the location of current development surrounding Anvil Lake, is the issue of nonpoint source pollution. Nonpoint source pollutants in the drainage area tributary to Anvil Lake represent a potentially significant threat to the Lake's water quality. Currently platted lots would suggest that the development of currently vacant lots surrounding the Lake will occur at densities not dissimilar to those of the currently developed portions of the watershed. Such development densities will decrease the quality and increase the quantity of stormwater runoff being conveyed to the Lake and/or available for infiltration into the groundwater. Further, as impervious surface is added to the drainage area tributary to Anvil Lake, the ability of rainwater to percolate into the surfacial aquifer is reduced. While current stormwater management ordinance provisions limit the magnitude of such alterations in runoff volume, increased runoff has the capacity to carry greater loads of potential contaminants to the Lake. Consequently, limited increases in heavy metals, sediment, and nutrient loadings may be

expected to occur as land uses change, although these loads may decrease or stabilize once more urban land use conditions stabilize within the drainage area.

SURFACE WATERS

Water Quality and Quantity

As of 2010, surface water quality in Anvil Lake was observed to be good. As described in Chapter II, the Lake was within the mesotrophic range, indicating that few water quality problems would be expected. However, declining lake levels in recent years appear to have contributed to the decline in water quality, placing the lake in the meso-eutrophic category. Not unexpectedly, therefore, the citizens within the Anvil Lake community have expressed concern regarding the maintenance of good surface water quality over the longer term. Because, the soils surrounding the Lake appear to be generally unsuitable for onsite sewage disposal systems, the management and maintenance of these systems is an issue of concern that relates to the maintenance of good lake water quality.

Linked to this issue is the issue of water quantity and lake level. As noted in Chapter II, there has been a general decline in water surface elevations observed in recent years. Some of the contaminants that degrade water quality are such that water loss through evaporation will elevate the levels of the contaminants, as a result of evaporative concentration, while the lack of inflow will reduce the through flow of contaminants within the system, both in terms of the rate at which contaminants enter the Lake as pass through the Lake as a component of the groundwater system. On the other hand, those contaminants that are within the system will remain for a longer time, potentially fueling continued growths of aquatic plants and algae.

The loss of volume in the Lake basin is a major concern within the Anvil Lake community. The magnitude of the current decline in Lake levels, that exceeds previous low water levels over the more than 70-year period of record, is a major cause of concern within this lake-oriented community. While there is recognition of the ongoing period of lower than normal precipitation in northern Wisconsin, the observations of lake residents that other groundwater-fed lakes in the Town of Washington appear to be responding differently from Anvil Lake underlies a desire among the community for a better understanding of the water balance of the Lake.

Ecologically Valuable Areas

Anvil Lake and its tributary drainage area contains large areas that can be considered to be ecologically valuable. As noted, these areas are largely contained within the Chequamegon-Nicolet National Forest lands. In terms of in-lake habitat, while this may be affected to a degree by the decline in lake surface elevation, native aquatic macrophyte beds providing prime fish spawning habitat, represent landscape features that contribute to the aesthetic character of the community as well as to the enjoyment of its citizens. Similarly, a significant portion of the shoreline of Anvil Lake remains in native shoreland vegetation, primarily comprised of woodlands. The removal of shoreline vegetation from some areas of the lakeshore can limit the ability of the Lake to sustain the recreational fishery, as has been noted, while the lack of native shoreland vegetation can contribute to the delivery of nutrients to the Lake, indirectly through the absence of vegetated buffer strips that absorb nutrients and particulates in stormwater runoff, and directly through the application of lawncare products within the riparian zone.

RECREATIONAL USAGE

While overcrowding and excessive recreational boating use is not perceived to create problems in Anvil Lake, recreational boating activities are impaired by loss of lake depth, primarily as a result of the regional drought that has limited water flow into the Lake. In addition, the use of high powered watercraft and PWCs increases the risk of shoreland erosion as a result of the reduced lake surface

elevations. Lands exposed by loss of lake volume are typically unvegetated and exposed to the erosive consequences of boat wakes. This disruption has consequences for the fishery as shoreland and littoral (nearshore) zone erosion can inundate spawning areas while aquatic vegetation necessary for fish habitat, breeding and feeding is diminished in quality and quantity, potentially negatively affecting the Lake fishery.

CHAPTER IV

ALTERNATIVE AND RECOMMENDED LAKE PROTECTION MEASURES

INTRODUCTION

Chapter III described four major issues of concern to be considered as part of this lake protection plan. These issues are related to: 1) land use management; 2) surface water quality and quantity management; 3) management of ecologically valuable areas; and, 4) recreational use management. With the possible exception of the issue related to water quantity, which may be related to the global change in climate patterns,[1] the issues identified by the Anvil Lake community through the community questionnaire survey are primarily related to lake protection. In other words, the issues are future oriented, with a need to take action today to limit the extent of undesirable impacts in the future, including those that can be foreseen in the near future. To an extent, the Anvil Lake Community is insulated from major impacts such as those related to major changes in land use by the fact that the Chequamegon-Nicolet National Forest controls development on much of the land surrounding the Lake. Those areas that remain undeveloped, outside of the National Forest, comprise significant areas of low-lying lands, wetlands, and soils that are unsuitable for development, as documented in Chapter II. Consequently, the major threat facing the community, aside from the threat of global change, is centered within the existing lakeside community; namely, land use changes associated with densification and urban density development within the riparian area, consuming open lands that are already platted or developed for residential use, and placing additional demands on the environment through the need for additional onsite sewage disposal, building sites, and recreational uses.

LAND USE MANAGEMENT

As noted in Chapter II, the continued growth of the Town of Washington will affect the Anvil Lake community, primarily through the development of already-platted lots, reconstruction of seasonal properties for year-round use, and the redevelopment of properties such as the resort properties to reflect changing demands of the recreational marketplace for onsite amenities and conveniences. The continued enforcement of development controls through the application of existing Vilas County ordinances and adherence to the Town and County comprehensive development plans, therefore, is recommended. The ordinances currently govern land development practices and land management practices within the larger portion of the area surrounding Anvil Lake, including the lands draining directly to the Lake and lands providing the groundwater recharge that sustains the water surface elevations within the Lake. Periodic review of these ordinances for concurrency with best available practices is recommended, based upon which reviews, Vilas County and the Town of Washington should consider developing and implementing new ordinances as necessary to facilitate the orderly

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[1] *Governor's Task Force on Global Warming,* Final Report by the Governor's Task Force on Global Warming*, July 2008.*

development and growth of the Town, and the safe and equitable utilization of the water resources of Anvil Lake (and other water resources) within the Town.

In addition, periodic review of development plans is recommended. Consideration of the use of clustered development, based on the principles of conservation development, especially in areas likely to be affected by redevelopment of the Lake's resort areas, could maximize the area of open space within the confines of the existing residential footprint. Such a developmental approach promotes retention of the wooded ambience that gives both the Town of Washington and the Anvil Lake community their charm, while at the same time providing economies-of-scale for developers and builders. The larger open space areas that consequently occur between clusters of homes promote not only this ambience but also provide enhanced habitat for wildlife and enhanced pollution absorption capacity within this landscape.

Array of Control Measures

Adoption and implementation of land use zoning and appropriate land use plans by the Town of Washington and Vilas County within the tributary area to Anvil Lake will contribute to ensuring that development within this drainage area is consistent with the water quality goals established for Anvil Lake. These ordinances and plans will direct the implementation of urban density land use practices to appropriate areas. Such areas include those lands within the drainage basin that can be appropriately served by wastewater treatment practices and that minimize the risk of release of nutrients and other contaminants to the Lake. At present, these practices are limited to onsite sewage treatment systems, primarily septic tanks. As these systems age, they may need to be relocated within a property, which, given the nature of the soils in the portions of the Town adjacent to Anvil Lake, could be problematical. Consequently, consideration of the use of holding tanks or other alternatives as may be developed in the future may be necessary to continue to ensure an adequate level of treatment of domestic wastewaters.

Zoning ordinances can regulate shoreland setbacks and shoreland management practices consistent with preserving and protecting the native shoreland buffer surrounding the Lake. Such buffers, of 35-feet minimum width, will reduce the transport of nutrients, sediments, and other land-based contaminants to the lake system. Such actions are an essential add-on to any in-lake management practices and also are recommended by the Wisconsin Lakes Partnership.[2]

In addition, land management practices applied to individual properties should be considered, including urban "good housekeeping" practices for the peri-urban residential lands surrounding the Lake. These latter practices include maintenance of riparian vegetative buffer strips and minimal fertilization of lands that have been converted to lawns, to ensure a healthy turf. Recent U.S. Geological Survey findings[3] regarding the potential impacts of suburban lawn care practices on stormwater runoff in residential watersheds in Wisconsin, for example, have heightened concern among lakeshore residents that the water quality of the Lakes may deteriorate, even under relatively stable land use conditions.

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[2]*The Wisconsin Lakes Partnership is a public-private initiative created by the Wisconsin Department of Natural Resources, the University of Wisconsin-Extension, and the Wisconsin Association of Lakes. This Partnership has published numerous booklets and brochures dealing with yard care and the environment, shoreland management, and care of onsite sewage disposal systems. These publications and other resources can be accessed through the internet at: http://www.uwsp.edu/uwexlakes/.*

[3]*U.S. Geological Survey Water-Resources Investigations Report,* Sources of Phosphorus in Stormwater from Two Residential Urban Basins in Madison, Wisconsin: 1994-95*, in press.*

Recommended Management Measures

The following management actions are recommended for the management of urban density development within the Town of Washington for the protection and maintenance of surface water quality in Anvil Lake:

1. Periodic review of County and Town ordinances for concurrency with state-of-the-art land management practices, including onsite wastewater management practices, stormwater management practices, shoreland development standards and practices, and related best management practices.

2. Adoption, periodic review, and enforcement of appropriate land use plans, including adoption of a process of comprehensive site plan review for undeveloped lots and lots proposed for redevelopment.

3. Promotion of the benefits of adequate shoreline setbacks, impervious surface coverage ratios, intact 35-foot shoreland buffer zones, and related property design standards to enhance open space, reduce potential contaminant loads to the Lake, and contribute to the ambience of the community.

4. Adoption and enforcement of a program of inspection of onsite sewage disposal systems to ensure their adequate and continued functioning, to minimize the risk of nutrient inputs to Anvil Lake.

5. Replacement of failing onsite sewage disposal systems with holding tanks or other equally effective wastewater management systems.

6. Promotion of "good housekeeping" practices, including tips for lake-friendly lawn care and similar actions that can be adopted by citizens at low- or no-cost; brochures and fact sheets to support such an information program may be available from state and federal agencies and the university extension service, among other potential sources.

In addition, developing areas and associated construction sites can generate significantly higher pollutant loadings than established areas of similar size. These areas include a wide array of activities, including individual site development within the existing urban area, and new land subdivision development. As previously noted, there is some potential for additional land development and redevelopment within the drainage area tributary to Anvil Lake. These construction sites may be expected to produce suspended solids and phosphorus loadings at rates several times higher than established urban lands, and control of sediment loss from construction sites is recommended.

Finally, in addition to the regulatory programs, public informational programs can be developed to encourage good practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Good land and home management practices and source controls include restricted use of fertilizers and pesticides; improved pet waste and litter control; the substitution of plastic for galvanized steel and copper roofing materials and gutters; proper disposal of motor vehicle fluids; and continued use of sand and reduced use of street deicing salt for winter road maintenance. In this regard, it should be noted that the respondents to the community questionnaire survey indicated that three-quarters of respondents were members of the Anvil Lake Association, 70 percent were aware of and had visited the Association's website, and four-fifths received and read the Association's periodical publication, *Lake Chimes*.

Recommended Management Measures

The following management actions are recommended for the management of nonpoint source pollution sources:

1. The Anvil Lake Association, in conjunction with the Town of Washington, should assume the lead in the continuation of a public educational and informational program for the residents around Anvil Lake and within the drainage area tributary to Lake, which encourages the institution of good land management practices including, pesticide and fertilizer use management, improved pet waste and litter control, and yard waste management, as well as other lake management-related topics.

SURFACE WATER MANAGEMENT

In-lake Water Quality Monitoring and Management

As of 2010, the surface water quality of Anvil Lake was observed to be good. Nevertheless, surface water quality is an issue of concern because of the desire of the residents to continue to utilize the Lake for full body contact recreation, boating and angling. To this end, the measures taken to minimize water quality degradation in the surface drainage area tributary to Anvil Lake, noted above, should also serve to protect both the surface and ground water resources of the watershed from contamination. Protection of the groundwater resources is not only water quality-related but also essential to ensuring the continued inflows to the Lake necessary to maintain the surface elevation of the waterbody at levels conducive to the pursuit of the desired recreational activities. Consequently, the array of control measures identified herein focus primarily on water quality monitoring and reporting.

Array of Control Measures

Anvil Lake is a mesotrophic waterbody. As such, it may be considered, by definition, to be in need of protection in order to maintain and enhance its current aesthetic and recreational uses. The array of land management and nonpoint source pollution controls discussed above are designed to address the most significant sources of contaminants to the Lake. For this reason, the conduct of an ongoing lake water quality monitoring program will provide a continuing measure of the effectivity of such measures and early warning of new or emerging threats to the environmental integrity of the Lake.

Recommended Management Measures

The following management actions are recommended for the management of surface water quality:

1. Continued participation of the Anvil Lake community in the Citizen Lake Monitoring Network (CLMN) volunteer monitoring program is recommended. The report of the citizen monitor should be featured at the annual meeting of the Anvil Lake Association and in the publications of the Association.

2. Consider the conduct of a fisheries and aquatic plant surveys at approximately five-yearly intervals.

Water Quantity Monitoring and Management

Water levels within Anvil Lake are wholly dependent upon the flow of groundwater into the system, supplemented in small part by direct precipitation on the Lake surface and runoff from the relatively small watershed tributary to the Lake. While the Anvil Lake Association has maintained a lake surface elevation gauge since the 1930s, little is known of the drivers or mechanisms underlying the fluctuations in water levels that have been observed. Clearly, these fluctuations are driven in part by the local rainfall and precipitation regime. However, the mechanisms by which such events translate into inflow to (and outflow from) the Lake are poorly understood.

Recommended Management Measures

The following management actions are recommended for the management of surface water quantity:

1. Continuation of the lake surface level recording program by the Anvil Lake Association is recommended. Linking of this local gauge to the national elevation grid (based upon the National Geodetic Vertical Datum or NGVD of 1929) is strongly recommended. Periodic re-survey of the Lake gauge to ensure that it has not been affected by ice movements or other disturbances is also recommended.

2. Development of an understanding of the groundwater flow system that sustains the Lake is recommended. Preliminary work by the U.S. Geological Survey has suggested that the principle recharge area to the Lake is located within the northern portions of the surface drainage area tributary to the Lake. Further investigation of the Lake's water balance, however, is needed to understand the periodic changes in water surface elevation. To this end, the U.S. Geological Survey has an ongoing program of surface and ground water conjunctive use investigations.

3. Formulation of a simulation model of the Anvil Lake hydrology, potentially utilizing the U.S. Geological Survey MODFLOW simulation model and its associated lake "package" that integrates surface water and groundwater systems would provide the Town and County, and lake community, with a tool to forecast lake response to a variety of potential changes, including changes in land use and land cover, precipitation, and climate conditions.

4. Development of an understanding of the recurrent nature of the shifts in Lake surface elevation through the use of paleo-limnological techniques such as the use of deep sediment cores may shed some light on the likely frequency of recurrence of extreme events, given the anecdotal evidence of lake levels that have been both higher and lower than at present. To this end, the Division of Enforcement and Science, Integrated Science Services Section of the Wisconsin Department of Natural Resources has an ongoing program of paleo-limnological research.

MANAGEMENT OF ECOLOGICALLY VALUABLE AREAS

Anvil Lake and its tributary drainage area contain ecologically valuable areas, including a diverse, native aquatic plant community suitable for fish spawning and wildlife habitat, woodlands, and wetlands. The major areas of concern associated with ecologically valuable areas in and around Anvil Lake relate to: 1) woodlands and wetlands, 2) shoreland management, and 3) citizen informational and educational programming. Two of the four issues of concern identified through the community questionnaire survey were associated with this topic: concerns related to development within the area tributary to Anvil Lake and concerns about the consequences of onsite sewage disposal on the Lake and its environs.

Woodland, Wetland and Aquatic Plant Management Alternatives

Woodland and wetland management refers to a group of management and restoration measures aimed both at the removal of nuisance vegetation and the manipulation of species composition in order to enhance, protect, and maintain the biodiversity of the Anvil Lake tributary drainage area. Riparian woodlands containing a diverse native flora represent landscape features that contribute to the aesthetic character of the community as well as to the enjoyment of its citizens. In the Anvil Lake drainage area, the most extensive wooded areas generally lie within the Chequamegon-Nicolet National Forest and hence enjoy a large measure of protection through public ownership of these resources.

Array of Control Measures

Protection of ecologically valuable areas is generally best accomplished through land use control measures, public acquisition of key woodland and wetland parcels, and/or acquisition of conservation easements. In addition, certain in-lake management measures could be used to moderate deleterious changes in the aquatic plant and animal communities that comprise the lakeward portions of the ecologically valuable areas within the Lake basin. Citizen informational and educational programming forms an important element of the management of environmentally valuable areas within and riparian to Anvil Lake by encouraging actions on the part of riparian residents and residents within the drainage area tributary to the Lake that would benefit the maintenance of ecologically valuable areas within and around Anvil Lake. Such practices include the protection of existing shoreland vegetation and placement of shoreland buffers strips utilizing native plants where appropriate as noted above. Maintenance of existing shoreland and upland vegetation, especially on steeply sloping hillsides, is strongly recommended.

The recommended future land use condition within the drainage area tributary to Anvil Lake is set forth in the adopted Town and County land use plans. These plans recommend the preservation of most ecologically valuable lands, including the environmentally valuable lands adjacent to Anvil Lake and within the drainage area tributary to the Lake. Recommended protection measures to be considered include the retention of these lands in appropriate zoning districts depending upon the type and character of the natural resource features to be preserved and protected, and enforcement of existing land use regulations within the drainage area, including the County shoreland ordinance.

The Vilas County comprehensive land use plan recommends that all lakes, rivers, streams, wetlands, and associated undeveloped floodlands and shorelands be protected.[4] Where wetlands and other environmentally valuable lands are threatened by encroachment or degradation, these lands should be considered for purchase or for acquisition of conservation easements. Land acquisition is an important means of protecting environmentally valuable lands from encroachment or further degradation, and provides a means for facilitating their rehabilitation and restoration. Outright purchase provides the greatest degree of control and protection, while the purchase of conservation easements can provide control over specified land uses on properties that remain in private ownership. Lands proposed for purchase should be appraised using standard governmental land acquisition procedures, and should be subject to a land management plan setting forth the processes and procedures for their long-term maintenance and development.

Recommended Management Measures

The following management actions are recommended for the management of woodlands and wetlands:

1. Implement the Vilas County comprehensive “smart growth” plan; consider the use of conservation development approaches to maximize the area of natural landscape within the drainage area tributary to Anvil Lake.

2. Protect woodlands and wetlands within the drainage area tributary to Anvil Lake; consider public acquisition of remaining large-lot, undeveloped shoreland parcels.

Shoreland and Nearshore Management Alternatives

Native aquatic macrophyte beds providing prime fish spawning habitat, and shoreland wetland areas providing habitat for amphibians and herptiles, represent landscape features that contribute to the

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[4] *Vilas County Land Use Planning Committee and Zoning & Planning Committee, and North Central Wisconsin Regional Planning Commission,* Vilas County Comprehensive Plan*, November 2009.*

aesthetic character of the community as well as to the enjoyment of its citizens. While the management of in-lake aquatic plant communities is discussed below, various potential in-lake management actions should be considered complementary to the management of environmentally valuable wetland areas within the shoreland zone. In addition, citizen informational and educational programming should be considered as an essential aspect of the management of environmentally valuable lands within the drainage area tributary to Anvil Lake.

Array of Control Measures

A significant portion of the shoreline of Anvil Lake, comprising approximately four-fifths of the surveyed shoreland, is well-vegetated at "normal" lake levels, and few major areas of erosion, which are likely to require additional protection against wind, wave, and wake erosion, were identified during the planning effort. While much of the lakeshore remains in native shoreland vegetation, the encroachment of residential properties into some areas of the shoreland was noted. This encroachment has been exacerbated as a result of the currently reduced lake levels by activities associated with "improvement of exposed lake bed." Loss of emergent shoreline vegetation from large areas of the lakeshore as a consequence not only of the reduced lake surface elevation, but also of encroachment into this exposed lake bed limit the ability of the Lake to sustain the recreational fishery, as noted in Chapter III. The lack of native shoreland vegetation contributes to the delivery of nutrients to the Lake through the absence of 35-foot vegetated buffer strips that absorb nutrients and particulates in stormwater runoff. Wherever practical, vegetated buffer strips should be used in lakeshore areas in order to maintain habitat value and the natural ambience of the shoreland area. Many shoreland protection measures can be implemented by local residents working with nature to maintain native plant communities that already exist in the lakeshore area.

The **physical removal** of specific types of vegetation by selective harvesting of plants provides a highly selective means of controlling the growths of nuisance upland and wetland plant species, including purple loosestrife, reed canary grass, buckthorn, non-native thistles, and other invasive, nonnative plants. Bagging and cutting loosestrife plants, for example, prior to the application of chemical herbicides to the cut stems, can be an effective control measure for small infestations of this plant, limiting shedding of seeds that will promote regrowth in future years. Loosestrife management programs, however, should be followed by an annual monitoring and control program for up to 10 years (or more) following the initial control program to manage the regrowth of the plant from seeds that may have been set prior to the application of the control measures. For other nonnative invasive plant species, selective cutting of shrubs and small trees, as in the case of buckthorn, can likewise remove nuisance species from the midst of native plants without causing significant disruption of the habitat area. This procedure may require the limited application of an herbicide to the remaining plant materials for effective long-term control. In larger areas, repeated mowing or occasional burning can be effective means of managing larger prairie areas, although prairie burns require trained personnel and would be likely to require local permits prior to this measure being used.

Chemical treatment with **herbicides** is a short-term method of controlling heavy growths of nuisance plants. The use of herbicides can potentially damage or destroy nontarget plant species that provide habitat for wildlife and other shoreland organisms. Widespread chemical treatments can also provide an advantage to less desirable, invasive, introduced plant species to the extent that they may outcompete the more beneficial, native species. Hence, this is not a feasible management option to be used on a large scale. Notwithstanding, chemical control is often a viable technique for the control of the relatively small-scale infestations of purple loosestrife and certain other plants. Chemicals are generally applied to the growing plants in liquid form. Chemical treatment can be administered at a relatively low cost and is, therefore, considered to be a viable management option. In the control of purple loosestrife and buckthorn, for example, chemical treatments combined with manual control measures can be extremely effective, as noted above. Thus, the use of chemical control measures may be considered a viable alternative in specific situations.

An alternative approach to controlling nuisance weed conditions, particularly in the case of purple loosestrife, is **biological control**. Classical biological control has been successfully used to control both weeds and herbivorous insects.[5] Recent evidence shows that the beetles, *Galerucella pucilla* and *Galerucella calmariensis*, and the weevils, *Hylobius transversovittatus* and *Nanophyes brevis*, have potential as biological control agents for purple loosestrife. Extensive field trials conducted in the late 1990s and early 2000s by various agencies and organizations indicated that these insects can provide effective management of larger-scale infestations of purple loosestrife.

Recommended Management Measures

The following management actions are recommended for the management of shorelands and nearshore areas:

1. Consider the use of environmentally-friendly shoreline protection measures where appropriate.

2. Maintain existing shoreline vegetation, with particular attention to the conservation and re-vegetation of 35-foot (as measured from the ordinary high water mark or normal high water level landward) shoreland buffer areas.

3. Manage nonnative species of upland and shoreland plants using manual, chemical, and biological control measures as appropriate.

Citizen Information and Education

As part of the overall citizen informational and educational programming to be conducted within the Anvil Lake community, residents and visitors should be made aware of the value of the ecologically significant areas in the overall structure and functioning of the ecosystems of Anvil Lake.

Array of Control Measures

Informational programming related to the protection of ecologically valuable areas in and around Anvil Lake should focus on need to prevent the spread of nuisance aquatic species, such as purple loosestrife in the wetlands and Eurasian water milfoil in the Lake, to Anvil Lake and its environs.

Recommended Management Measures

The following management actions are recommended for the information of lake residents, Anvil Lake Association members, and others in the Town of Washington community:

1. Continue informational programming as part of the Anvil Lake Association activities, including maintenance of the Association's website and periodic publication of the Association's newsletter, *Lake Chimes*.

AQUATIC PLANT MANAGEMENT

The aquatic plant communities in Anvil Lake have not been perceived to be a nuisance; however, changes in this flora as a consequence of reduced lake surface level elevations may be limiting habitat for fish and other aquatic life within and adjacent to the Lake, a concern that has been noted by respondents to the community questionnaire survey. Consequently, protection of the native aquatic plant community in and around Anvil Lake through the land management practices noted above is an essential element of this lake protection plan.

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[5]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* LakeLine*, Volume 17, Number 3, September 1997, pp. 20-21, 34-37.*

Array of Control Measures

Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use.[6] Generally, aquatic plant management measures are classed into five groups; namely, physical measures which include water level management; manual and mechanical measures which include harvesting and removal; chemical measures which include using aquatic herbicides; biological controls which include the use of various organisms, including insects; and, nutrient inactivation, which addresses the cause of the excessive aquatic plant growth. In addition, good housekeeping practices implemented in shoreland areas, on riparian properties, and within the drainage area tributary to Anvil Lake, encouraged through an active public informational and educational program, should be considered essential elements in any aquatic plant management plan.

While all of these options are discussed briefly below, the primary management measure to be implemented on Anvil Lake is one of maintaining the existing native aquatic plant and wetland flora, and minimizing the risks of introduction of nonnative species. Consequently, periodic inspection of the lake and its environs for the presence of nonnative species is strongly recommended, with rapid implementation of appropriate control measures to contain and eliminate, if possible, any future infestation is the primary management action recommended.

Aquatic Herbicides

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. The use of herbicides can contribute to an ongoing aquatic plant problem by increasing the natural rates of accumulation of decaying organic matter, in turn contributing to an increased oxygen demand which may cause anoxia. The use of herbicides can also potentially damage or destroy nontarget plant species that provide needed habitat for fish and other aquatic organisms. As a result, less desirable, invasive, introduced plant species may outcompete the more beneficial, native species. Hence, this is not a feasible management option to be used on a large scale. However, chemical control is often a viable technique for the control of the relatively small-scale infestations of milfoil and certain other plants. Chemicals are applied to the growing plants in either liquid or granular form.

Algicides, typically based upon copper sulfate, can be used to control excessive growths of floating microscopic aquatic plants or algae. This alternative could be considered to control the potentially extensive growths of algae in Anvil Lake. However, modifications of land use practices to ensure the integrity and maintenance of shoreland vegetation, and appropriategood management practices, as described above, are recommended.

Mechanical Harvesting

Mechanical harvesting of aquatic plants is a practical and efficient means of controlling extensive areas (suggested as being greater than 40 acres of harvestable aquatic plant beds) of rooted aquatic plant growth. Harvesting has the added advantage of removing the plant biomass and its associated nutrients from the Lake. Aquatic macrophytes are mechanically harvested with specialized equipment consisting of a cutting apparatus which cuts up to five feet below the water surface and a conveyor system that picks up the cut plants and hauls them to shore. Harvesting leaves enough plant material in the lake to provide shelter for fish and other aquatic organisms and to stabilize sediments. Mechanical harvesting does have some potentially negative impacts to fish and other aquatic life, may cause fragmentation and spread of some plants, and could disturb loosely consolidated bottom sediments.

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[6] *U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual*, August 1990.*

However, if done correctly and carefully, it has shown to be of benefit in ultimately reducing the regrowth of nuisance plants.

Manual Harvesting

Within the littoral or nearshore zone, especially adjacent to piers and docks where there is significant potential for damage to property and the lakebed, the use of specially designed rakes to manually remove aquatic plants from the shoreline area is an alternative. While aquatic herbicides are also an option for aquatic plant management within these areas, the advantage of manual control methods is immediate relief; chemical treatment involves a waiting period wherein the plant adsorbs the herbicide and the herbicide induces mortality in the plant. Using this method also removes the plants from the lake, avoiding the accumulation of organic matter on the lake bottom adding to the nutrients that favor more plant growth.

Biological Controls

Biological controls provide another alternative approach to controlling nuisance aquatic plant growths, particularly in the case of Eurasian water milfoil. Classical biological control has been successfully used to control both nuisance plants and herbivorous insects.[7] Recent documentation indicates that *Eurhychiopsis lecontei*, an aquatic weevil species, has potential as a biological control agent for Eurasian water milfoil.[8] However, the studies that have been completed using *Eurhychiopsis lecontei* as a means of aquatic plant management control suggest that this control measure is extremely sensitive to disturbances such as those created by recreational boating activity.

Physical Controls

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches, to improve the appearance of lakefront property, and to open channels for motorboating. Synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years, although pursuant to the requirements of Chapter 30 of the *Wisconsin Statutes* such materials must be removed annually, making such practices extremely time consuming and unwieldy.

Nutrient Inactivation

Reducing the nutrient availability in the Lake would have the benefit of limiting the opportunity for algal growth to occur, and potentially limiting the growth of rooted aquatic plants in the system. The use of chemical flocculants, such as alum, in certain waterbodies as a means of reducing in-lake nutrient concentrations and limiting sediment-water nutrient exchanges, is not warranted, although the recommended measures to reduce external nutrient inputs to the Lake through land management measures as noted above, remain an important element of this plan.

Boating Ordinances

The promulgation of more stringent controls on the use of powered watercraft within Anvil Lake is one means of regulating the conduct of recreational boating traffic that could be harmful to the most important ecologically valuable areas in the Lake. Controls on recreational boating traffic, for example, could limit boating activity within these specific areas of the Lake to defined traffic lanes to minimize the

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[7]*C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[8]*Sally P. Sheldon, "The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report," Department of Biology Middlebury College, February 1995.*

disturbance and propagation of nuisance plant species by the operation of watercraft. Boating ordinances must be enacted in conformity with State law and should be clearly posted at public landings. Placement of regulatory markers also must conform to State requirements.

Public Informational and Educational Programming

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. Thus, public information is an important component of an aquatic plant management program. Posters and pamphlets, available from University of Wisconsin-Extension, the Wisconsin Association of Lakes and the Department of Natural Resources, provide information and illustrations of aquatic plants, their importance in providing habitat and food resources in aquatic environments, and the need to control the spread of undesirable and nuisance plant species.

Recommended Management Measures

The following management actions are recommended for the management of aquatic plants:

1. Encourage the protection of native aquatic plants within the Lake as the basis for sustaining the recreational fishery of Anvil Lake. Specific consideration should be given to the establishment and maintenance of native shoreline areas within the Lake basin, as recommended under the protection of ecologically valuable areas above.

2. Continue informational programming as part of the Anvil Lake Association activities.

RECREATIONAL USE MANAGEMENT

Anvil Lake has the potential to be a very good fishery, given the wide diversity of habitats present within the system and spawning areas available. Angling on Anvil Lake is a hobby enjoyed by many of the residents surrounding the Lake.

Array of Control Measures

Managing Anvil Lake to improve the fishery is a viable management alternative for the Lake. Conduct of a periodic fisheries survey, improvement of habitat by leaving desirable aquatic vegetation in areas not heavily boated, and development of creel limits based upon the survey data are all viable options for establishing a successful fishery. Coarse woody debris, such as shoreline treefalls that do not create public safety concerns or boating hazards, should be left in place as habitat for algae and aquatic insects and as the basis for the Lake's food chain.

Recommended Management Measures

1. Conduct periodic fisheries surveys to determine the current status of the fishery; and

2. Review survey data and develop fishing regulations and habitat protection measures for improved fisheries as needed.

ORGANIZATIONAL DEVELOPMENT

The Anvil Lake Association provides an important vehicle for civic involvement in the management of Anvil Lake. Working in partnership with the local government unit, the Town of Washington, the Anvil Lake Association can promote good lake stewardship within the community and contribute to the protection and sustainable utilization of the waterbody. Consequently, the maintenance of the informational programming and active management actions of the Association is an important issue to be considered.

Coincident with the actions of the Anvil Lake Association, the actions of the Town of Washington as the local government authority and of Vilas County in regulating development densities, development areas, and related construction and property management activities can provide major protections to the Lake and the maintenance of good water quality. Further, it can be anticipated that future development will result in increasing demands for water-based recreational opportunities, which may increase the potential for water use conflicts to occur. Thus, there is a need for the Town and County governments to review and implement regulations governing recreational water use, especially during the open water season, but potentially also during the period of ice cover. Consequently, the development of a set of local ordinances that complement the lake management goals of the community is an issue to be considered.

Array of Control Measures

Dissemination of Information

Programming should be continued to keep the property owners in the Anvil Lake community informed of the current state of their Lake's water quality. To this end, continued participation in the State volunteer water quality monitoring program is recommended as a means of assessing the health of Anvil Lake on a regular basis. Such programs can provide an early warning of undesirable changes in lake water quality. Review of these data annually by the Anvil Lake Association Board of Directors can permit the Association, the County and the Town, to initiate appropriate responses in a timely manner. Regular reports on the results of these studies should continue to be featured at the annual meetings of the Association and should be continued as one means of informing residents of the current state of the Lake.

Development of Regulations

The Town of Washington and Vilas County should periodically review their ordinances for consistency with State law and the state-of-the-art of lake protection, and consider refining such regulations to support of sound land and water resources management practices. In addition, consideration of new or refined ordinances governing both open-water and ice-bound lake use should be considered. In terms of open-water regulations, ongoing enforcement of state boating regulations is assumed, including regulations governing speed, operation in proximity of other vessels, and provision of safety equipment. In terms of ice-bound regulations, state snowmobile regulations should continue to be enforced. Anglers during both seasons and recreational boaters during open water periods should: be aware of the regulations governing prevention of introduction of nonnative organisms, remove trash and debris or dispose of refuse in the receptacles provided, and be made aware of local ordinances and courtesy codes through appropriate signage and pamphlets provided at the National Forest headquarters, town hall, local retailers, and resorts.

Recommended Management Measures

The following management actions are recommended for the institutional development of the Anvil Lake community organizations:

1. Continue the partnership between the Town of Washington and the Anvil Lake Association as the principle community organizations serving the citizens of the Anvil Lake community.

2. Enforce the Town of Washington and Vilas County shoreland zoning requirements within the shoreland area tributary to Anvil Lake; consider refining and augmenting the Town and County ordinances as necessary to provide for the regulation of emerging issues of concern.

3. Consider the adoption of an onsite sewage disposal system inspection ordinance.

4. Employ appropriate household pet waste and horse manure management practices.

5. Continue informational programming as part of the Anvil Lake Association activities.

SUMMARY

This plan, which documents the findings and recommendations of a lake management planning study requested by the Anvil Lake Association, examines existing and anticipated conditions and potential management concerns affecting Anvil Lake. This plan also sets forth recommended actions for the resolution of emerging concerns and problems identified by the community through the questionnaire survey.

Anvil Lake was found to be a mesotrophic, moderately deep water lake located in proximity to the Eagle River metropolitan area in Vilas County in which its tributary drainage area is largely located. Surveys indicated that the Lake and the tributary area contain significant areas of ecological value, including numerous woodlands and high-quality wildlife habitat.

The Anvil Lake protection and recreational use plan, summarized in Table 11, recommends actions be taken to minimize human impacts on the Lake water quality and reduce human impacts on the ecologically valuable areas adjacent to the Lake and in its watershed.

The recommended plan supports the implementation of the Town of Washington and Vilas County land use plans, and enforcement of the current Town and County zoning codes. Periodic review of lake-oriented ordinances is recommended to ensure consistency with current practices.

Implementation of an ongoing program of water quality and water quantity/lake level monitoring is recommended. Continuing participation in the State volunteer lake monitoring program is recommended. Formulation of detailed water and contaminant budgets for the Lake is recommended to address citizen concerns relating to declining lake levels and water quality conditions as observed during recent years. To this end, the recommended plan proposes a program of research into the water budget of the Lake and emphasizes the preeminent role of groundwater and groundwater protection as critical features in lake water quality and quantity management. Development of an integrated surface water-groundwater simulation model such as the U.S. Geological Survey MODFLOW model would provide the community with a tool to evaluate and assess the impacts of land use and climatic changes on the Lake water quantity and water quality.

A further investigation into the paleo-limnology of the Lake could be considered in order to understand the periodicity of lake level fluctuations and their impact on the lake ecosystem.

The plan recommends continued surveillance activities, mainly to promote early detection and management of any potential future occurrence of nonnative invasive species in and around the Lake. Periodic future fishery surveys are also recommended.

The recommended plan includes continuation of an ongoing program of public information and education provided to riparian residents and lake users. There are a variety of publications and brochures available from the University of Wisconsin-Extension, Wisconsin Association of Lakes, the Wisconsin Department of Natural Resources and other organizations.

This recommended plan seeks to balance the demand for high-quality residential and recreational opportunities at Anvil Lake with the requirements for environmental protection of the Lake.

Table 11

RECOMMENDED PROTECTION PLAN ELEMENTS FOR ANVIL LAKE

Issue	Plan Element	Subelement	Location	Management Measures	Management Responsibility
Land Use	Land Use Management	Control and Regulate Development	Direct Drainage Area to Anvil Lake	Periodic review of local ordinances for concurrency with current land management practices	Town of Washington and Vilas County
				Adoption, review and enforcement of appropriate land use plans	Town of Washington and Vilas County
				Promotion of the benefits of lake friendly land management practices	Anvil Lake Association
				Adoption and enforcement of a program for inspection of onsite sewage disposal systems	Town of Washington
				Promotion of good urban housekeeping practices that are lake friendly	Anvil Lake Association
		Nonpoint Source Pollution Control	Direct Drainage Area to Anvil Lake	Develop a public educational and informational program encouraging the use of lake friendly, good housekeeping practices	Town of Washington, and Anvil Lake Association
Surface Water Management	Water Quality and Quantity Management	In-Lake Water Quality Management	Entire Lake	Participate in the state volunteer monitoring program, the CLMN	Anvil Lake Association
				Consider the conduct of a fisheries survey at approximately five-yearly intervals	WDNR and the Anvil Lake Association
		Water Quantity Monitoring and Management	Entire Lake	Participate in the federal stream groundwater and water budget program	Anvil Lake Association, Town of Washington, and U.S. Geological

Issue	Plan Element	Subelement	Location	Management Measures	Management Responsibility
				Consider conduct of a paleo-limnological investigation to assess impacts and periodicity of changes in lake levels	Survey Anvil Lake Association, and Wisconsin Department of Natural Resources
Ecologically Valuable Areas Ecologically Valuable Areas (Continued)	Woodlands, Wetlands and Shorelands Woodlands, Wetlands, and Shorelands (Continued)	Woodlands and Wetlands	Throughout Watershed	Implement Town and County land use plans; consider the use of conservation subdivision approaches to maximize natural landscape areas Enforce the Town and County shoreland zoning requirements; include consideration of environmentally valuable areas in zoning decisions Protect woodlands and wetlands within the drainage area	Town of Washington and Vilas County Town of Washington and Vilas County Town of Washington and Vilas County
		Shoreland and Nearshore Management	Along lakeshore	Consider the use of environmentally-friendly shoreline protection measures Monitor for nonnative species of upland and shoreland plants; apply manual, chemical, and/or biological control measures as appropriate	Anvil Lake community Anvil Lake community, Anvil Lake Association, Wisconsin Department of Natural Resources and Town of Washington
		Citizen Information and Education	Throughout direct drainage area to Anvil Lake	Continue informational programming as part of the Anvil Lake Association activities	Anvil Lake Association

Issue	Plan Element	Subelement	Location	Management Measures	Management Responsibility
Aquatic Plants	Aquatic Plant Management	Public Informational and Educational programming	Town boundaries	Continue informational programming as part of Anvil Lake Association activities	Anvil Lake Association
Recreational Use Management	Boating Regulations and Safety	Boating Ordinance	Entire lake	Continue educational programming as part of the Anvil Lake Association activities	Anvil Lake Association
	Angling	Fisheries Management	Entire lake	Conduct fisheries survey to determine the current status of the fishery; review survey data and develop fishing regulations and habitat protections measures for improved fisheries as needed; and implement recommendations as necessary	Wisconsin Department of Natural Resources
Organizational Development	Informational and Educational Programming	- -	Direct Drainage to Anvil Lake	Continue the partnership between the Anvil Lake Association and the Town as a means to promote public outreach and education Continue informational programming	Town of Washington and the Anvil Lake Association Anvil Lake Association in cooperation with the Wisconsin Lakes Partnership
	Ordinance Development	- -	Town boundaries	Enforce the Town and County shoreland zoning requirements and consider refining as necessary	Town of Washington and Vilas County

Source: Environmental Horizons, Inc.

APPENDIX A

PHOTOS OF COMMON AQUATIC PLANTS IN ANVIL LAKE

Photo A1

Muskgrass - *Chara spp.*

Source: Environmental Horizons, Inc.

Photo A2

Common Waterweed – *Elodea Canadensis*

Source: Environmental Horizons, Inc.

Photo A3

Common Arrowhead – *Sagittaria latifolia*

Source: Environmental Horizons, Inc.

Photo A4

Eel Grass, Water Celery – *Vallisneria Americana*

Source: Environmental Horizons, Inc.

Photo A5

Large Leaf Pondweed – *Potamogeton amplifolius*

Source: Environmental Horizons, Inc.

Photo A6

Small Waterwort – *Elatine minima*

Source: Paul Skawinski, Wisconsin State Herbarium.

Photo A7

Slender Waterweed - *Elodea nuttallii*

Source: Paul Skawinski, Wisconsin State Herbarium.

Photo A8

Dwarf (Slender) Water-Milfoil – *Myriophyllum tenellum*

Source: Robert W. Freckmann, Wisconsin State Herbarium.

Photo A9

Northern Naiad - *Najas gracillima*

Source: Paul Skawinski, Wisconsin State Herbarium.

Photo A10

Ribbon-leaved Pondweed - *Potamogeton epihydrus*

Source: Joanne Kline, Wisconsin State Herbarium

Source: Robert W. Freckmann, Wisconsin State Herbarium

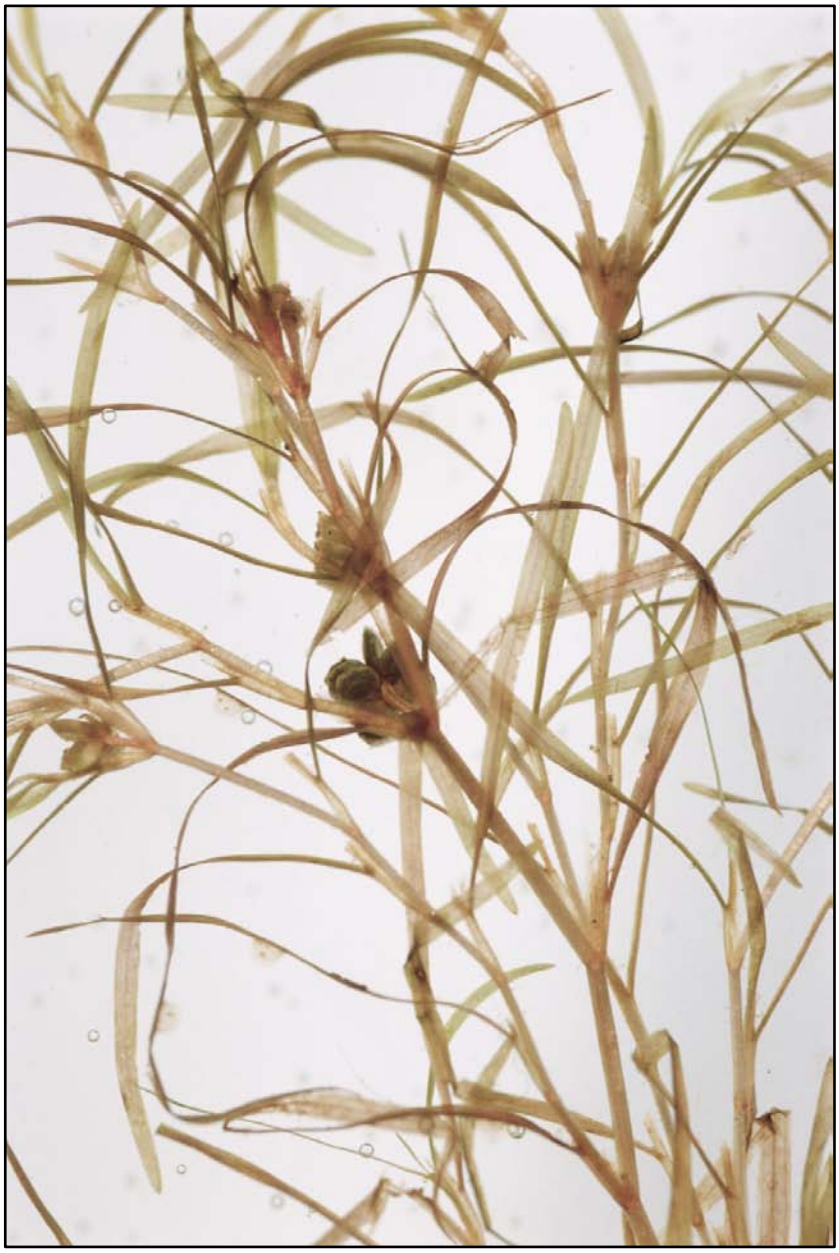
Photo A11

Small Pondweed - *Potamogeton pusillus*

Source: Environmental Horizons, Inc.

Photo A12

Spiral-fruited PPondweed - *Potamogeton spirillus*



Source: University of Wisconsin Extension.

APPENDIX B

ANVIL LAKE SURVEY INSTRUMENT

Town of Washington
1654 Rangeline Road
Eagle River, WI 54521

ANVIL LAKE
LAKE USE AND WATER QUALITY SURVEY

Dear Friends and Neighbors,

The Town of Washington is seeking your opinions and ideas, through this questionnaire survey. We are conducting this survey, in cooperation with Environmental Horizons, Incorporated, to determine your opinions regarding the state of the Lake and surrounding development, and to identify measures to protect and enhance our community.

Please take a few minutes to provide us with your opinions and responses to the following questions and return your thoughts to Environmental Horizons in the prepaid envelope provided. Your responses will be kept in strict confidence, and will help us to continue to develop an appropriate strategy for protecting our shared water resources.

Thank you for your participation. Your reply by September 15, 2010, would be appreciated.

Sincerely,

James Spring, Chairman
Town of Washington
Vilas County

Enclosure

ANVIL LAKE
RECREATIONAL WATER USE AND WATER QUALITY SURVEY

PART 1. PLEASE TELL US ABOUT YOURSELF (CIRCLE ONE):

A. Are you a:
   1. year-round resident
   2. part-time resident
   3. visitor

B. If you are a visitor, are you:
   1. a day user
   2. a camper

C. If Anvil Lake is not your primary residence, please indicate which statement **best describes** your time at Anvil Lake:
   1. Summer season (June to August)
   2. Extended summer season (spring to autumn)
   3. Summer weekends
   4. Winter season (December to March)
   5. Weekends year-round
   6. Vacations only

D. If you answered B or C above, about how many days per year do you spend at Anvil Lake?

   _____ days

E. How many years have you lived in this area?
   1. Less than one year
   2. One year to five years
   3. Six years to 10 years
   4. More than 10 years

F. Is this your primary residence?
   1. Yes (if YES, please answer question G below)
   2. No (if NO, please skip to question H below)

G. Did you vote in the April 2009 election?
   1. Yes
   2. No

H. If Anvil Lake is NOT your primary residence, what is the zip code of your primary residence?

   _____

I. If you use other Wisconsin Lakes for recreation (fishing, swimming, skiing, picnicking, camping, etc.), please list them:

   _____
   _____

J. If you own property on Anvil Lake, what was the primary reason for your purchase?

_____

PART 2. PLEASE TELL US ABOUT YOUR PROPERTY ON ANVIL LAKE:

1. How many piers are on your property? _____

2. Please indicate the length of your shoreline on Anvil Lake:

   a. 0 – 50 feet
   b. 51 – 100 feet
   c. 101 – 150 feet
   d. 151 – 200 feet
   e. 201 – 250 feet
   f. greater than 251 feet

3. How do you manage your shoreline? (circle all that apply)
   a. Maintain a shoreland buffer strip
   b. Maintain a shoreland buffer strip with native plants
   c. Keep a "no-mow" area along the lakeshore
   d. Have a shoreline protection structure, such as rip-rap
   e. Other (please specify) _____

PART 3. PLEASE TELL US ABOUT HOW YOU USE ANVIL LAKE:

A. When you use Anvil Lake, do you usually do so... (circle one):
   a. on your own
   b. with family
   c. with friends
   d. in a group

B. **Open Water Fishing** (*If you do not fish skip to D*)

1. How many days did you fish over the past year? _____ days

2. Do you usually fish from: (circle one)
   a. Pier or shore
   b. Boat
   c. Both equally

3. Which species of fish did you catch last year? (circle all that apply)
   a. Northern Pike
   b. Walleye
   c. Largemouth Bass
   d. Smallmouth Bass
   e. Other (please specify) _____
   f. Panfish
   g. Yellow Perch
   h. Crappie
   i. White Sucker

4. Thinking back over the last decade, do you think that the fishing opportunities on Anvil Lake have: (circle one)

   a. Improved b. Declined c. Stayed the same

   Please briefly state the reason for your answer:
   _____
   _____

5. How do you rate the fishing quality?
   ____ a. excellent ____ c. fair
   ____ b. good ____ d. poor

C. **Ice-fishing**

1. Do you ice fish on Anvil Lake?
   a. Yes
   b. No (*If you do not ice-fish skip to D*)

2. How many days did you ice fish over the past year? _____ days

3. Which species of fish did you catch last winter? (circle all that apply)
   a. Northern Pike
   b. Walleye
   c. Largemouth Bass
   f. Smallmouth Bass
   g. Other (please specify) _____
   f. Panfish
   g. Yellow Perch
   h. Crappie
   i. White Sucker

4. How do you rate the quality of the ice-fishing?
   ____ a. excellent ____ c. fair
   ____ b. good ____ d. poor

D. **Other Recreational Uses**

1. The following list contains a number of popular water based activities. If you engage in any of these activities, please indicate the approximate number of days per year you spend on the activity in the space provided. In the last column indicate the relative importance of that activity to you by ranking the activities from 1 through 5, with 1 being least important and 5 being most important.

	Year Round (number of days)		Spring/Summer Only (number of days)		Fall/Winter Only (number of days)		Relative Importance (1-5)
*Power Boat							
*Jet Ski							
Waterski/Wakeboard/ Tube							
*Sail/Boardsail							
*Row/Canoe/Kayak/Paddle							
Swim/SCUBA Dive/snorkel							
Snowmobile							
Cross-Country Ski							
Bird Watch							

Picnic/Barbecue							
Walk/Jog							
Other (specify _____)							

If you indicated boating use of the Lake, please complete the following:

Type of Boat:	*Ski Boat*		*Ponto on Boat*		*Fishing Boat or Other Motor Boat*		*Personal Watercraft/ Jet Ski*		*Other Boats (Non-motorized boats, sailboats, canoes, etc.*
Horse Power:									
Number Owned:									

PART 4. PLEASE TELL US HOW YOU FEEL ABOUT THE FOLLOWING ISSUES THAT CAN AFFECT YOUR USE OF ANVIL LAKE:

A. **Regulations and law enforcement issues**:

1. How would you rate your general level of satisfaction with *law enforcement* on the Lake (e.g., boating, fish and game regulations)? (circle one)
   a. Well satisfied
   b. Satisfied
   c. No strong feeling
   d. Not satisfied
   e. Very dissatisfied

   Why? _____

2. How would you rate your general level of satisfaction with *boating regulations* on the Lake? (circle one)
   a. Well satisfied
   b. Satisfied
   c. No strong feeling
   d. Not satisfied
   e. Very dissatisfied
   f. Need more information

   Why? _____

3. If you answered "Not satisfied" or "Very dissatisfied" to question 2 above, how would you change the *boating regulations* on the Lake?

   _____

   _____

B. **Watershed (all land that drains to Anvil Lake) issues**:

1. How do you rate your general level of satisfaction with the *level of development* (land use zoning regulations) in the Lake watershed? (circle one)
   a. Well satisfied
   b. Satisfied
   c. No strong feeling
   d. Not satisfied
   e. Very dissatisfied
   f. Need more information

Why? _____

2. How do you rate your general level of satisfaction with *sanitation regulations* (waste disposal, sewerage) in the Lake watershed? (circle one)
   a. Well satisfied
   b. Satisfied
   c. No strong feeling
   d. Not satisfied
   e. Very dissatisfied
   f. Need more information

Why? _____

3. Do you have your septic system serviced?
   a. Yes (If Yes, how often do you have the system serviced: _____years)
   b. No

C. **Water quality issues**:

1. Do you consider the Lake to have *good water quality*? (circle one)

   a. Yes b. No

   √ Based upon **WATER CLARITY** and/or water tests? (circle one)

   a. Yes b. No

   √ Based upon algae and/or **AQUATIC PLANTS**? (circle one)

   a. Yes b. No

   √ Based upon **AESTHETICS** and/or wildlife conditions? (circle one)

   a. Yes b. No

2. How would you describe good water quality?

   _____

   _____

3. In your opinion, how has the quality of the Lake changed since you first moved to or visited the area? (circle one)

   a. Improved
   b. Stayed the same
   c. Deteriorated
   d. Don't know

D. **Water quantity/Lake level issues**:

1. Low water levels in recent years have limited my use of Anvil Lake.
   a. True b. False

2. If true, please circle all of the following that apply:
   a. I have not been able to place my pier in the Lake
   b. I have not been able to use my recreational watercraft on Anvil Lake
   c. I have not been able to enjoy my shoreland area (for picnics, barbeques, or other family activities)
   d. I have had problems with the level of water in my well
   e. I have had problems with the quality of water from my well
   f. I have enjoyed the larger area of "beach" available
   g. My use of Anvil Lake for recreation has not been affected
   h. Fewer watercraft and lake users have enhanced my enjoyment of Anvil Lake
   i. Other (please specify) _____

E. **Major Concerns Relating to Anvil Lake**:

1. What are your **top FIVE concerns** about Anvil Lake (place a number "1" next to the issue that is most important to you, a number "2" next to the second most important issue, and so on)?

___ General water quality	___ Unpleasant odors
___ Number of boats	___ Speed of boats
___ Size of boats	___ Development around the lake
___ Number of water skiers	___ Shoreline erosion
___ Number of jet skiers	___ Wetland preservation
___ Use of lake and access sites by nonresidents	___ Water levels that fluctuate too much
___ Decline in fishery resources	___ Sedimentation/shallow areas
___ Parking for nonresidents	___ Boat and trailer parking
___ Excessive noise	___ Other (please specify) _____

2. What do you think could be done about your concerns to improve the situation?

_____

_____

F. **Aquatic Plant Management Issues**:

1. Do you feel that the Lake has excessive algae and aquatic plant growth? (circle one)

   a. Yes b. No c. Don't know

If you answered **no** or **don't know** to the previous question, *skip to Section E, Other Issues*.
If you answered **yes** to the previous question, please answer the following question.

2. How would you like to see the excessive algae and aquatic plants controlled?

	1.....2.....3.....4.....5 *Least Preferred.....Most Preferred*				
a. Use algae/aquatic plant chemicals	1	2	3	4	5
b. Place additional development controls on these areas:					
– Along the shoreline	1	2	3	4	5
– Within 500 feet of the lakeshore	1	2	3	4	5
– Within 1,000 feet of the lakeshore	1	2	3	4	5
– Within the watershed	1	2	3	4	5
c. Dredging	1	2	3	4	5
d. Septic pumping required by County	1	2	3	4	5
e. Stricter controls on boating	1	2	3	4	5
f. Other _____	1	2	3	4	5

G. **Other Issues**:

1. Should any of the following activities be restricted to certain AREAS of the Lake? (check all that apply)

   ____ a. Swimming ____ e. Fishing
   ____ b. Power boating ____ f. Other boating (e.g. non-powered or sailing)
   ____ c. Water skiing ____ g. Snowmobiling
   ____ d. Personal watercraft ____ h. Other (please specify)_____

2. Should any of the following activities be restricted to certain HOURS of the day on the Lake? (check all that apply)

   ____ a. Swimming ____ e. Fishing
   ____ b. Power boating ____ f. Other boating (e.g. non-powered or sailing)
   ____ c. Water skiing ____ g. Snowmobiling

____ d. Personal watercraft ____ h. Other (please specify)_____

PART 5. PLEASE TELL US ABOUT YOUR FEELINGS REGARDING LAKE MANAGEMENT ISSUES:

A. Would you be prepared to pay for any improvements to the lake or river environment or facilities that you may have indicated above? (circle one)

1. Yes 2. No

If *NO*, who should pay? _____

how should the funds be raised? _____

If *YES*, which additional improvements would you be willing to pay for?

_____

_____

B. Are you a member of the Anvil Lake Association?

1. Yes 2. No

C. Are you aware of the Lake Association website [http://sites.google.com/site/anvillake/]?

1. Yes 2. No

D. Do you read the *Anvil Lake Chimes*?

1. Yes 2. No (Please go to the next question)

(If YES, what types of articles do you find most interesting or informative?)_____

_____

_____

E. Do you think the Lake Association is generally doing a good job in informational programming and lake management? Please comment.

_____

_____

F. The Lake Association holds its ANNUAL MEETING on Independence Day (July 4th).

I regularly attend the annual meeting (circle one)

1. Yes 2. No

If *NO*, please indicate if you do not attend because (check all that apply):

____ I have to work ____ I am out of town during this period

____ The meetings are held at an inconvenient time

____ I would prefer the meetings to be held on another day

____ The meeting is not of Interest to me

G. Do you subscribe to the University of Wisconsin-Extension publication *Lake Tides*?

1. Yes 2. No

I. Are you a member of the Wisconsin Association Lakes? Do you subscribe to the *Lake Connection*?

1. Yes 2. No

J. Have you ever attended the Wisconsin Lakes Convention or the Northwoods Lakes Workshop?

1. Yes 2. No

(If YES, which event did you attend and when did you last attend these events)_____

_____

K. Are there any subjects or issues about which you would like more information?

_____

_____

L. Are there any other issues that you would like to draw to our attention at this time?

_____

_____

_____

_____

THANK YOU FOR YOUR COOPERATION

ENVIRONMENTAL HORIZONS, INCORPORATED
321 BARNEY STREET
WAUKESHA, WISCONSIN 53186-2402

ATTACHMENT

ANVIL LAKE AQUATIC PLANT SURVEY

Anvil Lake Aquatic Plant Survey

Susan Knight
Trout Lake Station
UW-Madison Center for Limnology
WI DNR
October 2010

Summary

Susan Knight, John Yadro, Tom Ewing, Melissa Simpson, David Schmidt and Matt Wagner participated in a point-intercept aquatic plant survey on Anvil Lake (WBIC 968800) on July 5-8, 2010. The sampling grid included 953 points of which 423 sites had vegetation. Many sites along the shore were not sampled because of low water. We found 17 (18 including plants seen but not collected on the rake) plant species including floating and submersed species growing at a maximum of 23.9 feet. Floristic Quality Index was 30.6 and the Aquatic Macrophyte Community Index was 52. There was a diversity of plant growth types and no invasive species. Many sites along the shore were not sampled because of low water. Together, all of these factors combine to indicate a good aquatic plant community.

Introduction and Methods

From July 5 to July 8, 2010, Susan Knight, John Yadro, Tom Ewing, Melissa Simpson, David Schmidt and Matt Wagner conducted a plant survey on Anvil Lake (WBIC 976100). Using a point intercept sampling technique, we used a rake on a pole (good for depths up to 15') and a rake on a rope (used for sites deeper than 15') to sample plants.

We worked as a team of three, with one person driving the boat and navigating to each point, a second person recording data and a third person (Susan Knight) raking, identifying each species and determining abundance. At each site we determined depth and bottom substrate (as muck, sand or rock). We recorded the total rake fullness as 0 (no plants), 1 (a few plants on the rake), 2 (rake approximately half full) or 3 (rake overflowing with plants). We also rated the abundance (using a scale of 1 to 3) of each species found at each point. At each site we looked for species observed within 6 feet of the boat, but not actually collected on the rake (visuals). As we neared shore, we also conducted a boat survey to collect comments about the shoreline and shoreline vegetation.

Using data collected in the survey, we calculated Floristic Quality Index (Nichols 1999) and Aquatic Macrophyte Community Index (Nichols et al. 2000) as tools for assessing the floristic integrity of Anvil Lake and to compare it to other nearby lakes. FQI is a computation assessing lake quality using two parameters: the number of species present and the coefficient of conservatism (C) for each species. C ranges from 1-10 and indicates how pristine an environment a species requires. These values were assigned by a panel of botanists for each plant species in Wisconsin. FQI is based on species recognized by Nichols (1999) as native aquatics. Some species collected are not included in this measure for several reasons: not all aquatic/wetland transition species are included (e.g. *Lysimachia terrestris*), identification is uncertain (e.g. moss or *Sparganium* sp.), or it may be an introduced species (none in this study). Also, visuals are not included in the FQI. Therefore, the total number of plants identified may be greater than

the number of species contributing to the FQI. The C value of each species is averaged to compute an average C value for the lake and this value is multiplied by the square root of the number of species seen on the lake. AMCI is a sum of seven parameters, each scaled 1-10 (for a maximum total of 70), and is another assessment of lake quality using plant data.

Results and Discussion

The grid included 953 sampling points. We visited 635 points, the rest being on shore or deeper than the maximum growing depth of plants, determined to be 23.9 feet (Figure 1). The plants were well distributed at almost all depths, though they fell off substantially below 21 feet. We determined there were 601 points as shallow as or shallower than 23.9 feet and, of these, 423 sites, or 70.45%, had vegetation (Table 1). There were 80 sites on land (termed "terrestrial" on maps and consequently no plant data) due to low water levels (Figure 2 and others).

We found a variety of substrate types, with muck dominating the central basin and sand in much of the shallow areas of the lake and very little rock (Figure 2). There is a fairly regular depth distribution throughout the lake (Figure 3).

We found a total of 18 species, including 17 found on the rake, and 1 visual (seen within 6' of the boat, Tables 2 and 3, Figure 4). Three species, stonewort (*Nitella* sp., Figure 5), wild celery (*Vallisneria americana,* Figure 6) and common waterweed (*Elodea canadensis,* Figure 7) were far more abundant than any other species. We found a variety of plant types, including floating and submersed species. There was also a variety of plant growth forms, with both short, stiff rosette species, such as needle spikerush (*Eleocharis acicularis*, Figure 8) dwarf water-milfoil (*Myriophyllum tenellum*), typical of sandy, low nutrient and often wave swept sites and also leafier plants, such as small pondweed (*Potamogeton pusillus,* Figure 9). Together, the species diversity and the lack of exotics indicate good water quality and a good aquatic plant community.

We found an average of just over 2 species per site, with many sites having 8 or 9 species (Figure 10). Sites with high plant density (rake fullness of 3, Figure 11) were distributed through most of the lake, with the exception of the eastern side of the lake.

The Floristic Quality Index (FQI, Nichols 1999,) was 30.6 (Tables 1, 4) and is greater than Nichols' (1999) findings of Lakes in the Northern Lakes and Forests Region (Table 4). FQI can be high because the average coefficient of conservatism is high and/or the number of species is high. In Anvil, compared to the other lakes, both the species diversity and the average coefficient of conservatism were slightly greater than other nearby lakes and the average for regional lakes. The Aquatic Macrophyte Community Index (AMCI, Nichols et al. 2000), was 52 out of a maximum of 70 (Tables 1, 5). AMCI takes into account seven variables, all scaled to a maximum of 10. Three factors, the percent littoral area vegetated, the maximum depth of rooted plants and the lack of exotic species rated the maximum score of 10. The Simpson diversity index (measuring diversity and evenness of species distributions) of 0.78 corresponds to a 4 on the AMCI scale, and is probably low because the three species mentioned above dominated at so many sites. A lake with the same number of species but with a more even distribution would have a higher Simpson Diversity score. The total AMCI score of 52 is lower than lakes in the northern lakes and forest region, because of the relatively low Simpson's Diversity Index, few sensitive species (according to Nichols' formula) and very few floating or emergent species.

We found no Threatened or Endangered species but Vasey's pondweed (*Potamogeton vaseyi*), found well distributed at 31 sites, is a species of Special Concern (meaning it is on a watch list). Overall, Anvil Lake has a good aquatic plant community, with good diversity throughout the lake littoral zone. Several factors, including good AMCI and FQI scores, the lack of any invasive species, and the presence of a Special Concern species combine to indicate that Anvil has good plant community and water quality. While a single plant surveys from a lake is difficult to interpret, this survey will be critical as a comparison to plant surveys conducted in the future.

Table 1. Anvil Lake Summary

Total number of points on grid	953
Total number of points sampled	635
Total # of sites with vegetation	423
Total # of sites shallower than maximum depth of plants	601
Frequency of occurrence at sites shallower than maximum depth of plants (%)	70.4
Simpson Diversity Index	0.78
Maximum depth of plants (ft)	23.9
Average # of native species per site (veg. sites only)	1.53
Species Richness (including visuals)	18
FQI (n=17)	30.6
AMCI	52

Table 2. Species list for Anvil Lake

Common Name	Species Name
Muskgrass	*Chara* sp.
Waterwort	*Elatine minima*
Needle spikerush	*Eleocharis acicularis*
Waterweed	*Elodea canadensis*
Slender waterweed	*Elodea nuttallii*
Quillwort	*Isoetes echinospora*
Brown fruited rush	*Juncus pelocarpus*
Dwarf water-milfoil	*Myriophyllum tenellum*
Northern naiad	*Najas gracillima*
Stonewort	*Nitella* sp.
Large-leaf pondweed	*Potamogeton amplifolius*
Ribbon-leaved pondweed	*Potamogeton epihydrus*
Small pondweed	*Potamogeton pusillus*
Spiral-fruited waterweed	*Potamogeton spirillus*
Vasey's pondweed	*Potamogeton vaseyi*
Arrowhead	*Sagittaria* sp.
Narrow bur-reed	*Sparganium angustifolium*
Wild celery	*Vallisneria americana*

Table 3. Most common species in Anvil Lake

Common Name	Species Name	Frequency of Occurrence (%)
Stonewort	*Nitella*	36.2
Common waterweed	*Elodea canadensis*	23.2
Wild celery	*Vallisneria americana*	16.7
Needle spike rush	*Eleocharis acicularis*	5.6
Small pondweed	*Potamogeton pusillus*	5.4
Vasey's pondweed	*Potamogeton vaseyi*	3.4
Slender waterweed	*Elodea nuttallii*	2.7

Table 4. Comparison of Floristic Quality Index Values, Washington Township Lakes and Regional Average

Lake	FQI	Number of Species	Average C*
Anvil	30.6	17	7.4
Finger	28.8	16	7.2
Bass	28.3	18	6.7
Tinsel	28.0	12	8.1
Harmony	28.0	12	8.1
Spirit	25.9	11	7.8
Spring Meadows	25.3	16	6.3
Rade	23.0	9	7.7
Northern Lakes and Forests, Lakes Average (Nichols 1999)	24.3	13	6.7
			*Coefficient of Conservatism

Table 5. Aquatic Macrophyte Community Index

	Northern Lakes and Forests Region*	Anvil Lake		Maximum
	Median	AMCI raw value	AMCI scaled value	AMCI Value
Max depth of plant growth (m)	3.5	7.3	10	10
Littoral area vegetated %	75	70.4	10	10
Submersed Species Relative %	80	0.996	5	10
Taxa Number	18	17 (18)	8 (8)	10
Exotic Species (relative %)	0	0	10	10
Simpson's Diversity Index	88	78	4	10
Sensitive species (relative %)	20	0.065	5	10
Total	**57**		**52**	**70**
	*Data collected prior to 2000, Nichols et al. 2000			

Figure 1. Anvil Lake maximum depth of plant colonization.

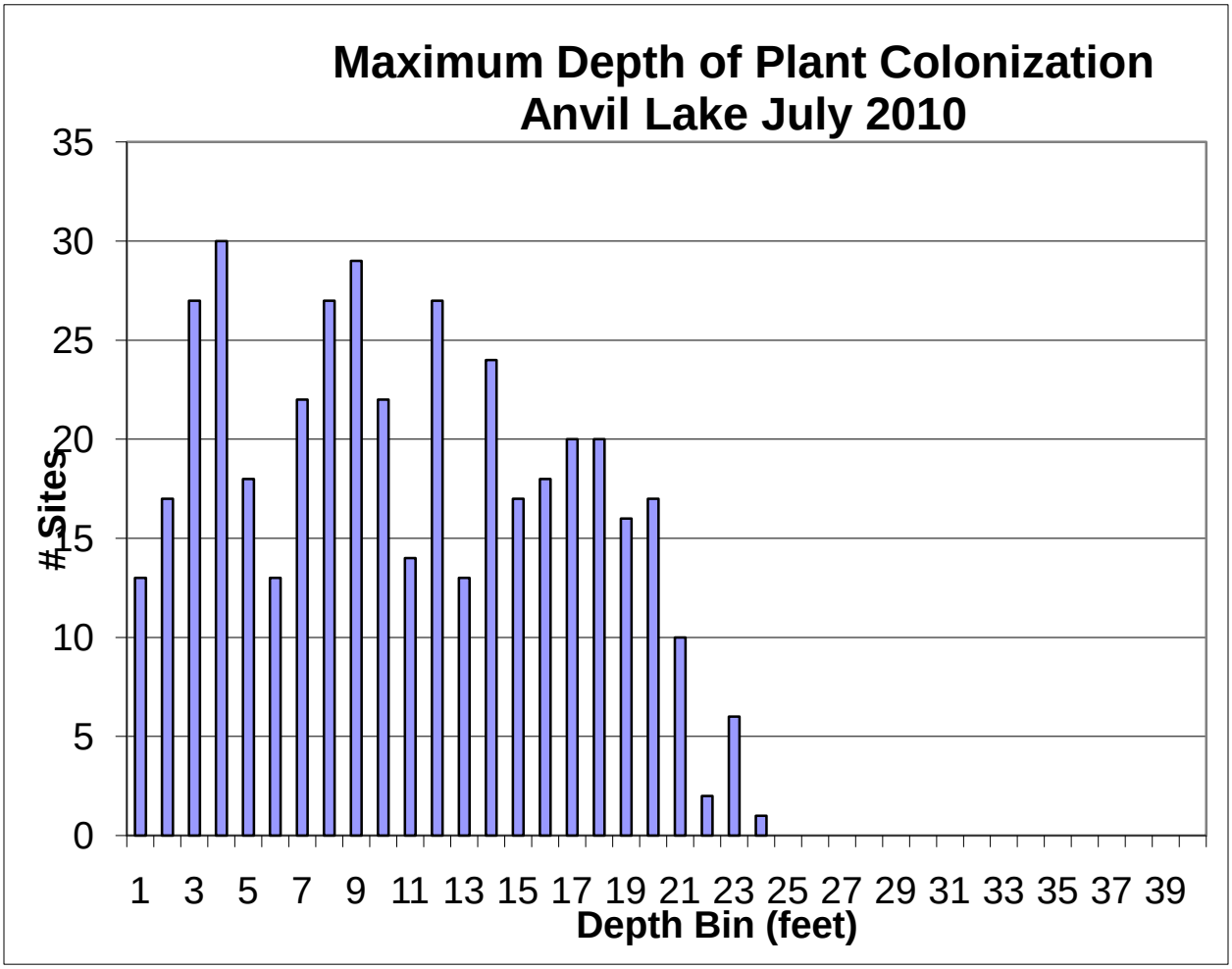


Figure 2. Bottom substrates in Anvil Lake

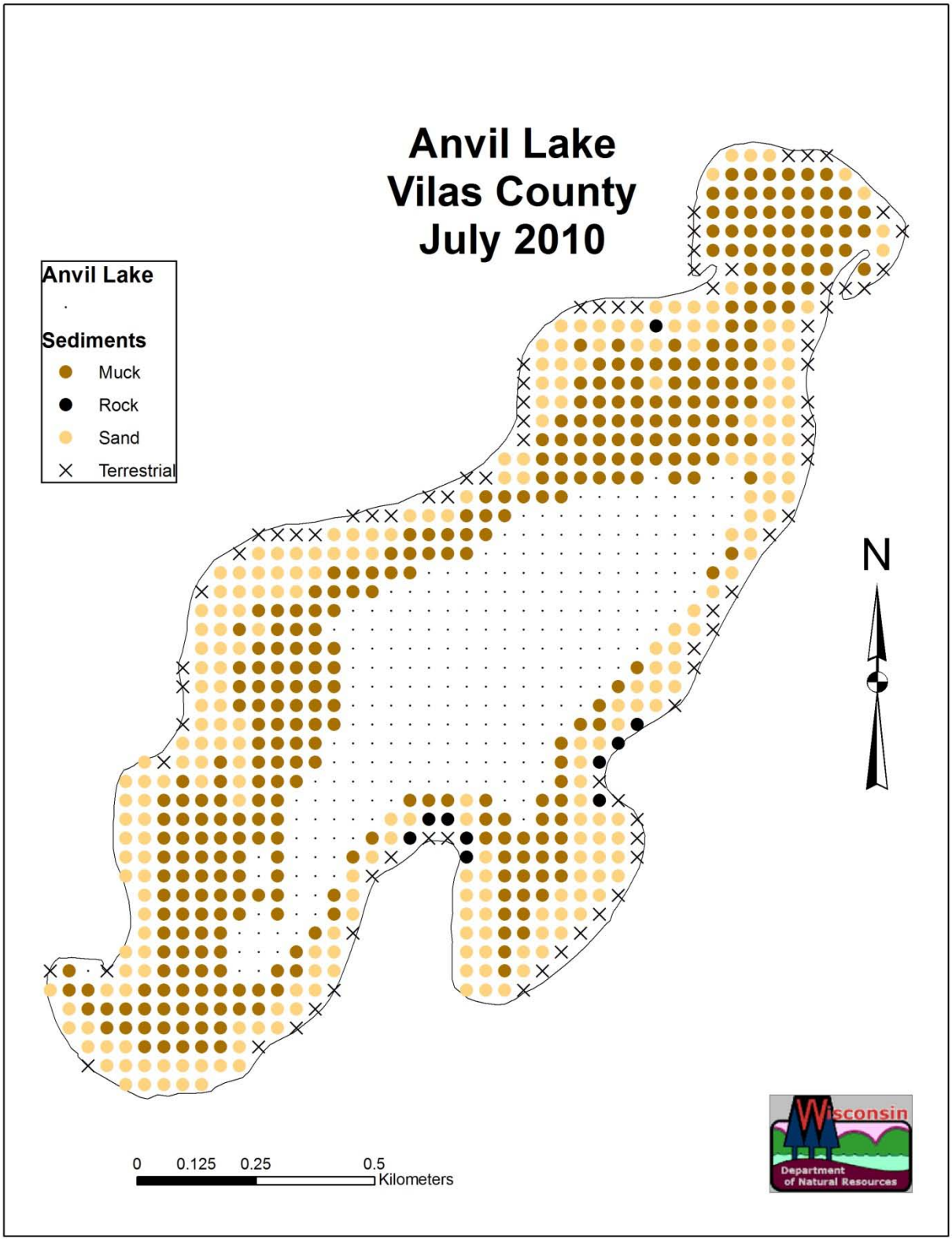


Figure 3. Depth distribution in Anvil Lake.

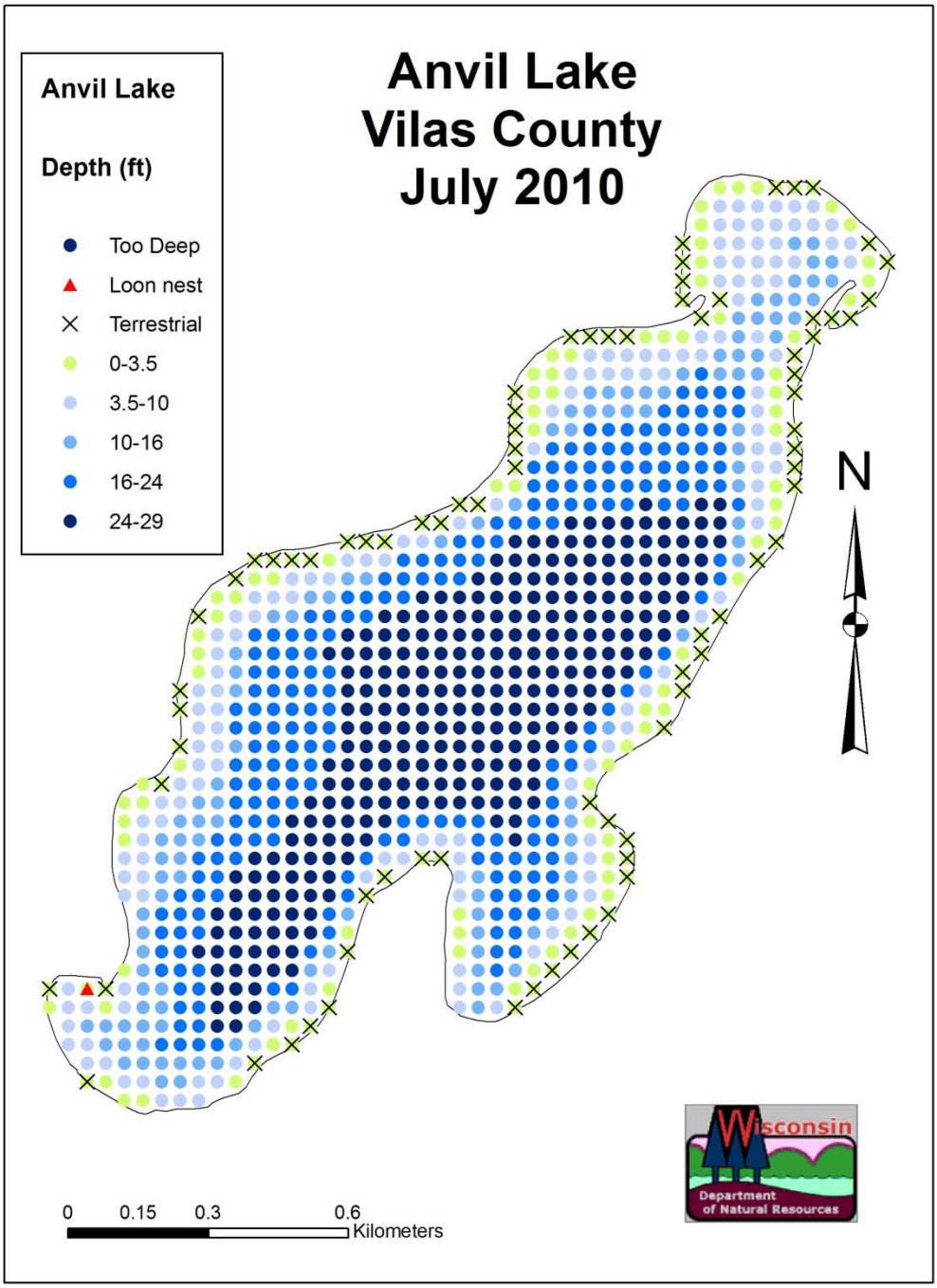


Figure 4. Anvil Lake plant species

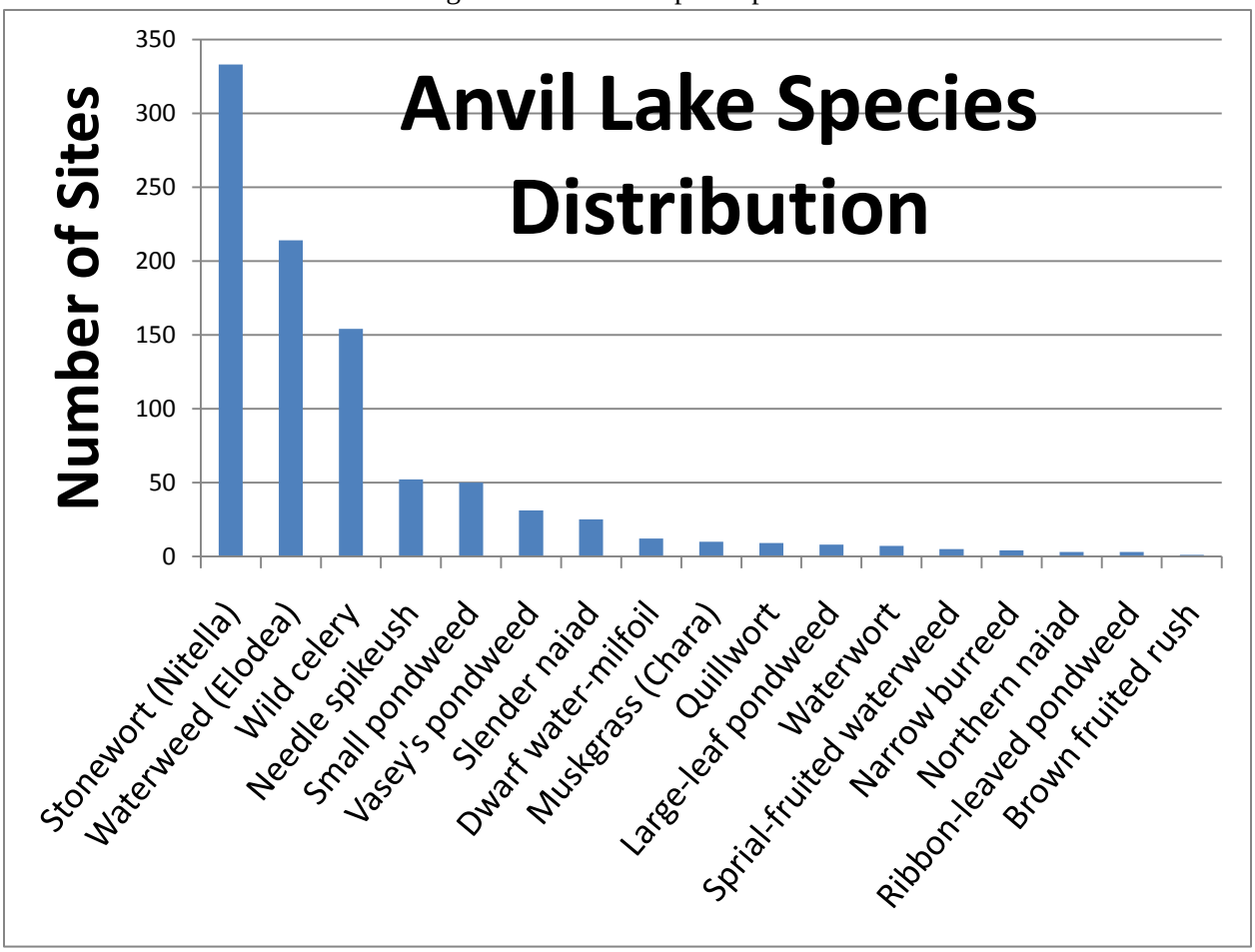


Figure 5. Stonewort (*Nitella)* on Anvil Lake

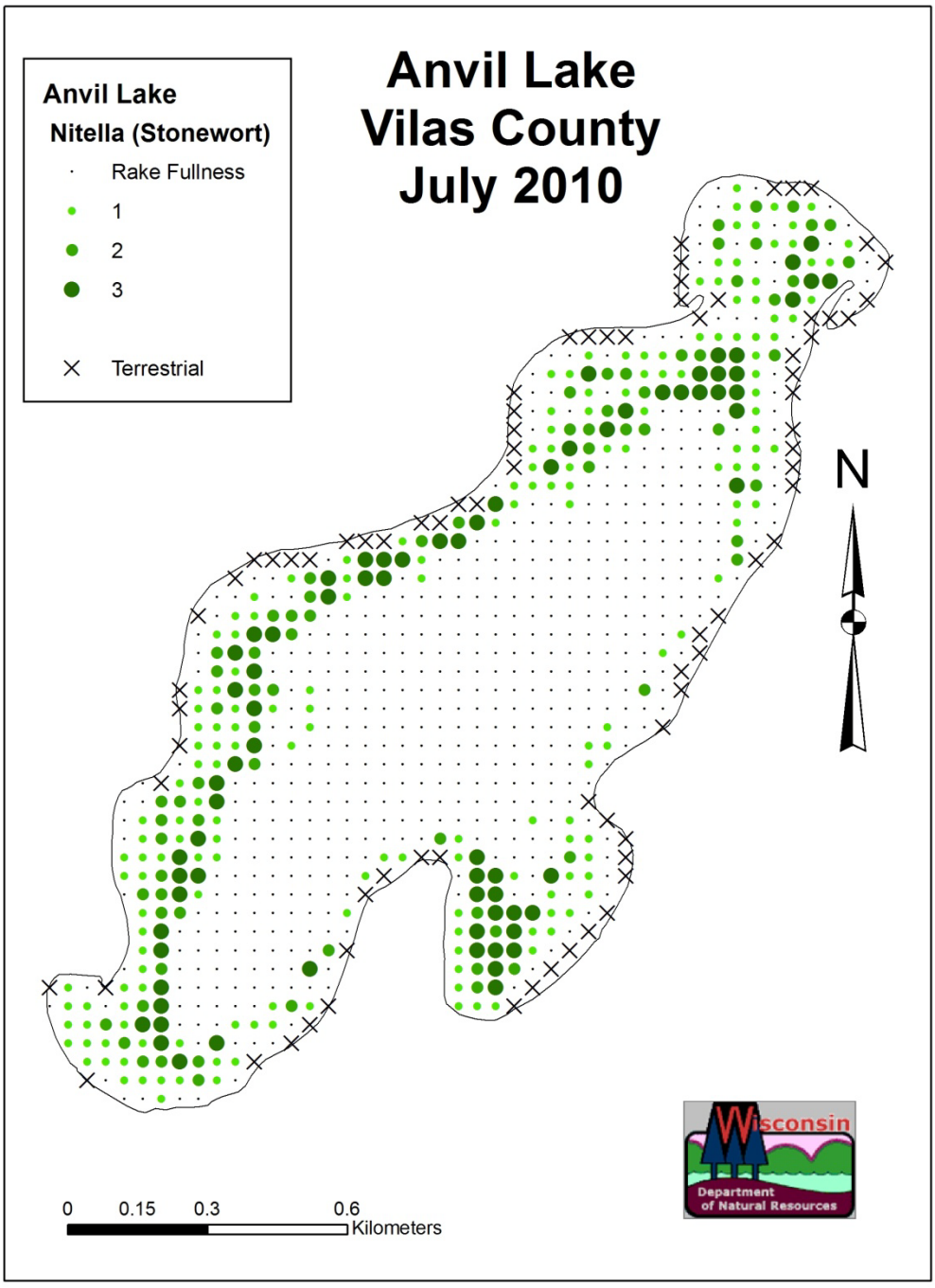


Figure 6. Wild celery (*Vallisneria americana*) on Anvil Lake

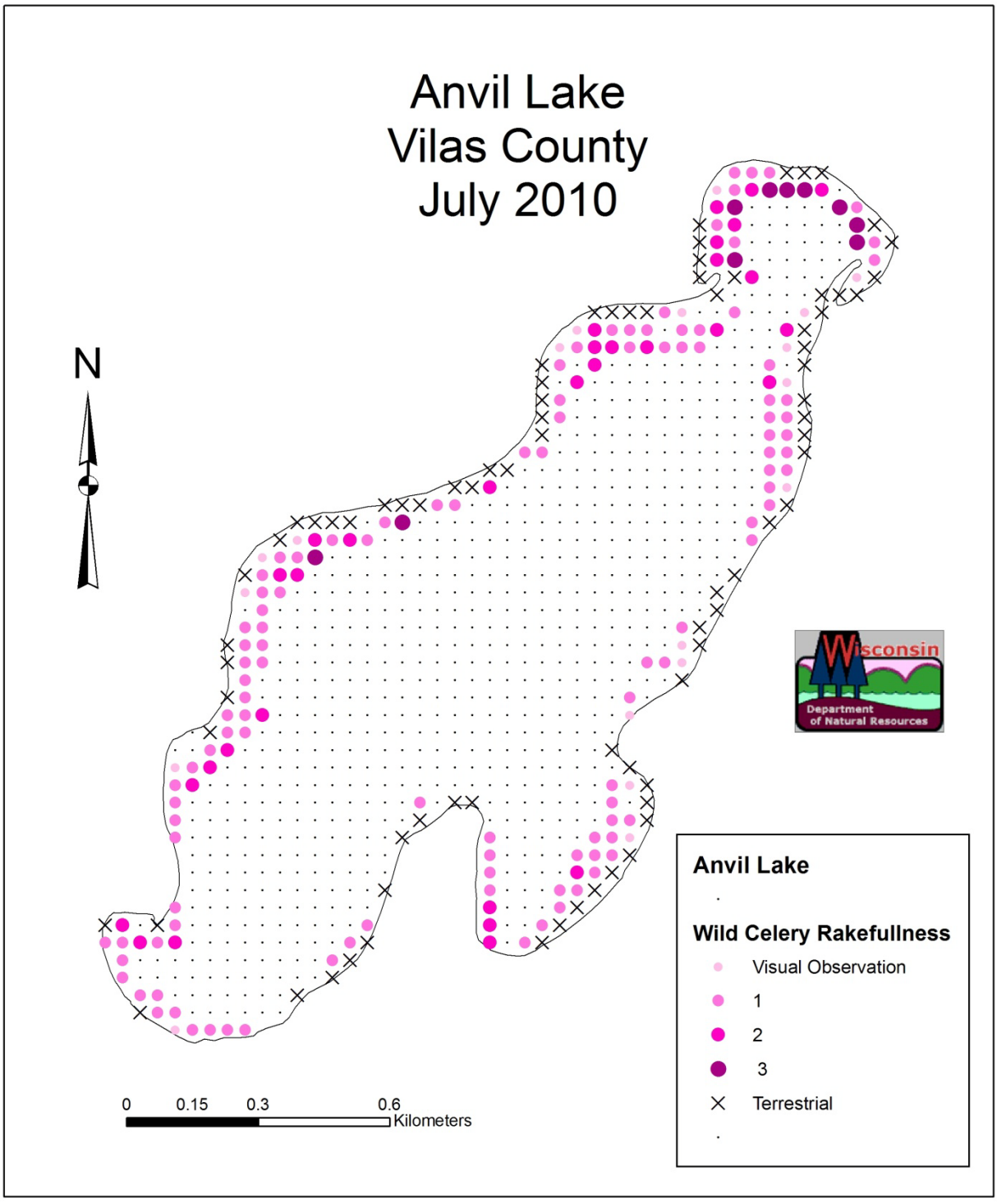


Figure 7. Waterweed (*Elodea canadensis*) on Anvil Lake

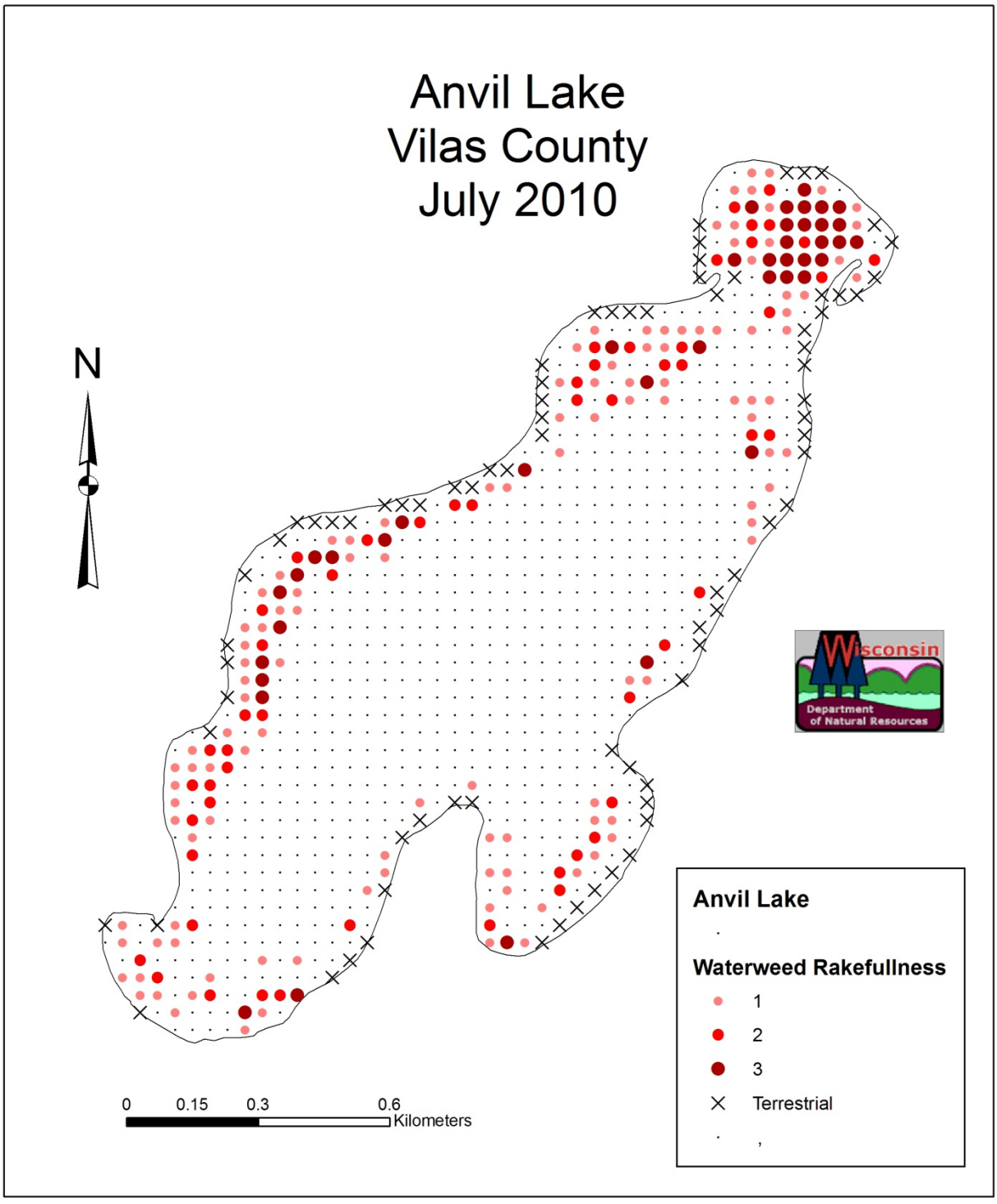


Figure 8. Slender waterweed (*Elodea nuttallii*) and needle spikerush (*Eleocharis acicularis*) on Anvil Lake

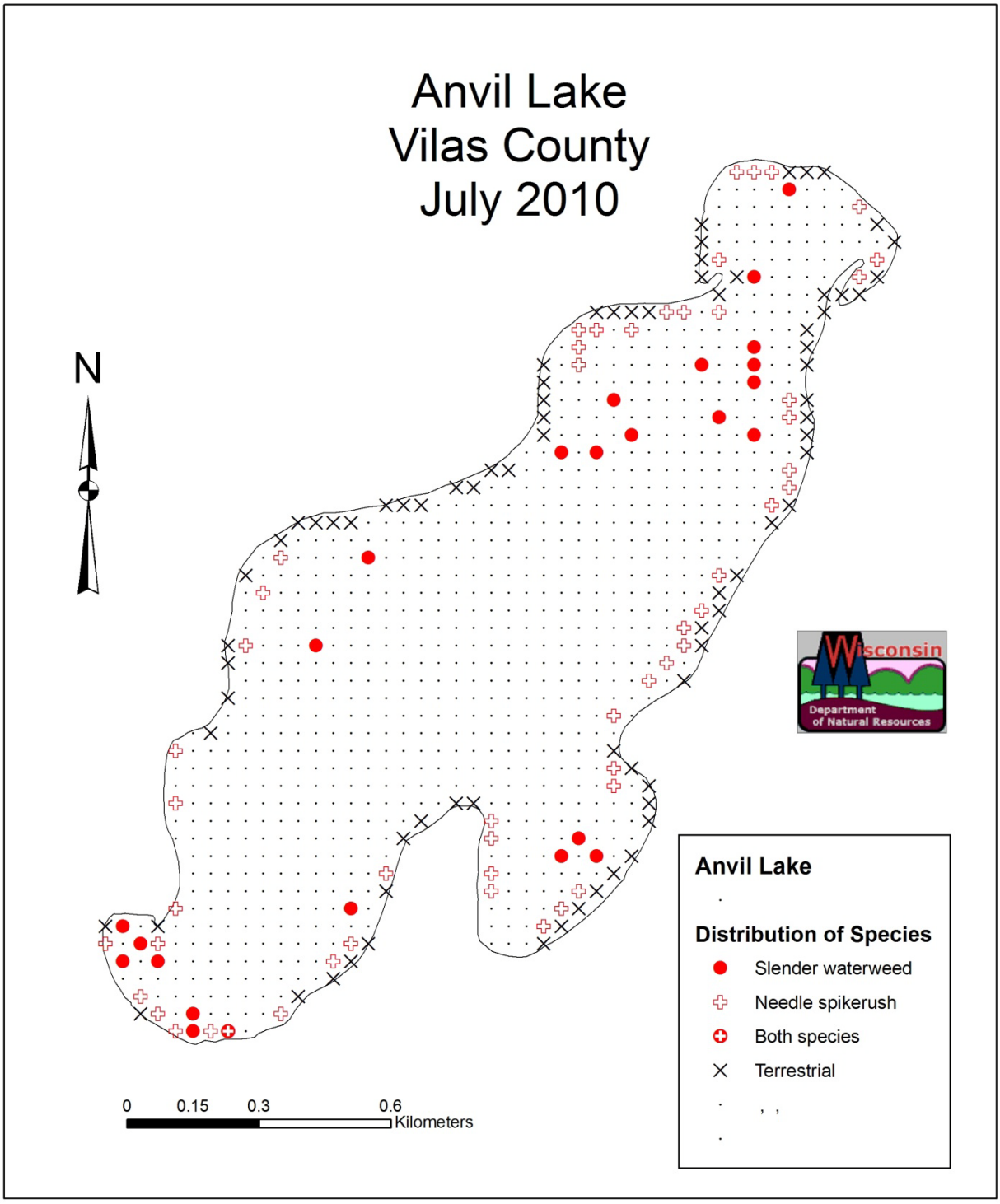


Figure 9. Vasey's pondweed and small pondweed on Anvil Lake

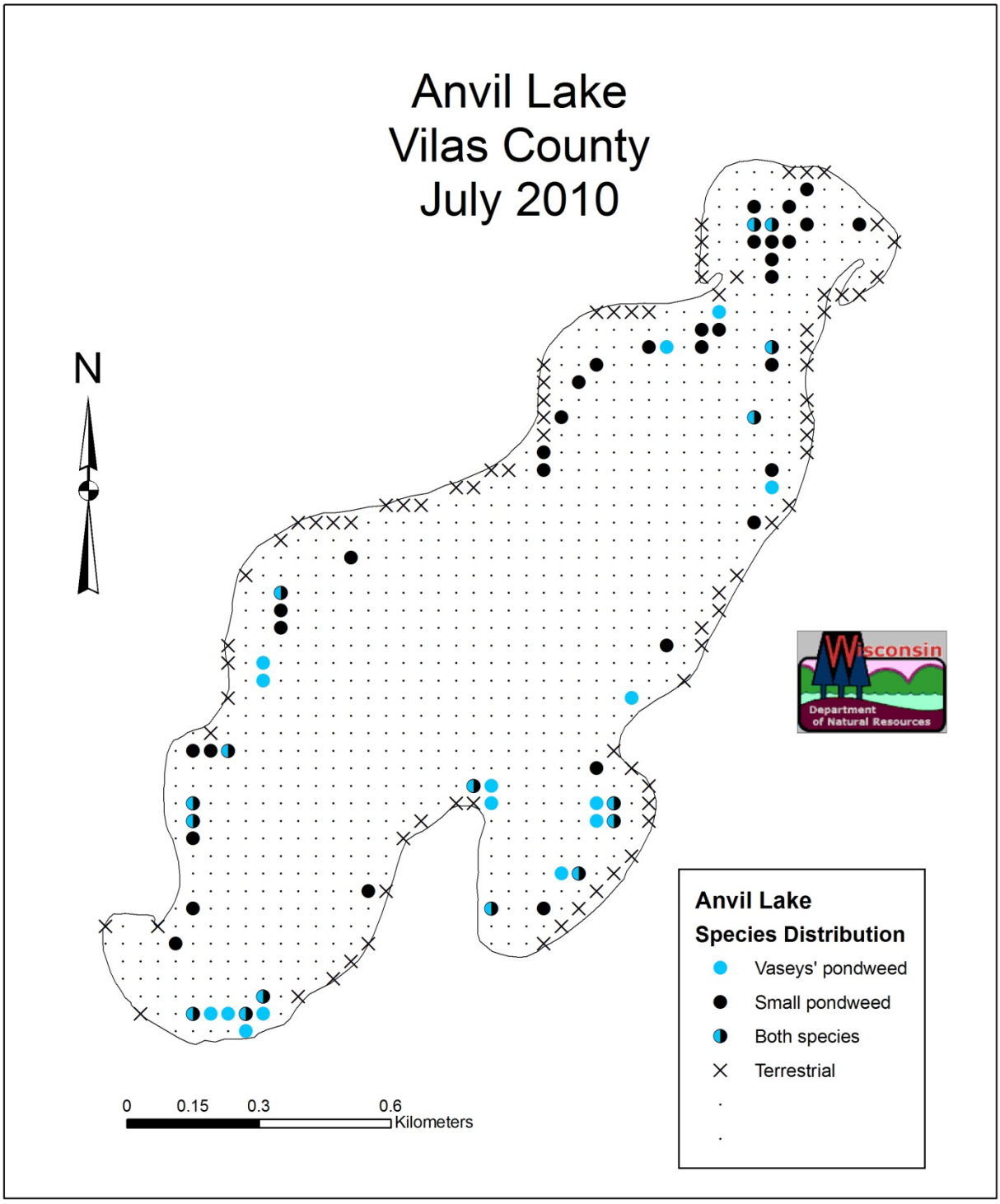


Figure 10. Number of species at each site on Anvil Lake.

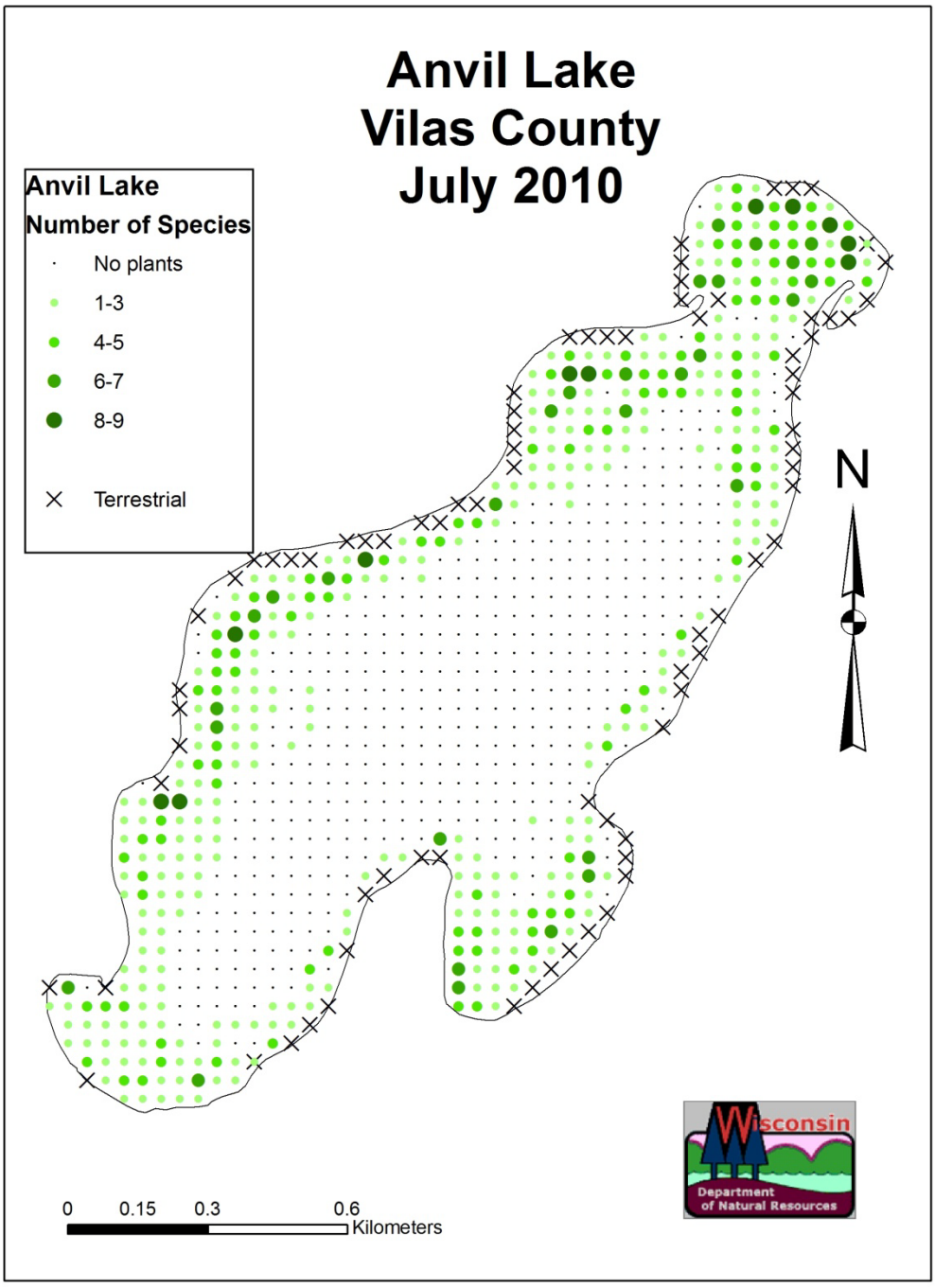


Figure 11. Rake Fullness at each site in Anvil Lake.