Big Arbor Vitae Lake
2018 Lake Assessment Report

Prepared by
Vilas County Land & Water Conservation

January 9, 2020

Assessment Type	Metric	Metric Context	Big Arbor Vitae Lake Results
Water Quality	Total Phosphorus	FAL[1] & REC[2]: 30 ug/L in deep lowland drainage lakes	19.8 ug/L average July-Sep 2018
	Chlorophyll a	FAL[1]: 27 ug/L in deep lowland drainage lakes REC[2]: >20 ug/L more than 5% of days	26.5 ug/L average July-Sep 2018 >20 ug/L in 2 of 3 sampling events (67%)
Aquatic Plant Point-Intercept	Floristic Quality Index	24.3 median for Northern Lakes and Forest Lakes Ecoregion	26.61
	Average Value of Conservatism	6.7 median for Northern Lakes and Forest Lakes Ecoregion	6.11
Shoreland Habitat	Docks/Mile	>16 docks/mile density correlated with less fish diversity	14.1

[1]Fish and aquatic life; [2]Recreation; [3]Frequency of Occurrence
Metrics & Contexts sourced from: WisCALM 2018; Hauxwell et al 2010; Nichols 1999; and Jacobson et. al. 2016.

Additional Data		
Water Quality	Secchi Depth	5.5 ft average
Aquatic Plant Point-Intercept Survey	Max Depth of Plants	17 ft
	FOO[3] shallower than max depth	59.69%
	Simpson's Diversity Index	0.87
	Rare Plants	None
AIS Early Detection	Verified & **New** AIS Found	Banded mystery snail, Chinese mystery snail, curly leaf pondweed, and rusty crayfish **New AIS: None**
Shoreland Habitat	% Natural Cover	86%
	% Impervious	7%
	Parcels With Runoff Concerns	80 of 93 (86%)
	Coarse Woody Habitat	52 logs/mile

Executive Summary

Big Arbor Vitae Lake is a deep lowland drainage lake in Vilas County. Of the 3 water quality sampling events, total phosphorus was less than established thresholds in all instances. Chlorophyll a results were more variable. Five plants make up the bulk of the aquatic plant community, however biodiversity hot-spots were located throughout the lake. The lake's floristic quality (26.61) is just higher than average for the region (24.3). No new aquatic invasive species (AIS) were found, however; previously verified AIS listed with DNR are: banded mystery snail, Chinese mystery snail, curly leaf pondweed, and rusty crayfish. The coarse woody habitat survey resulted in 52 logs/mile of shoreline. Most of the vegetative cover within the 35 ft. shoreland buffer area is natural (86%), however 7% is lawn. Pier density is at 14.0 docks/mile, which is just less than the 16.0 docks/mile threshold where negative impacts to fish diversity are seen. Additional littoral structures may add to this impact. Highlighted recommendations include a lake organization liaison for erosion control best practices, maintaining and increasing coarse woody habitat, and the continuation of water quality and AIS monitoring.

Introduction

Figure 1. Big Arbor Vitae Lake Map courtesy of Vilas County Online Mapping

Lakes are a vital natural resources to the economy and way of life in Vilas County. With over 75% of property taxes coming from lake front properties (based on 2016 tax roll), and tourism estimated to bring in an additional $212.5 million annually (*Total Tourism Impacts*), it is in the county's best interest to keep these lakes attractive. Vilas County sits at a headwaters region, meaning that this area's lakes and rivers are dependent on precipitation and groundwater. This area does not glean significant water from upstream waterways, so local conservation practices often protect our waters directly as well as maintain the water quality as it heads downstream out of Vilas County. With these ideas in mind, the Vilas County Land & Water Conservation Department successfully applied for a grant to assess lake health through the DNR's Directed Lakes program.

Big Arbor Vitae Lake has had a history of water quality studies. The purposes of the study of Big Arbor Vitae Lake are to: 1) fill data gaps by collecting data; and 2) identify any negative lake health issues for

future focus. This data can also be used by the Vilas County Land & Water Conservation Department in the future with its planned watershed assessments.

Big Arbor Vitae Lake is a 1070 acre Deep Lowland Drainage Lake located in the Town of Arbor Vitae in Vilas County. Big Arbor Vitae Lake's maximum depth is 41 feet and is made up of 40% sand, 35% gravel, 10% rock, 15% muck (*Big Arbor Vitae Lake*). It is connected to nearby Little Arbor Vitae Lake through Link Creek. Outlet flow is regulated by a small dam on Link Creek, which then flows downstream to Little Arbor Vitae Lake. There are two inlets, one on the north side of the lake, and one on the east side of the lake.

The adjacent riparian land is owned by the Northern Highland American Legion State Forest (roughly 75% of shoreline) and private landowners (roughly 25% of shoreline). Some private parcels are resort properties. The ground cover is primarily forests and bogs, however there is moderate development on the lake. Surrounding soils are indicated as sandy soils (primarily Rubicon Sand, Padus Sandy Loam, and Padus-Pence Sandy Loam) with slopes ranging from 0-35%. Over 26% of these around the lake are indicated as having Moderate erosion hazard for off-road, off-trail use; and 35% Moderate & 40% Severe erosion hazard for road, trail use. Wetland soils are primarily Seelyeville & Markey mucks or Loxley & Dawson peats with slopes ranging from 0-1% (*Web Soil Survey*).

Big Arbor Vitae Lake is represented by the Big Arbor Vitae Lake Association. This organization is qualified to receive DNR grants, and has received several grants in the past related aquatic invasive species, water quality, and lake management.

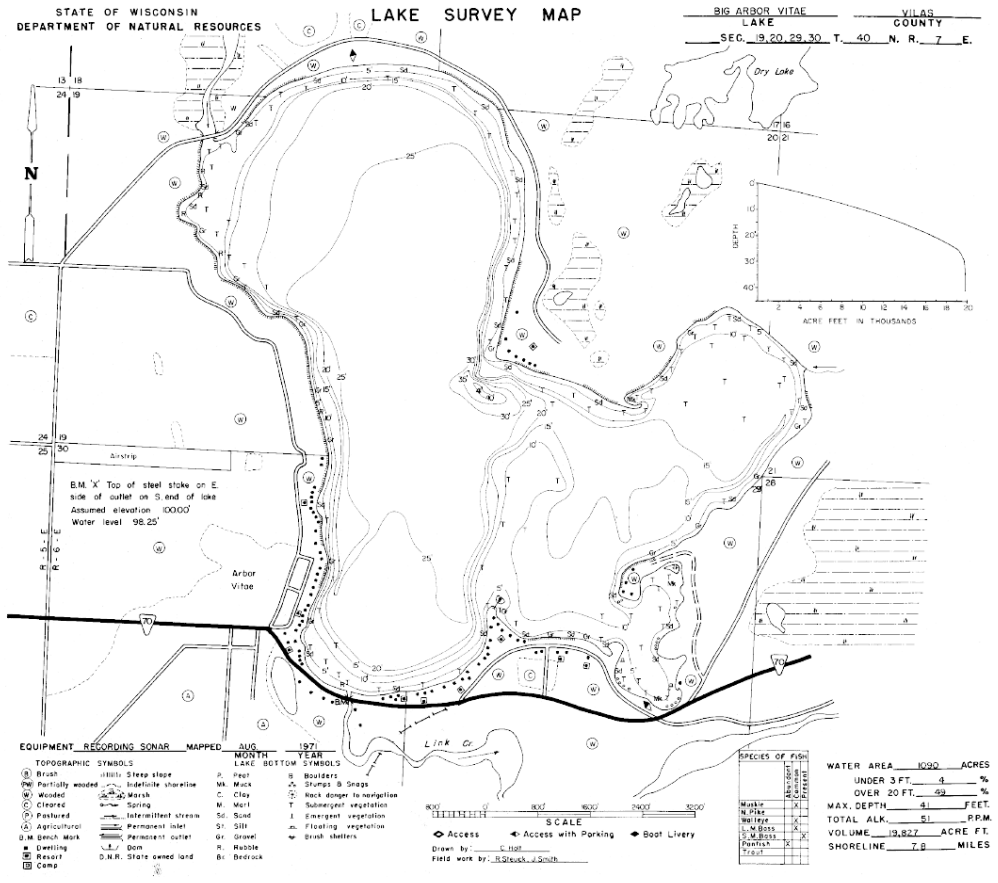

Figure 2. Big Arbor Vitae Lake bathymetry map. Courtesy WI DNR.

Results and Discussion

Note – See Appendix 1 for Methods

Water Quality

Big Arbor Vitae Lake is a 1,070 acre and 41 ft "deep lowland drainage lake". Water quality assessments reference WisCALM Deep Lowland Drainage Lake criteria. It is currently on the 2018 WI DNR Impaired Waters listing for Total Phosphorus, leading to excess algae growth.

The total phosphorus criteria for fish & aquatic life and recreation is 30 ug/L. The total phosphorus sampled on Big Arbor Vitae Lake did not exceed this criteria at any of 3 sampling events in 2018. The mean total phosphorus reading from the 3 sampling events in 2018 was 26.5 ug/L, with a minimum reading of 25.2 ug/L and a maximum reading of 28.0 ug/L.

The chlorophyll a criteria for Fish and Aquatic Life is 27 ug/L and for Recreation is 30% of days where chlorophyll a is >20 ug/L. The chlorophyll a results at each sampling event were averaged to be 19.8 ug/L, with a minimum reading of 8.89 ug/L and a maximum reading of 28.5 ug/L. Big Arbor Vitae Lake exceeded 20 ug/L chlorophyll a at 2 of the 3 sampling events (67%).

Using statistical formulas, DNR staff will determine whether Big Arbor Vitae Lake should remain on the Impaired Waters list. The Impaired Waters list is published by DNR every other year, with the new listing expected in 2020.

Water in Big Arbor Vitae Lake was reported blue & clear in July, green & clear in August, and green & murky in September. Secchi depths averaged 5.5 ft, and is indicative of fair to poor water quality. The higher pH (8.41) and alkalinity (48.2 mg/L) show Big Arbor Vitae Lake is a hardwater lake. Calcium concentrations are relatively low (13.7 mg/L) as is the conductivity (108 uS/cm), reflecting that it would be unlikely to support a reproducing zebra mussel population (Cohen). However, WI DNR recommends zebra mussel monitoring at concentrations of 10 mg/L calcium and above, correlated with a conductivity of 99 uS/cm threshold (Hein and Ferry).

Temperature and dissolved oxygen monitoring showed that Big Arbor Vitae Lake was stratified. "Warm water" fish need dissolved oxygen levels of at least 5 mg/L (Shaw et.al.). More than 5 mg/L dissolved oxygen was found on Big Arbor Vitae Lake down to 12-15 ft. deep. At 0 mg/L dissolved oxygen, chemical processes differ in this anoxic environment and certain nutrients like phosphorus can be converted to bio-available forms and released lake-wide during turnover events, fueling algae and plant growth. See Appendix 2 for water quality raw data and temperature and dissolved oxygen profiles.

Aquatic Plant Point-Intercept Survey

The Point-Intercept survey was done from July 20-July 31, 2018. Of the 1,090 point-intercept (PI) locations, 426 were visited – see Appendix 3 Figure 15. Those that were not visited were skipped because either they were deeper than the maximum depth of plants, or the points were non-navigable, terrestrial, or a temporary obstacle was encountered.

No plants found in Big Arbor Vitae Lake were considered rare by DNR Natural Herritage Inventory (*Wisconsin's Rare Plants*). See Appendix 3 for photos of highlighted plants.

Table 1. Big Arbor Vitae Lake 2018 Aquatic Plant Point-Intercept Statistics. Values sourced from UW-Extension Lakes Aquatic Plant Survey Data Workbook formulas.

Big Arbor Vitae Lake 2018 Point-Intercept Summary

Total number of sites visited	**426**
Total number of sites with vegetation	**228**
Total number of sites shallower than maximum depth of plants	**382**
Frequency of occurrence at sites shallower than maximum depth of plants	**59.69**
Simpson Diversity Index	**0.87**
Maximum depth of plants (ft.)**	**17.00**
Number of sites sampled using rake on Rope (R)	**93**
Number of sites sampled using rake on Pole (P)	**333**
Average number of all species per site (shallower than max depth)	**1.50**
Average number of all species per site (veg. sites only)	**2.51**
Average number of native species per site (shallower than max depth)	**1.49**
Average number of native species per site (veg. sites only)	**2.50**
Species Richness	**21**
Species Richness (including visuals)	**22**
Floristic Quality Index	**26.61**
Average Value of Conservatism	**6.11**

The Species Richness for Big Arbor Vitae Lake is 21. This figure includes only those species collected with the rake, and does not include visual sightings. Big Arbor Vitae Lake has more species on average than other lakes: average Species Richness for the Northern Lakes and Forests Ecoregion is 13 and the state of Wisconsin average is 13 (Nichols). See Appendix 5 for Species Richness Map.

The Average Value of Conservatism for Big Arbor Lake of 6.11 is just less than the Northern Lakes and Forest Lakes Ecoregion average of 6.7 and just above the state of Wisconsin average of 6.0 (Nichols). This shows that there are “average” types of plants that represent the region in Big Arbor Vitae Lake – not trending towards high or low quality systems.

The Floristic Quality Index weighs both the species richness and the average value of Conservatism. The Floristic Quality for Big Arbor Vitae Lake is 26.61. This value is above the Northern Lakes and Forest Lakes Ecoregion of 24.3 and the state of Wisconsin of 22.2 (Nichols).

The Simpson Diversity Index for Big Arbor Vitae Lake is 0.87. This indicates an average number of species and distribution of those species in Big Arbor Vitae Lake compared with other lakes in the Northern Lakes and Forest Lakes Ecoregion (where 0 = no diversity and 1 = infinite diversity).

Of the plant species found, Coontail (*Ceratophyllum demersum)* was by far the most prevalent, with a littoral frequency of occurrence of 35.9% and was found at 137 of the 228 sites with vegetation.

Table 2. Big Arbor Vitae Lake 2018 Aquatic Plant Point-Intercept Species Collected Via Rake, Coefficients of Conservatism, and Littoral Frequency of Occurrence if > or = 10%

Species – Collected via Rake	Common Name	Coefficient of Conservatism	Littoral Frequency of Occurrence
Ceratophyllum demersum	Coontail	3	35.9%
Potamogeton zosteriformes	Flat-stem pondweed	6	25.2%
Potamogeton friesii	Fries' pondweed	8	16.0%
Myrioplyllum sibiricum	Northern water-milfoil	6	15.2%
Potamogeton pusillus	Small pondweed	7	13.1%

One additional species was visually encountered within 6 ft. of a PI point, but not captured on a rake. These plants are not factored into Diversity calculations.

Table 3. Big Arbor Vitae Lake 2018 Aquatic Plant Point-Intercept Additional Species Visually Encountered

Species – Visuals	Common Name
Decodon verticillatus	Swamp loosestrife

Of all the sampling points on Big Arbor Vitae Lake, the most species rich areas occurred in the small bay (Mielke Bay) near the boat launch on Hwy 70 (southeast side of lake); the east bay near the east inlet (east side of lake); and the more shallow area that extends north across most of the lake near Point Island Drive. These areas were 10 ft. deep or shallower. See Appendix 3 Figure 23.

For Big Arbor Vitae Lake, a sample specimen of most of the plants were collected, photographed, and pressed. Pressed specimens were verified and are housed at the Freckmann Herbarium including: *Ceratophyllum demersum, Chara sp., Elodea canadensis, Elodea nuttallii, Heteranthera dubia, Lemna trisulca, Myriophyllum sibiricum, Najas flexilis, Nymphaea odorata, Potamogeton amplifolius, Potamogeton crispus, Potamogeton friesii, Potamogeton praelongus, Potamogeton pusillus, Potamogeton richardsonii, Potamogeton robinsii, Potamogeton zosteriformis, Ranunculus aquaticus, Sagittaria cristata, Stuckenia pectinata, and Vallisneria americana.* Plants not photographed or pressed were *Decodon verticillatus.*

AIS Early Detection Survey

On August 2, 2018, the AIS Early Detection Survey was completed. Targeted sites included: the Buckhorn Rd boat launch area; the boat launch area off of Hwy 70; the east inlet area; around the east side of the island in Mielke Bay (southeast side of lake); condo area on west side of lake; and the inlet on the north side of the lake. A meander survey around the perimeter of the lake was conducted. The Buckhorn boat launch had borderline visibility, but it was snorkeled. The other sites did not have good visibility in the water, so rake tosses and D-net sweeps were used in lieu of snorkeling. Although multiple species were searched for (see Methods section in Appendix 1 for species list), **no new targeted AIS were found** during the survey. Chinese mystery snails, banded mystery snails, and rusty crayfish were found during the

survey, all of which were previously documented as in SWIMS as "Verified". In addition, curly leaf pondweed was listed as a Verified species, 1st documented in 2008. While curly leaf pondweed was not found during the AIS survey here, it was found during the Aquatic Plant Point Intercept survey. No AIS are listed as "Observed".

Veliger tows were sampled in 2018. Results were analyzed by DNR staff in Madison. No zebra mussel veligers were found in the Big Arbor Vitae Lake sample (LaLiberte).

Sediment samples were taken on August 3, 2018 and analyzed by DNR staff in Madison for spiny waterfleas. No evidence of spiny waterfleas was found in the samples (SWIMS).

Coarse Woody Habitat

Coarse woody habitat was mapped on May 31, 2018 when the water was fairly clear and easy to detect submerged logs. 422 logs were counted between the ordinary high water mark and the 2 ft depth contour along the 8.1 miles of shoreline, giving the density of 52 logs/mile of shoreline – see Appendix 4.

192 logs crossed the ordinary high water mark, providing a habitat "bridge" between the water and land. 8 logs were submerged with the full tree crown, providing more complex structure to the Coarse Woody Habitat.

Shoreline Assessment

The shoreline of Big Arbor Vitae Lake consists of 93 parcels – some are privately owned and some are state owned and managed as part of the Northern Highlands American Legion State Forest.

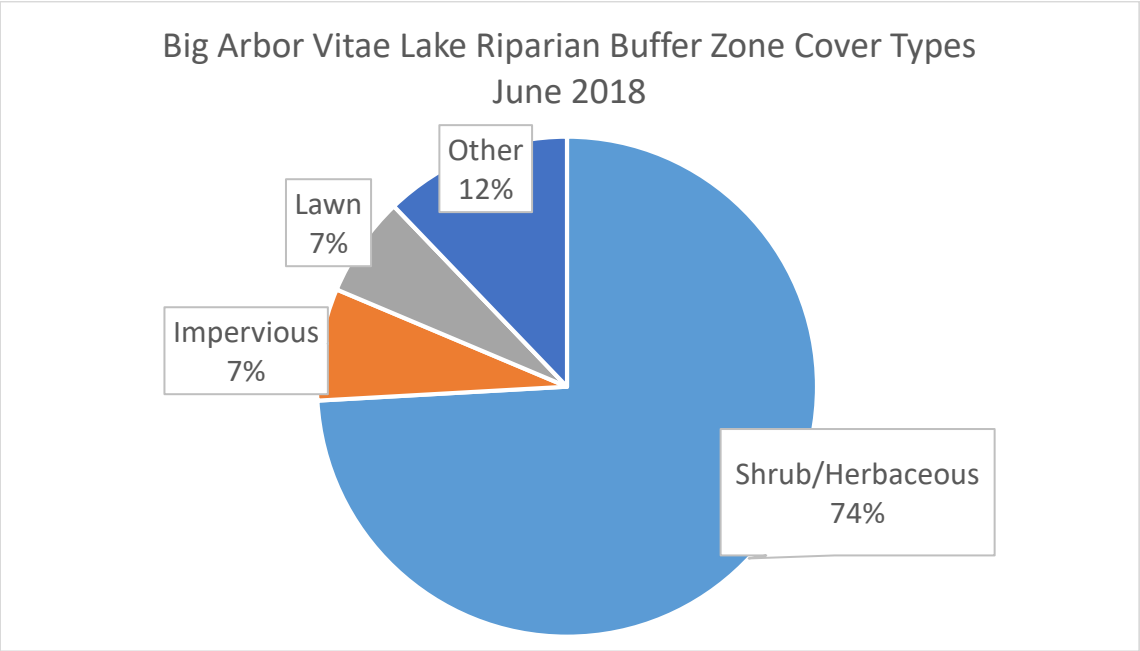

Figure 3. Ground cover type in Riparian Buffer Area (35 ft. inland from shore) on Big Arbor Vitae Lake, 2018. "Other" category includes duff.

Lake-wide, 74% of the riparian area (35 ft. inland from ordinary high water mark) was covered by a shrub/herbaceous layer. Lawn made up 7% of the riparian area, and Impervious surfaces made up 7%. In some instances the Impervious surface consisted of segments of road surfaces and rights-of-way and do not reflect the parcel owner's structures. The "other" category was comprised of duff, bare soil, and mulch sand pit sand and covered 7% of riparian buffer zone. See Appendix 5 for Riparian Buffer Zone Cover Types.

Since Wisconsin now allows 100 ft. frontage lake parcels, and each parcel (or each 100 ft.) is allowed a 35 ft. viewing corridor through the Riparian Buffer Zone (Vilas County Shoreland Zoning Ordinance), so 65% native vegetation remaining in the Riparian Buffer Zone is the lake-wide standard target. This rate does not reflect a biological or ecological best practice. Big Arbor Vitae Lake exceeds this statistic having 74% covered with shrub/herbaceous cover.

Many human structures or modifications were noted in the Riparian, Bank, and Littoral Zones. See Figure 8 for Human Structures in Riparian Buffer, Bank and Littoral Zones Charts. Because of their ecological importance, these areas are typically protected by County Zoning and DNR regulations and permits are often required to modify or place new structures in these areas. In Big Arbor Vitae Lake, piers were the most common structure. Ten docks or less per kilometer (16 docks/mile) of shoreline has been shown to be a threshold of maintaining high quality fish diversity in Minnesota (Jacobsen et. al). Big Arbor Vitae Lake is below this figure at 14.0 docks/mile. Additional littoral structures such as boat lifts, swim rafts, etc. would intuitively seem to add to this stress. Other major categories for structures were: other riparian structures (85); boats on shore (74); boat lifts (63); and buildings (40) within the riparian area.

Figure 4. Some areas of Big Arbor Vitae Lake showed denser dock placement. Lake-wide, there were 14.0 docks/mile on Big Arbor Vitae Lake. Having a lake-wide dock density greater than 16 docks/mile has been shown to have negative effects on fish diversity (Jacobsen et.al).

Within the Bank Zone, modifications included riprap, artificial beach, erosion control structures, and seawalls. There was 1625 ft of riprap noted, which would comprise about 4% of the total shoreline. Note that Big Arbor Vitae Lake is naturally quite rocky, and many shoreline areas could have been riprapped many years ago, but vegetation has been growing in. Riprap was not noted unless it was obvious. Artificial beaches totaled 160 feet of shoreline (less than 1% of the total shoreline). Bank erosion with a greater than 1 ft face was noted across 220 ft of shoreline. One seawall accounted for 65 ft of shoreline. Other erosion control structures were in place on 105 ft of shoreline. No bank erosion less than 1 ft face was noted. (See Figure 9.)

Figure 5. Landowners experiencing erosion issues may find structures such as geobags helpful, especially where there are steep slopes. Contact Land & Water Conservation for an assessment.

Several runoff and erosion concerns were documented within the riparian area: 1 parcel had

a point source; 61 parcels had stairs/trail/road to the lake; 48 had lawn/soil sloping to the lake; and 25 had bare soil. See Figure 10 for Number of Parcels with Erosion or Runoff Concerns.

Aquatic plant removal was not observed adjacent to any parcels.

Photos of the riparian area and data from the shoreline assessment are housed with the Vilas County Land & Water Conservation Department and will be shared with the Department of Natural Resources.

Figure 6. An old metal barrel was found along the shoreline.

Figure 7. Several parcels on Big Arbor Vitae Lakes are split by a road and right-of-way. These have higher percentages of impervious surfaces but do not reflect land use of the referenced parcel.

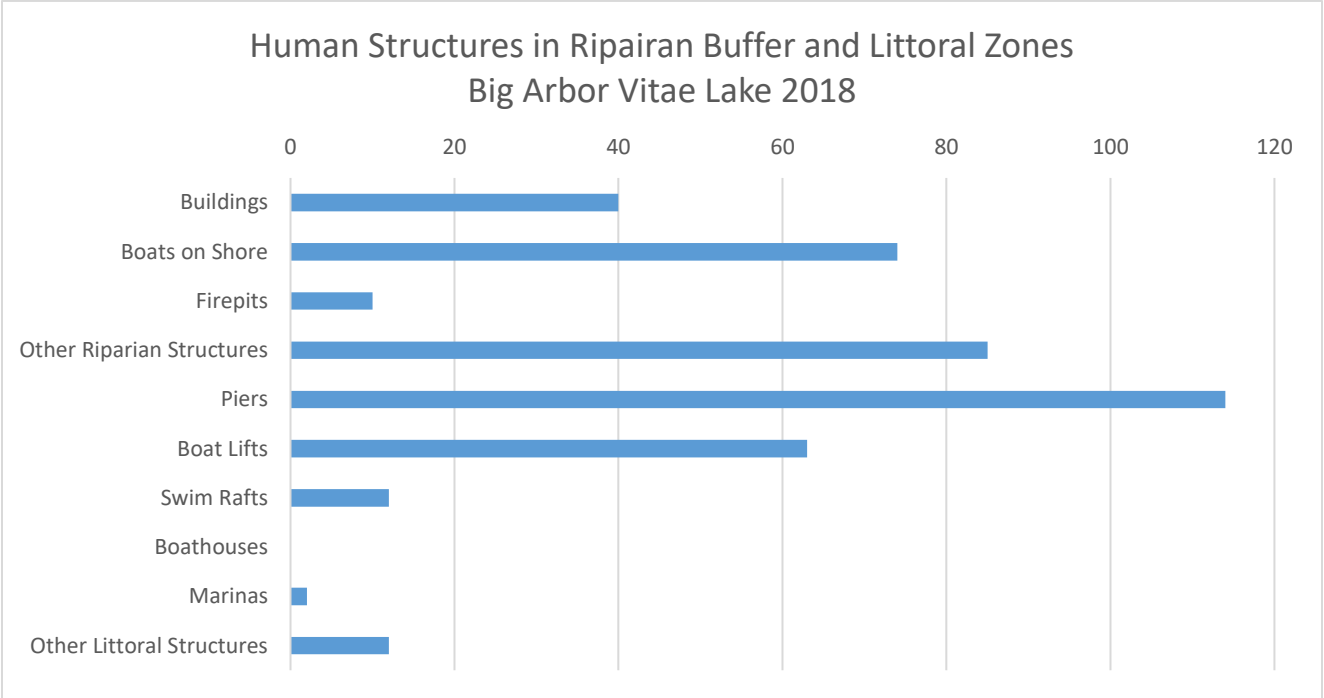

Figure 8. Number of human structures documented in the Riparian Buffer and Littoral Zones on Big Arbor Vitae Lake 2018.

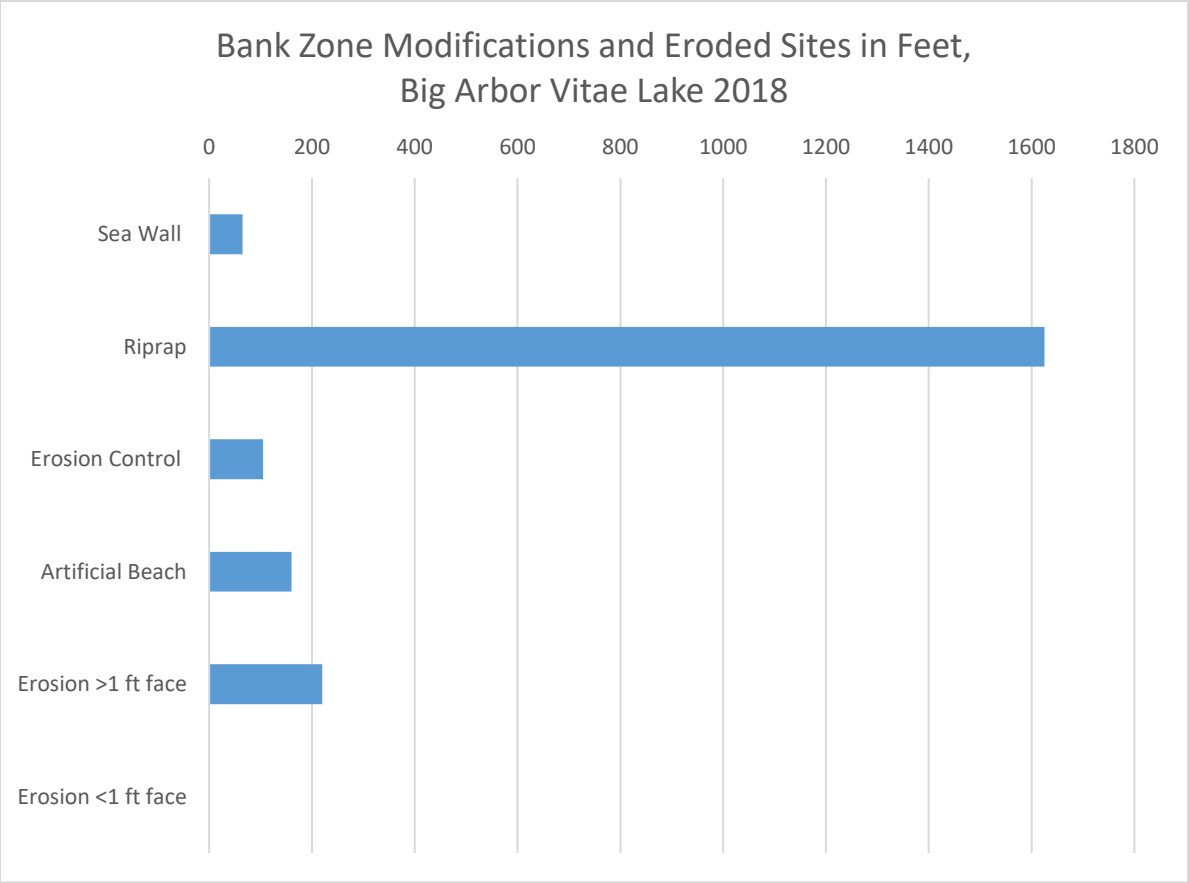

Figure 9. Length in feet of human modifications & eroded sites to Bank Zone on Big Arbor Lake 2018.

Figure 10. Minimizing impervious surfaces in and around lake access paths, maintaining vegetation, and curving the trail across the slope keeps shoreland erosion in check.

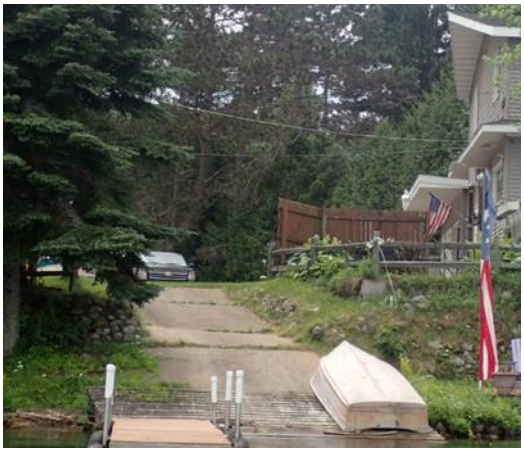

Figure 11. Impervious surfaces and straight trail access make a site even more prone to erosion. This site was augmented with a water infiltration pit to minimize runoff into the lake.

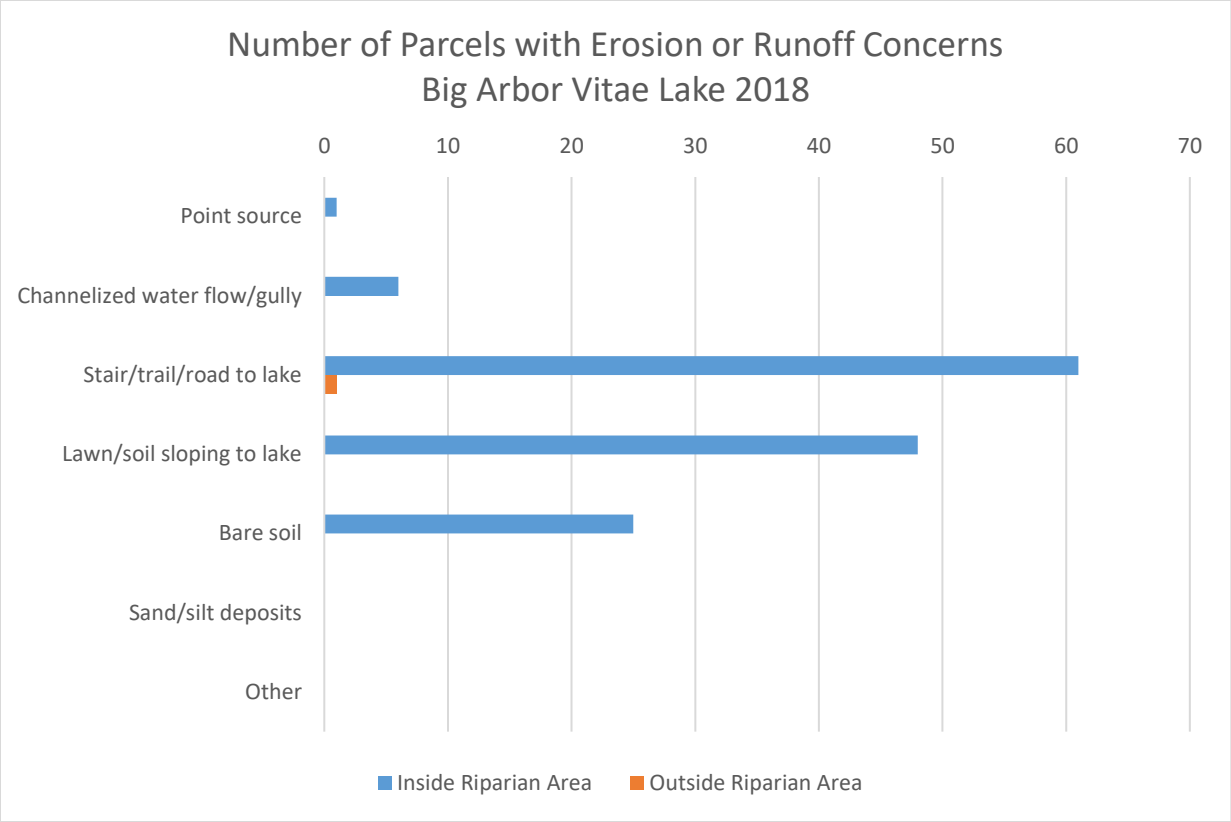

Figure 12. Number of parcels with runoff and erosion concerns in Riparian Zone and Outside Riparian Zone on Big Arbor Vitae Lake 2018.

Recommendations

The Big Arbor Vitae Lakes Association is active in protecting and managing Big Arbor Vitae Lake. If desired this group could facilitate:

- **Continue to monitor water quality regularly**
  - Having ongoing data for phosphorus, chlorophyll a, and Secchi depths will help determine if Big Arbor Vitae should continue to be listed on the DNR's Impaired Waters list. When water chemistry data is sampled, use a WI certified lab to process the results so they are usable for WI DNR as well (ex. WI State Lab of Hygiene) and can be compared from year to year. Contact Sandy Wickman from WI DNR 715-365-8951 or Sandra.wickman@wisconsin.gov for additional assistance.

- **Create a Shoreland Improvement Team to coordinate on-the-ground best practices for runoff and habitat concerns for interested landowners (liaison with County & DNR)**:
  - Lead Healthy Lakes campaign on Big Arbor Vitae Lake
  - Provide materials and serve as a point-of-contact for landowners to increase native vegetation, install erosion control practices, and manage stormwater within 35 ft. buffer zones and beyond
    - Prioritize the 6 active erosion areas (point source & channelized waterflow/gully) for improvements as landowners are willing. Contact Cathy Higley for assistance cahigl@vilasocuntywi.gov or 715-479-3738.
    - The number of parcels with erosion concerns was fairly high (86%). Addressing these issues with willing private landowners will take a coordinated effort, ideally with a well versed ripairan being locally available for those interested. Stormwater management (gutters, infiltrations, etc.) outside the 35 ft. buffer zone should also be addressed with willing landowners. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance.

- **Maintain and Increase Coarse Woody Habitat**:
  - Encourage leaving down wood where it falls to maintain fish habitat. Landowners may be interested in creating more coarse woody habitat along their shorelines by placing "fish sticks". Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance.

- **Encourage native vegetation to grow in the 35 ft. shoreland buffer areas:**
  - 7% of the 35 ft buffer zone was lawn. Encourage willing landowners remove turf grass in the buffer area and replace with native vegetation. Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance.

- **Protect areas biodiversity hotspots, expanses of intact shorelines, and areas rich in coarse woody habitat:**

- Share species richness, shrub/herbaceous, and coarse woody habitat maps widely with riparian owners, including the Northern Highlands State Forest (see respective maps in Appendices 3, 4, & 5).
- Encourage landowners of the "biodiversity hotspots" (see map on page 24), shrub/herbaceous cover >80% (see page 27), and dense coarse woody habitat areas (see p. 25) to protect their natural areas. This could be done through nominating landowners for VCLRA's Blue Heron Award, the Vilas County Land & Water Conservation Stewardship Award, or creating a BAVLA incentive program. With larger parcels, Northwoods Land Trust may be able to help with Conservation Easements. Contact Tom Ewing of VCLRA for further information 630-251-0247.

- **Continue to encourage recognition, prevention, and control of invasive species as appropriate:**
  - Continue volunteer and contract Clean Boats Clean Waters campaigns.
  - Continue routine monitoring of aquatic invasive species.
  - Consider any curly leaf pondweed management needs based on monitoring.
    - Contact Cathy Higley from Vilas County Land & Water Conservation 715-479-3738 or cahigl@vilascountywi.gov for assistance with aquatic invasives.

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Appendices

Appendix 1: Methods
Appendix 2: Water Quality Raw Data and Temperature & Dissolved Oxygen Profiles
Appendix 3: Aquatic Plant Point-Intercept Sampling Point Map, Plant Photos, and Species Richness Map
Appendix 4: Coarse Woody Habitat Map
Appendix 5: Shoreland Data Maps
Appendix 6: Erosion Susceptibility

Appendix 1: Methods

All surveys mentioned below were completed following the WI DNR's Directed Lakes protocols May 3, 2016 revision (Hein and Ferry, 2016). Any deviations from the protocols are mentioned within each section here. Decontamination of the boat and equipment via the DNR's bleach method or hot pressure washing method occurred before a new body of water was entered (*Boat, Gear, and Equipment Decontamination and Disinfection Manual Code 9183.1*).

Water Quality Sampling

Water quality sampling was done on three occasions and scheduled with the Lansat Satellite schedule Path 25 or 24. Temperature and dissolved oxygen profiles were measured at the deep hole using a YSI ProODO meter.

Lake water for chemistry analysis was collected with a 2 meter Integrating Sampler from the deep hole. Samples were analyzed by the WI State Lab of Hygiene in Madison, WI. "Blank" samples were also included for quality assurance. Sampling parameters varied by date:

2018

- July: Temperature and dissolved oxygen profile; Secchi; total phosphorus; chlorophyll a; alkalinity, pH, and conductivity
- August: Temperature and dissolved oxygen profile; Secchi; total phosphorus; chlorophyll a; calcium
- September: Temperature and dissolved oxygen profile; Secchi; total phosphorus; and chlorophyll a

Total phosphorus and chlorophyll a results were compared to the WisCALM criteria for deep lowland lakes.

Aquatic Plant Point Intercept Survey

WI DNR staff created a grid-based map consisting of 1,090 point-intercept (PI) sampling points for Big Arbor Vitae Lake and shared the resulting shapefile. Using the Minnesota DNR GPS Application software and a Garmin 76CX unit, the PI points were downloaded. As indicated in the Directed Lakes protocols, the standard WI Point-Intercept methods were used (Hauxwell et. al.). Land & Water staff navigated to each point that was shallower than the maximum depth for aquatic plants (determined during sampling) and identified each macrophyte collected on a double headed rake. A rake on a pole was used for sites shallower that 5 ft., while a rake on a rope was used for sites deeper than 5 feet. Species that were seen within 6 ft. from the boat that were not collected on the double headed rake were recorded as "visuals".

Plants were identified using several resources: *Aquatic Plants of the Upper Midwest 2nd Edition* (Skawinski), *Through the Looking Glass 2nd Edition* (Borman et. al.), *Manual of Vascular Plants of the Northeastern United States and Canada 2nd Edition* (Gleason and Cronquist), and "Identifying Pondweeds – A Brief Summary" (Knight).

Results were entered on the Aquatic Plant Survey Data Workbook (*Aquatic Plant Management in WI*). Statistics including Simpson's Diversity Index, Species Richness, Floristic Quality, and Average Value of Conservatism are sourced from this workbook's imbedded formulas.

Ideally, a representative aquatic plant for each species located would be collected, photographed, and pressed. Most plants found were treated as above, however a few were not – see the Results for more details. All pressed plants were verified and are now housed with the UW-Stevens Point Freckmann Herbarium.

AIS Early Detection Surveys

Staff snorkeled and rake sampled at targeted sites around the lake in search of aquatic invasive species. Boat launches, inlets, outlets, high use areas, and changes in habitat are typically targeted areas, and Big Arbor Vitae Lake's target sites included 6 areas: the Buckhorn Rd boat launch area; the boat launch area off of Hwy 70; the east inlet area; around the east side of the island in Mielke Bay (southeast side of lake); condo area on west side of lake; and the inlet on the north side of the lake. A boat meander survey around the lake edge that included littoral rake sampling and riparian visual surveys was also done to increase aquatic and riparian invasive species detection.

AIS visually searched for included: hydrilla, water hyacinth, European frogbit, curly leaf pondweed, water lettuce, yellow floating heart, fanwort, Eurasian water-milfoil, Brazilian waterweed, parrot feather, didymo, water chestnut, purple loosestrife, yellow iris, flowering rush, Japanese knotweed, Phragmites, Japanese hops, faucet snails, zebra/quagga mussels, Chinese & banded mystery snails, Asian clams, rusty crayfish, swamp crayfish, New Zealand mudsnails, spiny waterfleas, and starry stonewort.

Veliger tows using a 50 cm opening plankton net were taken at 3 different locations to detect zebra mussels. Results were analyzed by WI DNR staff (Gina LaLiberte).

Sediment samples using an Ekman Dredge were taken to detect spiny waterfleas at 1 location on the lake. Results were analyzed by WI DNR staff (Gina LaLiberte).

Coarse Woody Habitat

Coarse woody habitat was surveyed according to the existing 2016 draft of the Lake Shoreland & Shallows Habitat Monitoring Field Protocol (Hein et. al.). Coarse woody habitat situated between the ordinary high water mark and the 2 ft. depth contour at least 4 inches in diameter and 5 ft. long was documented and mapped. A Garmin 76CX was used to mark each piece of wood. Certain features about the wood were manually noted: "Branchiness" (no branches; a few branches; full crown); does the wood cross the ordinary high water mark (touch shore; not touch shore); and is 5 ft. of the wood currently submerged (in water; not in water).

Data was downloaded using BaseCamp software, and a map was created in ArcMap.

Shoreland Assessment

Coarse woody habitat was surveyed according to the existing 2016 draft of the Lake Shoreland & Shallows Habitat Monitoring Field Protocol (Hein et. al.). This survey collected information per land parcel. A shapefile was created that contained the parcel boundaries around Big Arbor Vitae Lake with a centroid in each parcel pushed out 50 ft. into the lake. A 35 ft. boundary inland was drawn around the lake to designate the Riparian Zone. This data was downloaded onto a Trimble Nomad data logger. The centroid and parcels lines and gave a target and boundaries to work with while on the lake assessing the parcels.

The Shoreland Assessment protocols call for documenting the condition of the Riparian Buffer Zone 35 ft. inland from shore, the bank zone, and the littoral zone – see Figure 13.

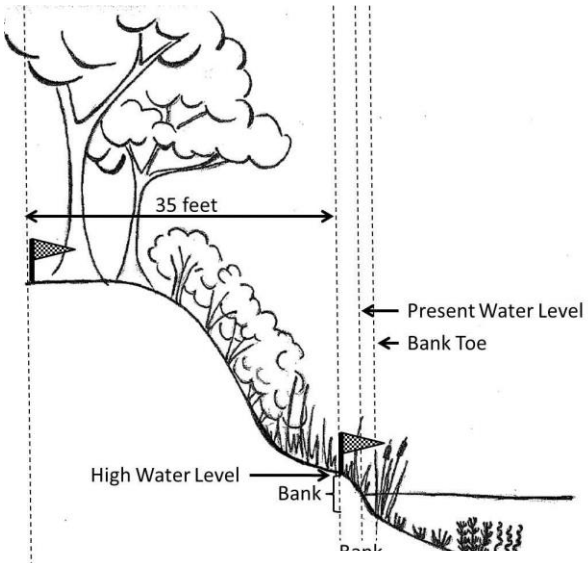


Figure 13. Shoreland areas assessed included the Riparian Buffer Zone, Bank Zone, and Littoral Zone. Graphic courtesy of WI DNR.

Data collected on the Riparian Buffer Zone were percent cover (canopy, shrubs, herbaceous, impervious surfaces, manicured lawn, agriculture, and other); human structures (buildings, boats on shore, fire pits, and other); runoff concerns (point source, channelized flow/gully, straight stair/trail/road to lake, lawn/soil sloping to lake, bare soil, sand/silt deposits, and other).

Data collected on the Bank Zone were horizontal lengths of the following: vertical sea wall; rip rap; other erosion control structures; artificial beach; bank erosion >1 ft. face; and bank erosion < 1ft. face.

Data collected on the Littoral Zone were the number human structures: piers, boat lifts, swim rafts/water trampolines, boathouses, and marinas. Presence/absence of aquatic emergent and floating plants were noted. Signs of aquatic plant removal were also noted.

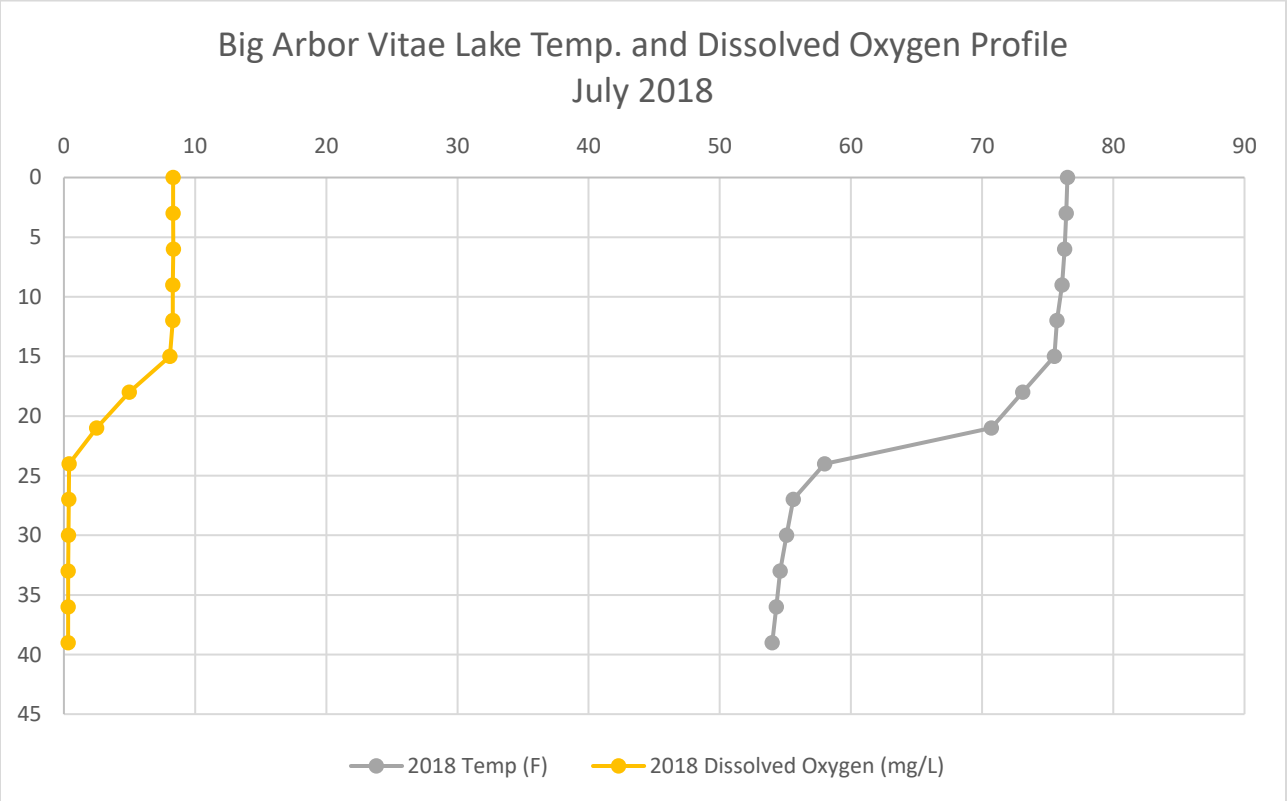
Photos of the 35 ft. Riparian Buffer Zone were taken at approximately 50 ft. from shore.

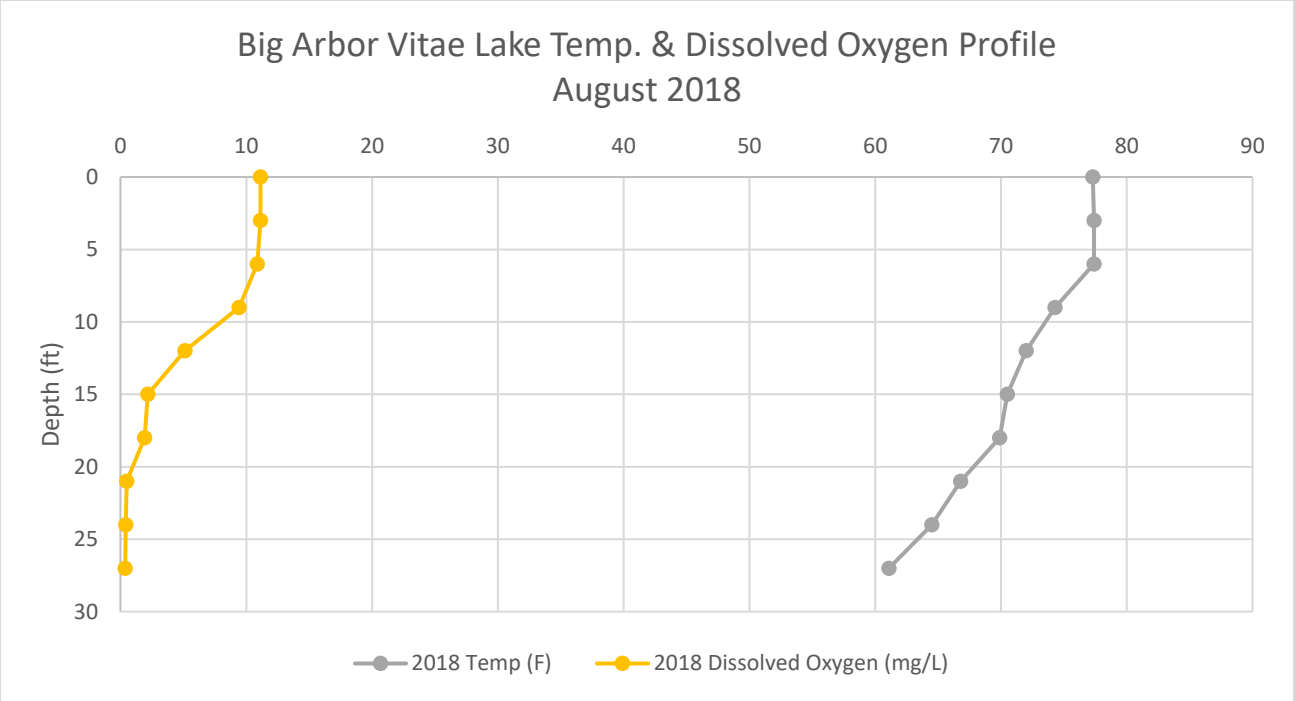
Appendix 2: Water Quality Raw Data and Temperature and Dissolved Oxygen Profiles

Table 4. Results of 2018 Big Arbor Vitae Lake water quality testing. Testing occurred on 7/17/18; 8/16/2018; and 9/18/2018.

	July 2018	Aug 2018	Sep 2018	Average
Secchi average (ft.)	6.5	5.0	5.0	5.5
Total Phosphorus (ug/L)	25.2	26.2	28.0	26.5
Chlorophyll a (ug/L)	8.89	22.0	28.5	19.8
Calcium (mg/L)	n/a	13.7	n/a	13.7
Alkalinity (mg/L)	48.2	n/a	n/a	48.2
pH	8.41	n/a	n/a	8.41
Conductivity (uS/cm)	108	n/a	n/a	108

The July, August, and September temperature and dissolved oxygen profiles show the lake stratified.





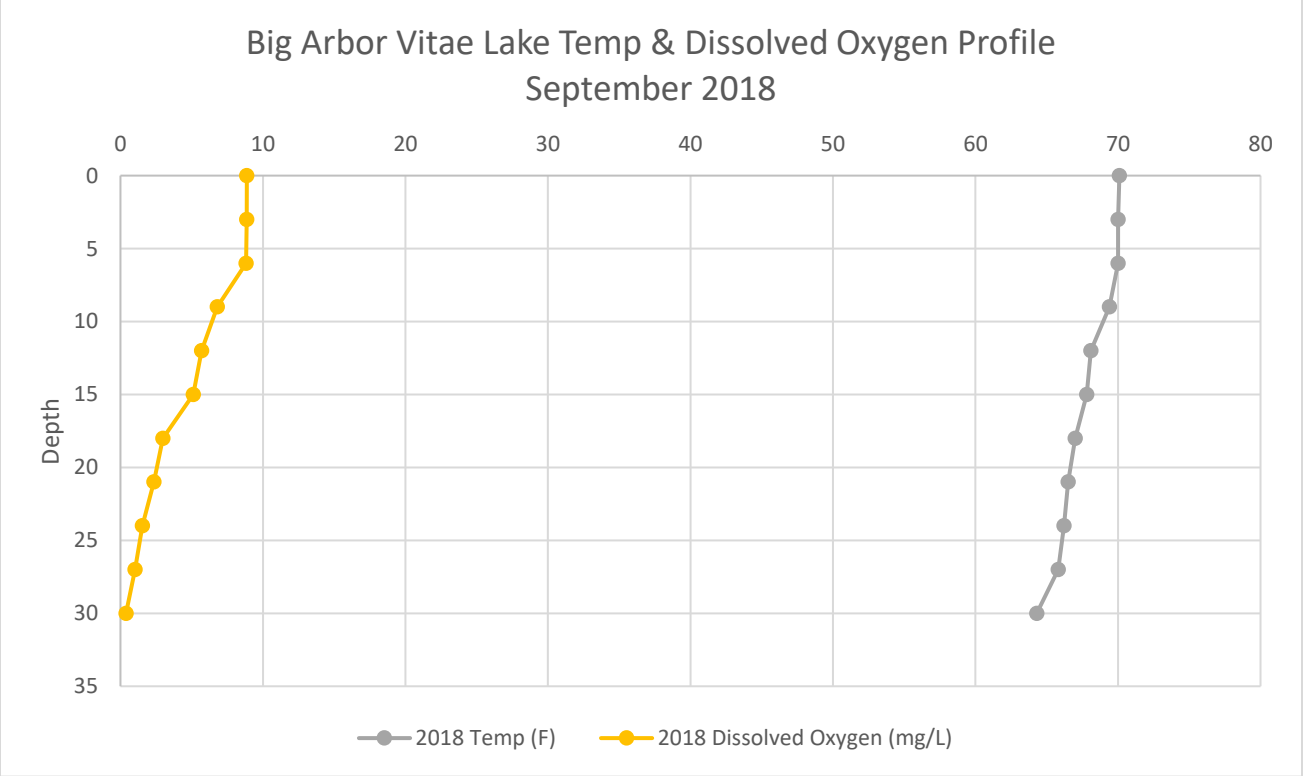


Figure 14. Temperature and dissolved oxygen profiles for Big Arbor Vitae Lake 2018. Sampling dates were: 7/17/2018; 8/16/2018; and 9/18/2018.

Appendix 3: Aquatic Plant Point-Intercept Sampling Point Map, Plant Photos, and Species Richness Map

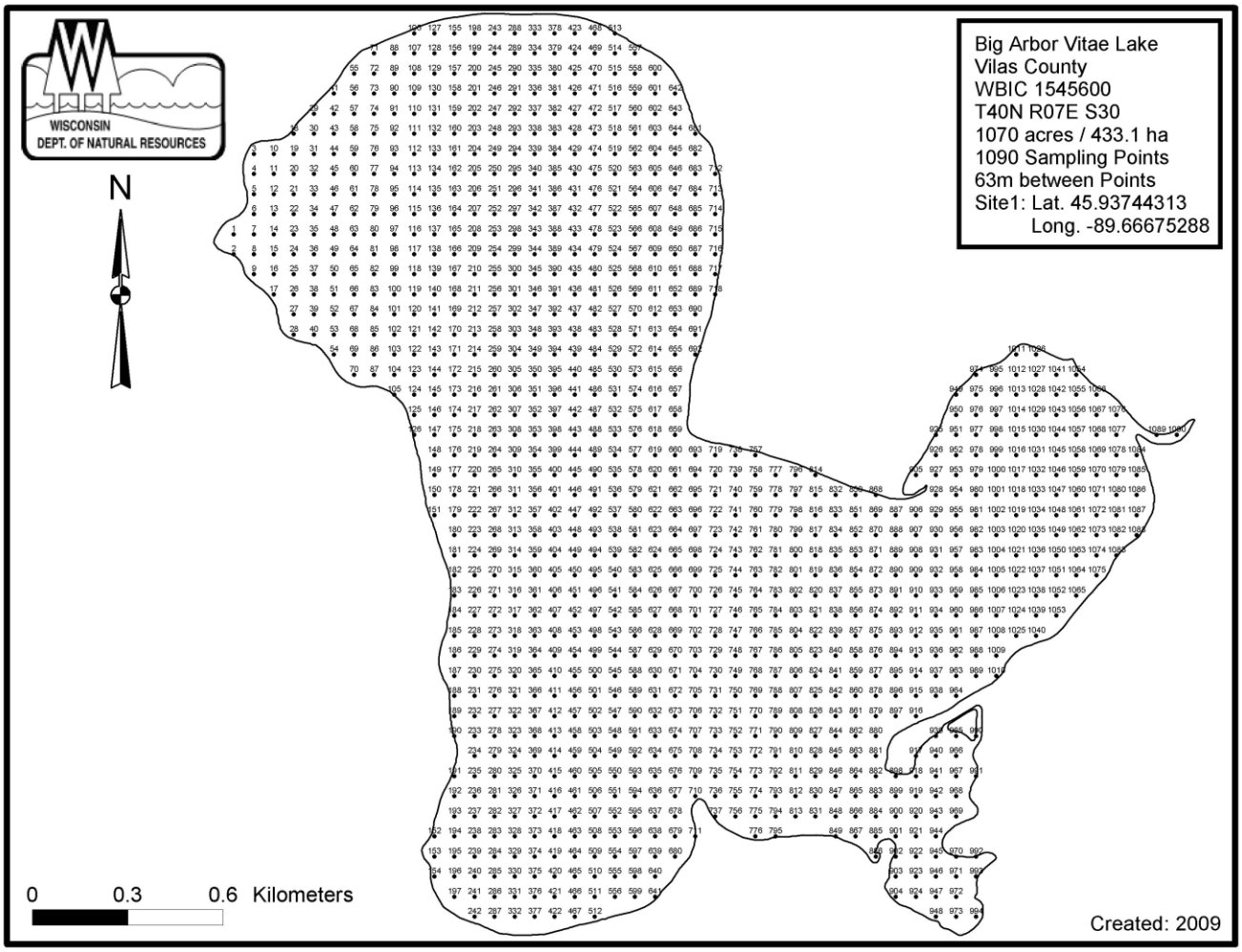


Figure 15. Big Arbor Vitae Lake Point Intercept Map. Courtesy of WI DNR.

Figure 16. Curly leaf pondweed (*Potamogeton crispus)* found in Big Arbor Vitae Lake 2018 point-intercept survey. This invasive plant was first reported in the lake in 2008.

Figure 17. Fried Pondweed (*Potamogeton friesii)* found in Big Arbor Vitae Lake 2018 point-intercept survey.

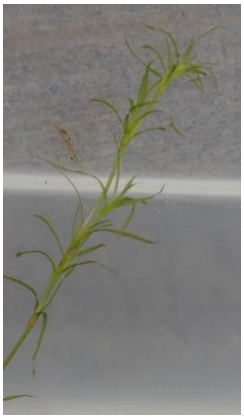


Figure 18. Slender naiad (*Najas flexilis*) found on Big Arbor Vitae Lake 2018 point-intercept survey.

Figure 19. Coontail (*Ceratophyllum demersum*) found in Big Arbor Vitae Lake 2018 point-intercept survey.

Figure 20. Northern water-milfoil (*Myriophyllum sibiricum*) found in Big Arbor Vitae Lake 2018 point-intercept survey.

Figure 21. Slender waterweed (*Elodea nuttallii)* found in Big Arbor Vitae Lake 2018 point-intercept survey.

Figure 22. Common waterweed (*Elodea canadensis*) found during Big Arbor Vitae Lake 2018 point-intercept survey.

Species Richness

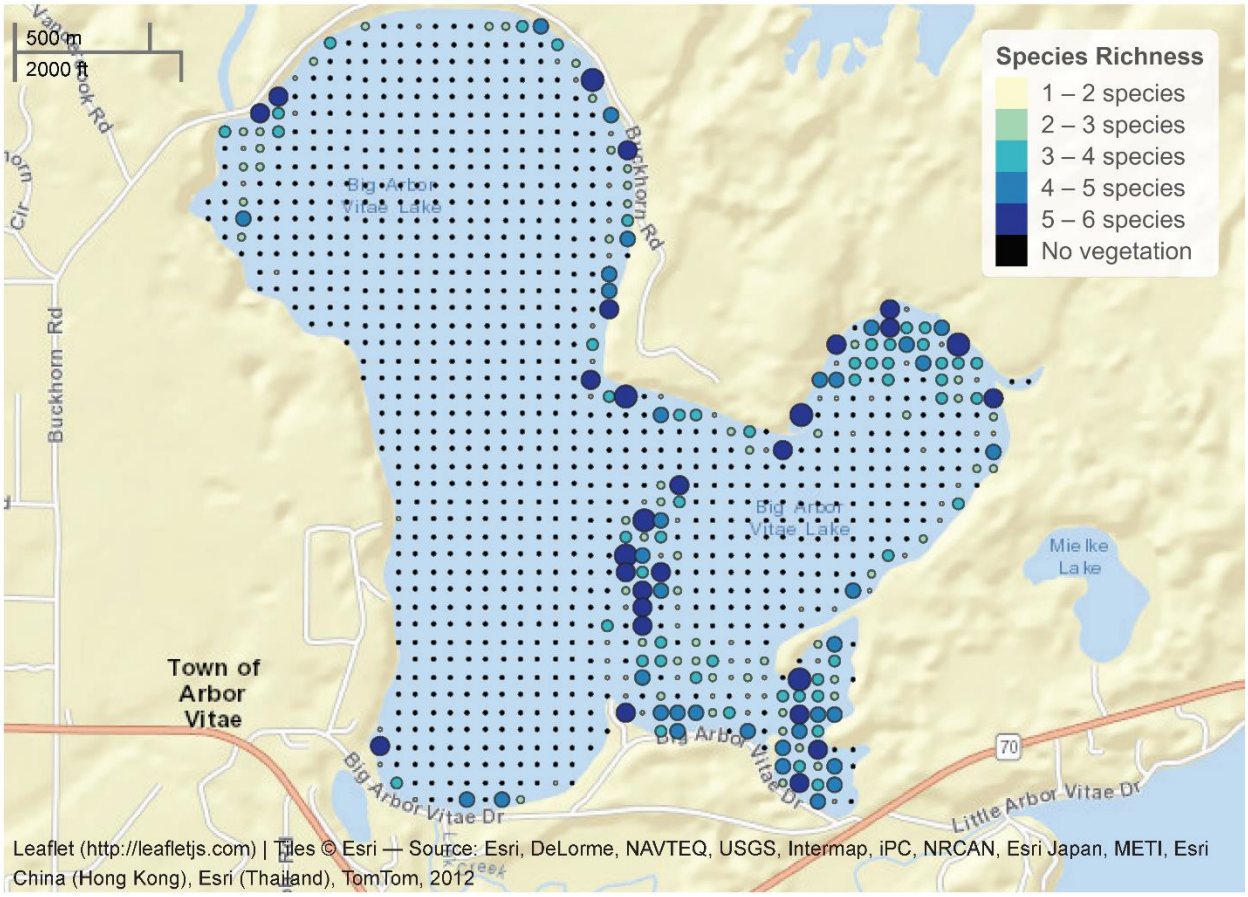


Figure 23. Big Arbor Vitae Lake species richness by sampling point. Map courtesy of WI DNR.

Appendix 4: Coarse Woody Habitat Map

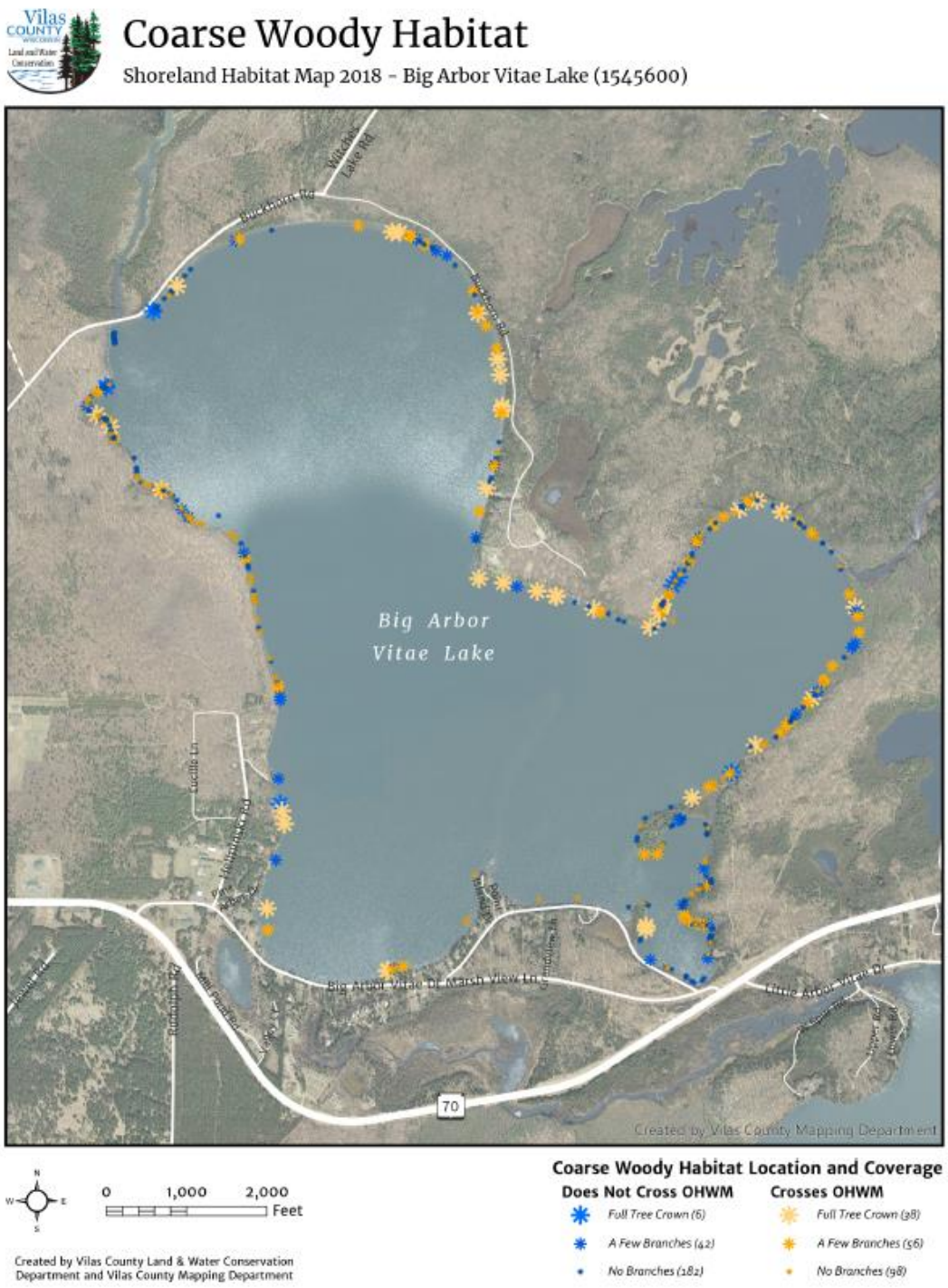


Figure 24. Coarse Woody Habitat Characterization for Big Arbor Vitae Lake, 2018. 52 logs/mile were documented.

Appendix 5: Shoreland Survey Maps

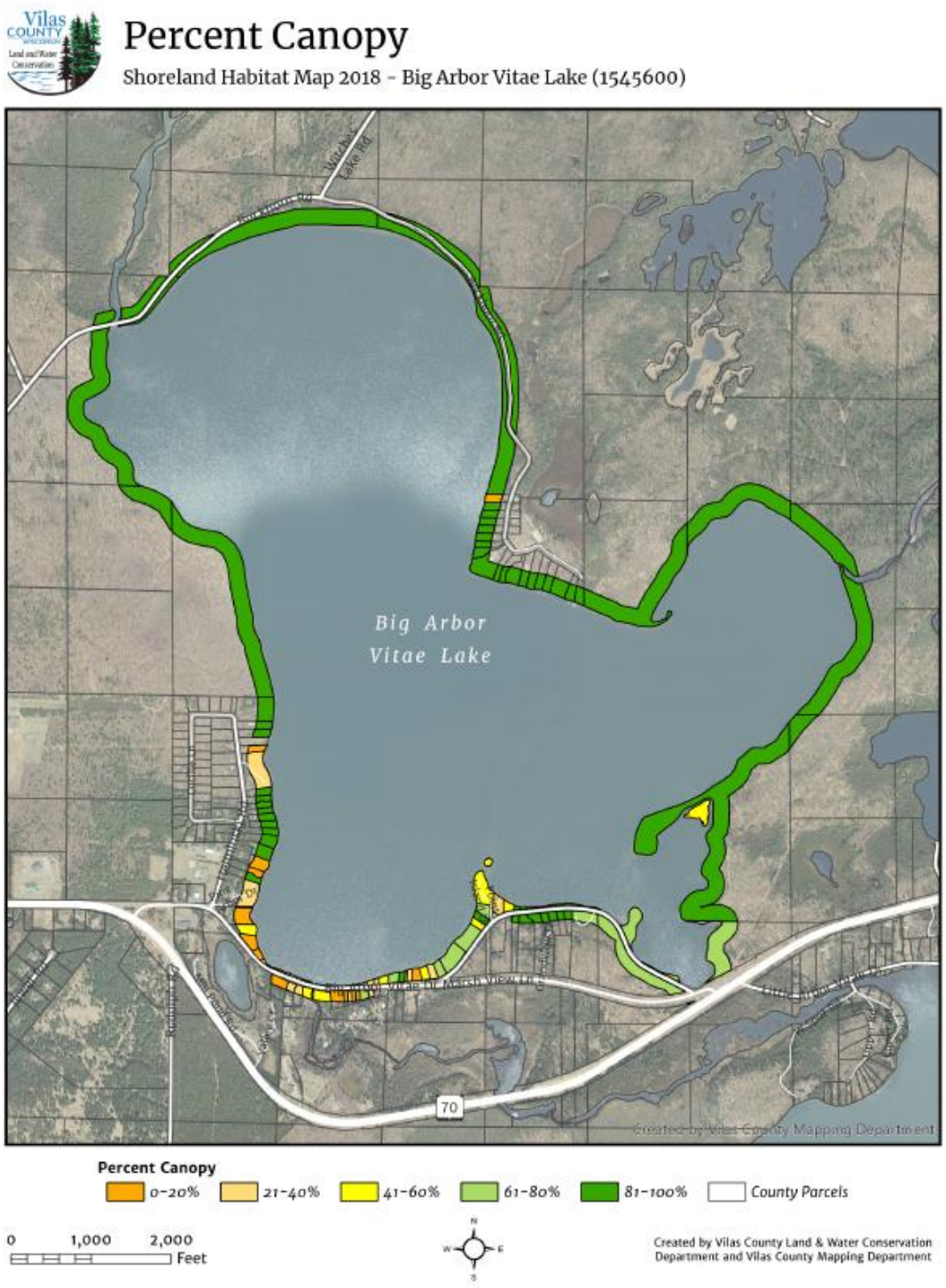


Figure 25. Canopy cover percent per parcel within 35 ft buffer area on Big Arbor Vitae Lake 2018.

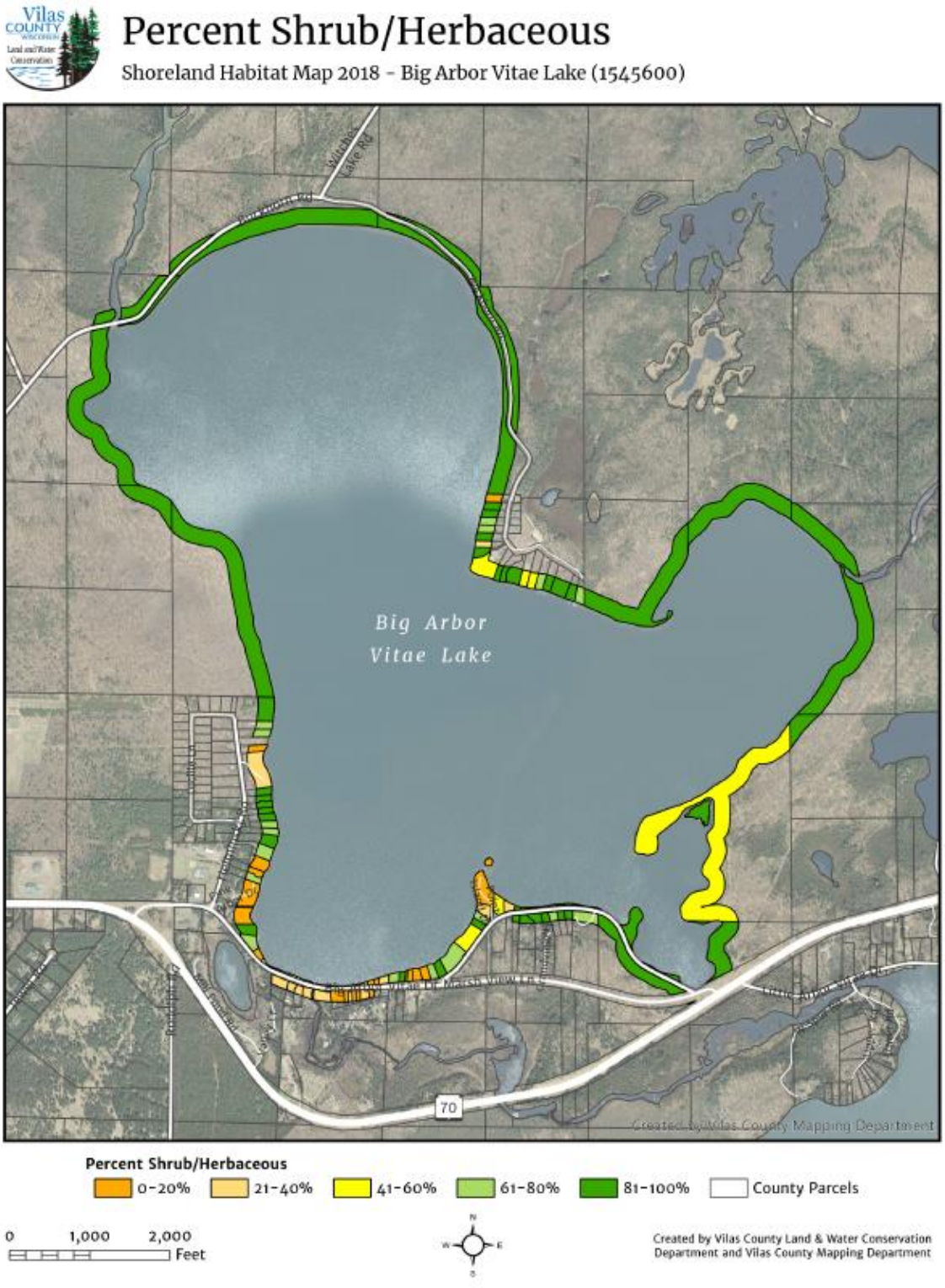


Figure 26. Percent shrub/herbaceous cover per parcel within 35 ft buffer area on Big Arbor Vitae Lake 2018.

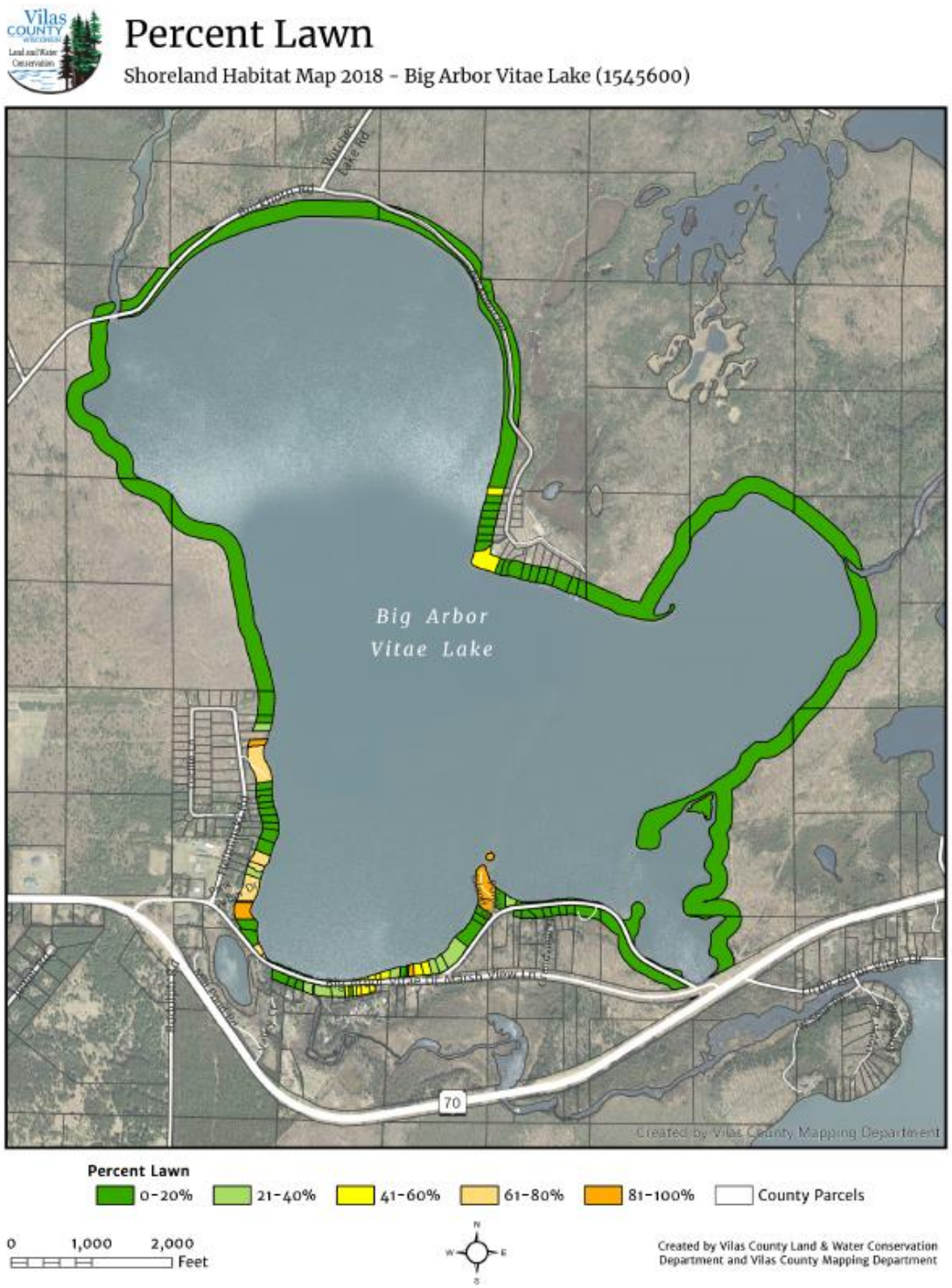


Figure 27. Percent lawn cover per parcel within 35 ft buffer area on Big Arbor Vitae Lake 2018.

Figure 28. Piers per parcel on Big Arbor Vitae Lake 2018.

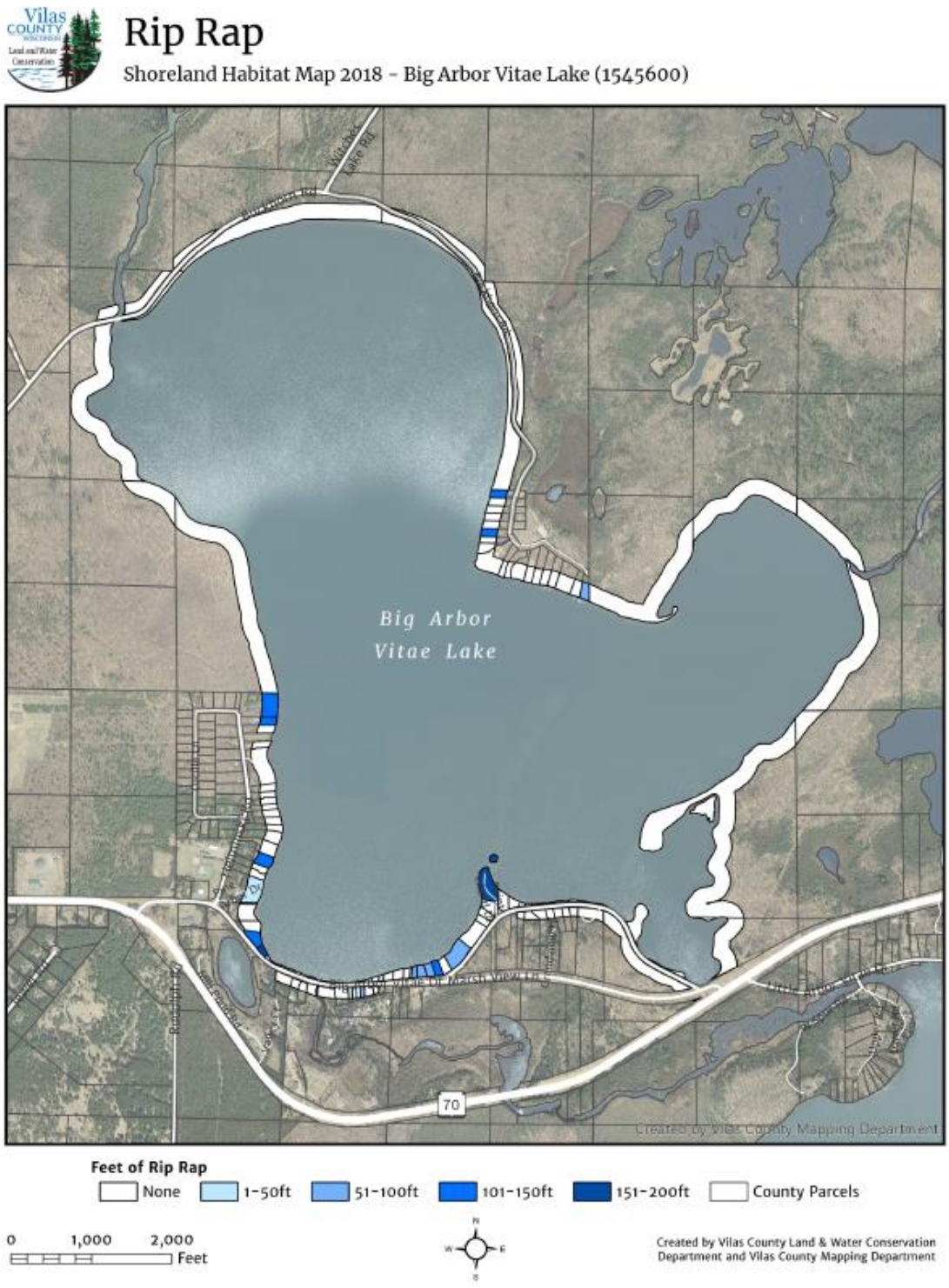


Figure 29. Riprap feet per parcel on Big Arbor Vitae Lake 2018.

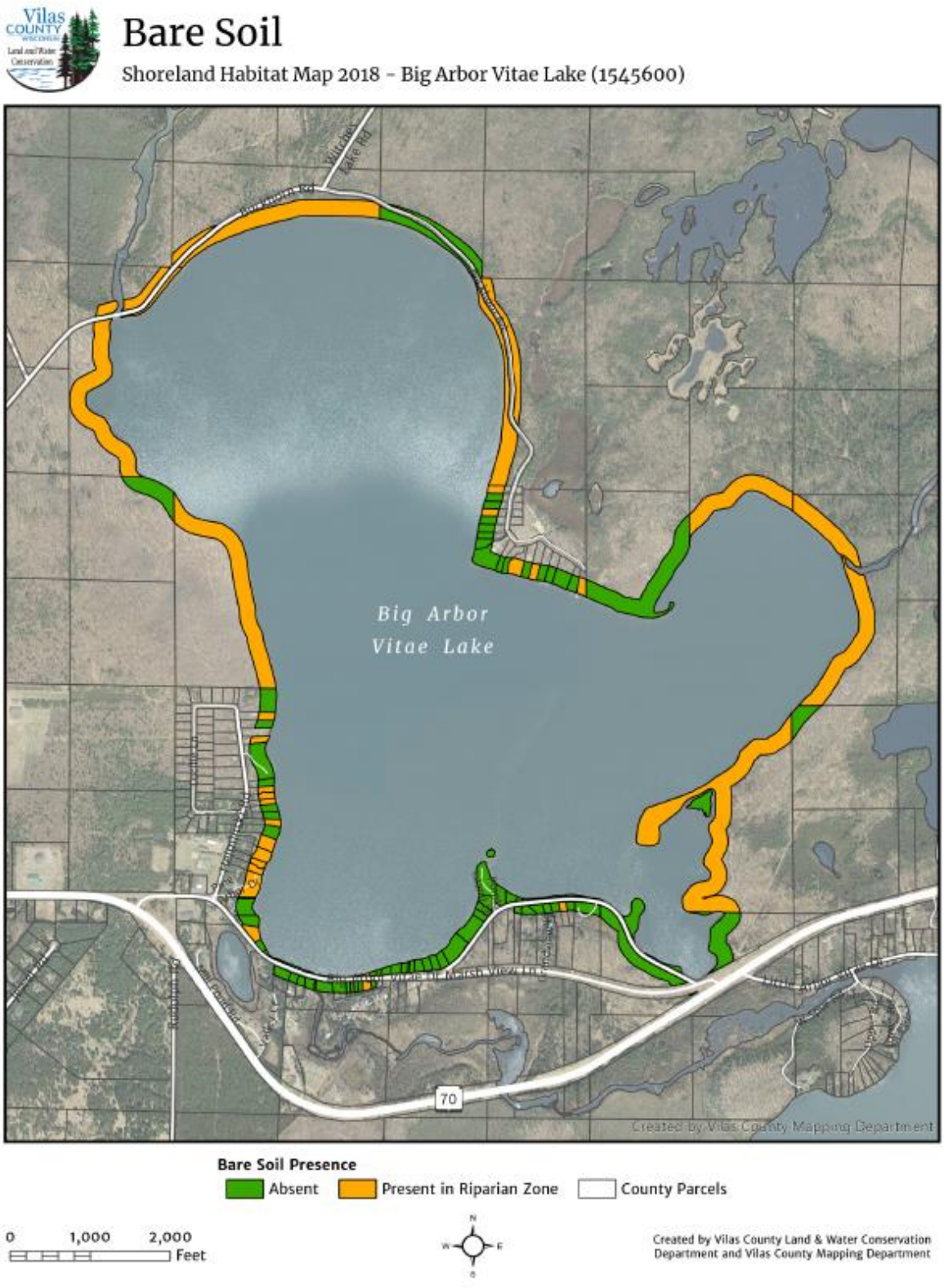


Figure 30. Parcels where bare soil is present on Big Arbor Vitae Lake 2018.

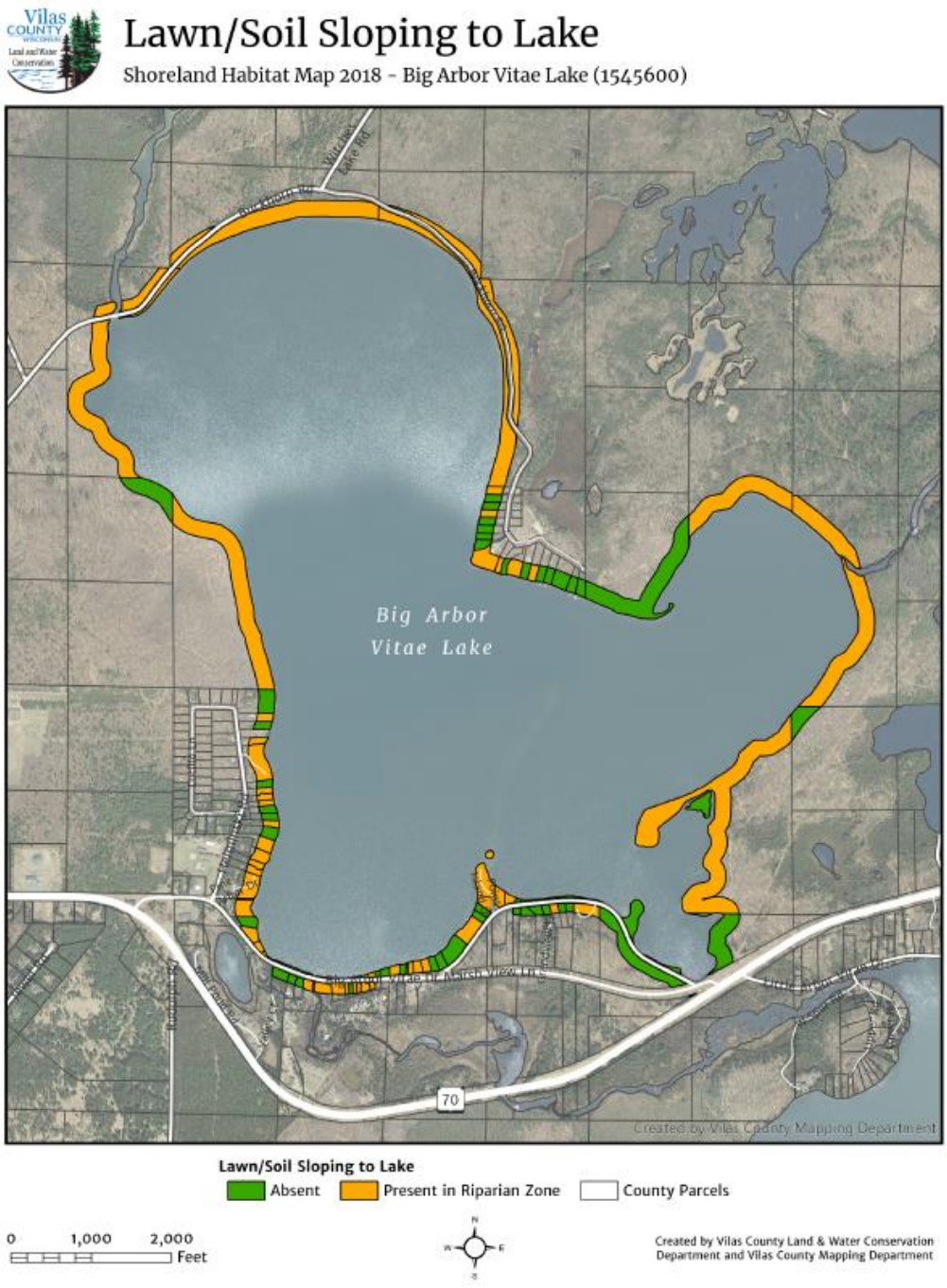


Figure 31. Parcels where lawn or soil slopes to lakes on Big Arbor Vitae Lake 2018.

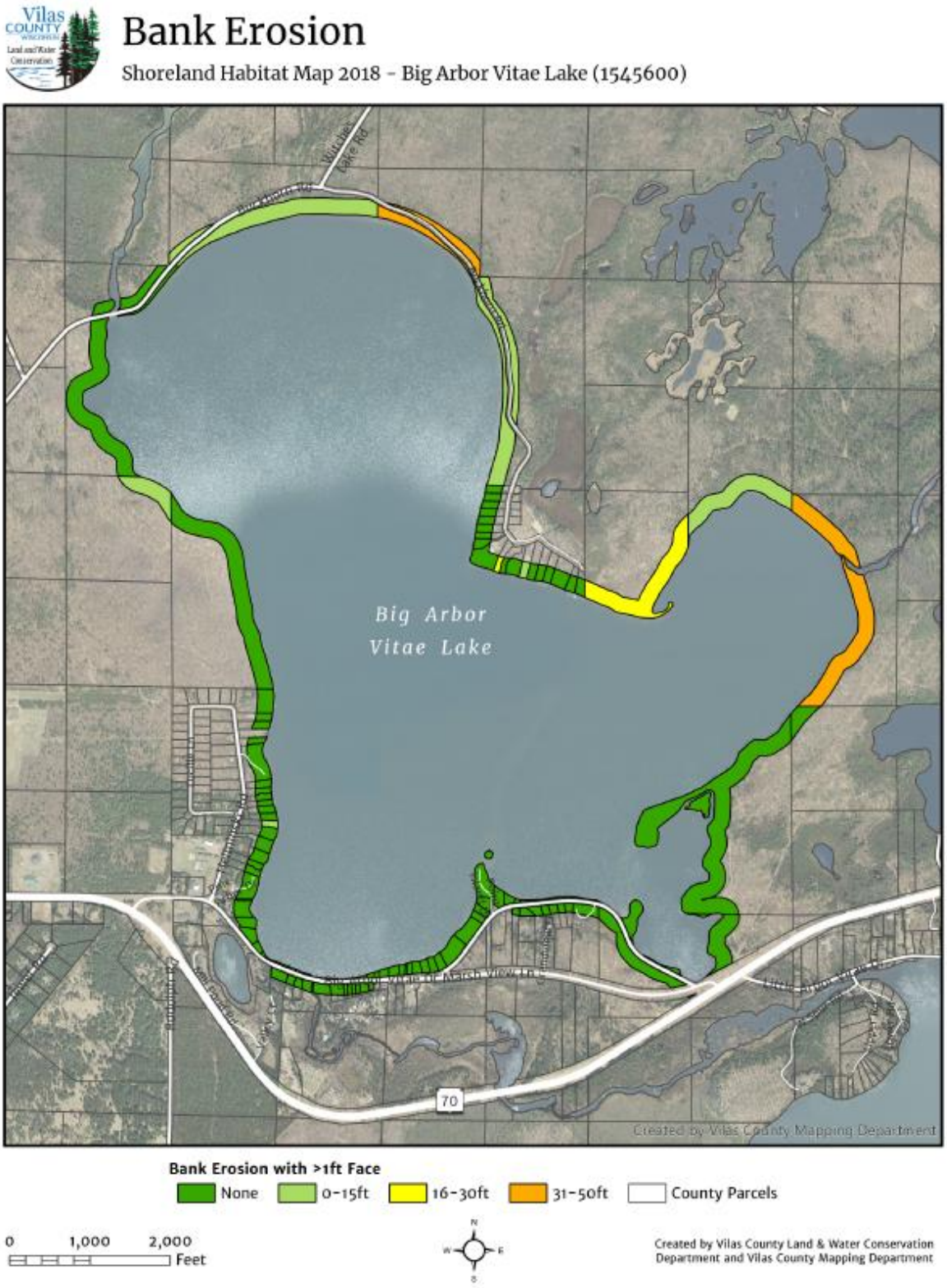


Figure 32. Feet of bank erosion >1ft face per parcel on Big Arbor Vitae Lake 2018.

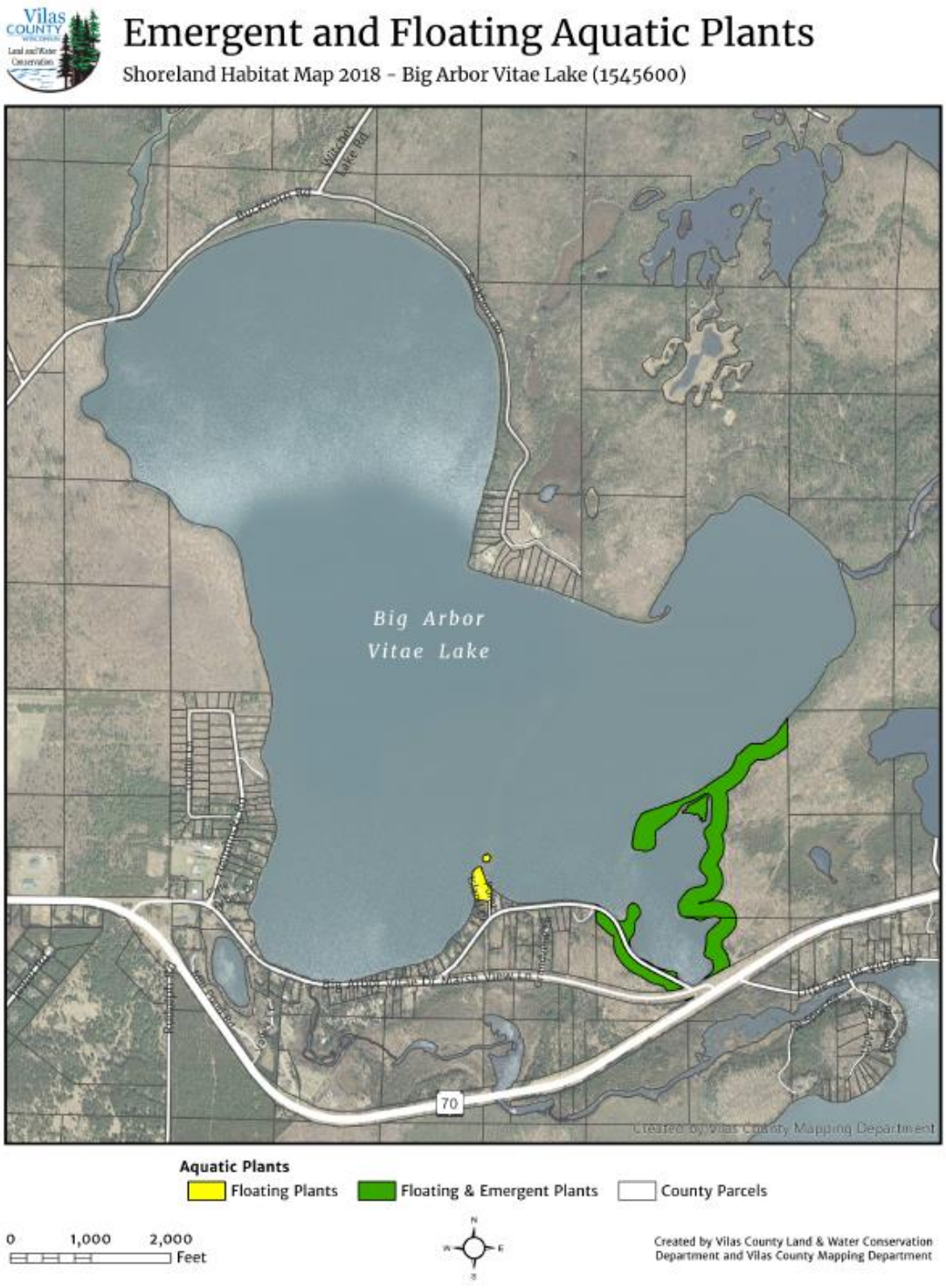


Figure 33. Floating and emergent plants on Big Arbor Vitae Lake 2018. No evidence of plant removal was found.

Appendix 18: Erosion Susceptibility

Areas Most Susceptible to Sheet, Rill and Gully Erosion

Arbor Vitae Lakes Subwatershed (070700010801)