COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DIVISION OF ADMINISTRATIVE LAW APEALS

IN THE MATTER OF
DEPARTMENT OF CONSERVATION AND RECREATION
Docket No. DEP-04-919
DEP FILE #233-547
NATICK

TESTIMONY OF HOWARD HOROWITZ, Ph.D. .

I, Howard Horowitz, do hereby swear and affirm the following:

1. I am Professor of Geography in the School of Theoretical and Applied Science at Ramapo College of New Jersey, and have taught there since 1982. I teach courses in natural resources for the Environmental Science and Environmental Studies majors, including Water Resources and Forest Resources. From 1979-1981, I worked as a consultant for the US Environmental Protection Agency on the Cancellation Proceedings for the herbicide 2,4,5-T, and gave testimony as an expert witness in those proceedings.

2. I received a B.A. in history from the University of Rochester in 1969, an M.A. from the University of Oregon in 1974, and a Ph.D. in biogeography from the University of Oregon in 1982.

3. I have been retained by the Petitioners in this matter to determine whether the application of diquat dibromide as proposed in the Notice of Intent, and as approved with conditions by the Natick Conservation Commission and the Massachusetts Department of Environmental Protection ("DEP")(the "Project"), will improve the natural capacity of Lake Cochituate, and the land under the lake, to protect "environmental interests" in a way that will minimize adverse impact on those interests. I have been asked to assume that the specific environmental interests of concern in this proceeding are pollution prevention, protection of public or private water supplies, protection of groundwatrer, protection of fisheries, and protection of wildlife habitat. I have undertaken this work on a *pro bono publico* basis. The great majority of my opinions, as set forth herein, are stated to a reasonable degree of scientific certainty. Because of the inherent uncertainty of some incompletely understood issues, a few of my opinions are based on professional experience and reasonable interpretation of the evidence.

4. The documents I have reviewed pertaining to this matter include:

a) Notice of Intent Application, Aquatic Management Program, Lake Cochituate, Natick, MA, April 2003, Aquatic Control Technology.

b) Massachusetts DEP Superseding Order of Conditions 233-47, Issued March 9, 2004.

c) Lake Cochituate Long-Term Vegetation Management Plan, Aquatic Control Technology, May 2004.

d) Notice of Claim for Adjucatory Hearing, March 23, 2004.

e) Administrative Appeal to the Massachusetts Department of Environmental Protection, dated June 19, 2003, with attachments.

f) Letter to Rachel Freed, DEP, from Martin Levin, Stern Shapiro Weissberg & Garin, RE: Wetlands/Natick DEP File 233-547 Lake Cochituate, dated October 24, 2003, with Exhibits.

g) Guidance for Aquatic Plant Management in Lakes and Ponds as it Relates to the Wetlands Protection Act, Wetlands/Waterways Program, April 2004.

h) Testimony of Richard F. Yuretich, Ph.D., prepared for this proceeding, dated April 28, 2005.

i) Testimony of Emily Monosson, Ph.D., prepared for this proceeding, dated May 2, 2005.

j) Scientific and other literature relevant to this testimony, as identified in the attached list of References.

In addition to reviewing those documents, I visited Lake Cochituate in August 2004, drove and hiked to various locations around the lake, and rented a boat to explore the shoreline and get a better sense of place.

5. The Guidance for Aquatic Plant Management in Lakes and Ponds, referenced in paragraph 4g above, states on p. 1-2 with respect to projects proposing aquatic plant management (such as the Project proposed in the NOI):

> "Applicants proposing a limited project under 310 CMR 10.53(4) must demonstrate that the project will improve the natural capacity of a resource area(s) to protect some or all of the interests of the Wetlands Protection Act (WPA). To meet this test, a project must improve the natural ability of a resource area to protect public or private water supply, groundwater, fisheries, wildlife habitat, or to provide flood control, storm damage prevention, and/or to prevent pollution. Although a project does not need to improve the natural capacity of the resource area to protect all of the interests of the act, it must improve at least one interest and it should minimize the adverse affect (sic) on the interests that are not targeted for improvement.
>
> Projects proposing aquatic plant management to improve the natural ability of a resource area to provide recreation, aesthetics, odor reduction, or other similar interests do not qualify under 310 CMR 10.53(4) because those interests are not protected by the WPA regulations. These projects would need to meet other applicable, relevant general performance standards."

Because I do not understand the project to have any relationship to flood control or storm damage prevention, I do not address those interests in my testimony.

6. The question of whether the Project will accomplish the goal of effectively removing or controlling nuisance weeds, while minimizing adverse effects on environmental interests requires a comparison of the efficacy and the impact of chemical weed control with other alternatives. In formulating my opinion, in addition to the documents reviewed, I rely on over twenty years of experience with vegetation management and control techniques.

7. During the 1970s, I was a reforestation worker and forest field researcher in the Pacific Northwest, and also did graduate work in biogeography at the University of Oregon. That reforestation work included numerous contracts for tree planting, stand exams, manual release, fire fighting, stream rehabilitation, and other jobs. This operational experience with a workforce has proven to be very relevant to these herbicide issues, because it leads to the examination of practical questions and solutions that desk-bound "experts" may never even consider.

8. With several colleagues, I co-founded Groundwork, a non-profit forest workers research group that developed a more accurate field survey system for evaluating conifer-shrub growth interactions than the survey systems in widespread use. Systematic growth measurements revealed that many areas listed as high priority sites for herbicide usage actually had little or no potential to benefit from such treatment. We worked with various federal agencies, state agencies, and universities on efforts to improve vegetation management practices on forest lands. Some of the Groundwork concerns were validated by the US GAO report Better data needed to determine the extent to which herbicides should be used on National Forest lands (CED-81-46), 1981.

9. Since coming to teach at Ramapo College, I have critically examined several operational herbicide programs on public lands and waters. These programs have ranged from lake treatments similar to the one proposed on Lake Cochituate to programs based in forests, in tidal wetlands, and on right-of-way corridors. Although the particular chemicals vary from one ecosystem to another, these vegetation management programs share basic policies that effectively tilt the decision-making process towards greater herbicide usage.

10. The recurring elements that tilt the decision-making process towards greater herbicide usage include the following. 1) Less than candid minimization of "risk" in public documents and hearings. This is accomplished largely by avoiding the issues altogether, using the smokescreen of "risk assessment" models which make the risks disappear behind dubious "margins of safety". 2) Systematic exaggeration of the economic benefits of herbicide usage, often resting on false economies of scale. 3) Avoidance of a legitimate Environmental Impact Assessment process, because of inadequate consideration of viable alternatives. 4) Reliance by government agencies charged with environmental protection and pesticide regulation on the expertise offered by pesticide applicators.

11. Herbicides and other pesticides have made their way onto our lands, into our waters, and into our own bodies. This disturbing reality has been verified by numerous monitoring programs in recent years, although the general public is at best only dimly aware of the problem. According to extensive field monitoring performed by the US Geological Survey, over 90% of our nation's surface waters, and over 90% of the fish samples, tested positive for residues of one or more pesticides. (Decades of pesticide use have resulted in their widespread occurrence in streams and groundwater. USGS Circ. #1225, 2000). This contamination extends into our own bodies. Every one of us has pesticide residues in our tissues, although there are significant differences in body burden levels between age groups, sexes, and other factors.

12. Herbicides show up widely in the environment because they are heavily used in many sectors of our society, including for weed management in lakes. The major pathways by which these pesticide residues travel through the environment are known. Direct application of an herbicide into a water body such as Lake Cochituate is an obvious pathway of potential contamination and exposure, especially if the lake feeds into a drinking water supply. Other pathways by which pesticides and other toxic chemicals enter into the ecosystem and into our bodies include movement through groundwater and soil, movement through air, movement through skin, and movement through the food chain. "Best management practices" are touted as protection against movement through these pathways. However, in reality, these "BMPs" are often quite insufficient to prevent environmental contamination.

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13. Given our knowledge of the widespread presence of these potentially harmful residues, it is regrettable that our federal and state regulatory systems do not effectively prevent the wasteful overuse of these pesticides. Although educational institutions teach about Integrated Pest Management (IPM) in classes, and regulatory agencies claim to be guided by its principles, public policy rarely encourages the implementation of IPM programs. Key elements of IPM programs include accurate field monitoring, objective evaluation of alternatives, and the choice of pesticides only when need is demonstrated and the alternatives are not as effective. Similar expectations are embedded in a variety of critical state and federal laws. Many effective IPM programs have been developed, and where implemented have reduced pesticide usage substantially. However, the regulations governing the issuance of pesticide permits generally do not require the key IPM elements to be effectively incorporated into the permitting process. I am describing a general pattern here, and will later discuss how the proposed herbicide treatment of Lake Cochituate fits this pattern in many ways.

14. The permitting systems operated by state agencies function as almost automatic approval systems for proposed herbicide usage, as long as the material is registered and the label is followed. Registration is the outcome of complex federal and state regulatory processes, and the label refers to the instructions for proper product usage. However, neither the registration process nor the label addresses the site-specific conditions unique to each place and circumstance, which is what IPM is supposed to do. Issues such as "need for treatment" and "alternatives" do not get effectively considered in the permitting process.

15. Risk assessment is a part of the regulatory process that depends on the quantification of highly uncertain variables. It requires extrapolation from abstract models, and the resulting numbers become embedded as critical "data" in the registration process. Despite its centrality in shaping pesticide registration decisions, the reality is that different models, with somewhat different sets of assumptions, will produce different outcomes. The judgment calls built into the models largely control the outcomes. The numbers the process generates are accorded scientific authority that they do not deserve. These risk assessment models do not provide reliable assurance of pesticide safety, to either ecosystems or to human health. The fact that a pesticide is registered does not guarantee that it is safe. The EPA has always explicitly recognized that, and does not permit labels to say "safe when used in accordance with instructions". Although it is wrong, the proponents of herbicide usage often suggest that EPA registration is proof of safety.

16. The Lake Cochituate Long Term Management Plan (2004) says "Registered herbicides must meet strict federal guidelines and demonstrate that there is not an "unreasonable risk" to humans and the environment when applied in accordance with the product label. According to Madsen (June/July 2000), "currently no product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to human health, the environment, or wildlife resources. In addition, it may not show evidence of biomagnification, bioavailability or persistence in the environment." With this sweeping paragraph, the plan inaccurately characterizes even the dubious risk assessment methodology relied on by the federal government in pesticide registration, in an apparent attempt to curtail any further discussion of scientific data regarding possible fish or invertebrate species hazards or environmental persistence in Lake Cochituate. The less than "one in a million chance of causing significant damage" is an unreliable number that should not be confused with legitimate science.

17. Since Lake Cochituate feeds directly into public water supplies it is especially important to avoid the potential for contamination. Hundreds of lakes are routinely treated with aquatic herbicides every year, but most of them do not feed into public water supplies. I have examined the regulatory permits for numerous herbicide treatments for lakes in the northeastern United States. Most of these lakes get retreated annually, sometimes with combinations of several herbicides and algicides. Although many of these herbicide treatments could have been avoided by the implementation of IPM procedures, citizens did not get involved in opposing their permitting processes because they were not drinking water supplies. However, concerned citizens, including me, have gotten involved in two instances where public water supplies were potentially affected by proposed herbicide usage: Greenwood Lake on the NY/NJ border in 1998, and Lake Cochituate at the present time.

18. Although the Greenwood Lake and Lake Cochituate proposals differ in some respects, they both involve the use of the herbicide diquat dibromide, and they both involve Eurasian watermilfoil as the principal target weed. Therefore, issues such as the impacts of diquat dibromide on fish and other species, and the effectiveness of alternatives for watermilfoil control, are common to both Greenwood Lake and Lake

Cochituate. Observations that I made regarding Greenwood Lake in 1998, about the ecosystem impacts of diquat and the effectiveness of alternative management strategies, apply equally to Lake Cochituate at the present time.

19. Diquat dibromide is harmful in many ways. To begin with, it may be feto-toxic, mutagenic, and teratogenic. Feto-toxic means "poisonous to embryos"; mutagenic means "causes genetic changes in living cells"; teratogenic means "induces changes in cells, tissues, and organs that cause birth defects". The literature on this is extensive, yet incomplete in many ways. Some studies indicate mutagenicity, others do not. Some lab studies had design limitations that made clear interpretation difficult. Selypes, et al (1980) "Mutagenic and embryotoxic effects of paraquat and diquat" (Bull. Env. Contam. Tox. 25:513-7) is one of several disturbing articles in this regard. The State of New Jersey Hazardous Substance Fact Sheet for Diquat (CAS # 85-00-7, 2001) states "Reproductive Hazard: Diquat dibromide may decrease fertility in males." Diquat also contains so-called "inert ingredients" that are not inert in the usual sense of the word, and may also be toxic. Among them is ethylene dibromide (EDB), a known carcinogen. The precautionary principle should prevail: potentially feto-toxic, mutagenic, and teratogenic substances should not be released into the environment on a routine basis, and should certainly not be deliberately introduced into sources of drinking water.

20. Diquat dibromide has been shown to be very harmful to fish. The literature on diquat and fish will disturb anyone who reads it. There is little or no margin of safety between operational treatment dosages and potentially damaging sub-lethal effects. Lethal doses are as little as 2.1 parts per million (ppm) for walleye, 5.1 ppm for smallmouth bass, and 7.8 ppm for largemouth bass. (See Holtz, 1990 The effects of the herbicides diquat and aquathol-K on selected physiological parameters in fishes from Chautauqua Lake, NY (SUNY_Fredonia, MS thesis, Table 1.1). Of greater concern are the sub-lethal impacts on fish, which are observed at far lower concentration levels. Holtz says (p8-9): "Because herbicides are generally applied at sublethal concentrations to aquatic ecosystems, comparison of lethal toxicity values is ecologically meaningless... Sublethal tests detect adverse effects in aquatic organisms at lower concentrations.... Therefore, sublethal tests may be more realistic and useful than acute lethal tests to determine safe levels of a contaminant."

21. The use of diquat for weed control in Chautauqua Lake coincided with the collapse of a world-class muskellunge fishery. See Bimber, et al (1981) "Fluctuations in the muskellunge (Esox masquinongy) population of Chautauqua Lake, New York" Env. Biol. Of Fishes, 6:207-211). Lab research indicates that diquat harms fingerling stage muskellunge at very low dosages.

22. Toxicity varies depending on the species and the stage of development; it tends to be most lethal to "swim-up fry". (See Skea, et al (1987) "The toxicity of ortho-diquat to the fry of several species of warm water fish" (NY DEC Tech Rep 87-1). The authors conclude:

"Diquat was found to be relatively toxic to all species tested, leaving no margin of safety between application rates and a no-effect level... The early life history stages of smallmouth bass, in addition to being killed by low concentrations of Diquat, experienced delayed mortality and sub-lethal effects within the next two weeks. Clams also exhibited delayed mortality when held up to 30 days post exposure in clean water. Compounding the problem is that Diquat has been shown to be toxic to small invertebrates which are the food of young fry. Invertebrate substrate and cover are also eliminated by the killing of the vegetation. Uneven distribution of the chemical also occurs. This creates "hot spots" or areas of high concentrations. These results raise serious questions regarding the continued use of Diquat in habitats where fish are a valuable resource."

23. Diquat has been shown to be harmful to frogs. The literature on diquat regarding non-game aquatic species is less abundant than for fish, but gives the reader no cause for confidence. See Dial, et al, (1987) "Lethal effects of diquat and paraquat on developing frog embryos and 15-day-old tadpoles, *Rana pipiens*" (Bull. Env. Contam. Toxicol. 38:1006-1011.)

24. Diquat has been shown to be extremely lethal to crustaceans and other aquatic invertebrates. A healthy ecosystem depends on invertebrate species, which range from insects to crayfish. Most species have never been studied for diquat toxicity, but the studies available are very disturbing. For example, amphipods such as *Hyallela azteca* are very important components of the food chain and are killed by miniscule doses of diquat. They would probably be wiped out from the areas scheduled for diquat treatment at the operational dosages proposed.

25. Other aquatic invertebrates, including snails, are also vulnerable to damage from diquat. Lake Cochituate is home to an endangered snail species, the Boreal turret snail (*Valvata sincera*) According to the Guidance for Aquatic Plant Management in Lakes and Ponds (p.2): "No project, including those that qualify under 310 CMR 10.53(4) or 10.53(3)(1), may be permitted if it will have any short or long-term adverse impact on the estimated habitat of rare vertebrate or invertebrate species as identified by procedures established under 310 CMR 10.59. This standard is intentionally stringent in order to protect the Commonwealth's most vulnerable species."

26. Diquat is harmful to microbial communities, which form the foundation of aquatic ecosystems. Although people may not pay much attention to organisms too small to see without a microscope, they are in fact important. According to Melendez, et al (1993) "Effects of diquat on freshwater microbial communities" (Env. Contam. Toxicol #25, 95-101), the herbicide was harmful to microbial communities at operational dosages. The harmful effects varied with the dosage, but damage occurred at all dosages. Microbial communities, including bacteria, algae, fungi, protozoa, and micrometazoa, were exposed to a single application of diquat and were monitored for 21 days. At 0.3 mg/L, which corresponds to the proposed concentration of diquat in this project, these impacts included changes in algal cell density, reduction of protozoan species richness, effects on electron transport , and others. "Most structural and functional responses were sensitive indicators of stress." At the end of the 21-day study period, the microbial communities had not yet recovered.

27. Diquat is very persistent in lake bottom soils. Diquat tends to bind with soil clay particles and remains bound there indefinitely. To quote from "Diquat Dibromide" from EXTOXNET (the Cooperative University Extension Toxicology Network): "Traces, or residues, of diquat have been found to persist in soil for many years with very little degradation". (p 4) Some herbicide advocates argue that this is a positive attribute, because soil-bound diquat will not readily travel through the food chain or become dissolved into the groundwater. However, with repeated treatments, "there is evidence that diquat has the ability to eventually use up, or saturate, all of the available adsorption sites on soil clay particles". (EXTOXNET). If that happens, then the diquat becomes a risk to groundwater and bioaccumulation. Diquat may be immobilized in the soil, but if the lake is ever dredged, and the "fill" is used on fields or developments, then toxics could silently spread by windblown dust and other pathways.

28. Diquat, like its cousin paraquat, tends to become greatly concentrated in the lake vegetation. As a non-selective herbicide, it damages desirable plants as well as nuisance weeds. Since diquat concentrates into plants of the lake, it becomes a candidate for bio-accumulation into the organisms that feed on these plants. As a non-selective contact herbicide, diquat will harm <u>all</u> of the plants which it touches, although many of these plants are not nuisance weeds. In fact, "nuisance weeds" are likely to be a small percentage of the lake's overall aquatic plant population. The non-selectivity of the herbicide has the potential to cause more damage to the Commonwealth's "environmental interests" than the selectivity of manual control.

29. With respect to the effectiveness of diquat in achieving removal of nuisance weeds, it is important to note that diquat and other herbicides may have a short-term cosmetic value, but they do nothing to address the source of the weed problem. Lake restoration must address the causes of the lake's problems, but herbicides and algicides do not address these causes. They treat only the symptoms, and their effectiveness is only temporary. Far from retarding lake eutrophication, decaying herbicide-treated vegetation often triggers anoxia and algae blooms, which triggers copper sulfate or other algicide treatments, and so forth. The "hundreds of lakes" the herbicide applicators treat and re-treat every year are on a "treadmill" of repeated chemical inputs, but the lakes are not getting healthier, and the underlying nutrient overloads are not getting reduced.

30. Herbicides are not the only viable option for dealing with nuisance weeds. Integrated Pest Management teaches unbiased consideration of all alternatives, with preference given to less-toxic alternatives whenever they are available and comparably effective. The fundamental goals of lake vegetation management are most effectively reached through a multi-pronged effort to improve water quality by nutrient source reduction and sediment reduction. With regard to weed control in particular, there are a variety of non-chemical approaches, each with certain advantages and certain drawbacks. They include a variety of manual and mechanical control methods, dredging, winter drawdowns, biological control using specific insects and fish, and others. A good long-term lake restoration plan typically involves some combination of these various alternatives.

31. Site-specific weed control methods treat fewer acres than broadcast herbicide treatments, because of the built-in excess of "blanket coverage". Nuisance weeds typically grow in patchy distributions, in which dense patches are interspersed with open areas and areas of native non-nuisance plants. It is "easier" to simply treat an entire arm of the lake, or other "block" of acreage, than it is to survey the lake thoroughly and regularly with a skilled team of divers. However, good lake management requires adequate and repeated vegetation surveys. With the resulting information, effective site-specific control needs can be accurately identified and dealt with. The boat-based surveys conducted on several dates in 2003, and described in the Lake Cochituate long term vegetation management plan (2004), are just a beginning point. For effective long-term management, more systematic surveys, and more frequent surveys, should be conducted. The Lake Dunmore/Fern Lake Association Milfoil Control Program in Vermont, for example, is based on weekly surveys by paid teams of divers.

32. The built-in excess acreage of "blanket treatment" of entire sections of lake water produces a large error in cost-benefit comparisons between treatment alternatives. Costs of each alternative are presented on a "per-acre" basis, but the seemingly low "per-acre" costs of herbicide treatment includes actual weed densities that vary greatly from place to place. When aquatic herbicides or other blanket treatments are applied, localized areas that have no target weeds get treated anyway, and the program is credited with areas of "benefit" that did not really benefit. Conversely, manual controls will not need to encompass as many acres, because they are more site-specific.

33. Herbicide application is a blanket approach, insofar as the chemical spreads through an area of water and interacts with everything it touches. A tiny percentage of herbicide finds its target. Most of it just enters the environment to interact with water, soil, non-target plants, and the living ecosystem. The proposed "5-foot safe zones", and the minimal protection offered by untreated spots generally located in deeper water, are not adequate measures to prevent the proposed herbicide application from have an adverse impact on fish, aquatic invertebrates, microbial populations, and other key components of the Lake Cochituate ecosystem. In my opinion, this violates the intent of the Wetlands Protection Act, because the proposed safe zones do not sufficiently "minimize the adverse affect on the interests that are not targeted for improvement". (310 CMR 10.53(4).

34. A site-specific management plan, by contrast, focuses vegetation control where it is actually needed, rather than on an entire block of acreage. The first essential component of such a plan is an adequate field survey to gather the needed localized information. The other essential component of an effective plan is an objective evaluation of alternatives, to see which combination of control methods makes sense for the conditions revealed by the surveys, and the long-term goals of the plan. In my opinion, the Lake Cochituate long term management plan (May 2004) does not clearly define the long-term goals of vegetation management, nor does it adequately evaluate the alternatives.

35. The plan is far too brief and sketchy to be an adequate basis for long-term vegetation management. As will be discussed below, it contains a perfunctory discussion of various alternatives, but the operational goals of the long-term plan are never clear. Do we want to eradicate milfoil from the lake, or do we want to keep it contained? The answer seems to vary with the alternative under discussion, although common sense suggests the latter. Which of the six herbicides discussed in the plan are envisioned for use in Lake Cochituate, and under what circumstances? Even the hydrology is minimal. As explained on p.3, "There were no specific references to a hydrologic budget in any of the existing reports that were reviewed for this project."

36. How are the 'in-lake actions" to be coordinated with the underlying issues of nutrient loading and sedimentation? The Long Term Plan says (p.13) "It is beyond the scope of this assessment and report for Lake Cochituate to identify the priority sources/origins of nutrients entering and the specific actions required to reduce this nutrient loading". The issue of sediment reduction is also removed from the table. How can there be a good long-term lake management plan without a coordinated attempt to address the underlying sources of the problems?

37. The <u>Lake Cochituate Long Term Vegetation Management Plan</u> does not meet the minimum standards of Integrated Pest Management in its brief discussions of treatment alternatives. IPM calls for an even-handed evaluation of treatment alternatives, but the analyses provided in the plan are neither adequate nor objective. Perhaps this is not a surprising outcome, since the Commonwealth's Lake Cochituate Long Term Vegetation Management Plan was prepared by Aquatic Control Technology, Inc., a large regional aquatic herbicide applicator. Except for dredging, which is beyond the scope of this case, I will briefly comment on these alternatives one by one in the following paragraphs.

38. In general, periodic winter drawdown can be an effective means of control for some but not all weed species. It can be especially effective in shallow areas that will be exposed to freezing air temperatures for the long periods of time during the winter. Drawdown can be an option only for water bodies with a mechanism to control the outflow. Because of the competing purposes of people with legitimate interests in the water, drawdowns may not be an option even on some lakes whose levels could be controlled. Drawdowns are likely to be effective if the water level is lowered sufficiently to expose shallow lake bottom soils to hard freezing 4-6" below the soil surface. Some nuisance weeds are not killed back by freezing, but Eurasian watermilfoil is killed back, if the winter is cold and the duration of the drawdown is sufficient. Because annual drawdowns favor the establishment of resistant species, a 2-year schedule of drawdowns is preferred by some lake managers, and less-frequent schedules are often used.

39. There are many obstacles to the incorporation of periodic drawdown in the mix of options for Lake Cochituate, although it is not physically impossible because of the outflow structure in North Pond. The Long Term Plan mentions a series of these obstacles (such as the need to study potential impacts to Town wells and modify outlet structures), and dismisses drawdown from further consideration. The plan is clearly correct in assuming that these obstacles are insurmountable in the short run. However, at

least some of the larger obstacles could conceivably be resolved through negotiation and planning in the long run. Other obstacles cited, such as the disturbance to recreational ice fishing, are relatively minor. The dedicated ice fisherman can hike out a few yards further beyond the lake margin. Drawdowns are ineffective when the winter is mild, but they are sometimes very effective because nuisance weeds tend to concentrate in the 3-8 ft. depth zone that may be exposed to freezing. Some seemingly big obstacles can be resolved by careful negotiation over time. A more detailed study of the costs and benefits of drawdown may be a worthwhile subject of long term planning.

40. There are a variety of mechanical and physical methods of aquatic weed control. They range from mechanical weed removal with harvesting machines, to physical prevention of weed growth with weed mats and other sediment covers. Various designs of weed harvesters are available for purchase by lake managers. Some newer designs allow access to shallower water than the older machines could reach. Most of these harvesters function similarly to lawnmowers, as they remove weed biomass but do not prevent the weeds themselves from growing back. Because harvesting machines can cut milfoil into fragments that may not all be removed, and may become rooted, weed harvesting is rejected as a control strategy in the Long Term Plan. In my opinion, the reasoning behind this rejection is insufficient, because the great majority of these fragments can be contained by well-designed systems of booms and nets, and then removed from the lake. Some fragments will escape, but no options are perfect, and the benefits of harvesting may exceed the costs, especially in severe infestation areas. In milfoil-infested recreational areas, substantial fragmentation is likely to occur anyway because of motorboats.

41. The physical removal of large volumes of weed biomass out of the lake water is a significant advantage of harvesting over herbicide treatment. A harvester will remove tens of thousands of cubic feet of weed biomass over the course of a single summer. By contrast, the herbicide-killed vegetation just decays in place, depleting dissolved oxygen, releasing additional nutrients into the water column, triggering algal blooms, and distressing the ecosystem. Neither the diquat nor the harvester kills the plant roots, so the resprouting of established weed patches will continue annually with both methods. In short, neither will accomplish eradication. Both can assist with control, and harvesting with weed removal is less likely to have adverse environmental impacts than diquat.

42. Some mechanical harvesting techniques may be more effective than others. In LaDue Reservoir (Ohio), a deeper cutting blade position (one inch into the mud) produced season-long control of Eurasian water milfoil by tearing into the roots, while "traditional" above-ground cutting produced regrowth after just three weeks. (EPA Lake and Reservoir Restoration Manual, 1990, p.145.) The Long Term Plan briefly mentions these root-digging harvesting techniques under Hydro-Raking, and proceeds to reject the option from further consideration, for the same reason that harvesting was rejected. It concludes that even though "removing some of the root structures may provide slightly longer-term control of the submersed milfoil growth, there is probably an even greater risk of creating and spreading plant fragments that could worsen the infestation" (p.21). In fact, areas of

milfoil dense enough for hydro-raking are not candidates for eradication by any control method.

43. For long term nuisance weed management, the machines are actually more cost-effective than the herbicides. To quote from the EPA Lake and Reservoir Restoration Manual, 1990, (p.150): "One study of harvesting and herbicide (Diquat and copper sulfate) costs showed that harvesting was more expensive only in the initial year when the machinery was purchased. In the following years, maintenance, operation, insurance, and weed disposal costs were lower than those for chemicals alone. Harvesting, in this case history, cost $115 per acre and herbicides $266 per acre, so that over a five-year period, not including herbicide price inflation or applicator fees, the use of chemicals would have been 2.6 times more expensive than harvesting, and without the benefits of nutrient and organic matter removal (Conyers and Cooke, 1983)."

44. Hydro-raking and harvesting are likely to be inappropriate among the contaminated sediments of Pegan Cove, but they are a cost-effective and reasonable long-term alternatives for other moderate-to-dense milfoil areas. The Lake Cochituate Long-Term Vegetation Management Plan embraces long-term control by herbicides, but rejects long-term control by machine harvesters and rakes. In my opinion, this arbitrary and capricious choice improperly narrows the range of alternatives for the long-term restoration of Lake Cochituate. It also fails to minimize adverse environmental impacts since the less hazardous harvesting method can be at least as effective as herbicide application.

45. Benthic barriers, or "weed mats", can be utilized to cover the lake-bottom sediment in localized areas where nuisance vegetation is a problem. Like mulches in a garden, these physical barriers between the ground surface and the water column can prevent weed growth in critical places. The initial expense of installing barriers in such locations is likely to be offset by the long-term savings. The EPA's Lake and Reservoir Guidance Manual (1990) compared 6 weed mat materials, and reported that gas-permeable screens such as Aquascreen (fiberglass) and polypropylene are most effective. Dartek (nylon) is effective if vented, and common burlap is effective for up to one season, then it rots. Proper placement is easiest during drawdowns, but scuba divers can do the job in deep water if necessary. Siltation may require occasional removal and cleaning of the sediment covers. Negative effects "appear to be few" compared to other weed control methods (p. 140), although initial costs may be quite high. It would be ecologically undesirable, and economically impractical, to utilize such weed mats on more than a small percentage of the lake area. However, they are an excellent choice for certain locations, such as near the Lake Cochituate public boat dock, or just beyond the perimeter of the public swimming beach.

46. Biological controls for aquatic weed management include the introduction of grass carp for the purpose of weed consumption, and the introduction of insect species that are natural consumers of weed species. Grass carp reproduction can be disastrous; most states prohibit all but the sterile Triploid variety, and some states prohibit grass carp altogether. If the grass carp are sufficient in number to have an effect, they are likely to

eradicate the weeds, but may also impact the desirable plant species as well. Eradication of most of the lake's macrophytes is not a desirable outcome. Nutrients the plants would have absorbed will instead trigger algae blooms in the water column, and other fish species are likely to be adversely affected. Fishery advocates in various parts of the country have opposed grass carp introductions as well as opposing herbicide usage. Both are seen as threats to the long-tem health of the freshwater fisheries. On the other hand, the Ball Pond Grass Carp Project in Connecticut has shown that successful results with sterile grass carp are possible: milfoil biomass was reduced without hurting either native fish populations or native plant species. (Benson, 2003). It is my understanding that the introduction of sterile grass carp is not an option at Lake Cochituate, as it is not permitted by state wildlife management authorities. However, if this is a matter of policy and not law, it may be desirable to confer with Connecticut authorities regarding their successful operation of the Ball Pond Grass Carp Project.

47. A variety of insects have also shown potential for the biological control of Eurasian water milfoil as it invades North American lakes. One native species of tip weevil, in the genus *Euhryciopsis*, has apparently been effective in reducing nuisance milfoil growth in Vermont lakes, although the reported degree of control is variable. Across the continent in British Columbia, which has also suffered from the Eurasian water milfoil invasion, researchers found that various insects – including caddis flies, weevils, and chironomids – like to graze on milfoil. There are potential risks associated with biological controls, especially those that may involve introduced species that control a pest in its native land. However, it makes sense to encourage native species that graze on milfoil tips, such as the weevil in Vermont lakes. The results are mixed: milfoil reductions may be more noticeable in some years than in other years. However, the Lake Cochituate Long Term Vegetation Management Plan concludes that because weevils have not been proven to be "a predictable and reliable" milfoil control method, they are rejected from inclusion as part of a long-term management plan for Lake Cochituate. Diquat is also unpredictable in its effectiveness, although it can be reliably stated that the diquat will not eradicate the milfoil and control will require repeated applications.

48. Last, but certainly not least, is the option of manual control. This involves intensive monitoring for weed infestations, and the hand pulling of individual weed plants from the lake bottom. To people with little or no experience in such jobs, it may seem to be impossibly slow and expensive, but well-designed manual treatments can actually be more effective than blanket herbicide applications. The parallels between hand-pulling in forest vegetation management and hand-pulling in lake vegetation management are remarkable. I know from years of professional experience how a crew of skilled forest workers can effectively accomplish the manual release of trees from brush species. I worked on the first successful Forest Service contract for hand pulling of ceanothus brush in the McKenzie District of the Willamette National Forest. The plants were small enough to be pulled out of the ground, using a tool that pulled out roots in the same way that a hammer's claw pulls out nails. This manual technology may seem "primitive", but it actually permitted the sophisticated option of "creating optimum plant composition". Shrubs that threatened to crowd or overtop conifer trees could be pulled, while other individual shrubs could be left intact for nitrogen fixation and other potential benefits.

I find that there are many parallels between hand-pulling as an alternative to herbicides in forest management, and hand-pulling as an alternative to herbicides in lake management. When well-designed, these manual control methods can be actually quite cost-effective, although they are frequently dismissed as impractical in agency documents that fail to adequately consider alternatives to herbicides. Successful manual control projects require skilled workers, which means well paid workers. These manual jobs cannot be done successfully and consistently by volunteers, but they can be done successfully and consistently by skilled workers.

49. The Lake Dunmore/Fern Lake Association Milfoil Control Program in Vermont is an example of successful manual control of lake weeds. It parallels my experiences in forestry. At Lake Dunmore, a skilled work force emerged to do thorough field surveys to monitor the lake, and also to systematically pull milfoil plants out by the roots where patches are found. Lake Dunmore is larger than Lake Cochituate, and has a much larger area of shallow water that requires careful monitoring. Nonetheless, a small team of paid workers (including snorkelers and SCUBA divers), with the help of community volunteers, successfully brought a burgeoning milfoil outbreak under effective control in a period of 7 years (from 1994-2001). They wrote a detailed handbook about their surveying and manual pulling protocols – the Lake Monitor's Handbook (Powers, et al, 2002).

50. The Lake Dunmore/Fern Lake approach to their Eurasian water milfoil infestation is one model of successful manual aquatic weed control, without the use of toxic herbicides. The program is briefly discussed, on pages 15-16 of the Lake Cochituate Long Term Vegetation Management Plan, and is described as largely irrelevant because of the lesser weed density in Lake Dunmore. However, the Lake Dunmore program history is portrayed in a misleading way that exaggerates the weed density differences. To quote from the Long Term Plan:

"The ongoing hand-pulling program at Lake Dunmore in Salisbury, Vermont is generally considered to be an effective program. Milfoil was first found in this nearly 1000 acre lake in 1989. Immediate steps were taken by the Vermont Department of Environmental Conservation (VT DEC) and the lake association to contain and prevent further spread of this plant. Volunteer hand-pulling efforts were initiated in the first few years. Two full-time seasonal lake monitors were hired to oversee hand-pulling efforts in 1994; the number of employees has increased to five in recent years. Between 2000 and 2003, the Association reported 6000-8000 milfoil plants removed from the lake annually. This required the efforts of four full-time lake monitors and a considerable volunteer effort. The program has effectively prevented milfoil from spreading, but the program was initiated when the milfoil coverage and plant density was very low."

51. The actual Lake Dunmore report, as presented to a lake management conference in 2002 (Wallin, 2002), tells a different story. Immediate steps were taken after the milfoil was found in 1989, and a large volunteer effort was initiated. These enthusiastic volunteer efforts helped provide knowledge and experience, but they were not effective in controlling the infestation. Compare the map of the infestation in 1989 with the map of the infestation in 1994: it is clear that the infestation had worsened tremendously. The

lake association decided to switch their main focus to training and hiring a small team of full-time paid summer workers. For the next few years, these workers used hand-pulling to attack and reduce this worsening infestation. To quote from the report: "One plot of milfoil was found extending into 25 feet of water covering an area of 80 feet by 320 feet; the patch contained approximately 18,000 milfoil plants. A systematic removal of the plants over the course of the summer, utilizing the crew and many volunteers, revealed a rapid invasion of native plants moving in behind the crew. Six years later (2001), only 25 plants were pulled from this site." (Wallin, p 6).

52. By the years 2000-2003, the worst patches of milfoil had been largely controlled, as can be seen from the map of the infestation in 2001. The program had shifted from a primary emphasis on hand pulling to a primary emphasis on thorough weekly field surveys, with rapid follow-up to pull individual plants found in those surveys before they could multiply into dense resilient patches of weed. The Lake Cochituate Long Term Vegetation Management Plan wrongly suggests that the rapid initial actions kept the infestation very small, and then wrongly implies that pulling 6000-8000 plants annually consumed the efforts of 4 full-time lake monitors and many volunteers. In fact, by 2000-2003, the dense patches of milfoil had already been scaled back to scattered resprouts. The relatively small number of plants pulled was a testament to the program's success.

53. The Lake Cochituate Long Term Vegetation Management Plan discusses a second example of hand pulling, from Dudley Pond. This second example is not an appropriate choice to represent the efficacy of hand pulling. It "utilized 150 people (two support people per diver) to clear dense milfoil from two coves that were approximately one acre in size". Efficacy was limited by "turbidity generated during the operation" and by fragments left on the bottom, and subsequent surveys revealed that "a 35-40% removal was accomplished" (p.16). This kind of volunteer effort may have a useful role to play in public education, but it does not resemble functional lake management any more than a big Arbor Day tree planting ceremony resembles functional reforestation!

54. An integrated long-term vegetation management plan at Lake Cochituate could utilize a broad mix of control methods to be successful and cost-effective. A thorough long-term lake restoration plan must include nutrient and sediment source reduction. Not one of the weed control alternatives is perfect; each has advantages and drawbacks. The proposed herbicide application project is not likely to resolve the lake's nuisance weed problem any more effectively than alternative control strategies, including a combination of harvesting, hand-pulling, hydro-raking, benthic barriers, and others. The Long Term Plan arbitrarily excludes harvesting and hydro-raking from the proposed management plan, and relegates hand-pulling and benthic barriers to very minor roles in a herbicide-dominated control approach.

55. The EPA's Lake and Reservoir Restoration Guidance Manual recognizes that herbicide treatments can produce a rapid reduction in vegetation for the short term (weeks to months), but warns that

"Pesticide use cannot be equated with lake restoration, since causes of the weed problem are not addressed, nor are nutrients or organic matter removed. Plants are left to die and decompose. New plants will shortly regrow, sometimes to densities greater than before." (p 147)

"Herbicide treatments are expensive for what they accomplish. They produce no restorative benefit, show no carryover of effectiveness to the following season, and may require several applications per year. The short-term benefit-cost ratio can be desirably high, but the long-term benefit-cost ratio is likely to be very low", (p 150).

Conclusion

56. Based on my research and experience, it is my opinion that the herbicide application project proposed for Lake Cochituate is unlikely to improve the natural capacity of Lake Cochituate and the land under the lake to protect the environmental interests of pollution prevention, protection of public or private water supplies, protection of groundwater, protection of fisheries or protection of wildlife habitat, by removing or controlling aquatic nuisance vegetation in a manner that will retard lake eutrophication or improve habitat value. The proposed project is unlikely to minimize adverse impacts on the afore-mentioned environmental interests. I base this conclusion on the following:

1) Alternative control methods rejected from consideration in the Long Term Plan, including harvesting, hydro-raking, and others, have equal or greater effectiveness in reducing nuisance weed growth in the long run.

2) Because weed biomass is removed instead of simply being allowed to decay on site, the non-chemical alternatives are likely to be more effective in retarding lake eutrophication than is the application of diquat.

3) The close proximity of public drinking water to the proposed treatment location makes the risk of adverse impact to this environmental interest greater from the application of herbicide than from non-chemical alternatives.

4) The known toxicity of diquat to various species of fishes, aquatic invertebrates (and in particular, the endangered Boreal turret snail), and other critical ecosystem components indicates that this proposed project is unlikely to minimize adverse impacts on these afore-mentioned environmental interests.

Signed under the pain and penalties of perjury this 2nd day of May, 2005.

Howard Horowitz Ph.D.

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