INTRODUCTION

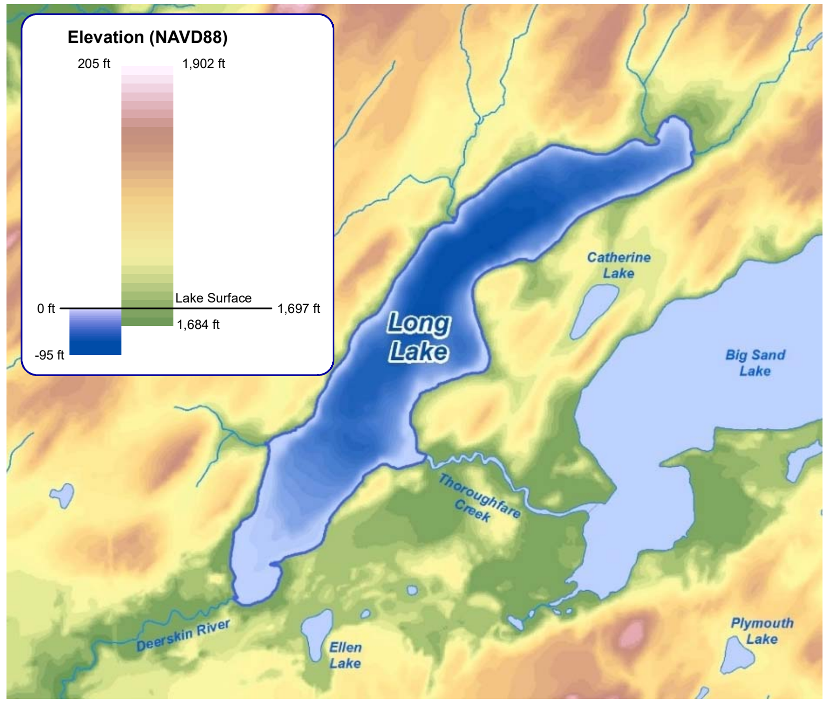


Figure 1. Long Lake, Vilas County.

Long Lake, Vilas County, is a lowland, two-story, drainage lake with a maximum depth of 95 feet. This approximately 889.3-acre mesotrophic lake has a relatively large watershed (>14,000 acres) when compared to the size of the lake (15:1). Long Lake contains 50 native plant species, of which southern naiad is currently the most common plant. One submergent non-native plant (Eurasian watermilfoil), and two shoreland emergent non-native plants (sweet flag and reed canary grass) have been identified from Long Lake. Connected via the approximately 1.25-mile-long Thoroughfare Creek, Big Sand Lake flows into Long Lake (Figure 1). Big Sand Lake is likely one of the first lakes in Vilas County to contain Eurasian watermilfoil, with official records of this plant occurring in the lake in 1990. Long Lake is drained by the Deerskin River which flows into Scattering Rice Lake of the Eagle River Chain of Lakes.

In 2000 the presence of Eurasian watermilfoil was verified by the Wisconsin Department of Natural Resources (WDNR) from Long Lake, although it was suspected of inhabiting the system for years before this date. In 2006, the WDNR completed a point-intercept aquatic plant survey, locating Eurasian watermilfoil in approximately 26% of the littoral area of the lake (< 18ft). During that timeframe the Long Lake of Phelps Lake District (LLPLD) was in the process of creating a lake management plan for the system with the aid of Northern Environmental, Inc.

Following the finalization of a lake management plan by Northern Environmental, Inc. in 2007, the LLPLD successfully applied for WDNR grant funds in August of 2009 to initiate EWM control measures outlined within their management plan which used commonly considered best management practices (BMPs) of the time – spatially targeted spot herbicide treatments. The funds were to cover the first of a five-year program (2008-2012) aimed at significantly reducing the EWM within the lake through annual early-season herbicide spot treatments.

In order to build off the strides made in EWM population reductions during the previous 5 years (2008-2012), the LLPLD created a plan that took a more aggressive approach to EWM management. During 2013 to 2017, the LLPLD's herbicide treatment threshold (trigger) included targeting all colonized areas of EWM (mapped with polygons) as well as immediately adjacent areas of EWM mapped with point-based techniques, with areas mapped as *small plant colonies* being targeted if possible. This strategy was unanimously supported during a July 2012 vote at an annual meeting by district members. The

LLPLD was successfully awarded a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasive Species (AIS) Established Population Control Grant in February 2013 to implement the EWM management program outlined within the *Long Lake Comprehensive Lake Management Plan Update* (July 2013) from 2013-2017. Remaining funds from the grant allowed the project to extend to 2018. As a part of that project, the LLPLD would revisit their aquatic plant management-related Implementation Plan to update its content based on the lessons learned during the project.

Starting in 2013, the LLPLD adopted an integrated approach to EWM management. The LLPLD sought to conduct EWM professional-based hand-harvesting methods in areas where spot herbicide treatments were not anticipated to be effective due to their small size or exposed nature. The 2013 trial program was conducted using traditional hand-harvesting techniques by a contractor. The subsequent hand-harvesting program has been conducted using a Diver Assisted Suction Harvest (DASH) component. To date, the coordinated hand harvesting efforts have demonstrated seasonal EWM population suppression and has been a tool to provide relief from nuisance EWM conditions in select areas of Long Lake.

2019 Aquatic Plant Management Update

During the winter of 2018-2019, the LLPLD worked to create an update to their aquatic plant management related Implementation Plan. During these discussions, conversation regarding risk assessment of the various management actions were prominent. The WDNR recently completed a *Strategic Analysis of Aquatic Plant Management in Wisconsin* (June 2019), which contains a detailed risk assessment discussion of each chemical within Supplemental Chapter 3.3 (pg 128):

https://dnr.wi.gov/topic/EIA/documents/APMSA/APMSA_Final_2019-06-14.pdf

Onterra provided extracted relevant chapters from the WDNR's *APM Strategic Analysis Document* to serve as an objective baseline for the LLPLD to weigh the benefits of the management strategy with the collateral impacts each management action may have on the Long Lake Ecosystem. Following a period of review and discussion between Onterra, the LLPLD, WDNR, and other project partners, the *Long Lake Aquatic Plant Management Plan Update* was accepted by the WDNR in June of 2019. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

The first Management Goal in the APM plan update is to: *Maintain EWM Populations Below Nuisance Levels.* One of the management actions in achieving this goal is to conduct a three-tiered EWM population management strategy on Long Lake (herbicide, mechanical harvesting, hand harvesting). The updated plan included specific conditions in which each management strategy would be considered.

When a Late Season AIS Survey documents colonized EWM populations that are *dominant or greater in density*, an herbicide spot treatment would be considered for the following early-spring. Herbicide spot treatment techniques would be implemented if the colonies have a size/shape/location where management is anticipated to be effective. In general, this would be areas confined to bays (not exposed), broad in shape (not narrow bands), and over roughly 5 acres in size. On Long Lake, this will be difficult as most areas contain a relatively narrow littoral footprint of EWM. Spot herbicide treatments may need to consider herbicides (diquat, florpyrauxifen-benzyl, etc) or herbicide combinations (2,4-D/endothall, diquat/endothall, etc) thought to be more effective under short exposure situations than with traditional weak-acid auxin herbicides (e.g. 2,4-D, triclopyr). Advancements in research into new herbicides and use patterns will need to be integrated into future management strategies, including effectiveness, native plant selectivity, and environmental risk profile.

Onterra ecologists completed a Late-Season EWM Mapping Survey on September 10 & 17, 2019. The results of the survey are displayed on Map 1. The survey showed that the EWM was present in many littoral areas of the lake, however the densest colonies were located on the southern end of the lake. A total of 82.2 acres of colonized EWM was mapped during the survey of which 14.0 acres were designated as *dominant* or *highly dominant* densities, while 68.2 acres were designated as either *scattered* or *highly scattered* (Figure 2). The acres of EWM colonies in Long Lake has trended higher since 2016. It is important to note that acreages do not reflect EWM occurrences mapped with point-based methodologies.

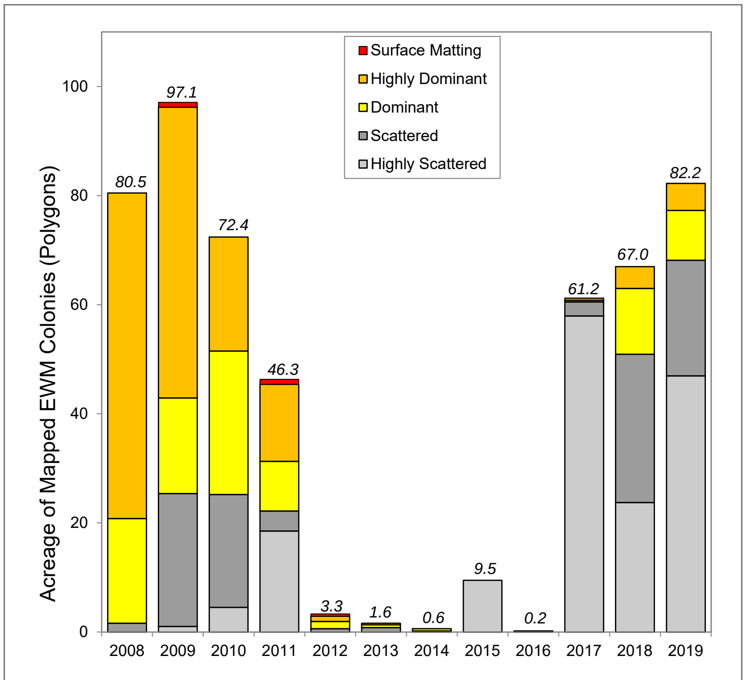


Figure 2. Acreage of EWM colonies in Long Lake from 2008-2019. Data from annual Onterra Late-Summer EWM Mapping Surveys.

2020 STRATEGY DEVELOPMENT

Much of the EWM population in the southern end of the lake meets the District's trigger for considering herbicide treatment. Following internal LLPLD discussions and teleconferences with Onterra, the LLPLD decided to pursue management of EWM in select high recreational and navigational areas of the lake using herbicide spot treatments. This management strategy is consistent with the LLPLD's recently WDNR-approved Aquatic Plant Management Plan (June 2019). As outlined within the APM Plan, the LLPLD would notify the WDNR as soon as herbicide management was being consider for the following year. The LLPLD voiced their management intentions to the WDNR in an October 17, 2019 email, resulting in a subsequent meeting between representatives from the LLPLD and WDNR.

The LLPLD evaluated the available herbicide options that would be expected to achieve the desired level of control in association with meeting the management goal of maintaining the EWM population below nuisance levels. The LLPLD understands that obtaining multi-year EWM population suppression from herbicide spot treatments is difficult also considered choosing not to manage these populations. Preliminary treatment designs were constructed by Onterra with and provided to the LLPLD for soliciting cost estimates on the proposed treatment options (Table 1). Appendix A contains the WDNR fact sheets for each of the herbicides included in the alternative's analysis. The LLPLD reviewed an earlier version of this report and the following paragraphs outline the herbicide treatment designs that the LLPLD considered for the proposed 2020 treatment.

Table 1. Permit Tables associated with the proposed 2020 herbicide treatment in Long Lake.

Application Area Specifics				ProcellaCOR		Chinook @ 8 gal/acre-ft					Aquastrike @ 1.5 gal/acre-ft		
Site	Acres	Ave. Depth (Feet)	Volume (Acre-feet)	PDU Rate (per acre-ft)	PDU Total	2,4-D Amine (ppm ae)	Endothall (ppm ai)	2,4-D Amine (gallons)	Aquathol K (gallons)	Chinook (gallons)	Diquat (ppm cation)	Endothall (ppm ai)	Aquastrike (gallons)
A-20	15.1	9.4	141.9	4.0	567.8	1.48	3.6	149.0	328.0	1135.5	0.33	1.66	212.9
B-20	15.9	9.1	144.7	4.0	578.8	1.48	3.6	152.0	334.0	1157.5	0.33	1.66	217.0
Total	**31.0**		**286.6**		**1,146.5**			**301.0**	**662.0**	**2,293.0**			**429.9**

Florpyrauxifen-Benzyl – ProcellaCOR™

The LLPLD is evaluating the option of selecting ProcellaCOR™ in association with the proposed 2020 herbicide treatment. This herbicide is specifically designed to control invasive watermilfoil populations. ProcellaCOR™ is in a new class of synthetic auxin mimic herbicides (arylpicolinates) with short concentration and exposure time (CET) requirements compared to other systemic herbicides. Uptake rates of ProcellaCOR™ into EWM were two times greater than reported for triclopyr (Haug 2018, Vassios et al. 2017). ProcellaCOR™ is primarily degraded by photolysis (light exposure), with some microbial degradation. The herbicide is relatively short-lived in the environment, with half-lives of 4-6 days in aerobic environments and 2 days in anerobic environments (WSDE 2017). The product has a high affinity for binding to organic materials (i.e. high KOC).

Netherland and Richardson (2016) and Richardson et al. (2016) indicated control of select non-native plant species with the active ingredient in ProcellaCOR™, including invasive watermilfoils (EWM and HWM) at low application rates compared with other registered spot treatment herbicides. The majority of native plants tested to date also suggest greater tolerance to this mode of action. Water lilies, pickerelweed, arrowheads, and native watermilfoils have shown sensitivity to ProcellaCOR™. Coontail may also be impacted at higher application rates. Because this is a new herbicide, data available from field trials is relatively limited. A 14.3-acre spot treatment with ProcellaCOR™ occurred in nearby North Twin Lake in 2019 with initial results during the *year-of-treatment* indicating a high level of EWM control coupled with statistically valid decreases of two native watermilfoil species in the site. The treatment in North Twin Lake will continue to be monitored in the *year-after-treatment* (2020) to determine whether the EWM reductions observed in 2019 extend beyond one growing season. A cost estimate for this strategy is approximately $55,000.

2,4-D/Endothall – Chinook®

Both of these herbicides have been used extensively across Wisconsin for invasive watermilfoil (2,4-D) and curly-leaf pondweed (endothall) management. It is theorized, but not proven, that a combination of 2,4-D/endothall may not require as long of an exposure time as either herbicide alone due to increased systematic impacts to the target plants particularly at cold water temperatures. The simultaneous exposure to endothall and 2,4-D has been shown to provide increased control of invasive milfoil in outdoor growth chamber studies (Madsen et. al 2010). A handful of whole-lake EWM and hybrid EWM (HWM) treatments in Wisconsin utilizing this strategy have been conducted to date with promising results of control and selectivity towards native plants. Numerous spot treatment field trials of 2,4-D/endothall are occurring in Wisconsin. There are two different ratios of these chemicals that are considered: 1) one dosing option partners a modest dose of endothall (1.5 ppm ai) with 2,4-D at its maximum application rate (4.0

ppm ae), and 2) a second dosing option adopts a ratio of 2,4-D/endothall used by UPL within Chinook®.

Spot-treatments that use the first ratio discussed above have shown variable results to date with some treatments achieving seasonal impacts to the EWM while others have resulted in control that extends beyond the year of treatment. This approach was used on Long Lake in 2016 with approximately two summers of reduced EWM in this site (Figure 3). More projects have utilized the second dosing strategy which uses a higher ratio of endothall in recent years. The preliminary results are more promising, but insufficient time has passed to understand the length of control. A cost estimate for this strategy is approximately $61,000.

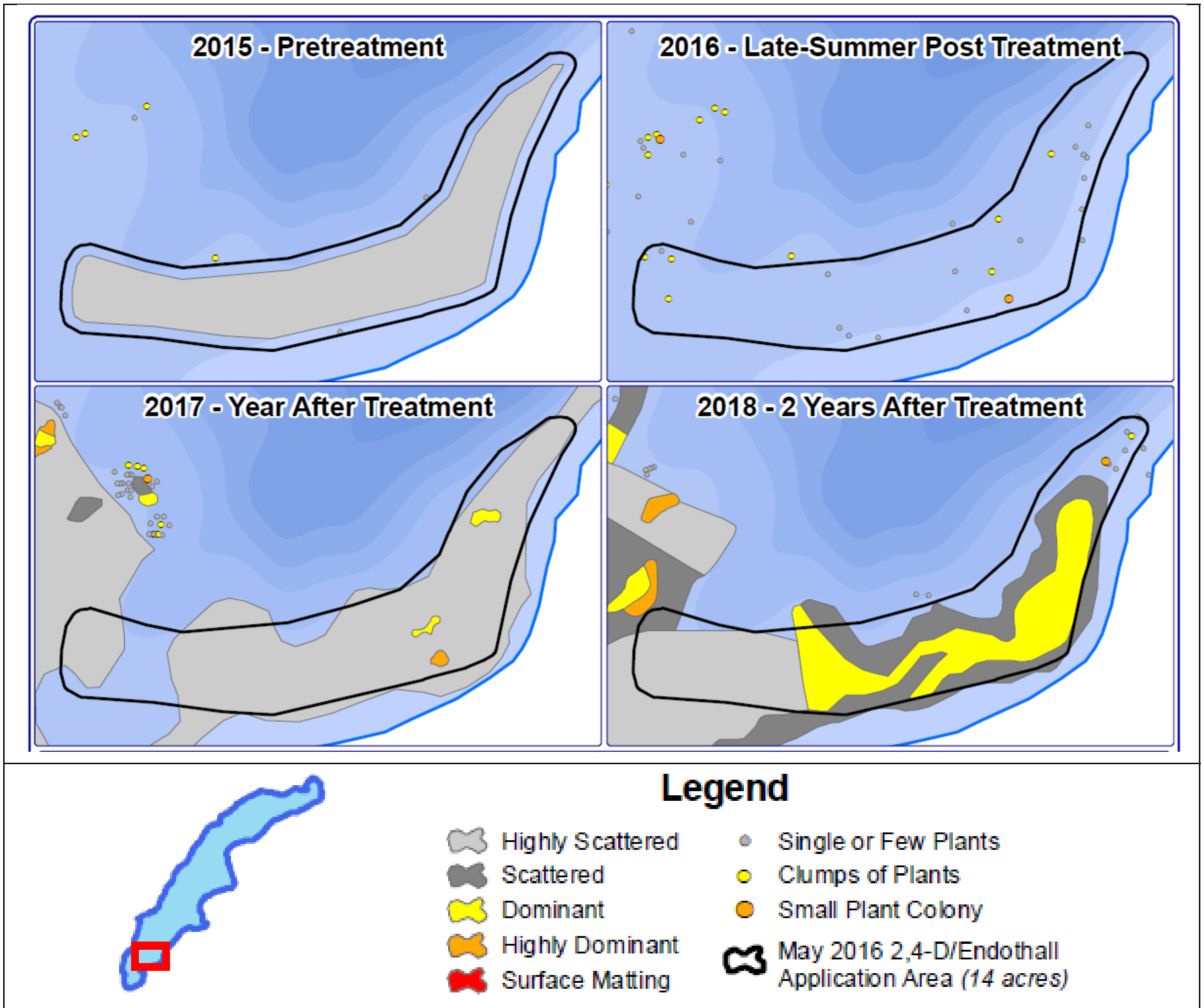


Figure 3. EWM Population Before and After a Spring 2016 2,4-D/endhothall herbicide treatment in Long Lake.

Diquat/Endothall – Aquastrike ™

Aquastrike is a commercially available combination of diquat and endothall. As a contact herbicide, diquat does not move (translocate) through plant tissue. Therefore, only the exposed plant material is impacted by the herbicide. Concern exists whether this herbicide has the capacity to kill the entire plant, or simply impacts the above ground biomass and the plant rebounds from unaffected root crowns. The addition of the endothall component is theorized to have increased systemic activity on EWM to result in complete control. This herbicide use-pattern has shown promise controlling HWM in a few Wisconsin treatments. The long-term control of EWM targeted with diquat/endothall continue to be evaluated on lakes across Wisconsin. A cost estimate for this strategy is approximately $42,000.

After reviewing the herbicide treatment options and considering the risk assessment and costs of each strategy, the LLPLD selected ProcellaCOR for use in the proposed 2020 treatment strategy. Map 2 reflects the proposed treatment strategy using ProcellaCOR with application rates of 4.0 prescription dose units (PDU's) over two sites totaling 31.0 acres.

Treatment Implementation

Approximately 1-3 weeks prior the early-season herbicide application, a qualitative assessment would be completed to verify application area extents and inspect the condition of the EWM colonies targeted for treatment through the use of a combination of surface surveys, rake tows, and submersible video monitoring. Parameters such as plant growth stage, water temperature, and water depth would be investigated to formulate the final treatment strategy.

Following the Pretreatment Confirmation and Refinement Survey, a brief email narrative report would be provided to the LLPLD, WDNR, and other project partners, including a map outlining the finalized control strategy. Spatial data would be provided to the third-party herbicide application firm prior to treatment. The chosen applicator, in conjunction with the LLPLD, will be responsible for completing appropriate permit-related documentation and deliverables to the WDNR.

Monitoring Plan

The proposed 2020 herbicide treatment areas will be quantitatively monitored through comparative sub point-intercept surveys consisting of 128 sampling points at a 30-meter spacing (Figure 4). Comparisons of the littoral frequency of occurrences of aquatic plants will be made from pre-treatment (summer 2019) to post-treatment (summer 2020). This will allow for an understanding of EWM treatment efficacy and non-target impacts to the native plant community in these sites. While these comparisons will allow for an initial understanding of the treatment results, replication of these surveys again during the year after treatment (2021) will allow for a better understanding if multi-year EWM suppression was achieved vs only a single season of impacts.

The pre-treatment data was collected from the proposed sites on September 11, 2019 and indicated that EWM was present at 47.5% of the sampling locations (Figure 4). The September 2019 survey indicated that many native aquatic plant species were present in the site with southern naiad (29.2%), clasping-leaf pondweed (25.0%), and muskgrasses (20.8%) being the most often recorded species (Figure 4).

A qualitative assessment of the 2020 herbicide treatment would include comparing the 2019 Late-Season EWM Mapping Survey (*year before treatment*)) to the 2020 Late-Season EWM Mapping Survey (*year of treatment*) mapping results. The treatment would be considered successful in meeting the EWM control goals if the *year of treatment* survey indicates little to no EWM present in the targeted areas during the year of treatment. Further, reductions in EWM in the targeted areas would be expected to last into 2021.

Onterra would work with the WDNR to develop an herbicide concentration monitoring sampling plan in association with the proposed 2020 early-season herbicide treatment. The plan would include volunteer collection of water samples at a number of locations and time intervals following the treatment. The LLPLD would be responsible for the laboratory analysis costs of these samples, approximately $145 per sample for ProcellaCOR. It is likely that the sampling plan would include at least two sites per application area at roughly eight post application intervals in the hours immediately following the herbicide application (i.e. potentially a minimum of 32 samples). Additional LLPLD costs for this aspect will include the shipment of the samples to SePRO's laboratory for analysis. Overnight shipping of the water samples may be required. Onterra would compile these data for use in subsequent reporting. At the time of the Pre-treatment Survey, Onterra would meet with volunteers from the LLPLD to deliver the herbicide concentration monitoring supplies and provide any necessary training.

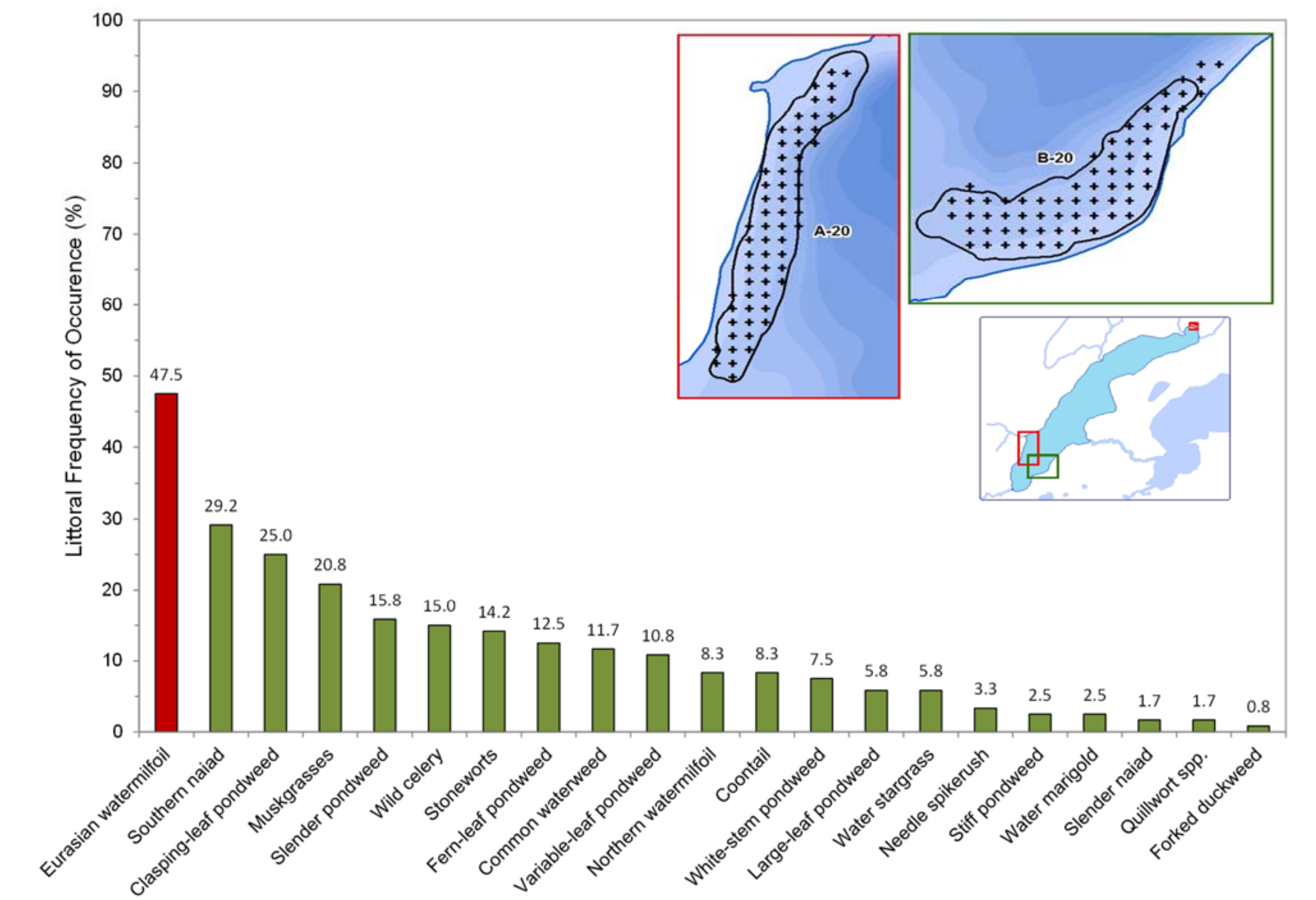


Figure 4. Littoral frequency of occurrence of aquatic plants from a September 2019 sub point-intercept survey within proposed 2020 treatment areas in Long Lake. (A-20 n=62, B-20 n=66).

Table 2 displays the approximate timeline for activities related to the EWM management actions that are proposed to occur in 2020 as a part of the project.

Table 2. Approximate Project Timeline. Some activities conducted as part of previous project.

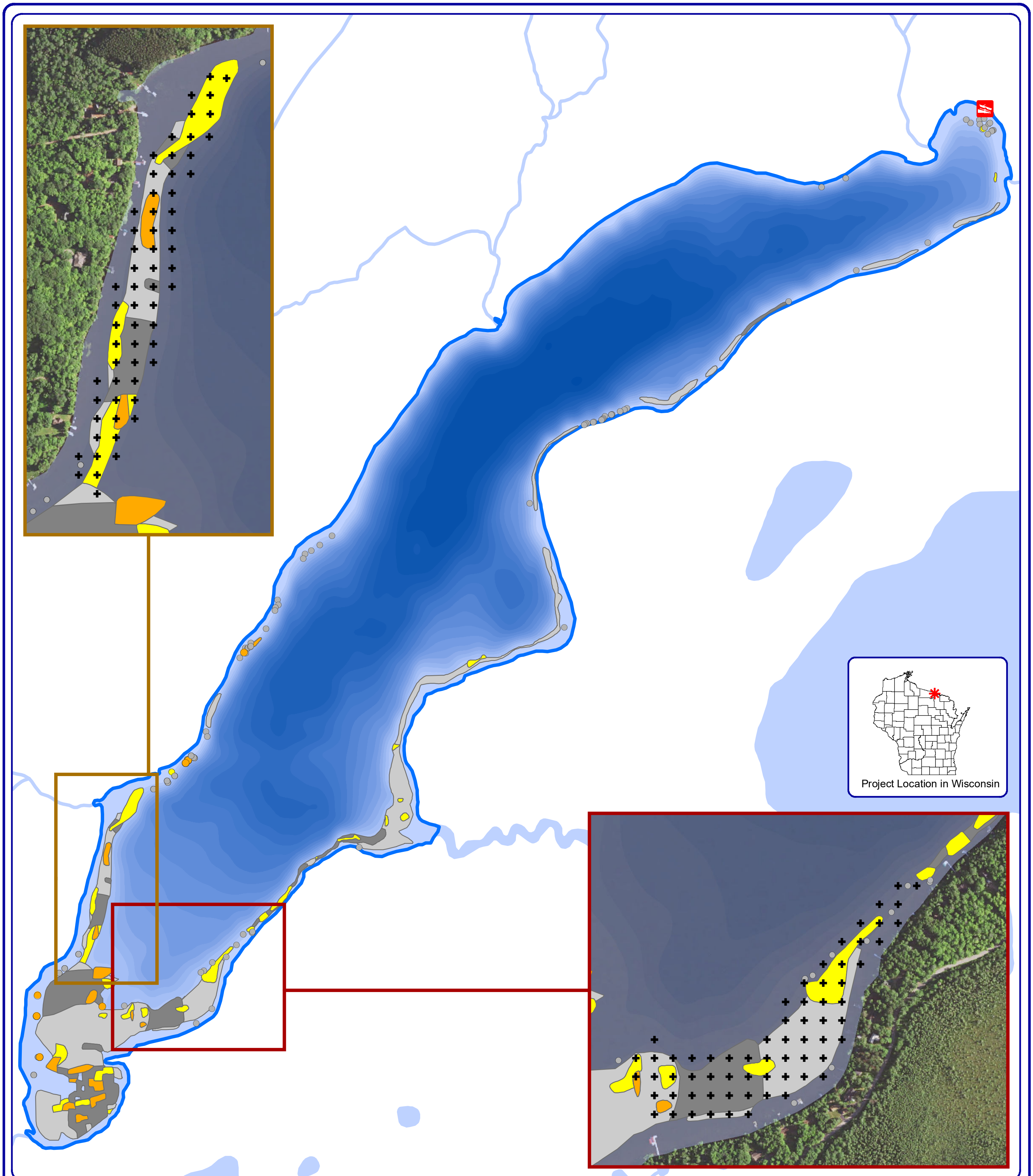
Task	2019					2020												2021	
	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F
2019 Late-Season EWM Mapping Survey		■																	
2019 Sub-Sample Point-intercept Survey (N=127)		■																	
LLPLD Board Discusses 2020 Intentions & Conveys to WDNR			▒																
2020 EWM Management Strategy Development Report					■	■													
Applicator RFP & Selection						▒													
WDNR Permit Application Submission (lead by Applicator)						▒	▒												
2020 Pretreatment Survey & Dosing Strategy Finalization										■									
2020 Communication & Data Transmission with Applicator										■									
2020 Herbicide Spot Treatment Implmentation											▒								
Volunteer Herbicide Concentration Monitoring Collection											▒								
2020 Late-Season EWM Mapping Survey														■					
2020 Sub-Sample Point-intercept Survey (N=127)														■					
2020 EWM Managment Strategy Assessment Report																		■	■

▒ Activities primarily lead by LLPLD

■ Activites primarily lead by Onterra

Hand Harvesting/DASH

Similar to recent years, the LLPLD will explore the option of conducting professional hand harvesting or DASH harvesting in 2020 in select areas of the lake where nuisance conditions are present and where herbicide treatment is not applicable. Any hand harvesting activities that take place will not be specifically coordinated or monitored as a part of the proposed project.



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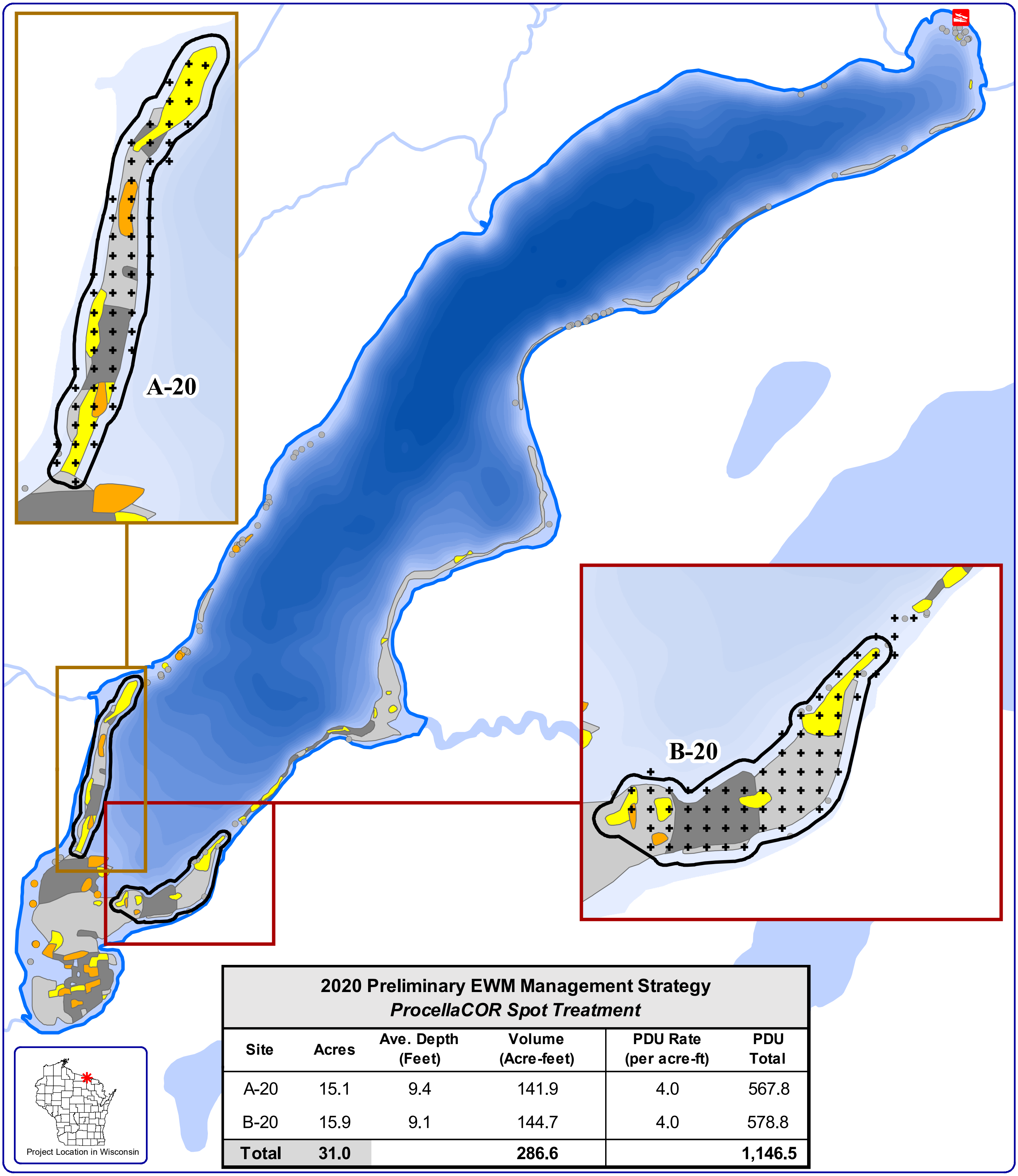
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra, 2014
Aquatic Plants: Onterra, 2019
Map Date: September 30, 2019, HAL

Map 1
Long Lake
Vilas County, Wisconsin

September 2019
EWM Survey Results



2020 Preliminary EWM Management Strategy
ProcellaCOR Spot Treatment

Site	Acres	Ave. Depth (Feet)	Volume (Acre-feet)	PDU Rate (per acre-ft)	PDU Total
A-20	15.1	9.4	141.9	4.0	567.8
B-20	15.9	9.1	144.7	4.0	578.8
Total	**31.0**		**286.6**		**1,146.5**

1,600
Feet

Legend

EWM Mapping Survey Results (September 2019)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Proposed Treatment Area
- Point-Intercept Sub-Sample Location

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Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra, 2014
Aquatic Plants: Onterra, 2019
Map Date: February 24, 2020

Map 2
Long Lake
Vilas County, Wisconsin
Preliminary 2020 EWM Mgmt Strategy v2

A

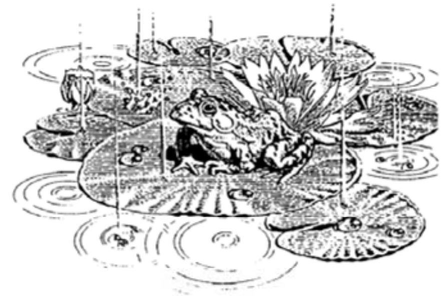
APPENDIX A

WDNR Chemical Fact Sheets

- Florpyrauxifen-benzyl (ProcellaCOR™)
- 2,4-D
- Endothall
- Diquat

January 2012

2,4-D Chemical Fact Sheet



Formulations

2,4-D is an herbicide that is widely used as a household weed-killer, agricultural herbicide, and aquatic herbicide. It has been in use since 1946, and was registered with the EPA in 1986 and re-reviewed in 2005. The active ingredient is 2,4-dichloro-phenoxyacetic acid. There are two types of 2,4-D used as aquatic herbicides: dimethyl amine salt and butoxyethyl ester. Both liquid and slow-release granular formulations are available. 2,4-D is sold under the trade names Aqua-Kleen, Weedar 64 and Navigate (product names are provided solely for your reference and should not be considered endorsements nor exhaustive).

Aquatic Use and Considerations

2,4-D is a widely-used herbicide that affects plant cell growth and division. It affects primarily broad-leaf plants. When the treatment occurs, the 2,4-D is absorbed into the plant and moved to the roots, stems, and leaves. Plants begin to die in a few days to a week following treatment, but can take several weeks to decompose. Treatments should be made when plants are growing.

For many years, 2,4-D has been used primarily in small-scale spot treatments. Recently, some studies have found that 2,4-D moves quickly through the water and mixes throughout the waterbody, regardless of where it is applied. Accordingly, 2,4-D has been used in Wisconsin experimentally for whole-lake treatments.

2,4-D is effective at treating the invasive Eurasian watermilfoil (*Myriophyllum spicatum*). Desirable native species that may be affected include native milfoils, coontail (*Ceratophyllum demersum*), naiads (*Najas* spp.), elodea (*Elodea canadensis*) and duckweeds (*Lemna* spp.). Lilies (*Nymphaea* spp. and *Nuphar* spp.) and bladderworts (Utricularia spp.) also can be affected.

Post-Treatment Water Use Restrictions

There are no restrictions on eating fish from treated water bodies, human drinking water or pet/livestock drinking water. Following the last registration review in 2005, the ester products require a 24-hour waiting period for swimming. Depending on the type of waterbody treated and the type of plant being watered, irrigation restrictions may apply for up to 30 days. Certain plants, such as tomatoes and peppers and newly seeded lawn, should not be watered with treated water until the concentration is less than 5 parts per billion (ppb).

Herbicide Degradation, Persistence and Trace Contaminants

The half-life of 2,4-D (the time it takes for half of the active ingredient to degrade) ranges from 12.9 to 40 days depending on water conditions. In anaerobic lab conditions, the half-life has been measured up to 333 days. After treatment, the 2,4-D concentration in the water is reduced primarily through microbial activity, off-site movement by water, or adsorption to small particles in silty water. It is slower to degrade in cold or acidic water, and appears to be slower to degrade in lakes that have not been treated with 2,4-D previously.

There are several degradation products from 2,4-D: 1,2,4-benzenetriol, 2,4-dichlorophenol, 2,4-dichloroanisole, chlorohydroquinone (CHQ), 4-chlorophenol and volatile organics.

Impacts on Fish and Other Aquatic Organisms

Toxicity of aquatic 2,4-D products vary depending on whether the formulation is an amine or an ester 2,4-D. The ester formulations are toxic to fish and some important invertebrates such as water fleas (*Daphnia*) and midges at application rates; the amine formulations are not toxic to fish or invertebrates at application rates. Loss of habitat following treatment may cause reductions in populations of invertebrates with either formulation, as with any herbicide treatment. These organisms only recolonize the treated areas as vegetation becomes re-established.

Available data indicate 2,4-D does not accumulate at significant levels in the bodies of fish that have been tested. Although fish that are exposed to 2,4-D will take up some of the chemical, the small amounts that accumulate are eliminated after exposure to 2,4-D ceases.

On an acute basis, 2,4-D is considered moderately to practically nontoxic to birds. 2,4-D is not toxic to amphibians at application rates; effects on reptiles are unknown. Studies have shown some endocrine disruption in amphibians at rates used in lake applications, and DNR is currently funding a study to investigate endocrine disruption in fish at application rates.

As with all chemical herbicide applications it is very important to read and follow all label instructions to prevent adverse environmental impacts.

Human Health

Adverse health effects can be produced by acute and chronic exposure to 2,4-D. Those who mix or apply 2,4-D need to protect their skin and eyes from contact with 2,4-D products to minimize irritation, and avoid inhaling the spray. In its consideration of exposure risks, the EPA believes no significant risks will occur to recreational users of water treated with 2,4-D.

Concerns have been raised about exposure to 2,4-D and elevated cancer risk. Some (but not all) epidemiological studies have found 2,4-D associated with a slight increase in risk of non-Hodgkin's lymphoma in high exposure populations (farmers and herbicide applicators). The studies show only a possible association that may be caused by other factors, and do not show that 2,4-D causes cancer. The EPA determined in 2005 that there is not sufficient evidence to classify 2,4-D as a human carcinogen.

The other chronic health concern with 2,4-D is the potential for endocrine disruption. There is some evidence that 2,4-D may have estrogenic activities, and that two of the break-down products of 2,4-D (4-chlorophenol and 2,4-dichloroanisole) may affect male reproductive development. The extent and implications of this are not clear and it is an area of ongoing research.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Wisconsin Department of Natural Resources
Box 7921
Madison, WI 53707-7921

DNR PUB-WT-964 2012

Diquat Chemical Fact Sheet

Formulations

Diquat, or diquat dibromide, is the common name of the chemical 6,7-dihydrodipyrido (1,2-a:2',1'-c) pyrazinediium dibromide. Originally registered by the EPA in 1986, diquat was reregistered in 1995 and is currently being reviewed again. It is sold for agricultural and household uses as well as for use on certain floating-leaf and submersed aquatic plants and some algae. The aquatic formulations are liquids: two of the more commonly used in Wisconsin are Reward™ and Weedtrine-D™ (product names are provided solely for your reference and should not be considered endorsements).

Aquatic Use and Considerations

Diquat is a fast-acting herbicide that works by disrupting cell membranes and interfering with photosynthesis. It is a non-selective herbicide and will kill a wide variety of plants on contact. It does not move throughout the plants, so will only kill parts of the plants that it contacts. Following treatment, plants will die within a week.

Diquat will not be effective in lakes or ponds with muddy water or where plants are covered with silt because it is strongly attracted to silt and clay particles in the water. Therefore, bottom sediments must not be disturbed during treatment, such as may occur with an outboard motor. Only partial treatments of ponds or bays should be conducted (1/2 to 1/3 of the water body). If the entire pond were to be treated, the decomposing vegetation may result in very low oxygen levels in the water. This can be lethal to fish and other aquatic organisms. Untreated areas can be treated 10-14 days after the first treatment.

Diquat is used to treat duckweed (*Lemna* spp.), which are tiny native plants. They are a food source for waterfowl but can grow thickly and become a nuisance. Navigation lanes through cattails (*Typha* spp.) are also maintained with diquat. Diquat is labeled for use on the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) but in practice is not frequently used to control it because other herbicide options are more selective.

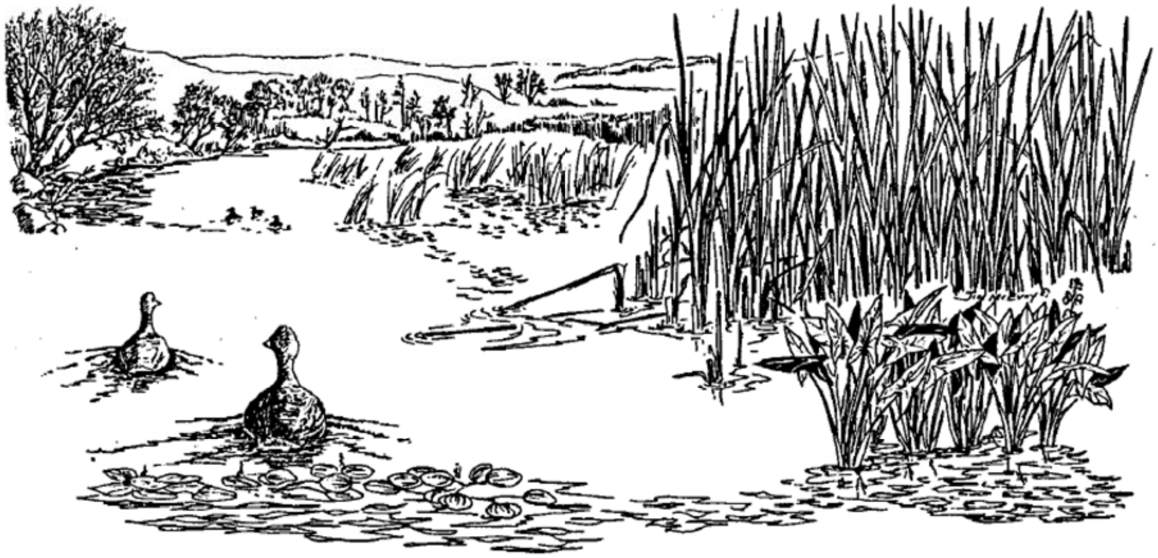
Post-Treatment Water Use Restrictions

There are no restrictions on swimming or eating fish from water bodies treated with diquat. Treated water should not be used for drinking water for one to three days, depending on the concentration used in the treatment. Do not use treated water for pet or livestock drinking water for one day following treatment. The irrigation restriction for food crops is five days, and for ornamental plants or lawn/turf, it varies from one to three days depending on the concentration used.

Herbicide Degradation, Persistence and Trace Contaminants

Diquat is not degraded by microbes. When applied to a waterbody, diquat binds with the organic matter in the sediment indefinitely. It does not degrade and will accumulate in the sediments. Diquat is usually detectable in the water column for less than a day to ~35 days after treatment. Diquat will remain in the water column longer when treating a waterbody with sandy soils due to the low organic matter and clay content. Because of its persistence and very high affinity for the soil, diquat does not leach into groundwater.

Ethylene dibromide (EDB) is a trace contaminant in diquat products. It originates from the manufacturing process. EDB is a carcinogen, and the EPA has evaluated the health risk of its presence in formulated diquat products. The maximum level of EDB in diquat dibromide is 10 ppb (parts per billion), it degrades over time, and it does not persist as an impurity.



Impacts on Fish and Other Aquatic Organisms

At application rates, diquat does not have any apparent short-term effects on most of the aquatic organisms that have been tested. However, certain species of important aquatic food chain organisms such as amphipods and Daphnia (water fleas) can be adversely affected at label application rates. Direct toxicity and loss of habitat are believed to be the causes. Tests on snails have shown that reproductive success may be affected, as well. These organisms only recolonize the treated area as vegetation becomes re-established.

Laboratory tests indicate walleye are the fish most sensitive to diquat, displaying toxic symptoms when confined in water treated with diquat at label application rates. Other game and panfish (e.g. northern pike, bass, and bluegills) are apparently not affected at these application rates. Limited field studies to date have not identified significant short or long-term impacts on fish and other aquatic organisms in lakes or ponds treated with diquat.

The bioconcentration factors measured for diquat in fish tissues is low. Therefore, bioconcentration is not expected to be a concern with diquat.

Human Health

The risk of acute exposure to diquat would be primarily to chemical applicators. Diquat causes severe skin and eye irritation and is toxic or fatal if absorbed through the skin, inhaled or swallowed. Wearing skin and eye protection (e.g. rubber gloves, apron, and goggles) to minimize eye and skin irritation is required when applying diquat.

The risk to water users of serious health impacts (e.g. birth defects and cancer) is not believed to be significant according to the EPA. Some risk of allergic reactions or skin irritation is present for sensitive individuals.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

Wisconsin Department of Agriculture, Trade, and Consumer Protection
http://datcp.wi.gov/Plants/Pesticides/

Wisconsin Department of Natural Resources
608-266-2621
http://dnr.wi.gov/lakes/plants/

Wisconsin Department of Health Services
http://www.dhs.wisconsin.gov/

National Pesticide Information Center
1-800-858-7378
http://npic.orst.edu/

Wisconsin Department of Natural Resources

January 2012

Endothall Chemical Fact Sheet

Formulations

Endothall is the common name of the active ingredient endothal acid (7-oxabicyclo[2,2,1] heptane-2,3-dicarboxylic acid). Endothall products are used to control a wide range of terrestrial and aquatic plants. Both granular and liquid formulations of endothall are available for aquatic use in Wisconsin. Two types of endothall are available: dipotassium salt (such as Aquathol®) and monoamine salts (such as Hydrothol 191). Trade names are provided for your reference only and are neither exhaustive nor endorsements of one product over another.

Aquatic Use and Considerations

Endothall is a contact herbicide that prevents certain plants from making the proteins they need. Factors such as density and size of the plants present, water movement, and water temperature determine how quickly endothall works. Under favorable conditions, plants begin to weaken and die within a few days after application.

Endothall products vary somewhat in the target species they control, so it is important to always check the product label for the list of species that may be affected. Endothall products are effective on Eurasian watermilfoil (*Myriophyllum spicatum*) and also kill desirable native species such as pondweeds (*Potamogeton* spp.) and coontail (*Ceratophyllum* spp.). In addition, Hydrothol 191 formulations can also kill wild celery (*Vallisneria americana*) and some species of algae (*Chara, Cladophora, Spirogyra, and Pithophora*).

Endothall will kill several high value species of aquatic plants (especially *Potamogeton* spp.) in addition to nuisance species. The plants that offer important values to aquatic ecosystems often resemble, and may be growing with those plants targeted for treatment. Careful identification of plants and application of endothall products is necessary to avoid unintended harm to valuable native species.

For effective control, endothall should be applied when plants are actively growing. Most submersed weeds are susceptible to Aquathol formulations. The choice of liquid or granular formulations depends on the size of the area requiring treatment. Granular is more suited to small areas or spot treatments, while liquid is more suitable for large areas.

If endothall is applied to a pond or enclosed bay with abundant vegetation, no more than 1/3 to ½ of the surface should be treated at one time because excessive decaying vegetation may deplete the oxygen content of the water and kill fish. Untreated areas should not be treated until the vegetation exposed to the initial application decomposes.

Post-Treatment Water Use Restrictions

Due to the many formulations of this chemical the post-treatment water use restrictions vary. Each product label must be followed. For all products there is a drinking water standard of 0.1 ppm and can not be applied within 600 feet of a potable water intake. Use restrictions for Hyrdtohol products have irrigation and animal water restrictions.

Herbicide Degradation, Persistence and Trace Contaminants

Endothall disperses with water movement and is broken down by microorganisms into carbon, hydrogen, and oxygen. Field studies show that low concentrations of endothall persist in water for several days to several weeks depending on environmental conditions. The half-life (the time it takes for half of the active ingredient to degrade) averages five to ten days. Complete degradation by microbial action is 30-60 days. The initial breakdown product of endothall is an amino acid, glutamic acid, which is rapidly consumed by bacteria.

Impacts on Fish and Other Aquatic Organisms

At recommended rates, the dipotassium salts (Aquathol and Aquathol K) do not have any apparent short-term effects on the fish species that have been tested. In addition, numerous studies have shown the dipotassium salts induce no significant adverse effects in aquatic invertebrates (such as snails, aquatic insects, and crayfish) when used at label application rates. However, as with other herbicide use, some plant-dwelling populations of aquatic organisms may be adversely affected by application of endothall formulations due to habitat loss.

In contrast to the low toxicity of the dipotassium salt formulations, laboratory studies have shown the monoamine salts (Hydrothol 191 formulations) are toxic to fish at dosages above 0.3 parts per million (ppm). In particular, the liquid formulation will readily kill fish present in a treatment site. By comparison, EPA approved label rates for plant control range from 0.05 to 2.5 ppm. In recognition of the extreme toxicity of the monoamine salt, product labels recommend no treatment with Hydrothol 191 where fish are an important resource.

Other aquatic organisms can also be adversely affected by Hydrothol 191 formulations depending upon the concentration used and duration of exposure. Tadpoles and freshwater scuds have demonstrated sensitivity to Hydrothol 191 at levels ranging from 0.5 to 1.8 ppm.

Findings from field and laboratory studies with bluegills suggest that bioaccumulation of dipotassium salt formulations by fish from water treated with the herbicide is unlikely. Tissue sampling has shown residue levels become undetectable a few days after treatment.

Human Health

Most concerns about adverse health effects revolve around applicator exposure. Liquid endothall formulations in concentrated form are highly toxic. Because endothall can cause eye damage and skin irritation, users should minimize exposure by wearing suitable eye and skin protection.

At this time, the EPA believes endothall poses no unacceptable risks to water users if water use restrictions are followed. EPA has determined that endothall is not a neurotoxicant or mutagen, nor is it likely to be a human carcinogen.

For Additional Information

Environmental Protection Agency
Office of Pesticide Programs
www.epa.gov/pesticides

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National Pesticide Information Center
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http://npic.orst.edu/

Wisconsin Department of Natural Resources

July 2018

Florpyrauxifen-benzyl Chemical Fact Sheet

Formulations

Florpyrauxifen-benzyl was registered with the EPA for aquatic use in 2017. The active ingredient is 2-pyridinecarboxylic acid, 4-amino-3-chloro-6-(4-chloro-2-fluoro-3-methoxyphenyl)-5-fluoro-, phenyl methyl ester. The current Wisconsin-registered formulation is a liquid (ProcellaCOR™ EC) solely manufactured by SePRO Corporation.

Aquatic Use and Considerations

Florpyrauxifen-benzyl is a systemic herbicide that is taken up by aquatic plants. The herbicide is a member of a new class of synthetic auxins, the arylpicolinates, that differ in binding affinity compared to other currently registered synthetic auxins. The herbicide mimics the plant growth hormone auxin that causes excessive elongation of plant cells that ultimately kills the plant. Susceptible plants will show a mixture of atypical growth (larger, twisted leaves, stem elongation) and fragility of leaf and shoot tissue. Initial symptoms will be displayed within hours to a few days after treatment with plant death and decomposition occurring over 2 – 3 weeks. Florpyrauxifen-benzyl should be applied to plants that are actively growing; mature plants may require a higher concentration of herbicide and a longer contact time compared to smaller, less established plants.

Florpyrauxifen-benzyl has relatively short contact exposure time (CET) requirements (12 – 24 hours typically). The short CET may be advantageous for localized treatments of submersed aquatic plants, however, the target species efficacy compared to the size of the treatment area is not yet known.

In Wisconsin, florpyrauxifen-benzyl may be used to treat the invasive Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid Eurasian watermilfoil (*M. spicatum* X *M. sibiricum*). Other invasive species such as floating hearts (*Nymphoides* spp.) are also susceptible. In other parts of the country, it is used as a selective, systemic mode of action for spot and partial treatment of the invasive plant hydrilla (*Hydrilla verticillata*). Desirable native species that may also be negatively affected include waterlily species (*Nymphaea* spp. and *Nuphar* spp.), pickerelweed (*Pontederia cordata*), and arrowhead (*Sagittaria* spp.).

It is important to note that repeated use of herbicides with the same mode of action can lead to herbicide-resistant plants, even in aquatic plants. Certain hybrid Eurasian watermilfoil genotypes have been documented to have reduced sensitivity to aquatic herbicides. In order to reduce the risk of developing resistant genotypes, avoid using the same type of herbicides year after year, and utilize effective, integrated pest management strategies as part of any long-term control program.

Post-Treatment Water Use Restrictions

There are no restrictions on swimming, eating fish from treated waterbodies, or using water for drinking water. There is no restriction on irrigation of turf. Before treated water can be used for non-agricultural irrigation besides turf (such as shoreline property use including irrigation of residential landscape plants and homeowner gardens, golf course irrigation, and non-residential property irrigation around business or industrial properties), follow precautionary waiting periods based on rate and scale of application, or monitor herbicide concentrations until below 2 ppb. For agricultural crop irrigation, use analytical monitoring to confirm dissipation before irrigating. The latest approved herbicide product label should be referenced relative to irrigation requirements.

Herbicide Degradation, Persistence and Trace Contaminants

Florpyrauxifen-benzyl is broken down quickly in the water by light (i.e., photolysis) and is also subject to microbial breakdown and hydrolysis. It has a half-life (the time it takes for half of the active ingredient to degrade) ranging from 1 – 6 days. Shallow clear-water lakes will lead to faster degradation than turbid, shaded, or deep lakes.

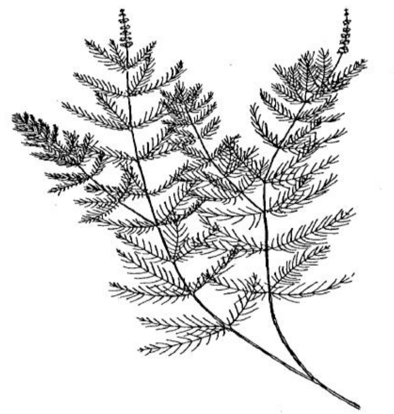
Florpyrauxifen-benzyl breaks down into five major degradation products. These materials are generally more persistent in water than the active herbicide (up to 3 week half-lives) but four of these are minor metabolites detected at less than 5% of applied active ingredient. EPA concluded no hazard concern for metabolites and/or degradates of florpyrauxifen-benzyl that may be found in drinking water, plants, and livestock.

Florpyrauxifen-benzyl binds tightly with surface sediments, so leaching into groundwater is unlikely. Degradation products are more mobile, but aquatic field dissipation studies showed minimal detection of these products in surface sediments.

Impacts on Fish and Other Aquatic Organisms

Toxicity tests conducted with rainbow trout, fathead minnow, water fleas (*Daphnia* sp.), amphipods (*Gammarus* sp.), and snails (*Lymnaea* sp.) indicate that florpyrauxifen-benzyl is not toxic for these species. EPA concluded florpyrauxifen-benzyl has no risk concerns for non-target wildlife and is considered "practically non-toxic" to bees, birds, reptiles, amphibians, and mammals.

Florpyrauxifen-benzyl does not bioaccumulate in fish or freshwater clams due to rapid metabolism and chemical depuration.



Human Health

EPA has identified no risks of concern to human health since no adverse acute or chronic effects, including a lack of carcinogenicity or mutagenicity, were observed in the submitted toxicological studies for florpyrauxifen-benzyl regardless of the route of exposure. EPA concluded with reasonable certainty that drinking water exposures to florpyrauxifen-benzyl do not pose a significant human health risk.

For Additional Information

Environmental Protection Agency Office of Pesticide Programs
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