NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION
Division of Fish, Wildlife and Marine Resources
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A Synoptic Review of Technical Information Regarding the Use of Herbicides in Fish-Bearing Waters of the State

March 7, 2005

This document supersedes the Bureau of Habitat Technical Memorandum entitled "1999 Guidance for Aquatic Herbicides", dated April 15, 1999. (The actual technical memorandum is dated April 15, but the cover memo was dated May 11, 1999).

Purpose

Regional Natural Resources staff (i.e., Regional Fisheries/Habitat Managers/Biologists) can be called upon to review applications for permits to treat aquatic vegetation with herbicides in fish-bearing waters. This document is a compilation of technical information from the 1981 Programmatic Environmental Impact Statement (PEIS)[1], pesticide product labels, chemical-specific Supplemental Environmental Impact Statements (SEIS) and scientific literature. It's purpose is to provide the necessary information to Regional Natural Resource staff to assist them in making decisions regarding aquatic vegetation control (AVC) permits from an ecological perspective. This document does not make recommendations such as one herbicide product over another. It does, however, try to identify circumstances when an herbicide active ingredient might present higher, potentially unacceptable, levels of risk to aquatic life. It also tries to identify when there is inadequate information to assess the potential risks that might be associated with a particular herbicide active ingredient or product.

This is only a synoptic review. That is, it does not contain all of the information available regarding a particular product or active ingredient. It should provide enough information to assist Natural Resources Staff most of the time in reaching a decision. If additional information is desired, or more detail is needed, consult the product label or request assistance from the Ecotoxicology and Standards Unit of the Bureau of Habitat (BoH).

Division of Fish, Wildlife and Marine Resources Interests in Aquatic Vegetation Control

6NYCRR Part 327.3(3) states that: " . . . permits [for aquatic vegetation control] shall be granted under such limitations as will protect to the greatest extent possible all terrestrial life, aquatic life

[1] Final Programmatic Environmental Impact Statement on Aquatic Vegetation Control Program of the Department of Environmental Conservation Division of Lands and Forests, May 1, 1981

other than aquatic vegetation intended to be controlled or eliminated, all public and domestic water supplies and irrigation, recreational, agricultural, and industrial water uses."

When this regulation is coupled with the mission statement for the Division of Fish, Wildlife and Marine Resources (DFWMR) and the mission statement for BoH, three principles emerge that can define DFWMR's "interests" in aquatic vegetation control:

1. Protect aquatic life from direct toxicity and excessive loss of habitat;

2. Maintain healthy and diverse ecosystems;

3. Manage fish-bearing waters of the state to support a wide array of uses.

From these three interests, a general "philosophy" can be constructed to guide Natural Resource staff in making decision regarding the use of aquatic herbicides:

> Aquatic plants are an integral part of a healthy aquatic ecosystem, and necessary to maintain a productive fishery. Aquatic herbicide use should be limited to only what is needed to prevent vegetation from interfering with human activities. Vegetation classified as Aquatic Nuisance Species (ANS)[2], however, should be considered as "biological pollution", and should be targeted for control or eradication (if possible), unless such control would cause long term harm to the ecosystem or productive use of the fish-bearing water.

Aquatic and terrestrial life can be impacted both by the direct toxic action of an applied herbicide, as well as by the actual removal of aquatic vegetation itself. Aquatic vegetation is an integral component of an aquatic ecosystem. Fish, reptiles, amphibians, aquatic birds, aquatic mammals, and invertebrates rely on aquatic vegetation for shelter, protection, spawning substrate, and food.

On the other hand, aquatic vegetation can grow in dense beds that impede boating, fishing, and swimming. Decomposing plants can release noxious odors, litter beaches, and remove dissolved oxygen from the water. However, by intercepting runoff, storing nutrients, and stabilizing sediments, macrophytes retard algal blooms and improve water clarity. Suddenly removing macrophyte beds could reduce water clarity, force fish to graze zooplankton offshore, and stimulate phytoplankton (algae) blooms from the unstored nutrients and reduced pressure of invertebrate predation. Widespread

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[2] Aquatic Nuisance Species (ANS) are: non-indigenous species that threatens the diversity or abundance of native species or the ecological stability of infested waters, or commercial, agricultural, aquacultural, or recreational activities dependent upon such waters", from Federal Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, (NANPCA) Public Law 101-646.

ecosystem changes can result from unwittingly removing macrophyte beds[3]. These changes can in turn impact the enjoyment that people receive from living around and recreating on lakes.

General Recommendations Regarding Waters Open to the Public

Waters open to the public include all of the larger lakes in the state where the bottom of the lake is state owned up to mean high water line. These include the Great Lakes (Erie, Ontario), Chautauqua Lake, Lake Champlain, Lake George, Oneida Lake and the Finger Lakes (except Hemlock). Other lakes where the ownership of the bottom may be uncertain are considered open to the public whenever there is any publicly-owned land touching the shoreline of the lake (e.g., a public beach, boat launch, or a roadway) and such lands are not posted or regulated against general public access. In all such water open to the public, the following guidelines should be considered before recommending in favor of the issuance of a permit for use of chemicals in water to control aquatic vegetation:

A. Undeveloped shorelines should not be treated.

B. Shorelines adjacent to publicly-owned lands may be treated only with the concurrence of the agency having jurisdiction of such lands.

C. Aquatic plants that are not interfering with human activities such as swimming and boating should not be treated. Previous recommendations (i.e., BoH Technical Memorandum entitled "1999 Guidance for Aquatic Herbicides, dated April 15, 1999). had stated generally that:

> "Treatment for rooted aquatics (vascular plants) may not be done more than 200 feet from shore or in water over six feet deep."

6NYCRR Part 327 does not specify such a limitation, except as a specific condition regulating the use of diquat dibromide (6NYCRR Part 327.6(b)(5)) and 2,4-D (6NYCRR Part 327.6(c)(5). For permit applications requesting the use of those herbicides, the cited regulations are applicable. Such a restriction cannot be specifically mandated for other herbicides without a revision of 6NYCRR Part 327.

The apparent intent of the "six foot deep / 200 foot from shore" rule is to allow herbicide use where necessary to allow human activity such as boating and swimming access, but to limit herbicide use in areas where human activities are not being In waters open to the public, without stating any specific numerical limits, the Bureau of Habitat (BoH) recommends that herbicide treatments should be limited to areas where swimming, boating, and other human

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[3] From Engel, S., (1985). Aquatic Community Interactions of Submerged Macrophytes. Technical Bulletin No. 156, Wisconsin Department of Natural Resources, P.O. Box 7921, Madison, Wisconsin 53707

activities are adversely impacted because of excessive growth of aquatic vegetation. Conversely, BoH recommends that in order to preserve areas of aquatic vegetation utilized as habitat, herbicide treatments should not occur when the targeted aquatic vegetation is in water so deep that it does not interfere with human activities, no matter how close to the shoreline the vegetation is located.

D. Herbicides should not be permitted in rivers or streams. A site specific environmental impact statement should be required before introducing aquatic herbicides into flowing waters.

E. The number of treatments allowed in a single year is governed by the pesticide product label, except for diquat dibromide, for which only one application per season is allowed (6NYCRR 327.6(b)(6)).

F. Any treatment which would result in demonstrable harm to fisheries resources should be denied or conditioned as the situation warrants. For example, the proposed area of treatment could be modified; a different herbicide recommended; the timing of the treatment changed to avoid fish spawning; etc. The use of less than the labeled application rate is not an acceptable condition. In earlier editions, BoH had recommended that the herbicide diquat not be applied in any water with a stressed bass, muskellunge, or walleye population. Such a recommendation is prudent, but the cause of the stress should also be taken into consideration. For example, a lake might have a bass population that is perceived to be stressed because large bass have very poor condition, but the forage fish population is extremely large and stunted. Such a combination might suggest that excessive aquatic vegetation is the cause of the stress. Too much vegetation might be providing too much shelter for forage fish, and larger predators simply can't get at them. In such a case, aquatic vegetation control treatments might work to benefit the fish community as a whole.

G. The use of an aquatic herbicide within a regulated wetland requires an Article 24 permit in addition to a pesticide permit. The Article 24 permit should address concerns and impacts specific to the wetland proposed for treatment.

H. These general recommendations might not be applicable when a treatment is proposed to control an aquatic nuisance species (ANS). See the following section.

I. Killing large masses of vegetation suddenly, particularly in the summer when a thermocline exists, could lead to a rapid depletion of DO as the dead vegetation decays, which could in turn result in fish kills. Several herbicide and algaecide labels specifically restrict treatments to ½ or less of the total lake surface area when conditions exist (such as warm water and large dense stands of vegetation) that could make DO depletion a concern. The likelihood of DO depletion should also be considered in backwater embayments or other sites on large lakes where there is poor water circulation.

Some of the individual items above may conflict with eachother. For example, a dense stand of vegetation may exist adjacent to an undeveloped shoreline that is perceived to be interfering with a human activity. In this instance, the Natural Resources Staff must develop a recommendation that balances the potential benefit to human users against the potential risks to the ecology of the lake.

Aquatic Nuisance Species (ANS)

Certain plant species that occur in the waters of New York State meet the definitionof Aquatic Nuisance Species (see footnote 2, above). The list includes:

A. Eurasian watermilfoil; *Myriophyllum spicatum*
B. water chestnut; *Trapa natans*
C. curly-leaf pondweed; *Potamogeton crispus*
D. fanwort; *Cabomba caroliniana*
E. European frogs-bit; *Hydrocharis morsus-ranae*
F. Purple loosestrife; *Lythrum salicaria* (wetland ANS)
G. common reed; *Phragmites australis* (wetland ANS)

Plants such as these alter the natural habitat of New York's waterways, and usually interfere with boating, fishing, and swimming by growing completely to the surface in thick, dense stands. They usually lack specific predators, pathogens, and parasites that may occur back in their native range and not in the newly invaded habitat. As a result they can often out-compete and displace native vegetation.

Plants such as these should be targeted for control. The habitat of a water body that has been colonized by invasive, non-indigenous plants is already impaired. It is particularly important to aggressively control these plants in the earliest stages of an introduction to keep the plant species from completely colonizing the lake. General recommendations such as not treating undeveloped shorelines or not treating plants that are not interfering with human activities may not be applicable when the purpose of a proposed herbicide treatment is to control one of the ANS identified above. However, if a water body has been infested with ANS for a long period of time, the overall risks to the aquatic ecology of large scale treatment programs must be taken into account, particularly if it seems unlikely that the treatment program will result in the eradication of the ANS, or if eradicating the ANS might result in other, undesirable changes.

Large scale, whole lake treatments have been both proposed and accomplished in New York in order to eradicate Eurasian watermilfoil. Eurasian watermilfoil reproduces primarily by fragmentation, so native aquatic plants that reproduce by seeds are likely to recover and repopulate a treated lake. Without any doubt, such treatments have the potential to dramatically alter lake ecology. The removal of all vegetation will also impact young fish and invertebrates that require vegetation for cover and forage. The macrophyte community will be dramatically altered when recovery does occur. All whole lake treatments to eradicate Eurasian watermilfoil should be carefully evaluated in a SEQRA review, but that is not to say that the treatment should not occur. A well-designed, carefully monitored whole

lake treatment has the potential to eliminate this aggressive invasive species, to restore a native plant community, and may result in an overall benefit to the state; and, therefore, should be carefully considered.

Such whole lake treatment proposals should be accompanied with a program to educate boaters, lakefront property owners, and others who use the lake about ANS, how they are introduced, and what can be done to keep Eurasian watermilfoil[4] from re-invading the lake once it has successfully been removed.

Chemical Specific Information and Recommendations

The purpose of this section is to provide information and recommendations to all Regional Natural Resources Staff who might be tasked to review aquatic vegetation control permit applications, so they may be aware of the chemicals which are approved for use; the allowable dosages or application rates for each chemical; and other concerns and issues related to specific herbicides. The Pesticide Control Specialist in each region should have available copies of the labels for each pesticide formulation as registered with EPA and the Department. Pesticide labels are also available via the internet using the Department's PIMS (Pesticide Product, Ingredient, Manufacturer System) at http://pmep.cce.cornell.edu/pims/current/ . Always consult the label to determine the maximum allowable amount of active ingredient in the chemical proposed for use, water use restrictions, or other pertinent information.

The following sections describe the active ingredients for aquatic algaecides and herbicides registered for use in New York State. Appendix 1 contains a cross reference listing of active ingredients, formulations, and product names.

Copper sulfate (pentahydrate) ($CuSO_4 \cdot 5H_2O$)

Copper sulfate is the chemical most commonly used for control of algae. Its use is regulated both by the approved pesticide label and regulations (6NYCRR Part 327.6(a)). These regulations describe specific restrictions as to when copper sulfate can be used, how much can be used, how it is applied, how frequently it can be applied, and specific water use restrictions which apply above and beyond those on the product label(s):

327.6(a) Copper sulfate for algae

(1) Active ingredient. $CuSO_4 \cdot 5H_2O$

[4] Most other ANS besides Eurasian watermilfoil reproduce by seeds, so a single whole lake treatment is not likely to be successful in bringing about long term control of other plant ANS.

(2) Purpose. Authorized for algae control

(3) Periods of treatment. Generally, May to September. Treatments later than Labor Day will require special authorization.
(4) Dosage. Not to exceed 0.3 ppm $CuSO_4 \cdot 5H_2O$ in the upper six feet of depth in ponds or lakes with over two acres of surface area. Not to exceed 0.3 ppm $CuSO_4 \cdot 5H_2O$ in the total volume of ponds with two acres or less of surface area. The above is based on water of average alkalinity for the State (100 ppm or over). In softer waters, a reduced dosage may be required.

(5) Method of application. No permit shall be issued for the direct broadcasting of crystals or "snow". Copper sulfate should be applied as a liquid using spray equipment or as a solid placed in a burlap bag dragged behind a boat.

(6) Repeat treatments. Shall not be authorized at any interval of less than two weeks.

(7) Water-use restrictions. Bathing and livestock watering shall be prohibited for at least 24 hours following a treatment.

Because these restrictions are in regulation, they must be observed even if they conflict with the approved label. A concentration of 0.3 ppm copper sulfate pentahydrate is equivalent to a concentration of 0.076 ppm ionic, or elemental copper. 6NYCRR Part 327.6(a)(4) states that "The above [0.3 ppm] is based upon water of average alkalinity for the State (100 ppm or more). In softer waters, a reduced dosage may be required." The Bureau of Habitat has interpreted this limitation in the following manner: In water of 100 ppm hardness or greater, allow 0.3 ppm copper sulfate. If the hardness is between 50 - 100 ppm hardness, allow 0.2 ppm copper sulfate (0.543 pounds per acre foot of water). If the hardness is less than 50 ppm, allow only 0.1 ppm copper (0.272 pounds per acre foot of water). Water supply reservoirs may be treated without a permit, but applications must still comply with label conditions and applicable regulations.

Copper sulfate use can lead to the depletion of dissolved oxygen as killed algae settle to the bottom and are degraded. Copper sulfate labels warn that only a third to a half of a lake or pond should be treated at a time to avoid DO depletion and a 7 - 14 day period should separate treatments. Users of copper based products should be aware that much of the copper applied to the water will settle to the bottom and accumulate in the sediments. It may eventually cause toxicity to bottom-dwelling benthic organisms. If Natural Resources Staff has concerns that a buildup of copper in lake bottom sediments might be causing adverse impacts to the benthos, the sediments should be tested. There are no other water use restrictions on the label[5].

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[5] Labels do contain the statement: If treated water is to be used as a source of potable water, the metallic residual must not exceed 1 ppm copper; however, use rates that high are not allowed in any water in New York State.

Chelated Copper Compounds[6]

These are other copper-based compounds that are also registered for use to control algae. Most use organically chelated copper (i.e., copper that is not in an ionic form but bound, or complexed, with other substances usually referred to as ligands) as the active ingredients. For all copper pesticides, the cupric ion (Cu^{+2}) is the primary toxic agent. Chelated copper products differ considerably, however, from copper sulfate. When applied to water, copper sulfate disassociates rapidly to release cupric ions (Cu^{+2}), the form of copper that is responsible for most toxicity. However, cupric ions are very reactive, and they don't persist in the water very long. They rapidly bind with soluble anions such as hydroxide (OH^-), carbonate (CO_3^{--}), dissolved organic carbon (DOC) such as humic and fulvic acids, and other substances which work to remove ionic copper from the water column and mitigate toxicity. The soluble organic chelated complexes work differently. Because they are soluble, the chelated copper complex remains in the water column for a longer period of time. Cupric ions are slowly released into the water as the organic ligands are degraded by microbial metabolism. As a result, chelated copper compounds exhibit lower toxicity to fish and most invertebrates than copper sulfate.

The product labels generally all bear the warning: "This product may be toxic to trout and other species of fish. Fish toxicity is dependent upon the hardness of the water and the sensitivity of the fish species present. Do not use in water if the carbonate hardness[7] of water does not exceed 50 ppm. [Do not use in waters containing Koi and hybrid goldfish[8]].

6NYCRR Part 327.6(a) specifically addresses the use of copper sulfate for control of algae. The use of <u>other</u> copper compounds to control algae or other aquatic plants is not addressed by this regulation. The lowest label application rate of two of the most common products, Cutrine Plus and Cutrine Ultra (0.6 gallons in 1 acre/foot of water), would result in a concentration of 0.2 ppm; and the lowest label application rate of Cutrine Plus Granular would result in an elemental copper concentration of 0.135 ppm in six feet of water (and higher in shallower water). These rates all exceed the copper sulfate dose-equivalent of 0.076 ppm copper as allowed under 6NYCRR Part 327.6(a). Using these products at rates lower than those recommended on the label is inadvisable (and illegal) because it

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[6] This section refers to ethylenediamine complexes, mixed ethanolamine complexes, and triethanolamine complexes of copper.

[7] The carbonate hardness of water includes the portion of total hardness associated with bicarbonate and carbonate in the water column. This has been called "temporary" hardness, because it disappears as water is softened by boiling and the ensuing precipitation of calcium carbonate and magnesium carbonate. From <u>Textbook of Limnology</u>, 2nd ed., by Gerald A. Cole, 1979.

[8] The section in brackets appears on the Cutrine Ultra and Cutrine Plus Algaecide/Herbicide labels. It may appear on others as well.

would expose aquatic organisms to risk, and there would be potentially little benefit as the dose would be less than what is required to control nuisance levels of algae.

Recent toxicity studies[9] have shown that copper sulfate is about four times more toxic than Cutrine Plus is a mixed copper ethanolamine complex. However, the margins of safety are minimal for non-target species, indicating the need for caution in their use.

Based on the most recent toxicity data relating to chelated copper products, the Bureau of Habitat recommends the following:

A. For chelated copper compound treatments, the applicant must:

1. Demonstrate that the carbonate hardness for the water to be treated is ≥ 50 ppm, and can be expected to remain ≥ 50 ppm continuously for the 5 - 10 days it will take for the copper from the product to dissipate from the water column.

2. Comply with label instructions limiting treatments to only 1/3 -1/ 2 of the total surface area of the pond under conditions of heavier infestation or low oxygen levels.

B. For non fish-bearing waters, or ponds completely owned by the applicant with little or no outflow, the products can be used as labeled.

C. For other waters, the Bureau of Habitat does not object to applications that would not exceed a maximum concentration of 0.2 ppm, the lowest label application rate for control of planktonic and filamentous algae, based on the Cutrine product labels.

D. For applications at higher rates, the use of chelated copper products should be carefully reviewed. Caged fish studies and/or a site-specific Supplemental Environmental Impact Study might be required.

E. The algaecide "Algimycin PWF" has the active ingredient Copper citrate, copper gluconate chelates. This chemistry has not been evaluated by the Bureau of Habitat. BoH cannot comment regarding it's potiential for impacts to aquatic life.

F. **Nautique** is another copper-based product registered for use in New York that is labeled for control of aquatic macrophytes. The Nautique label claims that this product is a chelated copper formulation, which suggests that it behaves similarly as the other chelated copper compounds discussed above. However, the label identifies the active ingredient only as copper

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[9] Murray-Gulde, C. L., J. E. Heatley, A. L. Schwartzman, and J. H. Rodgers, Jr. 2002. Algicidal effectiveness of Clearigate, Cutrine-Plus, and Copper Sulfate and margins of safety associated with their use. Arch. Environ. Contam. Toxicol. 43:19-27 (2002).

carbonate. When applied according to the label, Nautique has the potential of being applied at much higher copper concentrations than are currently allowed for copper sulfate. This product has not been reviewed by the Division of Fish, Wildlife and Marine Resources, and its use to control aquatic macrophytes is not addressed or covered by the aquatic vegetation control programmatic EIS. Furthermore, the Environmental Hazards section of the Nautique label explicitly states that "Trout and other species of fish may be killed at application rates recommended on this label." If an applicant should request to use Nautique for macrophyte control, the amount of Nautique to be applied should be carefully evaluated along with the overall size of the treated area and the size of the lake or pond. If the final concentration of copper in the water column would exceed that allowed for copper sulfate, (0.076 mg/l of elemental copper) a site-specific SEIS should be required before Nautique could be used, because the potential risks of this product have not been assessed.

G. Several other products have the active ingredient Arsonic acid, copper (2+), salt (see appendix 1). The chemistry of this product is completely unknown. The chemistry and potential adverse impacts should be thoroughly reviewed before this product is used in fish-bearing waters.

2,4-D

This herbicide is marketed in numerous formulations, including low volatile esters such as iso-octyl ester and butoxyethyl ester (BEE); diethyl- and dimethyl- amines, and salts. Despite the numerous formulations, the active ingredient of 2,4-D is measured as the 2,4-dichlorophenoxy acetic acid equivalent, which is generated when the products are applied to the water. The Bureau of Habitat considers all 2,4-D formulations acceptable for use, as long as all products are applied in accordance with their label.

Regulations were promulgated in 6NYCRR Part 327.6(c) that specifically govern the use of 2,4-D in New York State above and beyond the product labels. Those regulations include the following restrictions:

1. Authorized only for the control of emergent plants having a large part of their leafy growth projecting above or lying flat on the water surface[10];

2. Use restricted to late spring or early summer when the chemical is most effective;

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[10] Eurasian watermilfoil is not typically classified as "emergent" vegetation, however, it certainly meets the standard in the regulation of having a larger part of their leafy growth projecting above or lying flat on the water surface.

3. Use of chemical solutions (i.e., liquid formulations) for dosage of up to eight pounds active ingredient per acre may be permitted in the treatment of dense stands. Use of pellets for subsurface application requires special authorization.

4. The treatment area shall not extend beyond 200 feet from shore or beyond a maximum depth of six feet, whichever gives the greater distance from shore.

5. Use of waters for irrigation shall be prohibited for a period sufficient to permit the decay of phytotoxicity. The treated waters and those waters affected by the treatment shall not be used for other purposes during the treatment and for at least 24 hours thereafter.

NYCRR Part 327.6 does not identify what constitutes the "special authorization" needed for the use of granular, pelletized formulations of 2,4-D. In the absence of other guidance, the approval of a permit application to use granular products by the Regional Pesticide Control Specialist should be construed as the necessary special authorization required by the regulations.

Application rates of these granular formulations should not exceed 20 - 40 lb. active ingredient (acid equivalent) per acre (e.g., 100 lb/acre of a 20% active ingredient acid equivalent formulation), depending on the susceptibility of the target vegetation. For example, 20 lbs AI/acre should be adequate to control Eurasian watermilfoil, but 30 - 40 lbs AI/acre are required to control water chestnut. It should be noted that 2,4-D is the only aquatic herbicide registered for use to control water chestnut.

Diquat Dibromide

Diquat is a contact herbicide[11] that is absorbed through the foliage of submerged plants. It is a "knockdown" product; it kills standing vegetation but it does not kill the entire plant, and regrowth of treated plants should be anticipated. All diquat products are registered in New York State under a Special Local Needs (SLN) registration that provides for more stringent use conditions than are in effect in other states or under the EPA-registered label. Concerns were raised about diquat when toxicity tests conducted at the Bureau of Habitat's Rome Field Station showed that diquat was very toxic to very young fish. Diquat product labels allow undiluted herbicide to be poured directly out of the container into the water from the back of a boat. When applied in this manner, "hot spots", or high concentrations of diquat, can occur. These might persist within the dense weed beds long enough to potentially be lethal to young-of-the-year fish sheltered there. The Bureau of Habitat helped to develop the SLN registration. We recommended that the best way to prevent "hot spots" was to dilute diquat

[11] A contact herbicide kills only the plant tissue with which they make direct contact. They are applied directly to weeds and are not translocated. A systemic herbicide is one that is translocated throughout the plant, and can cause a toxic injury anywhere in the plant or throughout the entire plant.

and apply it only by boom sprayer. BoH also recommended that diquat not be applied in very shallow water (i.e., less than three feet deep).

The SLN establishes the conditions under which diquat can be used in New York State:

A. For application only to ponds, lakes, and drainage ditches where there is little or no outflow of water and which are totally under the control of the product's user.
B. Do not treat water where depth is three feet or less. Where water is three feet of more deep use the following rates based on the weeds present (see below).
C. Dilute all applications by mixing with water prior to a treatment at a dilution of 1 part product to 200 parts, or more, water.
D. Apply only by spray to the surface of a lake with a boom sprayer.
E. Do not use diquat for algae control in New York.
F. Do not combine copper with diquat in New York.
G. Do not apply by air in New York.
H. Do not use for control of waterlettuce in New York.
I. Do not apply under conditions involving possible drift to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use, or consumption.
J. Application rates:

		Gallons /surface acre
Submerged weeds	Bladderwort	1-2
	coontail	2
	elodea	2
	naiad	1
	Potamogeton spp.	2
	Eurasian watermilfoil	1-2
Floating weeds	Pennywort	1/ 2 - 3/4
	salvinia	1/ 2 - 3/4
	water hyacinth	1/ 2 - 3/4
	duckweed	1
Emergent weeds	cattails	1

Any application of diquat must be consistent with the requirements of the SLN registration. In addition to the limitations required with the SLN registration, Diquat is also specifically regulated in 6NYCRR Part 327.6(b). All of the restrictions listed in that regulation, however, are addressed by the SLN with two exceptions, water use restrictions[12] and treatment area. According to 6NYCRR Part 327.6(b)(5), diquat treatment areas shall not extend beyond 200 feet from shore or beyond a maximum depth of six feet, whichever gives the greater distance from shore.

[12] Water use restrictions for all of the chemicals are described in a separate section in this document.

Endothall

The are several formulations of this herbicide. Aquathol K uses the dipotassium salt of endothall in liquid form as its active ingredient. Aquathol Super K Granular is the same chemical in granular form and provides a slow release of the active ingredient at the lake or pond bottom thus having less impact on the entire water column. The label calls for application rates from 0.5 - 5.0 ppm, depending on the species of vegetation targeted for control. The label provides a chart so the user can determine how much product needs to be applied in order to achieve a particular active ingredient concentration in parts per million in different volumes of water.

Hydrothol 191 (Liquid) and Hydrothol 191 (Granular) are formulated with the dimethylalkylamine salt of endothall as the active ingredient. These chemicals can cause fish kills at dosages slightly above 0.3 ppm. The Hydrothol label states that the product is generally effective at controlling algae at application rates between 0.05 - 0.3 ppm; however, the label allows for application rates as high as 1.5 ppm for algae control. For control of aquatic macrophytes, the label application rates are as high as 3 ppm. Fish appear to avoid amine salts of endothall if given the opportunity. Young-of-the-year and other juvenile life stage fish sheltered in vegetation in shallow water, three feet or less, might not have the opportunity to avoid the chemical treatment, as these fish are not likely to venture out into open water. The lack of a sizeable safety margin between efficacious application rates and toxicity thresholds suggests this product ought not be used where early life stage fish are likely to be present.

Endothall, like diquat, is a contact herbicide that will "knock down" standing vegetation, but not necessarily kill the plant or prevent regrowth the following season, or even later in the same season. One difference between endothall and diquat is that endothall appears to work more slowly than diquat. This is significant because a large, rapid die-off of plant material could lead to a depletion of dissolved oxygen, particularly below the thermocline.

The Bureau of Habitat recommends against the use of Hydrothol products in fish-bearing waters. Aquathol K is the preferred endothall product for fish-bearing waters because it is inherently less toxic. Only as much endothall should be applied as is needed to control the target vegetation. For example, curly-leaf pondweed is controlled at an application rate of 1.5 - 3.0 ppm; Eurasian watermilfoil is controlled at an application rate of 3.0 - 4.0 ppm. Very few targeted aquatic plant species would require treatment at rates as high as 5.0 ppm.

Fluridone

Fluridone is a systemic herbicide that comes in two forms, an aqueous suspension (AS) and several varieties of granular formulations. The federal label allows liquid fluridone to be applied in concentrations as high as 150 ppb. Because of concerns raised by the Department of Health, liquid formulations of fluridone are registered under a Special Local Needs (SLN) registration, which states

that no single application can exceed a concentration of 50 ppb, and the sum of multiple applications during the same season cannot exceed a total of 150 ppb. The concentration limits are based on the volume that is applied, and not on concentration as measured in the water column. The restriction that application rates of the aqueous suspension of fluridone not exceed a water column concentration of 50 ppb is also stated in 6NYCRR Part 326.2(b)(4)(i). Lower application rates (≤ 20 ppb) are required within 1/4 mile of potable drinking water intakes.

Multiple applications during the same season is an important factor for successful fluridone treatments. A concentration of fluridone that is lethal to target plants must be maintained for a 30 to 90 day period. The current protocol for extended fluridone treatments is to apply the product, then periodically measure the fluridone concentration in the water column using fasTEST, which is an enzyme-linked immunoassay (ELISA) test. If the fluridone concentration starts to fall below efficacious levels in the treatment area, a booster application is made to restore the effective lethal concentration.

Fluridone is generally described as a selective herbicide, because some plants such as Eurasian watermilfoil (EWM) are killed at concentrations as low as 6 - 8 ppb, although at this low concentration, the duration of the treatment needed for success is longer. The experience with fluridone use in New York, particularly in whole lake treatments to remove all EWM, is that all vegetation is likely to be killed during the treatment. Ideally, native plants that grow from seeds will regrow in subsequent years, and some regrowth of native plants from seeds can also occur during the same year as the treatment.

Granular, "slow release" formulations are the preferred tool for partial lake treatments. Pelletized products are not limited to the same conditions on the SLN label; the federal EPA label is applicable. The same approach of multiple treatments based on the use of fasTEST results in order to maintain a lethal concentration can be accomplished with pelletized formulations as well. 6NYCRR Part 326.2(b)(4)(ii) states that pelletized formulations may only be applied in water two feet deep or greater.

Fluridone's mode of action is to disrupt the synthesis of enzymes that are needed by a plant for photosynthesis. Because this mode of toxicity is so specialized for plants, fluridone exhibits very little, if any, direct toxicity to fish or aquatic invertebrates at concentrations allowed on the product labels. The greatest concern related to fluridone use is that with whole lake treatments, all vegetation is likely to be killed, not just the target species, and there is no guarantee what kind of, and how much, aquatic vegetation will grow back. Dramatic changes in the plant community are likely to have similarly significant changes in the fish community. Partial lake treatments with pelletized formulations are not likely to have significant lake-wide impacts, particularly if the general recommendations (Regarding Waters Open to the Public), above, are observed.

Eurasian watermilfoil is particularly susceptible to fluridone, both because it is highly sensitive to low concentrations, and because it doesn't generally reproduce from seeds. Eurasian watermilfoil is also an ANS (see the section on Aquatic Nuisance Species, above). Ridding a lake of this invasive, nonindigenous plant can lead to a restored native plant community that is less likely to adversely affect

human activities. However, if the lake is populated by fish species that are highly dependent upon vegetation, and if impairment to that fish population is unacceptable, then smaller, partial lake treatments should be considered for EWM control rather than whole lake treatments.

A supplemental EIS covering the use of fluridone has been completed and approved by the Department.

Glyphosate

Glyphosate is a systemic herbicide that causes toxicity by interfering with the plant ability to synthesize proteins and produce new plant tissue. It is an effective herbicide for controlling emergent and floating vegetation. It is not effective against submerged vegetation because it is rapidly diluted and dissipated in the aquatic environment. It must be applied to foliage in order to be absorbed. Glyphosate should not be applied to vegetation ½ mile upstream of a drinking water intake in flowing water, or within ½ mile of a drinking water intake in a ponded water. Applications should be made to actively growing plants to maximize effectiveness, and spray nozzle settings must be set to avoid fine mists which are capable of drifting. Aquatic organisms are generally not sensitive to glyphosate, and the normal application rates are well below toxicity thresholds. A supplemental EIS covering the use of glyphosate has been completed and approved by the Department.

Sodium Carbonate Peroxyhydrate

This is the active ingredient of a new, non-copper based algaecide, Greenclean Granular Algaecide, that was registered in New York in 2004. When applied to water, the active ingredient reacts to generate hydrogen peroxide, which is a potent oxidizer. Hydrogen peroxide is highly unstable, and it quickly dissipates from the environment. The label states: "Apply Greenclean Granular to any water or surface sites except treated, finished drinking water reservoirs or drinking water receptacles." This product is also intended to remove algae from surfaces that are in contact with water and are likely to accumulate algal growth, such as non-painted floors, walkways, storage areas, patios, decks, siding, boats, piers, docks, ramps, etc. Other commercial and horticultural sites identified on the label include water gardens, power washing, landscapes, drainage systems, impounded waters, wastewater, and irrigation systems. It can be applied directly in its granular form, as a solution (liquid) or as a foam. The label application rates for treating water bodies are 90 - 500 lbs/million gallons of water for heavy algae growth and 9 - 50 lbs/million gallons of water for low algae growth/maintenance (a pond with a mean depth of three feet and a diameter of 63 feet would constitute a volume of 1,000,000 gallons of water). This product is a restricted use pesticide. All pesticides applied to surface waters are restricted use. However, because the product is individually classified as restricted use, even those applications that are not made to surface water bodies can only be made by certified pesticide applicators. The only environmental hazards identified on the label are that the product is toxic to birds and highly toxic to honeybees. The Bureau of Habitat has no experience with this product and cannot make recommendations other than that the product be used strictly in accordance with the label. A technical

review of this product and its toxicity to non-target organisms suggests that this product will not be harmful to fish or aquatic invertebrates.

Simazine

Currently, no products containing simazine as the active ingredient are registered for outdoor use in fish-bearing waters in New York state. Accordingly, no permit applications for simazine products should be approved.

2,4,5-TP (Silvex)

No herbicides containing this active ingredient may be authorized due to the potential for dioxin contaminants.

Water Colorants

Certain products function to control aquatic plants and algae by adding dyes to the water. These dyes block critical wavelengths of light and inhibit photosynthesis. They are not pesticides *per se*, because they are not directly toxic to plants. However, because their label makes pesticidal claims (i.e., control aquatic weeds, etc.) they must be registered, and permits are required before they can be applied to waters of the state. The products registered for use in New York use tartrazine (acid yellow 23) and erioglaucine (acid blue 9) as the active ingredients. They are generally applied at rates that result in a water column concentration of 1 - 2 ppm (mg/L). Both dyes are food grade dyes. A search of EPA's ECOTOX database revealed that the Ceriodaphnia dubia 48 hour EC_{50} for tartrazine was 5706 mg/L. No fish toxicity data were listed. For erioglaucine, the 48 hour EC_{50} for Daphnia magna was >97 mg/L[13]. The rainbow trout 96 hour LC_{50} for erioglaucine was between 412 - 1474 mg/L. Toxicity thresholds for these dyes are several of orders of magnitude higher than the concentrations at which they are used.

Water Use Restrictions

Water use restrictions are specific limitations placed on water that has been treated with a pesticide. The following table identifies the water use restrictions generally associated with each active ingredient. There might be differences on individual product labels. Not all individual product labels were checked.

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[13] When a LC_{50} or EC_{50} is described as "greater than (>)", it signifies that little or no mortality (or effect) occurred, and the LC_{50} or EC_{50} is higher than the highest concentration tested.

Active Ingredient	Water Use Restriction	Source
copper sulfate	Bathing and livestock watering shall be prohibited for at least 24 hours following a treatment	6NYCRR Part 327.6(a)(7)
chelated copper compounds	None	
2,4-D	Use of the waters for irrigation shall be prohibited for a period sufficient to permit the decay of phytotoxicity. The treated waters and those waters affected by the treatment shall not be used for other purposes during the treatment and for at least 24 hours thereafter.	6NYCRR Part 327.6(c)(6)
2,4-D cont'd	Unless an approved assay indicates the 2,4-D concentration is 100 ppb or less, or, only growing crops and non-crop areas labeled for direct treatment with 2,4-D will be affected, do not use water from treated areas for irrigating plants or mixing sprays for agricultural or ornamental plants. Unless an approved assay indicates the 2,4-D concentration is 70 ppb or less, Do not use water from treated areas for potable water (drinking water).	2,4-D liquid BEE labels
diquat dibromide	Treated waters shall not be used for irrigation, bathing, fishing, or by man or animals for drinking or food processing for a period of 14 days after treatment	6NYCRR Part 327.6(b)(7)
Endothall, (mono (N,N-dimethylalkylamine salt)	Do not use water from treated areas for watering livestock, for preparing agricultural sprays for food crops, for irrigation for domestic purposes within the following periods: up to 0.3 ppm - 7 days after application; up to 3.0 ppm - 14 days after application; up to 5.0 ppm - 25 days after application Do not use fish from treated areas for food or feed within three days of treatment	Hydrothol 191 Label and Hydrothol 191 granular label

Active Ingredient	Water Use Restriction	Source
Endothall, dipotassium salt	Do not use water from treated areas for watering livestock, for preparing agricultural sprays for food crops, or for domestic purposes within seven days of treatment. Do not use fish from treated areas for food or feed within three days of treatment	Aquathol Super K granular label
Endothall, dipotassium salt cont'd	Do not use water from treated areas for watering livestock, for preparing agricultural sprays for food crops, for irrigation of for domestic purposes within the following periods: up to 0.5 ppm - 7 days after application; up to 4.25 ppm - 14 days after application; up to 5.0 ppm - 25 days after application. Do not use fish from treated areas for food or feed within three days of treatment.	Aquathol K label
Fluridone	Swimming is not allowed in treated waters for twenty four (24) hours following the application.	6NYCRR Part 326.2(b)(4)(iii)
fluridone cont'd	Irrigation from a fluridone AS application may result in injury to the irrigated vegetation. The label suggests the following time frames to avoid irrigation with treated water to reduce the potential for injury: established tree crops - 7 days after application; established row crops/turf/plants - 14 to 30 days after application; newly seeded crops/seed beds or areas to be planted - assay required.	SLN Label
glyphosate	None	Glyphosate GEIS[14]
sodium carbonate peroxyhydrate	None. Waters treated with GreenClean Granular are permissible to be used without interruption	GreenClean label
water colorants	None	

[14] Use of the Registered Aquatic Herbicide Fluridone (Sonar) and the Use of the Registered Aquatic Herbicide Glyphosate (Rodeo and Accord) in the State of New York, Final Generic Environmental Impact Statement, Version 5.0. January 10, 1995.

Water Holding or Flow Restrictions

Natural resources staff should be concerned that an herbicide applied in a lake or pond might leave the pond via the outfall, and have effects downstream in areas where riparian owners have not been notified of the treatment and/or have not given their consent. Also, some aquatic herbicides specifically state on the label that they are intended for use in ponds " . . . with little or no outflow". The likelihood of the herbicide leaving the treatment area via an outfall should always be addressed during the permit application process. The application should explain why this is not a concern; e.g., the treated areas are far away from the outfall, they are using a granular formulation that will not cause a significant concentration of herbicide in the water column, treated areas are small relative to the surface area of the lake, the lake has a relatively small outfall, the herbicide in use has a relatively short half-life in water, or there are no water use restrictions with this product. Alternatively, the applicants could treat the reach of downstream water that would be affected as part of the proposed treatment area, and meet all regulatory requirements for that reach as well as in the lake, although herbicide treatments in flowing waters are highly discouraged. If there are substantive concerns, such as in a long-duration, lakewide Sonar treatment for Eurasian watermilfoil eradication, then a site-specific EIS for the proposed treatment should be required.

In some situations where the movement of an herbicide out of the lake via an outfall is viewed as a potential problem, applicators have proposed to limit, restrict, or totally block the flow of water out of the lake. At present, there are no specific limits or regulations regarding blocking the flow of water out of a lake into a stream. Nor are there any specific requirements in Pesticide law or regulations requiring that flow be blocked or restricted for a treatment to take place. So the issues to be considered are: 1) determining if a flow restriction is necessary; 2) deciding if blocking the flow out of a lake is ecologically acceptable for both the outfall stream that will lose flow, and the lake itself that must retain the additional water; and 3) If so, how long must the flow be blocked or restricted?

Regional natural resources staff should make the determination whether or not restricting the flow out of a lake is acceptable or not. Some lakes have dams already installed, and flow restrictions are a common occurrence. Some outfalls are very slow, quiescent waters, and restricting the flow out of the lake might not have much downstream impact, particularly for a short period of time. Outfall tributaries might receive flow from other lakes or tributaries, thus restricting the flow from one upstream source might not have a significant downstream affect. If restricting the flow would pose a threat to aquatic life in the outfall stream, then the flow restriction should not be allowed. Natural Resources staff must determine if an Article 15 permit would be required, particularly if restricting the flow would necessitate installing a structure.

Flow restrictions should be as short as possible. They would generally coincide with the duration of any applicable water use restrictions. For example, the Aquathol Super K Granular label states: Do not use water from treated areas for watering livestock, for preparing agricultural sprays for food crops, or for domestic purposes within seven days of treatment. Do not use fish from treated

areas for food or feed within three days of treatment. If there was a concern that this herbicide treatment could have downstream effects, and flow restriction was acceptable, then the flow would have to be restricted at least seven days, the duration of the water use restriction.

Pond Restoration/Water Quality Improvement Products

In the past few years, an increasing number of Pond Restoration or water quality improvement products have appeared on the market, such as *Algae-Tron, BacMan, Bacta-Pur, PondSaver, and POWER.* These products contain concentrated volumes of native soil bacteria that clarify water by "consuming" excess nutrients. These products were originally developed for use in hatcheries to clean up uneaten fish food and waste. Many of the modern products are marketed on the basis that they can control algae and suppress the growth of aquatic macrophytes. The EPA recently ruled that products that make pesticidal claims, such as "control" algae, or "suppress" aquatic plant growth, are in fact pesticides and must be registered. None of these products are currently registered as pesticides in New York. Current guidance from the EPA is that if products make specific claims to suppress or control the growth of algae or aquatic plants, then they should be registered and managed as pesticides. They must be registered both by the EPA and New York State, and according to 6NYCRR Part 326.2(h), can only be applied by certified applicators with a permit. If the products do not make pesticidal claims, but only claim to clarify the water, or improve water quality, then they are not considered to be pesticides, can be applied by anyone, and a permit is not required. This guidance is consistent with the guidance being provided to regional pesticide control specialists. These products are generally not toxic or otherwise harmful to fish or aquatic invertebrates.

Barley Straw

In recent years, barley straw has been identified as a substance that will control the growth of algae in ponds. It is unlawful to sell barley straw if the seller claims that barley straw "controls" algae. This is because the words "controls algae" makes barley straw a pesticide from a legal perspective according to the EPA and is therefore subjected to all the rules associated with unregistered pesticides. Certified commercial applicators, lake management companies, and garden/nursery companies cannot legally sell barley straw if algae control claims are made.

Research has been conducted on barley straw to assess whether or not it really can control algae. The results have been inconclusive. Natural Resources staff should refrain from encouraging or promoting the use of barley straw to control algae. In public waters, Natural Resources staff should definitely discourage anyone from placing barley straw into a pond or lake. In regards to privately-owned waters, inquiries about the use of barley straw should simply be referred to the following websites: Information on the use of barley straw can be obtained via the internet from Ohio State University at: http://ohioline.osu.edu/a-fact/0012.html or from Purdue University at: http://www.btny.purdue.edu/Pubs/APM/APM-1-W.pdf.

Additional Comments

1. Diquat and endothall are "knockdown" products. They do not kill the entire plant, but they will knock down the standing plant biomass. Aquatic vegetation treated with these compounds will regrow shortly after treatment. However, they can provide seasonal control.

2. Fluridone, 2,4-D, and glyphosate are "systemic" herbicides that actually kill plants completely. Plants treated with these compounds are not likely to grow back. Stands of treated aquatic vegetation can regrow from seeds or reintroduction. Plants that did not receive a lethal dose can recover.

3. Eurasian watermilfoil reproduces asexually by fragmentation. A one inch fragment can settle to the sediment and grow into a new plant. Mechanical harvesting of Eurasian watermilfoil is likely to produce fragments that can re-seed areas where vegetation was removed by harvesting or herbicides.

4. When large masses of vegetation are killed suddenly by herbicides, they will sink to the bottom and be degraded by bacteria. Microbial degradation of large masses of dead aquatic vegetation can deplete the water column of dissolved oxygen, particularly in the summer under the thermocline, or when the lake is shallow. To preclude this problem, treatments should occur as early in the growing season as possible. The lake could also be divided up into sections which are treated at different times.

5. Whole lake treatments are generally restricted to fluridone applications to eradicate Eurasian watermilfoil. Regional Natural Resources staff should carefully consider the worst-case impacts when reviewing such proposals. The worst case scenario is that all vegetation will be removed, and only limited re-growth will occur in subsequent years. There could be a dramatic shift in the aquatic vegetation community, which could in turn dramatically change the fish community. For example, In Chautauqua lake, milfoil disappeared in the early 1990s, probably because of herbivorous insects. Milfoil was replaced in part by eelgrass[15]. This change in vegetation was surely a factor in a concomitant shift in the fishery from sunfish to white perch, as eelgrass favors the white perch's reproductive process of broadcasting eggs over vegetation. The potential for such changes in a lake ecosystem need to be considered and balanced against the obvious benefit of eradicating the Eurasian watermilfoil. Any such whole lake treatment proposal should include a comprehensive, long term plan for keeping Eurasian watermilfoil from being re-introduced.

[15] Chautauqua County Federation of Sportsmen, Ad Hoc Chautauqua Lake Vegetation Control Committee, Position Statement, Chautauqua Lake Vegetation Control Program, April 27, 1999.

Appendix 1. Pesticide products registered for use in New York State as aquatic herbicides and/or algaecides, from NYSDEC PIMS database, as of December 13, 2004 (http://pmep.cce.cornell.edu/pims/current/)

Active Ingredient	Formulation	Product name
Copper	Copper sulfate pentahydrate	AB Brand Copper Sulfate Crystal F&B Copper Sulfate Crystal Diamond Copper Sulfate Nalco Cuprose Algaecide Blue Viking Copper Sulfate Crystal Tennessee Brand Copper Sulfate Crystal Formula F-30 Algae Control Martex Bluestone Pond Master Copper Sulfate Crystals
	Arsonic acid, copper (2+), salt	Aquatrols Radiance Algaecide for Lakes and Ponds Earthtec Stock Plex
	ethylenediamine complex	Pondmaster Aquatic Herbicide Pondmaster Aquatic Algaecide* Aquacure Aquatic Herbicide Komeen
	Mixed ethanolamine complex	Cutrine-Plus Algaecide/Herbicide Lescocide-Plus Algaecide Lesco Lescocide-Plus Granular Algaecide Clearigate Captain Liquid Copper Algaecide
	triethanolamine complex	Cutrine Ultra Gordon's Aquacure Aquatic Algaecide K-Tea Algaecide
	Copper citrate, copper gluconate chelates	Algimycin PWF
	Copper carbonate	Nautique Aquatic Herbicide

Active Ingredient	Formulation	Product name
2,4-D (2,4-dichlorophenoxyacetic acid)	Dimethylamine	2,4-D Amine 4 Riverdale Weedestroy AM-40 Agrisolutions 2,4-D Amine 4 Opti-amine Nufarm Weedar 64 Broadleaf Herbicide Tenkoz Amine 4 2,4-D Herbicide Savage Dry Soluble Herbicide
	Butoxyethyl ester (BEE)	Navigate Aqua-Kleen Nufarm Aqua-Kleen
	Sodium salt	Aquacide Pellets
	2 ethylhexyl ester	2,4-D LV4 Riverdale 2,4-D L. V. 4 Ester
	iso-octyl (2-octyl) ester	Barrage HF
Diquat dibromide	N/A	Reward Landscape & Aquatic Herbicide (SLN) Aqua-Trim II, Liquid Vegetation Control (SLN) Reward AccuGel Aquatic Herbicide (SLN)
Endothall	mono(N,N-dimethylcocoamine) salt	Hydrothol 191 Granular Aquatic Hydrothol 191 Aquatic
	Dipotassium salt	Aquathol Super K Granular Aquatic Herbicide (SLN) Aquathol K Aquatic Herbicide (SLN)
Fluridone	N/A	Sonar AS (SLN label) Avast (SLN label) Sonar SRP Avast SRP Sonar Q Sonar PR

Active Ingredient	Formulation	Product name
Glyphosate	isopropylamine salt	Shore-Klear Aquatic Herbicide Riverdale Aquaneat Aquatic Herbicide Aqua-Neat Aquatic Herbicide Du Pont Glyphosate VMF Herbicide Eagre Aquatic Herbicide Aquamaster Herbicide Nufarm Aquaneat Aquatic Herbicide Glyphomate 41 Gordon's Farm Pondmaster Surface and Shoreline Herbicide Aqua Star Rodeo Accord Aquapro Glypro Glyfos Aquatic Herbicide Hi-Yield Kilzall Aquatic Herbicide
Sodium carbonate peroxyhydrate	N/A	Greenclean Granular Algaecide
Water colorants	Tartrazine, Erioglaucine	Aquashade Aquashade OA Hydroblock Gordon's Pondmaster Blue Admiral WSP Admiral Liquid