Clear Lake Integrated Aquatic Plant Management Plan

August 1, 2004

Lake County Department of Public Works
Water Resources Division
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Acknowledgements

After periods of restructuring and redirection The Clear Lake Integrated Aquatic Plant Management Plan (hereafter referred to as the “Plan”) will help the control effort to go forward.

Whenever a project of this scope takes place there are numerous people to thank. The Plan is the result of many hours of work contributed by several dedicated groups is no exception.

Managing Aquatic Plants Task Force

Clear Lake Advisory Committee

County Staff

Water Resources Division of Department of Public Works
Pamela Francis, Robert Lossius, Skip Simkins, Tony Gallegos, Peggie King

Agriculture Commissioners Office
Mark Lockhart, Maile Field, Peggie King, Denise Patrick, Steve Hajik,

State Agency Staff

California Department of Fish and Game
Mike Rugg, Joel Trumbo

California Department of Food and Agriculture
Bob Hesterberg, Robin Breckenridge, J. Robert Leavitt, Larry Bezark, Frank Zarate

Lakeport Chamber of Commerce
Mellisa Fulton, Peggie King, Jan Connor

Consultants
The Team, Jones & Stokes
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Managing Aquatic Weeds, Hoyer-Canfield

Interim Plan for Managing Aquatic Plants in Clear Lake, Maile Field, 5/16/01

Clear Lake Aquatic Weed Pilot Project, (Peggie King, 1999), Greater Lakeport Chamber of Commerce and Lake County Department of Public Works, Water Resources Division


University of California, Berkeley Image Library

University of Florida, Center for Aquatic and Invasive Plant
PLAN OVERVIEW

Clear Lake is a natural, shallow, warm-water lake lying in the Central Coast Range of California. It is the largest natural freshwater lake that lies within California’s borders and is one of the oldest lakes in North America. The lake is located in Lake County in rural Northern California. Lake County’s economic health and future well being are closely tied to the health of the lake. The lake is eutrophic (nutrient rich, productive, alive and well) and thus supports an abundant fishery and extensive wildlife as well as a diverse aquatic plant community. The lake is highly regarded for recreation and has visitors from all over California as well as from out of state. It is the water supply for many local communities and residents and its waters are used outside of the county for downstream irrigation.

During most of the second half of the 20th century, the lake was subject to summer blooms of nuisance algae. These nuisance blooms have been attributed at least in part to nutrient loading into the lake from human activity. Partially due to an attempt to manage the algae problem, mainly by limiting nutrient sources, measurable improvements in water quality and clarity have been experienced over the past decade. The lake has now transitioned from being algae dominated to becoming excellent habitat for aquatic plants. This is due partially to the natural characteristics of the lake, being relatively shallow and warm (non-freezing) combined with the increasing clarity of the water allowing sunlight to reach the bottom and the plants, encouraging plant growth.

The initial problem from this increased plant activity as experienced by lake visitors/users and shoreline residents results from “weeds” limiting lake access and usage in many areas. The longer-term threats, especially from more invasive recently introduced species, could either result in the closure of the lake to all activity and severe damage to the county’s economy or to extremely expensive county and state emergency eradication efforts if the “weeds” are left unmanaged. While these plants (especially when unwanted) are called weeds, scientifically they are defined as aquatic macrophytes. In this plan “aquatic plants” is generically used to refer to the many species found in Clear Lake. It is important to realize that a healthy lake requires a sustainable healthy aquatic plant community.

The most notorious of the invasive aquatic plant species currently found in the lake is Hydrilla. Hydrilla was discovered in the lake in 1994 and since then has
been the target of an eradication effort by the California Department of Food and Agriculture’s (CDFA). Hydrilla is, currently, the only aquatic plant species that is actively managed and controlled on a lake-wide basis; the effort is ongoing and so far has been making good progress.

Starting in the late 90’s several groups were assembled including citizens, business owners and local and state government agencies to address the required management and control of aquatic plants in Clear Lake. This document is the result of those efforts plus considerable staff time by County personnel. It contains compiled rationale, issues, scientific data and a recommended implementation plan.

The goals of this Plan are designed to best balance the many requirements placed upon any program to manage and control aquatic plants. Requirements include protection of the many beneficial uses (and users) of the lake, the ongoing health of the lake and the environment, and protection of the abundant wildlife found in the area. To ensure proper balance is achieved and maintained requires that such goals consider ongoing data collection, expert technical guidance, and community education and participation.

The Plan provides extensive information on the characteristics of the entire watershed area, the lake, and the aquatic plants found in the lake. This information was gathered and compiled from many sources including an assessment commissioned by the county utilizing the latest hydroacoustic bottom analysis and satellite imagery to provide a baseline of the current lake and its aquatic plant population. All of this data provides the basis for the many decisions and trade-offs that comprise this balanced Plan. The Plan is dynamic and will be adjusted as requirements are updated, new data is collected, and results are monitored.

Also presented are the many considerations of alternative methods available to control aquatic plants. Some of the most common and effective methods in the short term are considered to be damaging in the long term. Some methods are applicable to Clear Lake, some are not. Decisions are reached and rationale discussed. Again, these areas of the Plan will be updated as results are analyzed and new technology and methods are discovered and evaluated.
The implementation plan has been organized into two sections:

- **Working Framework** which sets programmatic boundaries which are controlled by a permitting process

- **Strategic Actions** which give additional substance to the Plan and complements the basic working framework

**Working Framework and Permitting**
The direct reduction of existing aquatic plants will be achieved through a mixture of the application of approved herbicides by licensed applicators as well as harvesting of existing plants. Both methods require the application for and receipt of a permit from the Lake County Department of Public Works prior to any action.

Although the plan commits us to an integrated approach of herbicides, and harvesting, the ongoing Hydrilla Eradication Program temporarily restricts our ability to harvest in many areas of the lake (harvesting causes plant fragmentation in hydrilla and could potentially spread the plants to new areas), so for an extended period of time we will have to rely more on herbicides than many might prefer. As the Hydrilla infestation is reduced and eliminated we would expect to see a shift in the balance between herbicides and harvesting as influenced by the recommended data collection process and ongoing studies of the results of applications and harvesting in the lake.

**Strategic Actions**
There is a large range of critically important actions also proposed as part of this plan. These include but are not limited to:

- Data collection of the ongoing extent of aquatic plan growth, and the relative effectiveness of different treatments in the lake
- Integration with the Hydrilla program
- Adaptive Management (using the data to modify the program)
- Reduction of nutrient loads into the lake
- Public Education Programs
- Prevention of the introduction and spread of Invasive Aquatic plants into the lake.
- Enforcement

3 Clear Lake Integrated Aquatic Plant Management Plan
PROBLEM STATEMENT

The Clear Lake ecosystem is shifting has shifted from being algae-dominated to being plant-dominated. The causes and effects are not completely understood but there appears to be an inverse relationship between algae and aquatic plant growth. A decrease in algae presence enables aquatic plant growth; the increased amounts of sunlight reaching the lakebed seem to provide plants an advantage over suspended algae. Anecdotal history of the lake from the 1950s through the 1980s indicates a relative absence of aquatic plants and very heavy algae during the warm months with occasional extreme noxious algae blooms. Since the early 1990’s there has been a reduction in algae and an increase in aquatic plants. In the middle to late 1990s, submerged aquatic plant growth reached nuisance proportions in several shoreline areas. Consequently, for the first time in memory, rooted aquatic plant growth, rather than algal blooms are interfering with swimming, boating and other beneficial uses of the lake.

Although improved water clarity is appreciated, the submerged aquatic plants now proliferating have created a nuisance in some areas, preventing safe swimming and boating in some areas. The lake-based tourism related businesses that have developed over the past half-century are being adversely affected. Moreover, aquatic plant growth has increased in the last decade to produce congestion of near shore waters previously unknown to the present generation. The result has been a profound frustration of boaters who are unable to gain access to the lake from private docking facilities. There is also a question related to fisheries impacts. While aquatic macrophytes are an integral part of healthy fish and wildlife habitat, under extreme circumstances aquatic plant growth may lead to degradation of fish habitat.

Stakeholder Issues
Stakeholders include the tourism industry including lakeside resort owners and
employees as well as second-tier tourism trade businesses; all Lake County residents; waterfront and county wide property owners; native American Tribal members who gather materials for ceremonial or basketry purposes; visitors who use the lake including swimmers, boaters and people who fish either recreationally or for food; the lakeside and downstream water users who irrigate or drink lake water; farmers and other business people; and others tangentially.

Hydrilla Program

In 1994 *Hydrilla verticillata*, an exotic, tenacious submerged aquatic plant, was discovered in Clear Lake. Since then a California Department of Food and Agriculture (CDFA) emergency noxious weed eradication program has been underway. The program is eradicating hydrilla and preventing its spread to downstream irrigation and navigation channels, and potentially, in the case of high water floods, to the Sacramento-San Joaquin River Delta.

Hydrilla reproduces in several ways. 1) The plant produces tubers that have been known to survive in sediments for up to a decade before sprouting; 2) plant fragments broken or cut from parent plant can form new plants (Research has shown that almost 50 percent of Hydrilla fragments having a single whorl of leaves can sprout a new plant); 3) turions, leafy reproductive structures that form at the intersection of branches off the main stem and survive adverse conditions such as cold water temperatures, drying, ingestion and regurgitation by waterfowl, and herbicide applications.

The Clear Lake hydrilla program surveys for the plant, identifies and monitors infestation sites and eradicates all viable plant material. Plant surveys are done with teams of workers that throw modified grappling hooks into plant beds or drag the hooks along the lakebed and then examine their finds. When Hydrilla is found, a minimum of five-acres surrounding the location is treated with a contact herbicide. Then fluridone pellets (commercial name: Sonar) are applied to the lakebed. The hydrilla program developed a map of Clear Lake delineating 80 shore zones around the lake using landmarks, producing a clock-like map. About three-fourths of the zones have been known to host hydrilla at one time or another. The number of finds per year is decreasing by about 50 percent. Clear Lake remains the only water body under CDFA hydrilla eradication that has not been closed to boating. Members of the public are prohibited from manual or mechanical control of submerged aquatic plants within one-quarter mile of find sites. Chemical treatment is allowed by licensed applicators through a permit process.
AQUATIC PLANT MANAGEMENT
GOALS

Objectives

The objective of this document is to present information that will provide guidance for the environmentally sound management of aquatic plants in Clear Lake. This plan will be adaptive in nature due to the changing regulatory environment, uncertainties about future plant populations, and the whims of natural phenomenon and potential conflicts with other management goals and lack of critical information specific to Clear Lake.

Goals

♦ Management of aquatic plants on and in Clear Lake shall be based on the multi-use concept.

♦ Ensure lake-users reasonable and easy access to the lake.

♦ Define a single-point permitting process for guiding lakefront property owners who wish to control the submerged aquatic plants adjacent to their property.

♦ Identify methods/treatments of vegetation management, cost effectiveness of varying treatments and other pertinent variables, to guide the decision making process.

♦ Include provisions to create an Aquatic Plant Management Technical Advisory Group for the evaluation of this plan on an annual basis for the duration of its implementation.

♦ Whole-Lake Ecosystem Management – with special consideration to exotic invasive species - must be considered.

♦ Develop monitoring, tracking and evaluation components for the plan, so that ongoing aquatic plant control projects are observed and relevant.
data recorded. Utilizing Geographic Information System (GIS).

- Establish zones of special biological or cultural significance.
- Develop a program to minimize risk of future introduction of non-native species of plants or animals.
- Develop an Outreach/Educational program.
- Identify and obtain funding sources to help accomplish various objectives.

Recommendations for Future Policy Decisions
Management decisions should consider several factors. These principles can be applied to the management of fish and wildlife habitat, recreational areas, navigation, etc.

Define the management objectives for the specific area. Objectives should be dynamic and revisited on a regular basis, modified to reflect management effectiveness.

It is important to be attentive. Many nuisance or invasive weed problems can be prevented if they are addressed at an early stage. When the situation gets out of hand it is more difficult to control nuisance levels of plants.

Managers should be realistic. Invasive weed issues take a lot of time, effort and persistence. A long-term program is necessary to effectively deal with chronic nuisances. A one-time effort will not reduce the problem forever.

Incorporate an integrated management approach. Implement a variety of methods that are site specific, best able to control the particular situation and take the intended use of the affected area into consideration. Not all control methods provide similar results.

Utilize adaptive management strategies. This requires the manager to make careful observations and evaluate the effectiveness of weed control efforts. Techniques should be modified if they aren’t working and different control strategies incorporated to suit the site-specific conditions. A management program must be prepared to be responsive to changes as they occur.
WATERSHED AND LAKE CHARACTERISTICS

Watershed Characteristics

The Clear Lake watershed, an area of approximately 500 square miles, is in the northern Coast Range geomorphic province of California. The topography is generally steep and rugged, but the watershed includes some gently sloping valleys and terrace remnants draining through primarily mineral soils. Elevations range from 4,299 feet at the top of Mount Konocti to 1,318 feet at the level of Clear Lake.
Fifty percent of the lake inflow is from the Scotts Creek and Middle Creek watersheds (Richerson et al. 1994), which enter the lake through Rodman Slough. Clear Lake discharges into Cache Creek through the Clear Lake Dam, which is approximately 5 miles downstream of the lake. The 5-mile portion of Cache Creek between Clear Lake and the Clear Lake Dam is often referred to as the Clear Lake outlet channel. Other major tributaries to Clear Lake include Adobe Creek, Kelsey Creek, and Schindler Creek. The groundwater flow into Clear Lake is estimated to be about 1,100 acre-feet (af) and a very small fraction (<0.3%) compared to the contributions from rainfall and river runoff (Richerson et al. 1994). The Big Valley and Upper Lake groundwater basins are estimated to contribute about 85% of the total groundwater inflow to the lake.

**Lake Characteristics**

Located in the central Coastal Range of Northern California approximately 90 miles north of San Francisco, Clear Lake is the largest natural freshwater lake located entirely in California. The lake has over 100 miles of shoreline and a surface area of slightly more than 44,000 acres (68 square miles, 17,806 hectares). The 68-square-mile lake has a 105-mile-long shoreline and is generally divided into 3 main areas known as the Upper Arm (31,700 ac.), Lower Arm (9,200 ac.), and Oaks Arm (3,100 ac). The mean depth of each arm is approximately 23 ft., 34 ft., and 36 ft., respectively. The majority of the lake bottom has a depth ranging from 20 to 50 feet and a storage capacity of approximately 313,000 acre-feet (af) between 0 and 7.56 feet Rumsey. The lake is 18 miles long (7.5 miles wide at its maximum width) and drains approximately 500 square miles. Although quite large in area, Clear Lake is also very shallow, with an average depth of 26 feet and a maximum depth of 45 feet (some volcanic vents have been measured significantly deeper). The Upper Arm of the lake is most uniform and shallow.
The lake sediments are primarily silt and other fine sediments, although in several areas rock outcropping continue out into the lake bottom.
Beneficial Uses

Natural Resources and Recreational Uses

Clear Lake is a regional resource for recreation-based tourism, with large sections of the 105 miles of shoreline developed with homes and resorts, most of which are connected to the lakeshore with piers and docks. The towns of Clearlake Oaks, Lucerne, Nice, Lower Lake, and the incorporated cities of Lakeport, and Clearlake border the lake. The lake is an important source of domestic and agricultural water supplies. The County maintains 5-launch and 7-swim area public access sites at various points around the lake. There are also parks with lake access operated in the cities of Clearlake and Lakeport in addition to the Clear Lake State Park located on the southern shore. Beyond its importance for summer fisherman, swimmers, and boaters, the lake supports a year around fishery and provides abundant boating opportunities.

Fishing leads County recreation in popularity. Known as the Bass Capital of the West, Clear Lake provides numerous opportunities for bass fishing enthusiasts and generates substantial revenue for the County. Anglers enjoy recreational fishing, derbies, and tournaments at the County’s lakes and reservoirs. Each year more than 25 fishing tournaments take place on Clear Lake. Florida-strain largemouth black bass, yellow and blue channel catfish, white and black crappie, green sunfish, and bluegill are among the sports fish in Clear Lake.

The Native Americans of the Clear lake Basin use its natural resources for social, cultural as well as economic purposes. The local Pomo Tribes, known for their basketry skills, gather materials in the riparian zone around the lake and throughout the county.
Irrigation and Potable Water Source

The lake provides water for both drinking and irrigation. The following map shows some of the locations of Water Treatment Plant Intakes within a half mile (due to security issues the exact location is no longer available to the general public). In addition there are private water intakes used primarily for landscape irrigation and possible drinking water at undisclosed locations around the lake. Many of these are unregulated and undocumented individual systems. Commercial agriculture also pumps water from the lake for irrigation.
Fish and Wildlife Uses

Clear Lake historically and presently contains valuable fish and wildlife resources that are not only important to consumptive users, but also to the ecological integrity of the lake and surrounding area. All types of aquatic vegetation including submersed, emergent, and floating-leaved are significant components of all lake ecosystems and are critical to support successful reproduction and recruitment, and provide food resources either directly or indirectly, for growth for a wide variety of aquatic animals.

Plans should focus on maintaining natural habitats and attempt to reestablish native aquatic vegetation. Native submersed aquatic plants provide an important component to Lake Systems that enhance fish and wildlife resources. However, in the absence of native submersed plants, the exotic aquatic plants can furnish habitat to fish and other aquatic animals and provide benefits to the ecosystem. Yet fundamental questions about aquatic plants - fish and wildlife interactions remain: a) can this invasive species provide quality fish and wildlife habitat (as do native plants); and b) at what levels of growth and abundance do negative impacts of this plant outweigh any potential positive attributes?

Clear Lake and tributary streams generally support an abundant and productive warmwater fishery, supporting an estimated 29 fish species, with 13 native and 16 introduced species of fish (USDA Forest Service 1999, Jones & Stokes Associates 1997). Common fish species in Clear Lake and tributaries include largemouth and smallmouth bass, channel and white catfish, bluegill, brown bullhead, crappie, threadfin shad, carp, and rainbow and brown trout. Native fish species in Clear Lake include the Clear Lake Hitch, of cultural significance to local Tribes, and Sacramento Roach. The hitch, roach, catfish, and rainbow trout use lower reaches of tributary streams for spawning during the spring (March–June). The Clear Lake Splittail is presumed extinct (Moyle et al. 1995).

The composition and population levels of fish species in Clear Lake and tributary streams have been affected largely by the introduction of nonnative fish species and the direct and indirect alteration of habitats (USDA Forest Service 1999). Exotic species have altered natural predator-prey relationships, and bass and carp are known to be voracious predators of native hitch and roach species (Moyle et al. 1995). Loss of aquatic and lakeshore vegetation has resulted in a loss of cover and foraging habitat for
fish species. Juvenile life stages fish species, such as the native Clear Lake hitch, require cover in tule beds or other aquatic vegetation to avoid predators such as introduced carp and bass species (Moyle et al. 1995).

As part of its valued tourism resource, Clear Lake provides wildlife habitat for a variety of waterfowl and songbirds. Although a substantial amount of the lake’s shoreline has been modified by development, there are many areas that still support these uses. Even developed shoreline areas, if some tules or other rooted aquatic plants are allowed to remain, can provide cover, feeding, and nesting areas for birds and other animals.

There are several areas around the lake that host nesting Osprey, including the northshore, Soda Bay, Rodman Slough, and areas near the City of Clearlake. Bald Eagles winter here and there are now four known nesting pairs - one on the northshore near Paradise Cove, one in the lower arm of the lake near Jago Bay, one south of Lakeside County Park, and one in Buckingham.

During the summer the lake is home to Western and Clarks Grebes, Pied-billed Grebes, American Coots, Great Blue Herons, Green Herons, Black-crowned Night Herons, Bitterns, Kingfishers, Double-crested Cormorants, Osprey, Bald-Eagles, and Golden-Eagles to name only a few of the wide variety of birds. During the winter, migrating Common Mergansers, Common Loons, Buffleheads, Common Goldeneye, Eared Grebes, Great White Egrets, and other animals frequent Clear Lake. Rodman Slough is a migratory stopover known as a “migrant trap” where migrating songbirds often touch down on their journey south. Migrating warblers are often found there in spring and fall as they are at the McVicar Preserve which is adjacent to Anderson Marsh State Historic Park on the south end of the Lake. A huge variety of songbirds, both migrant and resident frequent all riparian and marsh areas on the lake, including Marsh Wrens, Warblers, woodpeckers, sparrows, juncos, Western Bluebirds, finches, American Robins, and more.

Tule habitat is very important to all these species - there is concern that tules are being over-taken by water primrose and control of this infestation has been suggested. On the other hand, careful monitoring of the impacts of chemical treatment needs to be carried out. The vast weedmats undoubtedly provide some feeding areas for birds like Pied-billed Grebes and coots, but tule habitat is by far the most valuable.

The lake is also important to a variety of wild mammalian species, e.g. deer,
bobcat, mink, muskrat, opossum, skunk, raccoon, otter, which live around the lake and rely upon its waters for survival.

While the fish and wildlife management community generally recognizes the need to limit the impacts related to aquatic plants, there is still much concern and debate surrounding the type and level of control available for managing these plants in Clear Lake.
AQUATIC PLANT CHARACTERIZATION

Aquatic Plant Community: Past and Present

Before European settlement, there was an estimated 9,300 acres of freshwater wetlands in the basin, with 7,520 acres removed during the last 150 years. Land use and land conversions have directly and indirectly resulted in the removal of wetland habitat (Richerson et al. 1999). Aquatic vegetation in shallow water habitats was formerly common in Clear Lake (Coleman 1930). Significant remaining stands of tule marsh vegetation include the Anderson Marsh, Rodman Slough, and an area south of Lakeport and west of the Clear Lake State Park. Major tule marshes are an important habitat resource. Not only do the tules provide spawning and nesting areas for fish, they also are nesting areas for birds such as Western Grebes. For example, the area from south Lakeport all the way down to the County Park contains vital Western and Clark’s Grebe nesting habitat. The summer of 2004 saw hundreds, if not thousands of nesting grebes in this area. Some pairs fledged as many as two or three babies and continued to breed well into July. Tules are vital to the Grebes because they build their nests from tules, and then attach them to the tules. The County has enacted a shoreline ordinance with provisions for not allowing any net loss of the existing tule marsh areas.

The most extensive submerged aquatic plant beds are located in the shallow western end of Upper Arm of the lake and scattered along significant portions of the remaining nearshore. Though these beds are problematic to navigation and certain ecological processes, they also serve as a source for plant fragment “rafts” that float into adjacent open-water areas, thereby creating problems there, as well. It is estimated that upwards of two-thirds of the shoreline of Clear Lake has nuisance aquatic plant growth occurring seasonally.

An extensive assessment of aquatic vegetation on Clear Lake has only recently been undertaken, (2002 season). Vegetation was present in 196 of the 747 sample sites (26%). The most abundant species found was Sago pondweed. The distribution of Sago pondweed occurred primarily in the main basin of Clear Lake. Sago was identified at nearly double the locations as the second most abundant species, Coontail. Eurasian watermilfoil, third in abundance, was found in 5% of all sample sites, and 19% of vegetated sites. The Eurasian watermilfoil was primarily distributed in the southeastern arms of the lake.
Overall vegetation distribution is concentrated along the western and southern littoral zones of the lake. Geographic distribution of each individual species is represented on the attached maps (see Appendix F).
Vegetation BioCover (Bottom Coverage) Analysis

The hydroacoustic data was also analyzed for overall vegetation bottom coverage, a measurement referred to as ‘biocover.’ Hydroacoustic data is not affected by water clarity, so it is the most reliable and efficient means to map vegetation bottom coverage. Similar to the bathymetric data analysis, the bottom coverage data for all the transects were plotted using GIS mapping software. The software then uses algorithms to interpolate bottom coverage between the transects. For this analysis, the model used is based on the geophysical minimum curvature method. The result is a full-lake vegetation bottom coverage map and associated statistics (see Appendix). The bottom coverage data does not make a distinction between species, which is the reason for also conducting the Vegetation Species Analysis.

The results of the bottom coverage analysis show that much of the littoral zone of the lake is vegetated. The shoreline gaps in bottom coverage are mostly areas that are very rocky or deep and do not support vegetation, or are places where the model did not interpolate bottom vegetation presence between transects. One unusual area that shows little bottom coverage is a section of the north-northeast littoral zone. The reasons that this area has sparse biocover were not determined in the scope of this study.
Vegetation BioVolume Analysis

Each hydroacoustic data point contains information on mean plant height, bottom coverage of vegetation, and water depth. Plant height and bottom coverage data can be combined with water depth information to produce a new metric called plant ‘biovolume,’ a representation of the fraction of the water column filled with submersed vegetation. For example, in 6 feet of water with a 3-foot mean plant height and 100% plant bottom coverage, plant biovolume would equal 50%. If plant height were reduced to 1.5 feet in this example, biovolume would decrease to 25% despite no difference in plant bottom coverage. Biovolume calculations allow quantification of how much of the water column is affected by nuisance plant growth resulting in reduced navigation, habitat quality, etc.

The results of the biovolume analysis suggest that only 104 acres of the lake have biovolume above 50%. This is about 2% of the total submersed vegetated area of the lake.

When considering the effects of significant biovolume, it is important to consider the ecological and recreational impacts of biovolume to those areas. While areas of significant biovolume may be relatively low, often those areas are in key ecological or recreational pockets of a lake (due to shallow water depth, nutrient inputs, and/or increased water column disturbances).
Predictive Analysis

A predictive map showing areas of increased risk for significant biocover is included in the Appendix. This map was based on analyzing the extent of the littoral zone, the presence/absence of vegetation, the distribution of biocover and biovolume, the sediment compositions, and the locations of particular species existing in the lake (particularly Eurasian watermilfoil).

Three predictive categories were delineated for this map: high potential for continued vegetation development, elevated potential for vegetation establishment, and low potential for vegetation growth. Sediment composition played an insignificant role in the predictive model for Clear Lake because sediment macro-types are largely homogenous throughout the lake. The possible exceptions are areas of rocky/cobbly shoreline. However, while these areas have a reduced likelihood of noticeable biocover, they still possess some likelihood because vegetation was observed in some of these areas.

The area labeled ‘elevated potential for vegetation establishment’ represents the portions of the lake that meet most or all of the above-defined criteria for vegetation presence in Clear Lake, but which are not currently vegetated. Depending on changes in the lake water conditions (water clarity, nutrient inputs, etc.) or lake plant species, these areas show the greatest potential to support submersed aquatic plant communities. This area of elevated potential totals 8,578 acres, or nearly 22% of the lake.
**Table 1**  List of Species sampled during August/September 2002 ReMetrix survey

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceratophyllum demersum</td>
<td>Coontail</td>
</tr>
<tr>
<td>Potamogeton pectinatus</td>
<td>Sago pondweed</td>
</tr>
<tr>
<td>Scirpus validus</td>
<td>Softstem bulrush</td>
</tr>
<tr>
<td>Ludwigia peploides</td>
<td>Creeping water primrose</td>
</tr>
<tr>
<td>Myriophyllum spicatum</td>
<td>Eurasian watermilfoil</td>
</tr>
<tr>
<td>Heteranthera dubia</td>
<td>Water star-grass</td>
</tr>
<tr>
<td>Potamogeton nodosus/illinoensis</td>
<td>Longleaf pondweed/Illinois pondweed</td>
</tr>
<tr>
<td>Najas flexilis</td>
<td>Slender Water Nymph</td>
</tr>
<tr>
<td>Elodea canadensis</td>
<td>American Elodea</td>
</tr>
<tr>
<td>Potamogeton crispus</td>
<td>Curly-leaf pondweed</td>
</tr>
<tr>
<td>Scirpus acutus</td>
<td>Hardstem bulrush</td>
</tr>
<tr>
<td>Chara sp.</td>
<td>Muskgrass</td>
</tr>
<tr>
<td>Potamogeton zosteriformis</td>
<td>Flat-Stem Pondweed</td>
</tr>
<tr>
<td>Filamentous Algae</td>
<td></td>
</tr>
</tbody>
</table>

(See Appendix F for distribution maps for each species)

**Table 2**  Lake County Vector Control Aquatic Plant List: Additional documented species known to be present in Clear Lake

<table>
<thead>
<tr>
<th>Species</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azolla filiculoides</td>
<td>Water velvet</td>
</tr>
<tr>
<td>Azolla mexicana</td>
<td>Water velvet</td>
</tr>
<tr>
<td>Cephalanthus occidentalis</td>
<td>Button bush</td>
</tr>
<tr>
<td>Eichhornia crassipes</td>
<td>Water Hyacinth</td>
</tr>
<tr>
<td>Hydrilla verticillata</td>
<td></td>
</tr>
<tr>
<td>Lemna sp.</td>
<td>Duckweed</td>
</tr>
<tr>
<td>Nuphar polysiphonium</td>
<td>Cow lily</td>
</tr>
<tr>
<td>Nymphaea sp.</td>
<td>Water lily</td>
</tr>
<tr>
<td>Phragmites australis (= communis)</td>
<td></td>
</tr>
<tr>
<td>Polygonum amphibium var. emersum</td>
<td>Smartweed, Knotweed</td>
</tr>
<tr>
<td>Polygonum spp.</td>
<td>(several species) Smartweed, Knotweed</td>
</tr>
<tr>
<td>Potamogeton americanus</td>
<td>American pondweed</td>
</tr>
<tr>
<td>Potamogeton linearis</td>
<td></td>
</tr>
<tr>
<td>Potamogeton natans</td>
<td>Floating-leaf pondweed</td>
</tr>
<tr>
<td>Potamogeton nodosus</td>
<td></td>
</tr>
<tr>
<td>Sagittaria sp.</td>
<td>Arrowhead, Duck potato</td>
</tr>
<tr>
<td>Salix goddingii</td>
<td>Willow</td>
</tr>
<tr>
<td>Scirpus californicus</td>
<td>Southern bulrush</td>
</tr>
<tr>
<td>Scirpus validus</td>
<td>Softstem bulrush</td>
</tr>
<tr>
<td>Typha angustifolia</td>
<td>Cattail</td>
</tr>
<tr>
<td>Typha domingensis</td>
<td>Cattail</td>
</tr>
<tr>
<td>Typha latifolia</td>
<td>Cattail</td>
</tr>
</tbody>
</table>

28
Hydrilla


Hydrilla was found in Clear Lake on August 1, 1994 during a routine detection survey conducted by personnel from CDFA and CAC. The CDFA and Lake County biologists responded rapidly and applied copper aquatic herbicide to some infested areas within two weeks of the first detection.

An initial delimiting survey found 175 to 200 acres along the shoreline of the upper arm of the lake were infested. Infestation levels varied from a few scattered plants to dense populations. In addition, in both 1994 and 1995, thousands of hydrilla fragments were visible at some of the boat ramps in the upper end of the lake.

The Clear Lake California Department of Fish and Game Hydrilla Project personnel divided the lake’s shoreline into 80 management units plus 3 management areas along the Clear Lake outlet channel in order to better track and plan the eradication effort. These management units were based upon landmarks for ease of identification; they are not of equal size.

In general the Clear Lake Project crew starts in late April and early May and focuses their detection efforts on the known infested areas. These areas are all fairly near the shoreline, out to about 500 feet from the shore. There has been a decrease in the number of plant finds every year since the plant population has been low enough to count discrete finds. In addition, the number of infested management units has decreased from a maximum of 54 in 1998 to six in 2002.

Despite the decrease in the total number of hydrilla finds in 2001, the Clear Lake Project survey crew did find hydrilla in one previously uninfested management unit, number 44, and in one unit where hydrilla had not been found since 1999, number 75. In 2002, the crews did not find any hydrilla in previously non-infested units. In 2003 one new find of hydrilla was found in unit 25.
Starting in 2000, some management units have been free for over three years and are no longer actively treated. Because of the success of the Clear Lake Project, the number of such previously infested, but now non-infested and non-treated units has increased every year since 1999.

In 1994, only two infested areas were located in the lower arms of the lake, southeast of the Narrows. In 2001 and 2002, there were 22 infested areas that were located southeast of the Narrows. Moreover, since 1998, there has been an increase in 13 units in the lower arms as compared to an increase of only two units in the upper arm. In addition, most of
the previously infested but now non-infested units are in the upper section of the lake.


31 Clear Lake Integrated Aquatic Plant Management Plan
The Plan has sought specific guidance for viable aquatic plants control options. Starting with, input from stakeholders such as the Managing Aquatic Plants (MAP) Task Force, Clear Lake Advisory Subcommittee (CLAS), Clear Lake Rimlanders Association, the R and R Association, local city officials, and interested members of the general public whose comments and recommendations have been thoughtfully considered. In addition, critical input was obtained from government agencies the CDFA, RWQCB, CDFG, CDPR, NRCS and the Corps of Engineers, as well as, consultants and university staff.

Public involvement in the Aquatic Plant Management currently has evolved through three stages:

1. Pilot Project evaluating control methods, funded by a California Boating and Waterways grant, administered by a partnership of Greater Lakeport Chamber of Commerce and County Department of Public Works.
2. The Managing Aquatic Plants Task Force, a citizen stakeholder group which provided a venue for education and consensus building. Oversight provided by County Agriculture Commissioner’s Office.
3. Clear Lake Advisory Subcommittee, review and oversight of previous 2 stages. In addition reviewed and commented on developing interim and long-term programs by Water Resource Division of County Public Works Department.

Each of these groups’ contributions will be summarized in the following section. Continued public involvement and outreach is an essential and ongoing goal of this program.

Pilot Program

In 1996 California Senate Bill No. 1416 was passed authorizing Boating and Waterways to grant funds to Lake County to conduct a pilot project. The bill was passed as an emergency statute allocating $147,000 to explore options for nuisance aquatic weed control methods that could be compatible with the hydriilla eradication program conducted by the California Department of
Food and Agriculture on Clear Lake. $15,000 of these dollars was allocated to the Department of Fish and Game for program support. Funding allocations were available as follows: 1996-97 $45,000, 1997-98 $43,000, and 1998-99 $44,000. The grant expired on December 31, 1999. The Greater Lakeport Chamber of Commerce (Chamber) initiated the process to procure funding, however the Department of Boating and Waterways could not give the money directly to the Chamber which led to the partnership between the Chamber and the Lake County Department of Public Works (DPW). The pilot program worked 2 years evaluating several applied management techniques. (See Appendix D, Evaluation of Control Measures).

On November 1999, several options for future management of nuisance aquatic vegetation control were presented to the Lake County Board of Supervisors, ranging from taking no action to governmental control. The outcome of the hearing directed the Agriculture Department to: pursue the development of a management program for non-hydrilla aquatic vegetation; to seek funding to develop an environmental impact report and administer a permit to assure that chemicals only be applied by a licensed certified aquatic applicator.

This project provided an opportunity to gather information and assisted in the initiation of a process that has lead to focused, dynamic management objectives for the Clear Lake water body in order to maintain and enhance its natural beauty and meet public trust obligations.

Managing Aquatic Plants Task Force (MAP)

Local concern regarding problems associated with the aquatic plant infestations, centered on future impacts on recreational opportunities, fish and wildlife resources, and ecological health of lake, ultimately resulted in the formation of the Managing Aquatic Plants-Task Force (MAP) in 1999, by the Lake County Agricultural Commissioners office.

MAP Task Force was comprised of representatives of the California Department of Fish and Game (CDFG) the Lake County Department of Public Works (DPW), lakeshore property owner, restaurant and resort owners, environmental groups and other interested parties. The MAP Task Force was a temporary Lake County Board of Supervisors appointed committee, established to direct the process for the control and/or elimination of aquatic
plants in the lake, and to address the problems associated with nuisance aquatic plant growth.

In addition MAP developed a draft plan, hosted a Weed Faire, developed two pamphlets, began GPS work, and orchestrated public involvement in aquatic weed management issues.

Clear Lake Advisory Subcommittee (CLAS)

The MAP Task Force was dissolved in January of 2002. Its role was taken on by the already established subcommittee to the County Resource Management Committee (RMC), which reports to the County Board of Supervisors (BOS) on lake related issues. The Clear Lake Advisory Subcommittee (CLAS) is composed of stakeholder groups and BOS appointed members representing a balanced cross-section of interests. The advisory group traces its history back almost two decades. Starting as the Algae Committee it reported directly to the BOS on algal related issues. CLAS has since been restructured over time and broadened its reach to include lake issues in general. The subcommittee functions on a watershed approach to Lake Management, which is manifest in the ongoing Clear Lake Basin Management Plan for which this committee is also providing oversight.
EVALUATION OF CONTROL ALTERNATIVES

It is clear that actions can be undertaken to greatly reduce the amount of invasive non-native aquatic plants in the system, and keep noxious aquatic plants populations at a reasonably low level, while restoring and conserving the recognized benefits of a diverse native aquatic plant community. Proven techniques for controlling aquatic plants fall into the following categories: Environmental, Mechanical, Chemical, Biological, Cultural and Preventative. What works in one situation may not work in another.

Detailed descriptions of the management options can be found in the appendices of this report. The follow sections attempt to give the reader a quick overview of the various options and issues in relation to their use on Clear Lake. To more clearly understand the techniques please refer to the appendix section.

Environmental Controls

Water Drawdown involves exposing plants and root systems to prolonged freezing and loss of water. The use of Drawdown as an aquatic plant management tool is more common for use in reservoirs and ponds than in natural lakes. Drawdown is not feasible in Clear Lake.

Non Toxic Dyes are chemicals that prevent penetration of necessary light energy to developing plants that may in turn reduce aquatic macrophyte growth. Non Toxic Dyes are not feasible in Clear Lake.

Fertilization: Critical plant nutrients in short supply may be added to cause an algal bloom that shades out rooted plant growth. Fertilization is not feasible in Clear Lake, due to 303d listing as a nutrient impaired water body and not being economically feasible.

Mechanical/Physical Controls

Mechanical control techniques have been in use for centuries to battle nuisance
growth of both terrestrial and aquatic plants.

Techniques that inflict physical damage to plants range from hand-operated implements to very specialized mechanized equipment. Simply cutting rooted plants below the water surface, by either hand-operated or mechanized cutters, may lead to death and eventual decomposition for some species. However, for many typically problematic perennial species (e.g. Eurasian Water milfoil, Egeria, and Hydrilla), cut shoot material may continue to thrive if not removed by some secondary process. One feasible process recommended in this plan is to treat the immediate area being cut with a contact herbicide to kill escaped fragments when harvesting fragmentation propagated species.

Harvesting does not result in long-term reductions in growth because root crowns and roots are left intact. Duration of control for most species would be minimal, generally less than one season. Cut plants must be removed from the water or destroyed with contact herbicide. Fragments are numerous, making clean up difficult and laborious. Harvesting is considered a short-term technique that temporarily removes nuisance plants. To achieve maximum removal of plant material, harvesting is usually performed during summer when submersed and floating-leaved plants have grown to the water’s surface.

Conventional single-staged harvester boats combine cutting, collecting, storing, and transporting vegetation into one piece of machinery. Cutting machines are also available which perform only the cutting function. Maximum cutting depths for harvesters and cutting machines range from 5 to 8 feet with a swath width of 6.5 to 12 feet.

Harvesting operations result in the immediate, non-selective removal of the upper shoot portions of targeted plant stands. In areas where excessive plant growth has led to degraded habitat and water quality, harvesting often provides temporary improvement to conditions. A specific location can be targeted leaving an area open for fish and wildlife. There is usually little interference with recreational use of the water body during harvesting operations. By cutting only the top 5 ft of the plant, some habitat remains. Harvesting dense stands of aquatic plants may promote good fish growth in harvested areas and allow predator fish to forage more effectively.

Conventional aquatic plant harvester systems can not be utilized to control the plant fragment masses in the shallow water and near shore areas. Conventional harvester systems generally have a minimum operating draft of more than 3 ft.
and therefore, would not be able to collect fragment masses in shallow water areas. Smaller fish, turtles, and macroinvertebrates are themselves subject to becoming harvested, especially in dense plant stands that hinder their escape (Booms 1999). Nichols (1991) suggests that harvesting nontarget native species that reproduce by seed, regenerate poorly from fragments, or regrow slowly are at a competitive disadvantage to plants with growth characteristics similar to Eurasian Water Milfoil. Fragment production by harvesting has often been mentioned as a detrimental consequence of this technique, since generated fragments can serve as a source for dispersal to new areas.

Harvesting costs depend on a variety of factors such as program scale, composition and density of vegetation, equipment used, maintenance, skill of personnel, and site-specific constraints. Detailed costs are not uniformly reported, so comparing project costs of one program to another can be difficult. Currently, contract aquatic plant harvesting operations cost about $750.00 per acre on non-prevailing wage rate projects and $1000.00 per hour if prevailing wage is required (Houghton Lake 2001). Using a recent estimate of control at one acre per day, contracting would be very costly. The current purchase price for a new harvesting system is approximately $110,000 plus an ongoing operations and maintenance expense each year.

The following are recommendations for mechanical control in Clear Lake. Use conventional harvesters in open water areas for short-term control of actively growing aquatic plant beds for the following scenarios:

- For control in small areas where herbicides can not be used or where environmental conditions (e.g. high water exchange) prevent effective control by diluting required herbicide concentrations.

- For creating boat lanes across extensive weed beds.

- For treatments within or near sensitive areas (e.g. water intakes, protected fish and wildlife active nursery rearing areas).

Presently the use of mechanical methods is very restricted in Clear Lake, due to the ongoing Hydrilla Eradication Program. If hydrilla is successfully eradicated from the lake, in the coming years, there will be opportunities for the expansion of mechanical methods. The Plan needs to carefully consider other invasive species prone to spread from fragments when considering present and future use of this control method.
Biological Controls

Biological control is the use of parasitoid, predator, pathogen, antagonist, or competitor populations to suppress a pest population, making it less abundant and thus less damaging than it would otherwise be. Control organisms may be insects (or other arthropods), pathogens, or vertebrate herbivores. The biological methods of control are limited at this time. Introduction of non-native organisms is highly regulated by governmental agencies, and research requirements are substantial and expensive. The current budget crisis in California has resulted in several cuts in these programs further delaying potential introductions. Although surveys for classical biological control agents (agents that control the exotic plant in its native range) have been conducted no classical agents have been released from quarantine (Lars Anderson, pers. comm.) and it is unlikely that classical agents will be available in the near future.

Grass carp were brought into the United States from Malaysia in the 1960’s and have been used to control aquatic weeds extensively in the South. Sterile triploid carp varieties have been developed, to eliminate breeding and thereby limit population to stocked fish. They have been used in parts of California (e.g. Imperial Irrigation District canals). However, even these sterile individuals are not allowed by state statute in areas such as Clear Lake, nor necessarily suitable or affordable if permitted. (See Appendix D). Grass carp are not an option in Clear Lake.

Successful biological control results in a suppression of the pest plant, not its elimination. Because of the potentially cyclical nature of control and the lower predictability of control temporally, biological control is most useful for long term control in lower priority sites and over large areas where other management actions would be less feasible or cost effective. High priority areas, where effective and rapid control is needed (e.g., boat channels, swimming beaches, docks), should be managed with other approaches.
Chemical Control

Aquatic plants have been successfully managed using various formulations of systemic and contact herbicides for several decades. While several formulations of both systemic and contact herbicides are registered by the U.S. Environmental Protection Agency for controlling aquatic plants, not all of those products are currently registered in the State of California and are therefore unavailable for use on Clear Lake. When treating submersed plants, herbicide effectiveness depends upon dose and contact time (also known as concentration and exposure time relationships or CET), which is in turn dependent upon the water exchange, a characteristic of the treatment zone.

Herbicides are divided into two groups, contact and systemic, by mode of action. Contact type herbicides rely exclusively on physical contact with the target plants. Systemic herbicides, unlike contact herbicides, translocate throughout the plant and under ideal conditions can provide complete control of the target weed. These herbicides are primarily absorbed by the leaf and stem tissues and move to the actively growing apical regions of roots and shoots, killing the entire plant.

The modes of action of many herbicides are directed at photosynthesis (plants), and therefore, when used according to label recommendations these compounds have no direct impacts on fish and wildlife. In many instances, using herbicides to remove or reduce nuisance levels of invasive aquatic vegetation can have many positive impacts on lake ecosystems. However, using aquatic herbicides can result in some types of indirect ecological impacts on lakes, but any negative impacts are usually short term. When aquatic herbicides are used for controlling vegetation in a broad-spectrum manner, desirable native submersed plants growing in the treated area can also be removed or injured. If all submersed plant biomass is quickly destroyed in an area, indirect ecological effects can occur, such as: release of nutrients into the water column from quickly decaying vegetation (nutrients that would become available for phytoplankton and filamentous algae), removal of oxygen by the increased biological oxygen demand (BOD) during plant decay process and the removal of structure and food sources for aquatic organisms and wildlife.

The waters of Clear Lake are considered public and therefore only licensed applicators have been allowed to apply herbicides to the waters of the lake. On March 12, 2001, the Ninth Circuit Court of Appeals decided that discharges of pollutants from the use of aquatic pesticides to waters of the Western United
States require coverage under an NPDES permit, (Headwaters, Inc. v. Talent Irrigation District). A general permit has been developed by the State Water Resources Control Board (SWRCB) in order to provide coverage for broad categories of aquatic pesticide use in California. This General Permit covers the uses of properly registered and applied aquatic pesticides that constitute discharges of “pollutants” to waters of the United States. Part of the NPDES permit of herbicide monitoring involves sampling for the active ingredient (ai) residue of all approved herbicides. (See Appendix I)

The above map indicates the monthly monitoring at the main inlet and outlet of the lake (primary sampling sites as required by NPDES permit). In addition, dissipation studies for residues of active ingredient (ai) are monitored over several days for random individual applications throughout the lake by County staff.
Cultural Control

Many of the problems associated with aquatic plants are more social than biological in importance. Selected use areas attempt to control people rather than plants, as in the establishment of natural areas.

There is a public resistance to developing lake zones to control recreational activities on the lake. Enforcement is also a serious consideration.

Many areas around the lake are not appropriate for development due to slope, lot size, easements, etc. These areas will not be managed except to control outbreaks of noxious or exotic invasive species of concern.
No Action Alternative

There are several situations in which taking no action is appropriate. Consensus on control strategy may be unattainable or simply taking no action may be more favorable alternative. However, this is rarely, if ever, the case when dealing with invasives and not considered a good policy. No action might be the choice while waiting for new, more effective or environmentally friendly strategies to be developed.

If taking no action is considered, it is important to consider the eventual consequences to the target water body and perhaps surrounding water bodies, particularly in the case of a non-native invasive weed such as Brazilian Elodea and Eurasian Milfoil. The effects of dense weeds on water quality, fish and wildlife habitat, aquatic organisms, and recreation and tourism are all concerns to be addressed when considering the no action alternative. In order to maintain a perspective, the consequences of taking no action should be weighed against the costs and benefits of various plant control options.

The residents of Lake County and visitors to the area are very unhappy about the excessive aquatic plants and their impacts to recreation in the lake, and, currently, they are looking for an effective control.

Considering the fact that there are no large-scale control options without associated risks, the no-action alternative has appeal, but too has risks as noted above. Though the negative impacts of native and other exotic plant encroachments throughout the littoral zone of Clear Lake are substantial, some of these impacts, such as swimming safety, can be addressed only through chemical or mechanical control.

Because of the complexities involving the tourism, the local economy and safety in Clear Lake, taking no-action on the aquatic weeds is not appropriate.

Preventative Techniques

A prevention program that educates the public about noxious aquatic weeds is a valuable and important part of aquatic management planning. Weed control is not weed prevention. Education is a great prevention tool. This can be accomplished in the form of continued newsletters, flyers, and newspaper articles. More neighborhood workshops for training in the recognition of
troublesome aquatic plants can help citizens with the early detection of different noxious weeds. Public awareness of the problem can make a difference in the spread of exotic plants. Signs are being posted at the boat ramp and nearby lakes describing the invasive plant problem and the need to keep boats, trailers, and fishing gear free of plant fragments. Regular weekend volunteers checking boats for noxious weeds at the boat ramp would reinforce this message. Boat washing stations have been used successfully at some lakes.

Increased education and outreach on landuse practices that may contribute to aquatic plant problems by adding nutrients: fertilizing, septic system integrity, creekside and shoreline burning and dumping of yard wastes, grading and development that does not have adequate control measures in place.
CONSIDERATIONS IN MANAGING PLANTS

This plan should prioritize the most valuable resources and lake uses in order to design and implement activities for restoring and maintaining Clear Lake in a healthy condition now and in the future. After reviewing the ecological status of Clear Lake, and upon considering the documented negative impacts that aquatic plants can have on lake ecosystems, it is clear that invasive aquatic plant infestations can cause problems for the overall health of the water body. These problems include consequences to biological diversity, important fish and wildlife resources, recreational activities, and economics in the region. Since certain non-native aquatic plants currently occupy such a large percentage of the system, it is not realistic to believe that all the problematic species can be eradicated from Clear Lake. However, it is possible that actions can be undertaken to greatly reduce the amount of non-native aquatic plants in the system, and keep invasive aquatic plants populations at a reasonably low level, while restoring and conserving the recognized benefits of a diverse native aquatic plant community.

In order to achieve such a goal, it is imperative that a lake management plan be developed to address the short-term problems associated with the *Hydrilla* infestation for the next several years, followed by addressing the long-term reduction and continued control of other invasive plants in Clear Lake over the next several decades.

Watershed management practices, including maintenance practices of shoreline property and sewage disposal issues should be reviewed and assessed to determine impacts of those processes on the implementation and success of aquatic plants control techniques applied to the lake.

**Limnological Impacts of Aquatic Plants Control Techniques**

A shallow warm water lake like Clear Lake generally supports a complex ecosystem. Everything in the system is interconnected and our actions on one part of the system can affect all other parts, although the actual method and quantity of interaction is usually unforeseeable. Inputs and nutrient loading can be caused by natural events (fire, geologic activity, drought, flooding) or anthropogenic impacts (mining, development, species introduction, wetland
loss.) Long term impacts to the system are considered most unforeseeable.

The inputs to the system include the water that enters the lake through direct rainfall, stream flow, and ground water flow. A constituent of these inputs are the nutrients occurring naturally in the watershed. Of primary concern are nitrogen and phosphorous. The nutrient contribution to the system includes increased erosion caused by human activity in the watershed such as roads, as well as runoff of fertilizer, pesticides used in the watershed by agriculture and near-lake homeowners. Sewage inputs, while reduced in recent years, are still a source of excess nutrient flow to the lake from old or inadequate septic systems around the lake. Finally, one of the most significant inputs to the system is sunlight. While the average quantity of sunlight has been constant, the depth of penetration varies significantly depending on the water clarity that affects the dominance of plant growth or algae. Clear Lake is a eutrophic water body, meaning that it is nutrient rich and highly productive. Because of nutrient availability there will always be some level of algae or plants. Their abundance is directly related to the nutrient level. Land use changes without adequate and proper erosion and sediment control can increase sediment and nutrient loading into the lake, making algae and/or plant conditions a greater nuisance.

A myriad of plants and animals starting at the microscopic level in the muck at the bottom of the lake as well as suspended in the water consume some of the nutrients in the water and are in turn consumed by higher species in the food chain. Many of the plants and animals at all levels in the food chain die and decompose and again recycle through the food chain. The fish, invertebrates, and especially decomposing bacteria consume oxygen and if the levels are too low, die-off can occur. The plants utilize carbon dioxide and release oxygen during daylight, through sun driven photosynthesis. In addition, the plants, especially those near the shoreline provide shelter for spawning fish and habitat for the smaller plants and animals that the fish eat.

Because of the complexity of the system, whatever we do to one part may have an impact on many other parts of the system. For example: If we kill aquatic plants all at once in the summer without removing them from the lake, the decomposition process will consume oxygen from the water, which can cause fish kills. If we remove too many aquatic plants near the shoreline in the spring we may adversely affect fish spawning activities as well as reproduction of invertebrates necessary for the survival of young fish. Aquatic plant control could remove the hiding and feeding places the juvenile fish require to grow.
through their critical first few months of life.

Fish and Wildlife Impacts of Aquatic Plants Control Techniques

Physical problems of water bodies are usually relatively straightforward and solvable when compared with the issues related to plant and animal community ecology. Most aquatic organisms fall into three categories: 1) organisms that increase in abundance as aquatic vegetation increases, 2) organisms that decrease in abundance as aquatic vegetation increases, and 3) organisms that are unaffected by aquatic vegetation density. Although the nuisance aquatic plants should be curtailed for maintenance of safe conditions, recreational and economic reasons, there is still much concern and debate in the local fish and wildlife management community regarding the type and level of control for managing the plants in aquatic systems. Specific recommendations from the fish and wildlife management perspective include: limiting the use of harvesters which can exacerbate the spread of aquatic plants and limiting the use of the aquatic herbicides during sensitive times in reproductive lifecycle if necessary.

For largemouth bass the first noticeable spawning activity is nest building by males, which starts when the water temperatures reach 14 to 16 degrees C, usually in April (Emig 1966). Spawning activity will often continue through June (Moyle 1976). Early use of herbicides during this spawning period is effective, yet there are concerns from California Department of Fish and Game about impacts to eggs in the nests, although has not been scientifically proven. Utilizing mechanical harvesters that do not completely remove aquatic plant habitat is an option, but would be disruptive to nesting fish. In addition, other biocontrol options such as fungus and pathogens could be explored. Moreover, fish and wildlife aquatic plant relations in Clear Lake should be examined in greater detail as insufficient data exists for a lake of this size. Fish population and reproductive success measurements need to be made in both vegetated and unvegetated areas of the lake. Many birds feed on aquatic vegetation and associated fauna and/or use the vegetation in nests. A commitment to long-term monitoring/research should be implemented in which aquatic plant managers and biologists need to coordinate their respective activities to collect accurate data to assist in the decision making process.

Although nuisance levels of aquatic plants are not desired, these plants help to maintain water quality, water clarity and provide fish and wildlife habitat.
Water Quality Impacts of Aquatic Plants Control Techniques

It is often easier to work with visible (e.g., physical blockages of access to lakes with aquatic vegetation) than invisible (e.g., water quality, dissolved oxygen depletion) problems that appear with excessive aquatic plant growth. From an ecological standpoint, control of nuisance and/or exotic macrophytes can be considered a disturbance that often leads to temporary and/or permanent changes in the ecosystem structure and function. For instance, control of dense macrophyte stands can lead to an increase in available nutrients, and subsequently may stimulate excessive algal growth. On the other hand, control of nuisance, canopy-forming macrophytes can lead to improvement in dissolved oxygen conditions, which can be beneficial to other biota. Thus, there are tradeoffs in water quality (both negative and positive) that must be considered when developing an aquatic macrophyte management plan. These water quality tradeoffs also need to be evaluated with respect to the overall feasibility of application of a particular control technique, or suite of techniques.

Described here are specific water quality impacts for a variety of macrophyte control techniques that are feasible for Clear Lake. Critical information regarding undesirable plant density, nutrient content (may be estimated from literature values), and aerial coverage, as well as changes in native macrophyte densities, will be needed in order to make better decisions regarding impacts of control on water quality.

Macrophyte Control without Removal of Biomass from the System

Both herbicide treatment and mechanical shredding control macrophytes without removal of biomass from the system. Herbicides generally promote death through cellular damage and inhibition of metabolic functions while mechanical shredding devices clip and cut up macrophytes, leaving the tissue in the water column. Both techniques can be useful in controlling areas infested with aquatic plants, the later only preferable where extensive growth has occurred and a regular maintenance program is in place to keep boat lanes open.

Negative impacts: Aquatic macrophyte tissue can constitute a large reservoir of important nutrients such as nitrogen and phosphorus that can be mobilized directly into the water column as a result of macrophyte control and
subsequent plant tissue decomposition (Nichols and Keeney 1973). This flux can potentially lead to stimulation of nuisance algal growth. In particular, decomposition of submersed macrophyte tissue can be rapid as a consequence of control, resulting in a pulse of nutrients to the water column. Since nitrogen- and phosphorus-rich sediments are the primary nutritional source for uptake and incorporation into tissue by rooted macrophytes (Barko and Smart 1986), leaving biomass in the system after control represents a recycling pathway whereby sediment nutrients are ultimately transported into the water column via plant uptake and decomposition.

Decomposition of macrophyte tissue in the system may also impart an oxygen demand due to microbiological respiratory activities during the decomposition process (Jewell 1971). In shallow wind-swept regions, dissolved oxygen demands will be offset by reaeration generated by surface water turbulence. However, in shallow embayments and other areas protected from wind-generated turbulence, dissolved oxygen demands created by macrophyte decomposition may lead to anoxia. In addition to stresses on biological components (i.e., fishes, invertebrates, etc), the development of anoxia in bottom waters can lead to enhanced nutrient flux from the sediment, further exacerbating the potential for stimulated algal growth. In addition, nitrification (i.e., metabolic conversion of ammonium-nitrogen to nitrate-nitrogen) ceases under anaerobic conditions, resulting in the flux of ammonium-nitrogen from the sediment in the water column for uptake by algae. Eutrophication models, such as BATHTUB (Walker 1996), may be useful in predicting the potential impacts of decomposition and phosphorus mobilization resulting from macrophyte control, on changes in overall algal productivity in a lake.

Control of macrophytes can also lead to some indirect negative impacts on water quality. Non-selective destruction of all macrophyte cover can result in more frequent sediment resuspension and higher turbidity in the water column. Particularly in shallow lakes with large fetches, such as Clear Lake, water quality can be dominated by wind-induced sediment resuspension in the absence of submersed macrophyte coverage, promoting enhanced nutrient recycling, reduced water clarity, and higher concentrations of nuisance algae (Dillon et al. 1990; Maceina and Soballe 1990; Hellstrom 1991). In contrast, the occurrence of desirable native aquatic macrophytes in these shallow systems usually coincides with a clear water state and lower nuisance algal biomass (Hosper 1989; Dieter 1990; Scheffer 1990). Native macrophyte species provide refuge for zooplankton and fishes (Scheffer et al. 1993), and play an important role in stabilizing the sediment from resuspension by dampening wave activity and shear stress (James and Barko 2000).
Marsh Lake, a shallow impoundment located in western Minnesota, provides a good example of the role that native submersed macrophyte (sago pondweed, *Potamogeton pectinatus*) coverage can play in reducing sediment resuspension and improving water quality in shallow lakes. In the absence of macrophyte coverage, resuspension occurred frequently as wind speeds increase above 12 km/hr. During years when submersed macrophytes were present and covered the bottom of the lake, resuspension was minimal, even at very high wind velocities.

**Positive impacts:** Herbicide treatment and mechanical harvesting offer some positive impacts on water quality that need to be considered as well. For instance, opening up the canopy of a nuisance macrophyte stand via these techniques can lead to improved habitat for benthic invertebrate and fish communities via reaeration. For instance, dramatic changes in dissolved oxygen occurred in experimental plots after control of waterchestnut via mechanical shredding in Lake Champlain (James et al. 2000). This annual non-native macrophyte forms a dense surface canopy during the summer, which inhibits reaeration from the atmosphere and promotes the development of anoxia in the bottom waters. While it was hypothesized that mechanical shredding without harvesting the macrophyte material from the system would exacerbate dissolved oxygen conditions by increasing the oxygen demand in the water column, the opposite pattern occurred. Dissolved oxygen increased substantially in the water column due to removal of the surface canopy and improved reaeration. The authors suggested that improved reaeration neutralized any impacts that macrophyte decomposition might have had on dissolved oxygen stores in the shredded plots.

Reaeration and increased mixing and water exchange can have an indirect positive effect on sediment-water interactions. Under oxidized conditions, the sediment microzone can act as a sink for phosphorus due to the formation of ferric hydroxides and associated adsorption of phosphorus, immobilizing it from flux to the water column. Nitrification will dominate nitrogen dynamics in the oxidized microzone as well, minimizing the buildup of ammonium-nitrogen near the bottom waters.

**Conclusions:** Non-selective control of macrophytes using methods that leave biomass in the system can lead to negative water quality impacts such as mobilization to the water column of nutrients stored in macrophyte tissue, stimulation of nuisance algal growth, dissolved oxygen demand and anoxia.
with associated enhancement of sediment nutrient flux, and both temporary (i.e., during the control process) and longer-term (i.e., as a result of non-selective destruction of macrophytes) problems with sediment resuspension and associated water quality impacts (i.e., high turbidity, nutrient recycling, stimulated algal growth). Positive impacts on water quality include opening up the canopy for reaeration and increase in dissolved oxygen levels.

If the biomass and tissue nutrient content of macrophytes to be controlled is known (this information can be obtained via a macrophyte survey), literature values on leaching and breakdown rates can be used to estimate nutrient (primarily phosphorus) flux and dissolved oxygen demand as a result of macrophyte decomposition. These overall fluxes can be incorporated into budgetary or steady-state models to estimate algal and dissolved oxygen response to macrophyte decomposition. The models must, however, be adapted to consider macrophyte (and lack thereof) influences on the light climate, as well as the nutrient budget. They must also consider attached algae uptake of nutrients and growth.

Finally, the timing and frequency of macrophyte control needs to be considered in the assessment of water quality impacts. For instance, preemptive control, or control during the spring, when biomass and associated tissue nutrient mass is much lower, may lessen the severity of water quality perturbation versus control at peak biomass during mid to late summer. Methods that require more frequent application throughout the growing season (i.e., mechanical shredding every month) may exacerbate nutrient recycling versus control that persists for the entire summer period.

### Macrophyte Control with Removal of Biomass from the System

Mechanical harvesting is the primary means of both controlling macrophytes and removing biomass from the system. Generally, harvesters use conveyor belts to transport biomass to a truck that hauls it away for composting. Other harvesting techniques include hand pulling and diver-operated suction harvesting (Madsen 2000).

**Negative impacts:** There are two major impacts; one of the greatest impacts of mechanical harvesting on water quality is temporary resuspension of sediments during the procedure. As with contact herbicide applications (diquat and endothall) and mechanical shredding, mechanical harvesting is non-selective; thus, removal of all of the biomass can lead to more frequent periods of
sediment resuspension over longer time scales (weeks), due to increased exposure to wind and wave activity. Resuspension of nutrient-rich sediment can lead to nutrient enrichment of the water column and the stimulation of algal growth. Finally, mechanical harvesting non-selectively removes and/or kills invertebrates and small fishes in the littoral zone (Madsen 2000). The second major impact is the potential spread of invasive species by fragmentation.

**Positive impacts:** *There are situations where removal of macrophyte biomass and associated nutrients via mechanical harvesting can be beneficial to water quality.* In these instances, the nuisance aquatic macrophyte to be controlled typically dies back in the summer (e.g. curlyleaf pondweed) as a part of their life cycle, releasing nutrients to the water column at the height of the growing season that can be utilized by algae for growth. Removing macrophyte tissue under these circumstances can reduce nutrient loading to the water column. For instance, James et al. (2000) suggested that greater harvesting of curlyleaf pondweed prior to its natural senescence could significantly reduce phosphorus flux to the water column of Half Moon Lake during the summer via decomposition. In contrast, for other macrophyte species such as Eurasian water milfoil, which slough bottom leaves throughout the summer and die back in the autumn (Smith and Barko 1990), mechanical harvesting during the summer will probably not be effective in reducing nutrient loads to the water column.

Like other non-selective macrophyte control techniques, mechanical harvesting may improve dissolved oxygen conditions by opening up the canopy, promoting reaeration, and reducing day-night oxygen swings (Madsen 2000). This change in dissolved oxygen dynamics can lead to shifts in oxygen concentration at the sediment-water interface which can negatively effect nutrient fluxes (i.e., reduce sediment phosphorus flux out of the sediment).

**Conclusions:** Mechanical harvesting can be associated with temporary sediment resuspension during operation. Non-selective removal of macrophyte biomass can also lead to more frequent resuspension and associated increased turbidity and enhance nutrient recycling over longer time scales. Under certain circumstances, mechanical harvesting can be beneficial in removing macrophyte tissue nutrients that would otherwise be recycled back into the water column during the height of the growing season. Opening up the surface canopy can stabilize dissolved oxygen dynamics and promote reaeration.
IMPLEMENTATION PLAN

Previous sections of this Plan have described both issues and methods related to Plant Management. This section describes the actual implementation plan proposed. For ease of discussion we have broken the implementation plan into two elements: Working Framework which is controlled by a permitting process and Strategic Actions which are also important and give additional substance to the Plan and complement the basic working framework. Both of these elements of the plan are described in more detail in the following sections.

Working Framework and Permitting

The direct reduction of existing aquatic plants will be achieved through a mixture of the application of approved herbicides by licensed applicators as well as harvesting of existing plants. Both methods require the application for and receipt of a permit from the Lake County Department of Public Works prior to any action.

Although the plan commits us to an integrated approach of herbicides, and harvesting, the ongoing CDFA Hydrilla Eradication Program temporarily restricts our ability to harvest in many areas of the lake so for an extended period of time we will have to rely more on herbicides than many might prefer. As the hydrilla infestation is reduced and eliminated we may expect to see a shift in the balance between herbicides and harvesting as influenced by the ongoing data collection process and ongoing studies of the results of applications and harvesting in the lake.

Strategic Actions

There is a large range of critically important complementary actions also proposed as part of this plan. These include but are not limited to:

- Data collection of the ongoing extent of aquatic plant growth, and the relative effectiveness of different treatments in the lake
- Integration with the CDFA Hydrilla Program
- Adaptive Management (using the data to modify the program)
- Reduction of nutrient loads into the lake
- Public Education Programs
- Prevention of the introduction and spread of Invasive Aquatic plants into the lake.
- Enforcement
WORKING FRAMEWORK AND PERMITS

Permitting

Modification of the aquatic habitat is being undertaken to enhance aesthetics, improve public safety, and insure unimpeded access to and from boating facilities to the deeper parts of the lake. During 2000, 2001, and 2002 the California Department of Fish and Game (CDFG) was cooperative in developing and permitting local management strategies to deal with nuisance aquatic species within Clear Lake. In 2003 the County implemented an emergency program to run the permitting program because of understaffing at CDFG.

The Permitting Plan, modeled after year 2002’s coordinated single-point system, should insure continued protection of the natural resources, ongoing and improved data quality for analysis, while providing options for the control of nuisance vegetation.

All aquatic plant management activities, regardless of extent or method, must be approved in advance. Details of the Permitting Plan are as follows:

**Permit Structure**

The approval process is initiated by submission of an “Aquatic Plant Management Program Application” (see appendix E) to the County of Lake, Department in charge of the program. Valid applications must be accompanied by an Administrative Map of the Shore of Clear Lake, scale 1”=50’ (hereafter referred to as a Lake Bed Map) of the treatment site and requisite fees, when necessary. One permit per parcel is required for all herbicide treatments. The complete application is processed and copies are sent to the CDFA Hydrilla Eradication field office and the Lake County Agricultural Commissioner’s Office for approval or denial based on their jurisdictional authority and the current status of related activities. The applicant will be notified within 48 hours that the permit is ready for pickup and signature committing to compliance with all programmatic and specific conditions.
Herbicides

Administrative Controls. A greater degree of safety in the use of pesticides can be achieved by implementing rules that restrict who can recommend and use aquatic herbicides. These management practices include the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) regulations concerning product registration and labeling, state regulations governing applicator licensing, and permits:

A. All label directions FIFRA will be adhered to.

B. Herbicides will be applied by licensed and registered Qualified Applicators (holders of current and valid QAL or QAC license issued by the California Department of Pesticide Regulation) only.

C. The commercial applicator (the permit applicant) shall make a site visit to verify the need for treatment and the suitability of the site for treatment prior to receiving a permit. The information gathered (weed species, growth stage, area) will help the applicator determine the method of control and the appropriate herbicides to employ.

D. Immediately prior to treatment, the commercial applicator will examine a series of indicators and modify treatment plans accordingly. These indicators include (but are not limited to) heavy precipitation, recreational activity, boat traffic, water depth, water turbidity, and wind. If this examination indicates a potential for reduced control efficacy and/or increased water quality impacts, the treatment will be rescheduled. D.O and temperature reading will be collected at mid column above the bottom within the treatment area. D.O. levels below 5ppm and/or temperatures above 80 degree F could possibly act as thresholds, which prohibit herbicide applications.

E. Chemical applications shall be cumulatively restricted to an area of no more than 30% of any individual parcel or ownership as measured between extensions of the parcel’s lot lines and lakeward from the shoreline for 300feet.

F. A 16-foot wide boat lane out to open water can also be maintained as
part of the permitted activity.

**Approved Herbicides.** Certain practices can reduce the area and duration of impacts to water quality by substituting less toxic materials for more toxic products.

Only those registered herbicides, which have minimal spatial and temporal impact on beneficial uses, will be considered for use in Clear Lake. Those include copper-based herbicides, diquat, fluridone, endothall, triclopyr, 2,4-D, and glyphosate. As new herbicides are approved through California EPA, their environmental impact will be reviewed and balanced with benefits. A Special Local Needs Permit may also be obtained while awaiting approval of a California Label. The Restricted Use Herbicide acrolein will not be considered for use because of fish toxicity.

**Notification.** Even after all prudent and reasonable safety steps have been accomplished; some individuals feel at risk from herbicides. Making public notification of herbicide applications gives those individuals an opportunity to take the steps they feel are in their best interest. Prior to initial herbicide application, the individual applicators shall take steps to notify adjacent and/or potentially affected properties as per FIFRA label requirements.

The location of parcels with permits will be input into the county GIS database before any applications occur. This information can be accessed by the public through the county Internet GIS website.

The applicator will report conditions, apperarance, DO and temperature data with herbicide type/quantity and area treated per individual parcel/permit, in the Supplemental Pesticide Use Report, SPUR (see appendices). These reports will be sent to the Aquatic Weed Management Program Coordinator, County of Lake Department of Public Works, by the 15th of the following month.

**Mechanical**

**Alternative Control Methods.** This program shall employ integrated pest management (IPM) strategies that integrate the use of herbicides with other approaches and reduced the overall dependence on chemicals.

However, cutting of aquatic weeds by any method increases the risk of
spreading *hydrilla* and other invasive species. For this reason, mechanical harvesting is prohibited within ¼ mile of sites where *hydrilla* is being actively managed. Mechanical control and retrieval of cut vegetation may be allowed in areas more than ¼ mile away from active *hydrilla* management areas. Coordination with the CDFA Hydrilla Eradication Program will be ongoing to assure compliance with program concerns.

Any control program that results in fragmentation must include a method for the collection of plant fragments and disposal of fragments landward of the high water mark. Fragments must be prevented from reentry into any waterbody until such time as fragments are unviable.

**Permit Data Collection**

The data collected are intended to support an adaptive management program. Analysis of data produced by such documentation will create a basis for comparison of how various program elements meet objectives.

A GIS database has been established to manage the APMP. A polygon and associated characteristics will be generated within 48 hours of permit application. This will allow an ongoing tabulation of the total area managed, according to: time period, area, method, herbicide type, and applicator. Upon submittal of Supplemental Pesticide Use Reports the GIS database will be updated to reflect actual treatment size, method and conditions.

Applicators will generate a record of the activities performed and the results of the treatment. The water temperature, concentration of dissolved oxygen, and approximate water depth shall be measured and recorded. The amount of herbicide applied and the area treated shall be measured and recorded. A follow-up evaluation and measurement of DO and temperature will be made at an interval when the greatest mass of dying vegetation might be expected, according to the herbicide employed in aquatic vegetation control.

Applicators will be required to carry valid permit(s), including the lakebed map with highlighted permit areas. Before leaving the site the map must be updated to reflect the actual treatment area. Agricultural biologists from the Commissioners office will monitor one application per week during the active treatment season which generally runs from April through September.
In compliance with NPDES permit requirements, sampling for active ingredients will take place during the same time period mid month at the inflow and outflow of the lake. A dissipation check will occur at 10 percent of applications during the season for each active ingredient shown.

The applicator will report DO and temperature data with herbicide quantity and area treated per parcel (APN), in the Supplemental Pesticide Use Report. These reports will be sent to the Aquatic Weed Management Program Coordinator, County of Lake Department of Public Works, by the 15th of the following month.

### Maximum Allowable Acreage Managed

**Guiding Principals**

- This limit should be at or below the threshold that is established for less than significant impact.
- The Technical Advisory Group should play a key role in evaluating this number based on latest-best available data.
- Management by any method is limited to ten percent of total lake surface area showing elevated and high potential for vegetation establishment: currently this is 1043 acres based on the ReMetrix survey showing 10,428 acres, or approximately 26% of the lake with vegetation, (ReMetrix 2002).
- The Department in charge of the program will stop issuing permits once this threshold has been reached.
- Agency programs to control or eradicate non-native invasive species will not be restricted by these principals (i.e. CDFA Hydrilla Eradication Program).

Much of the lakeshore is undeveloped (20.3% according to latest Lakebed Management database) and treatments for access are therefore unnecessary, (1523 wooden structures are recorded on 2641 parcels). In many areas the shoreline is not conducive for aquatic plant growth due to factors such as depth, substrate and current.

An addition, important natural and/or cultural areas will be identified where no treatments will be allowed except by lake-wide programs designed to protect the lake from specific invasive plants. An example is the CDFA Eradication Program to protect against hydrilla.

Permits allow for management of only 30 percent of individual property by herbicide methods, as measured by area enclosed by extensions of property.
lines 300 feet lakeward. This factor alone allows for a mosaic pattern of treated and untreated areas on a per parcel scale.

Other factors limiting the extent of management are purely economic. The cost of treatments includes permit fee, applicators time, and material costs may be as much as $6,000 per acre. During the 2002 season, 60.1 acres were treated by herbicides and 50.8 acres were treated by harvesting for a total of 110.9 managed acres.

Use of herbicides will be limited to approved aquatic herbicides determined by the United States Environmental Protection Agency and the California Department of Pesticide Regulation. The current list of aquatic herbicides is limited to glyphosate, copper, diquat, potassium salts of endothall, triclopyr, 2,4-D, and fluridone. As new products become available, that are designated and labeled for aquatic use, they too may be utilized in the program according to label specifications. Best Management Practices regarding the appropriate use of these materials will be adhered to by all applicators.

Alternative Methods
Although the plan commits us to an integrated approach of herbicides, and harvesting, the ongoing Hydrilla Eradication Program temporarily restricts our ability to harvest in many areas of the lake (harvesting causes plant fragmentation in hydrilla and could potentially spread the plants to new areas), so for an extended period of time we will have to rely more on herbicides than many might prefer. As the Hydrilla infestation is reduced and eliminated we would expect to see a shift in the balance between herbicides and harvesting as influenced by the recommended data collection process and ongoing studies of the results of applications and harvesting in the lake.

Other methods will be tested and encouraged to replace the use of herbicides or harvesting, if recommended by the Technical Advisory Group.
STRATEGIC PLANT MANAGEMENT ACTIONS

Document the Extent of Infestation(s)

The first step needed is to adequately address the problem. This first adequate assessment is occurring concurrently with the development of this document and will serve as a baseline for follow-up measurements.

**Action**

*Vegetation Change Analysis*

Monitor changes in area, location, and species composition over multiple seasons. Only by performing ongoing monitoring will we be able to evaluate effectiveness of the program and ascertain trouble areas. More than one methodology available, such as hydro-acoustic devices, physical weed hooking and remote sensing. A program could be designed to analyze species areal coverage using satellite multispectral analysis and/or aerial photography.

**Potential Key Players:** Consultant, DPW, CDFA, and USGS

**Cost Estimates:** Alternate Years: $20,000-$35,000,

**Potential Funding Source:** Transient Occupancy Tax (TOT) Funds, Grants, Boat Use fees, Boating Access permits

**Time-Frame:** Year: August-September

**Benchmark:** Follow-Up survey, Results/Maps/Report:

**Issues:** Water clarity insufficient for remote-sensing technologies, costly, degree of accuracy only records plants at or near surface. The density of sampling may be modified depending on data needs and budget.
Protect Access to Recreational Uses of Lake

The primary aquatic plant problem and conflict on Clear Lake is access to water sport activities, fishing, skiing and swimming. Local agencies need to keep the public access areas open for use. County maintains 5 double and 1 single boat ramps, 7 swimming areas; City of Lakeport maintains 4 double boat ramps, 1 swimming area; City of Clearlake maintains 3 double and 2 single boat ramps, 2 swimming areas; State Parks maintains 1 double boat ramp, 1 swimming areas. See Appendices and Map pages for public access points.

Action

Program at Public Access Areas

Every effort will be made to assure access to the lake for residents and visitors at the public facilities. The two cities with public access areas and the county maintained public access areas should be kept clear of aquatic weeds, as needed. Due to various substrates, depth and other local conditions, a one-size-fits-all maintenance plan to control nuisance aquatic weeds is not recommended. However, based on Best Management Practices (BMPs), a proactive program should be implemented and coordinated among the various agencies with jurisdiction and maintenance responsibilities.

Two basic options for treatment of submerged vegetation in these nearshore areas:

1. Herbicide application in boat launch embayments, public piers and swimming areas.

2. Mechanical harvesters could be used to provide boat lanes near boat launches, when approval from CDFA can be granted.

Potential Key Players: DPW, DBW, CDFA, CAC, Public Services, cities, CSD, RWQCB, CDFG, CSP & Rec.
Cost Estimates:

- Mechanical: $100,000-$200,000/Harvester, Trailer, Shore Conveyor, Maintenance, Transportation, Disposal Plants, Insurance, Operators, Training, Fragment Traps, Monitoring

- Chemical: $2,000 - $5,000 / Acre, depending on chemical choice, water depth and contractor, NPDES permitting, Monitoring/Reporting,

Potential Funding Source: TOT funds, general fund, Benefit Assessment, Grants, Boat Use fees

Time-Frame: 2003 season, ongoing investigation and dialog

Benchmark: Plan for Treatment. Operational harvester on the lake.

Issues:

- Mechanical: Funding, Compliance with Hydrilla Eradication Quarantine, Does the county purchase/lease equipment? Which department and staff will be assigned to operation and oversight? Contract with a private company for the service? Lack of suppliers on West Coast, What size and how many harvesters will be needed? Requirement of containment systems for fragment control, Effects on non-targets?

- Chemical: Funding, Appropriate use of herbicides, effects on non-target organisms, proximity to water intakes or irrigation and drinking, notification requirements, Native American use of riparian vegetation, monitoring and reporting,

Action

Harvester for Boat Lanes and Removal of Large Floating Weed-Mats

Use conventional harvesters in open water areas for collecting and removing free-floating plant fragments. Overall effectiveness of this type operation may be increased by testing increased production rates of the “larger-than-normal-sized” conventional harvesters for controlling actively growing aquatic plants beds and free-floating plant fragments.
**Potential Key Players:** DPW, CDFA, CAC, Private Contractors, CSD  
**Cost Estimates:** $100,000-$200,000/harvester, Trailer, Shore Conveyor, Maintenance, Transportation, Disposal Plants, Insurance, Operators, Training, Fragment Traps, Monitoring  
Potential Funding Source: TOT funds, general fund, Benefit Assessment, Grants  
**Time Frame:** ongoing investigation and dialog  
**Benchmark:** Operational harvester on the lake.  
**Issues:** Compliance with Hydrilla Eradication Quarantine, Short-term control only, requires retreatment to keep actively growing plant removed. Biological Pollution accelerating spread of non-native invasive species. Does the county purchase/lease equipment, Which department and staff will be assigned to operation and oversight, Contract with a private company for the service, Lack of suppliers on West Coast, What size and how many harvesters will be needed, Requirement of containment systems for fragment control, Effects on non-targets.

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**Action**

*Streamlined Permitting Process for Private Shoreline Property Owners*

Provide single point of contact for property owners and/or licensed herbicide applicators. Design a permit that is not overly burdensome. Design a single permit that is acceptable to all regulatory agencies. Design a permit that provides adequate information for evaluating program impacts. Design a system where there will be minimal processing time between agencies. A system was put in place for the 2002 season, however a yearly review and refinement is warranted. County of Lake will be the only permitting agency, after PLAN is CEQA reviewed.

**Potential Key Players:** DPW, CAC, CDFG, CDFA, RWQCB  
**Cost Estimates:** Need for Program manager to provide oversight  
**Potential Funding Source:** Fees for Processing, CDFG charged $280 per permit with TOT funds used to offset $180 for a net permit cost of $100 to defray costs incurred in program  
**Time Frame:** After CEQA review  
**Benchmark:** County Only Permit System in place  
**Issues:** CEQA requirements, CDFG requirements, Enough data collected to meet legal requirements for oversight, Which department is responsible for
ongoing program, Non-compliance, Enforcement, Cost of monitoring, Who is responsible for monitoring.

**Action**

*Cost-Share with Tourist Based Resort Owners*

Help to assure the visiting public has access to the Clear Lake without interference of excessive nuisance vegetation. Assist the resort owners who responsibly maintain access to the lake with technical and monetary support.

Share the cost of treatments for creation and maintenance of boat lanes and swimming access on commercial resort properties. Provide a pool of monies that can offset the cost of such treatment. Resort owners would be required to apply for assistance, which would require a short workshop on aquatic plant identification and management. Reimbursement would be limited to a maximum amount based on percentage of actual cost per resort owner. Funds would be available until funds are depleted.

**Potential Key Players**: PDW, CAC, CDFG, BOS, Contractors  
**Cost Estimates**: dependent on availability  
**Potential Funding Source**: TOT funds, grants  
**Time Frame**: 2005 -  
**Benchmark**: Cost-Share Program in place, Workshop designed  
**Issues**: Actual percentage and maximum dollar amount of reimbursement, distribution of limited funds, excessive area treated, lottery may be required, management and structure of program, herbicide vs. mechanical options.
Prevent Introduction and Spread of Invasive Aquatic Plants

Based on an increasing body of knowledge on shallow lake ecology, it is becoming evident that native littoral vegetation is an important component of these systems from a water quality and habitat standpoint. They also provide habitat for invertebrates, young-of-the-year fish, and sport fishes and a food resource for waterfowl and mammals.

Many water bodies are rapidly filling with aquatic plants dominated by invasive, non-indigenous plants. Biomass production by these species can be many times that of the native species that are reduced or eliminated from the sites because of competition. Non-native or exotic plant species are often deemed undesirable because of their growth potential and because they replace native species.

Invasions of exotic species such as aquatic plants can result in dramatic changes in macrophyte community structure, leading to changes in water quality and trophic structure. In particular, invasive non-native aquatic plants can result in suppression or displacement of native macrophyte species. The formation of dense surface canopies by species such as aquatic plants can lead to disruption of dissolved oxygen exchange, the development of low dissolved oxygen and/or anoxia below the canopy, enhanced nutrient recycling, and strong vertical gradients in pH and temperature. These changes may lead to physiological stress to the invertebrate and fish community, unlike conditions in a mixed native submersed macrophyte community (Madsen 1997). Fish communities may be impacted by dense, monospecific stands of aquatic plants as forage species can evade predators, resulting in larger numbers of small fish at the expense of larger predatory fish (Lillie and Budd 1992).

Action

Program to Address Invasive Species on Lake Ecosystem Basis

Evaluation and management of the whole lake as a single system is necessary.

- Evaluate effect of invasive aquatic plants (i.e., creeping water
primrose) on tule beds and other key aquatic habitat.

- Investigate patterns of invasive species infestations as a function of other measurable parameters, such as sediment type, depth, presence of other aquatic species, etc…

**Potential Key Players:** DPW, CAC, CDFA, CDFG, CDBW, UCD, NCRS  
**Cost Estimates:** $20,000-$100,000  
**Potential Funding Source:** California Boating and Waterways, California Department of Food and Agriculture, grants  
**Time Frame:** ongoing  
**Benchmark:** management program/personnel in place  
**Issues:** Funding, monies directed away from immediate public concerns, long-term commitment, control verses eradication, prevention of spread

### Action

**Prioritize Aquatic Plant Species of Local Concern**

Not all species of aquatic plants are invasive. Some species are notorious for their invasive nature. Habitat value varies among aquatic plants species and growth habit. Various species have growth habits that create a greater nuisance to boaters and swimmers. Species listed as noxious by the California Department of Food and Agriculture (CDFA), United States Department of Agriculture (USDA) or California Department of Food and Agriculture (CDFA), California Exotic Pest Protection Council (Cal EPPC) should be a priority.

**Potential Key Players:** UCD, NRCS, CAC, DPW, LCWMA, USACE  
**Cost Estimates:** minimal  
**Potential Funding Source:** departmental budgets  
**Time Frame:** ongoing  
**Benchmark:** completion of list  
**Issues:** methodology for identification, eradication verses control

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*Parrots Feather*
**Action**

**Permanent Staff Position: Limnologist, Lake Manager or Fisheries Biologist**

Lake County's community recognizes that the local economy and culture is heavily dependent upon Clear Lake, yet there is no local or state biologist/lake manager devoted to understanding and proactively maintaining the lake's ecosystem health. Recommend the County of Lake hire a fresh water ecologist, limnologist, or warm water fishery biologist to work full-time on the multitude of lake and watershed issues to ensure the future health of the lake from a broad, lakewide perspective. See also 1996-1997 Fisheries Working Committee recommendations

**Potential Key Players:** DPW, City of Clearlake, City of Lakeport, CDFG, Tribes, USFWS, CDFG

**Cost Estimates:** $130,000 annually; Salary, Benefits, Overhead, Equipment

**Potential Funding Source:** partnerships

**Time Frame:** 2005-

**Benchmark:** Staff position created and funded, Initial costs greater than maintenance costs.

**Issues:** Coordination with agencies, priorities and responsibilities, equipment needs

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**Environmental Protection**

Water for irrigation and drinking water is regularly pumped from the lake. Some aquatic plant control techniques pose higher risks of removing non-target organisms, particularly emergent vegetation along the shoreline.
**Action**

*Clean Water Act (NPDES) Compliance*

It was determined by a federal court ruling in late 2001 that the Non-Point Source section of the Clean Water Act should be applied to herbicide applications to waters of the Western United States. The County of Lake was counseled to apply for coverage under a general permit issued by the regional Water Quality Control Board (RWQCB). Regulatory compliance necessitated the development of a Monitoring and Reporting Plan (MRP) and associated Quality Assurance Program Plan (QAPP). Monitoring of active ingredients in herbicides approved for use to control aquatic plants is presently required and should continue at some level into the future.

**Potential Key Players:** DPW, CAC, CDFA, CDFG, and Licensed Applicators  
**Cost Estimates:** 2002- $100,000, 2003- $45,000, 2004- $60,000 annually  
**Potential Funding Source:** TOT funds, Benefit Assessment, Boating Fees, grants  
**Time Frame:** present  
**Benchmark:** Yearly NOI filed with RWQCB  
**Issues:** Redirects limited resources from on-the-lake management of aquatic plant problem, stringent requirements constitute excessive burden, repetition of dissipation studies, inadequate training, burden on applicators, argued potentially unnecessary if herbicides used according to label instructions as mandated under USEPA and FIFRA regulations.

**Action**

*Habitat Protection*

Identify key areas where no, or restricted, control measures are allowed. Areas of the lake, such as, undeveloped and/or key nesting areas for fish and wildlife will be designated wildlife areas.

**Potential Key Players:** UCD, DPW, CAC, CDD, CDFG, Fish and Wildlife Committee, USFWS, Land Trust, Audubon  
**Cost Estimates:** minimal  
**Potential Funding Source:** staff budgets  
**Time Frame:** present
**Benchmark:** Areas designated on maps  
**Issues:** affect on fishing/boating access to some areas of lake with dense untreated aquatic vegetation, infestations of non-native invasives into identified sensitive areas may warrant intervention.

## Action

*Review Maximum Allowable Acreage for Treatment*

Set an upper limit on cumulative acreage that will be treated with herbicide applications for control of aquatic vegetation. This limit should be at or below the threshold that is established for less than significant impact. The technical advisory group should play a key role in evaluating this number based on latest-best available data. Based on percentage of total lake surface area, miles of shoreline, vegetative potential or some part thereof. Request Technical Advisory Group develops maximum acreage to be actively managed.

**Potential Key Players:** DPW, CAC, CDD, CDFG, RWQCB, Advisory Groups  
**Cost Estimates:** N/A  
**Potential Funding Source:** N/A  
**Time Frame:** 2004-  
**Benchmark:** Method for tracking cumulative acreage  
**Issues:** What is the threshold for non-significant impact, re-evaluation of cumulative area on yearly basis, public acceptance, permitted activity often significantly greater than actual application, will tracking application with GPS unit continue to be required. Some areas are more important as habitat to fish and wildlife. Prioritize natural areas.

## Integration with Hydrilla Eradication Program

The California Department of Food and Agriculture is the designated agency to eradicate *Hydrilla* wherever it is found in the State of California. Clear Lake has been under quarantine since the initial find in 1994. Clear Lake is virtually
the only body of water where fishing and boating has been allowed to continue while under quarantine, by the goodwill of CDFA. There are however restrictions that are imposed on the County program due to CDFA efforts.

- Primarily, *Hydrilla* can spread by fragmentation; therefore, the CDFA does not allow physical removal in areas where hydrilla has been found. This severely limits the use of physical methods from large-scale harvesting to small-scale handpulling as management tools. Presently, CDFA is prohibiting any use of harvesters or other mechanical weed control methods within ¼ mile from any spot that has had hydrilla in the past six years.

- Secondly, treatment with the systemic herbicide fluridone (Sonar) is a key tool in the eradication program. CDFA must follow the Department of Pesticide Regulations (DPR) label restrictions on cumulative fluridone that may be applied in any one area during the season and maximum daily applications. There is concern that multiple users of fluridone could cause that limit to be exceeded.

**Action**

*Limit Physical Control Techniques*

Physical control techniques (harvesting) are known to cause fragmentation of plants. For the purposes of this document harvesting can be simply hand pulling, non-mechanized cutting or large-scale commercial harvesting boats. Most of our serious problem aquatic plants reproduce by fragmentation. There are no effective feasible means for 100% control of fragmentation, by any control method. Establish Red Zones where no harvesting is permitted determined on yearly basis with Technical Advisory Group (TAG). Zone will be based on ¼ mile buffer from active hydrilla control areas. Establish Yellow Zone where mechanical control limited to hand methods. Zone determined on yearly basis with assistance of TAG. Based on areas with historical hydrilla infestations but not under active treatment regime.

**Potential Key Players:** DPW, CAC, CDFA, CDFG  
**Cost Estimates:** N/A  
**Potential Funding Source:** N/A
Time Frame: ongoing
Benchmark: alternative methods available
Issues: limiting options, hand methods can be a low cost method for small scale control (especially if done by the property owner), compliance with hydrilla eradication program, spread of Eurasian water milfoil and other invasive species.

Action
Limit Use of Fluridone (Sonar)

Continued cooperation with CDFA Hydrilla Eradication Program. Because of extensive use in CDFA Hydrilla Eradication Program, partial-lake utilization of fluridone is problematic because of questions as to the maximum allowable concentration in the water that would provide selective control of invasive aquatic plants. Coordinate with CDFA to determine where and when fluridone may be used.

Potential Key Players: DPW, CAC, CDFA, CDFG, RWQCB
Cost Estimates: N/A
Potential Funding Source: N/A
Time Frame: present
Benchmark: agreement with CDFA
Issues: lack of substitute herbicide similar effectiveness and environmental sensitivity. Ability to monitor applications through permit process. Maximum allowable rates according to label.

Manage Nuisance Aquatics Using Current and New Technologies

New techniques, herbicides and equipment are constantly being developed. It is imperative to utilize the best of these new products and techniques in a timely and efficient manner. It may require facilitation with local regulatory agencies to permit. A consideration of alternative control methods including less toxic and non-toxic methods will be made prior to selecting the control
method in a specific situation.

**Action**

*Utilize Latest Herbicides Technology*

*Renovate,* (triclopyr) from SePRO Corp., is a newly registered by California EPA spring 2004. The product is weed selective and is extremely effective on Eurasian water milfoil, creeping primrose, and broadleafs, but does not affect coontail, hydrilla, tules or pondweeds, many of which are native. Acts very quickly, no restrictions on drinking water or swimming, only restriction on distance from irrigation intakes, short waiting period. Conduct test plots using the aquatic herbicide *Renovate* to attempt to control non-native invasives, concentrate use on Creeping Water Primrose. Funding should be obtained to closely monitor changes in plant communities. As other products become approved by Federal EPA, apply for a Special Local Needs permit or Research Authorization Permit to Department of Pesticide Regulation (DPR)

**Potential Key Players:** CDPR, DPW, CAC, CDPR, CDFA, CDFG, RWQCB, and Pesticide Manufacturer  
**Cost Estimates:** Application fee and yearly renewal  
**Potential Funding Source:** Partnership with manufacturer  
**Time Frame:** present  
**Benchmark:** agreement with CDFA  
**Issues:** Obtaining special use permit, Lack of substitute herbicide similar effectiveness and environmental sensitivity. Yearly fee for Special Use permits. CDPR is real interested in seeing some work with Renovate.

**Strategy**

*Utilize Biological Controls*

Make determination whether to intensively stock Eurasian Watermilfoil Weevils or similar species. Funding should be obtained to monitor weevil populations and damage to the target plant. Appropriate pathogens and fungus controls should be explored.

**Potential Key Players:** DPW, CAC, CDFA, CDFG, RWQCB  
**Cost Estimates:** TBD
Potential Funding Source: CDFA Integrated Pest Management
Time Frame: present
Benchmark: agreement with CDFA
Issues: lack of substitute herbicide similar effectiveness and environmental sensitivity. Lack of funding for state bioresearch program

Action
*Evaluate Harvesting with Containment Systems*

Conduct trials in an appropriate area. A combination of closing off an area with containment buoys barriers and harvesting while area is closed off. Determine fragmentation effects; identify which species are floating or sinking, how well can fragments be contained. Ability to treat area with herbicide if fragmentation not being adequately contained.

Potential Key Players: DPW, CAC, CDFA, CDFG, and UCD
Cost Estimates: $80,000
Potential Funding Source: grants, CBW
Time Frame: 2005-
Benchmark: Study plan and funding
Issues: CDFG favors harvesting over herbicide use. CDFA Hydrilla Eradication Program policy currently prevents harvesting within ¼ mile of any area where hydrilla has been found within 6 years. No current technology available to collect 100% of fragments caused by harvesting.

Action
*Study the Feasibility of New Products and Techniques in Clear Lake*

Equipment such as weed rollers have not been utilized in Clear Lake. Controlled trials of certain models in appropriate areas could be attempted. Simple small-scale bottom barriers made of common materials have been used in other lakes and may be an option for small areas around docks.

Potential Key Players: DPW, CAC, CDFA, CDFG, RWQCB
Cost Estimates: TBD
Potential Funding Source: grants
Time Frame: present
Benchmark: agreement with CDFA
Issues: Trials done in other lakes may be adequate to make determination of potential effectiveness in Clear Lake. Limited options available. Mercury and nutrients in bottom sediments that can be methylated or suspended are a concern. Methods that cause fragmentation of plants are limited in application due to invasive non-native species present.

Study Ecology of Nuisance Aquatic Species

While there is abundant information in the scientific literature, very little information related to aquatic plant management specifically in Clear Lake’s unique ecosystem exists. Further study could prove helpful.

Action
Impact of Water Primrose on Tules

It appears creeping water primrose (*Ludwigia peploides*) is spreading rapidly along the shoreline. Although native to the western United States its presence in Clear Lake was not noticed until the last few years. It has now become the dominant shoreline vegetation in many areas. However, protection by the county Shoreline Ordinance does not prevent the apparent decline of tules in areas where primrose is present. There is a need for further documentation on this competitive relationship.

Potential Key Players: UCD, DPW, CAC, CDFA, CDFG, and WMA
Cost Estimates: $20,000+
Potential Funding Source: grants, NRCS, USFWS
Time Frame: 2005
Benchmark: Study developed and initiated
Issues: Rodeo/Round-Up kills both tules and primrose, Primrose is prime habitat for mosquitoes that carry West Nile Virus. Tules provide waterfowl habitat, Fisheries values need to be determined. Weedar 64 herbicide might work but is restricted use herbicide.
**Action**

*Colonization of Non-Natives into Managed Areas*

Document species reestablish dominance in treated areas. Determine effect of; substrate type, treatment type, maturity of infestation, depth, etc. Seek to answer the following questions: Can species composition be manipulated to favor natives or species considered less of a nuisance? Need and effectiveness of revegetation? Do undesirable invasives colonize treatment areas?

**Potential Key Players:** DPW, CAC, CDFA, CDFG, and UCD  
**Cost Estimates:** $50,000  
**Potential Funding Source:** grants  
**Time Frame:** 2005-  
**Benchmark:** Study(s) developed and funded  
**Issues:** Multi-year project, short-term benefit elusive, resources directed away from visible control measures.

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There is, however, little hope of totally eradicating these exotic plants so a better title for them may be “naturalized flora.” (Moxley and Langford 1982).

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**Action**

*Dispersion of Early Infestation of Non-Native Invasives*

The lake is vulnerable to new species introductions, via boats, fisherman, aquarium and water-garden enthusiasts. Studying dispersion may be helpful in future control/eradication efforts. Develop an early detection and treatment program to prevent establishment and spread of new invasive species into surrounding waterbodies (i.e. Pillsbury, Hidden Valley, Indian Valley, Mendocino, Berryessa, etc).

**Potential Key Players:** DPW, CAC, CDFA, CDFG, UCD  
**Cost Estimates:** TBD, significant of cost associated with yearly surveys and dedicated staff time  
**Potential Funding Source:** CBW, CDFA, surrounding lake management authorities  
**Time Frame:** present  
**Benchmark:** agreement with CDFA  
**Issues:** Surveys and educational program. Prevention/control plan needed for follow-up
Action

Response to Treatment Timing

Timing especially of herbicide treatments is directly related to efficacy. Postulated that early treatment late winter to early spring may be extremely effective on some species. Determine species/chemical/timing efficacy for optimum control on Clear Lake.

Potential Key Players: DPW, CAC, UCD, CDFA, CDFG, RWQCB, Herbicide manufactures
Cost Estimates: $40,000
Potential Funding Source: Herbicide manufactures
Time Frame: 2003-
Benchmark: protocol on treatment timing vs. efficacy
Issues: impact on fish spawning, agreement with CDFG, more herbicide required for earlier application at high lake levels, extensive monitoring required to determine effectiveness, lake levels fluctuate on average 7 feet over the season. CDFG has threshold of Dissolved Oxygen levels (DO 5ppm) below which no treatment is allowed.

Action

Investigate Vegetation-Fish Population Dynamics

Evaluate the relationship between fisheries and aquatic plant management activities. Electrofish before and after treatments. Monitor recruitment through evaluation of seining records. Coordinate data collection efforts with CDFG to evaluate plant management effects, if any, on fisheries.

Potential Key Players: DPW, CAC, CDFA, CDFG, LCVCD, UCD
Cost Estimates: $TBD
Potential Funding Source: partnership with Vector Control and CDFG, grants, fee for fishing tournaments
Time Frame: 2006-
Benchmark: Report on available data/study
Issues: Need for local fisheries biologist, need for local equipment, some historical electrofishing data available from CDFG, beach seining data available from LCVCD
Education Program

The public is generally not aware of the economic and environmental impacts of noxious weeds, aquatic or otherwise. There is a need to improve awareness and provide educational information to the public. Start an aggressive public education campaign supported through the Clear Lake Advisory Subcommittee (CLAS) group to encourage lake front homeowners to manage their private lake access using the approved BMPs and permitting requirements. Pamphlets, bulletins and brochures are useful at meetings, for follow-up consultations, and educational purposes with all age groups. Education, awareness and assistance in weed identification fosters cooperation and partnerships with the private sector.

Action

*Develop Workshops and Training for Commercial Applicators*

Before embarking on a season of herbicide applications, the commercial applicator will evaluate the types of weed infested sites in Clear Lake and consider alternative control measures. The County Agricultural Commissioner and the Lake County Department of Public Works Aquatic Weed Management Program Coordinator will apprise the registered applicators in the county of educational opportunities including continuing education credits towards renewal of their licenses, specifically with respect to the aquatic weed management. The range of educational opportunities include, but are not limited to, the University of California Extension, the Pesticide Applicators Professional Association, and the Weed Science Society of America.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** $2,000  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** 2005-  
**Benchmark:** Program developed and initiated  
**Issues:** Adequate staff and time to complete staff
**Action**

*Develop Workshops for Hand Pulling and Cost-Share Program*

Provide a mandatory workshop for participants in experimental programs (Cost Share, Hand-Pulling). Many Lake front property owners are unaware of the complicated nature of aquatic plant management in a large multiple-use public waterbody such as Clear Lake. The proper application of appropriate methods is essential to assure the success of the overall management effort. Plant identification, especially invasive exotics of highest concern, is an important skill to impart to shoreline property owners.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** $5,000  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** 2005-  
**Benchmark:** Program developed and initiated  
**Issues:** resistance by property owners to mandated attendance, resistance by CDFA to allow controlled handpulling in non-active management areas. Funds available for cost-share program.

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**Action**

*Develop Educational Materials: Brochures, Pamphlets, Mailings, and Press Releases*

Targeted mailing in fall and spring to lakeshore property owners to go out with billing, and flood protection information. Specific and general brochures available in print and on the website for local residents and educators. Regular press releases highlighting various aspects of program and aquatic species found in Clear Lake. Develop a monthly “Shorelines” newsletter for public dissemination.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** $20,000+  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** present
Benchmark: Copies available to public
Issues: adequate staff time available, space provided in local newspapers, providing copies on line and at various public places will significantly reduce mailing costs but limit distribution.

**Action**

*Provide Adequate Signage at Lake Access Points*

As a supplement to the hydrilla programs signs throughout the county at public boat ramps provide signs on other aquatic weeds of local concern. Informational pamphlets in weatherproof boxes near public access areas.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** $3,000+  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** 2005  
**Benchmark:** Signs designed. Pamphlets printed. Boxes in places  
**Issues:** Largest expense in first year. Coordination with CDFA and California Boating and Waterways may prove useful.

**Action**

*Provide Presentations to Local Groups and Classrooms*

Develop curriculum and outreach materials for K-12 students in local schools. Continue to make staff available to community groups and local educators as guest speakers.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** $3,000+  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** present  
**Benchmark:** Presentations scheduled. PowerPoint presentation created.  
**Issues:** adequate staff time available, Creation of materials not prepackaged. The Aquatic Plant Management Society has developed a 5-6 grade APM lesson plan.
**Action**
*Provide Information on WebPages and Links to Other Sites*

Aquatic weeds of local concern.

**Potential Key Players:** UCD, DPW  
**Cost Estimates:** $1,500+  
**Potential Funding Source:** grants, NRCS, USFWS  
**Time Frame:** present  
**Benchmark:** Site updated to reflect latest and best information on Aquatic Plant Program  
**Issues:** adequate staff time available,

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**Enforcement**

While the goal would be 100 percent voluntary compliance with the program, especially permitting requirements, past experience shows this is not always the case. Applicators will be required to carry valid permit(s), including the lakebed map with highlighted permit areas. Before leaving the site the map must be updated to reflect the actual treatment area. Failure to comply could result in fines and the revoking of all outstanding permits. Agricultural Biologists from the Commissioners office will monitor random applications during the active treatment season of June through August.

In compliance with NPDES permit requirements, sampling for active ingredients will take place during the same time period at the inflow and outflow of the lake. A dissipation check will occur at 10% of the sites during the season for each active ingredient shown. The agriculture biologist will be monitoring DO and Temperature weekly in anticipated treatment sites to determine when thresholds are approaching.

Secondly, education and outreach efforts need to be in place so that ignorance is not an excuse for non-compliance. Currently restricted herbicides can be ordered over the Internet and delivered directly to your door. Individual
property owners are responsible with following label requirements. Past practices of pulling bedsprings, chains etc, behind boats or jet skis can severely spread invasive aquatic weeds by fragmentation. Such activity needs to be curtailed.

**Action**

*Enforcement of Non-Permitted Aquatic Plant Management Activities.*

The Agriculture Commissioner Office has been responding to complaints and issuing a non-punitive Notice of Violation (NOV). Local and State agency staff on the lake need to report suspected violations. A penalty system needs to be developed.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG  
**Cost Estimates:** TBD,  
**Potential Funding Source:** fines  
**Time Frame:** 2003-  
**Benchmark:** Policy developed  
**Issues:** Available staff and boat available for follow-up necessary for enforcement, adoption of ordinance by County of Lake, need for outreach to educate public on policy,

**Action**

*Ban Sale of Aquatic Invasives in County*

Agriculture Commissioner can apply for additional quarantine restrictions, as a special local need, to prevent the sale of exotic invasive species in the ornamental horticulture and aquarium businesses within the County of Lake specific invasive aquatic species, such as Water Hyacinth, Parrot Feather and Brazilian Elodea, etc. Voluntary compliance will be sought in the interim.

**Potential Key Players:** DPW, CAC, CDFA, and CDFG  
**Cost Estimates:** $2,000+  
**Potential Funding Source:** grants, NRCS, USFWS,  
**Time Frame:** present  
**Benchmark:** Ban of specific exotic species established in county
**Issues:** Lack of state program for invasive (currently in development). Resistance to additional government regulation.

**Action**

*Adopt Aquatic Plant Ordinance*

An ordinance giving permit authority to the county to control methods, monitor impacts and provide for local control of program should be developed and refined.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG
**Cost Estimates:** minimal to develop, enforcement costs TBD
**Potential Funding Source:** department staff time
**Time Frame:** ongoing

**Benchmark:** Ordinance reviewed by Clear Lake Advisory Committee (CLAS) and submitted to Board of Supervisors with recommendation to adopt. *(Urgency Ordinance No. 2625, Chapter 26 of County Code was signed by Board of Supervisors on March 18th 2003).*

**Issues:** Resistance to additional government regulation, A policy one-step short of an ordinance could be adopted to provide guidance but difficult to enforce. Frequent updates to ordinance may be required.

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**Adaptive Management**

Choose the combination of control efforts that best meets the needs of lake users with the least impacts to the environment is a task that need regular reappraisal, and possible adaptation. Evaluate each control option described elsewhere in the document using an integrated vegetation management approach. This approach involves examining the alternatives with regard to such factors as:

* The extent of problem plant(s) infestation
* Scale, intensity, and timing of treatment
* Effectiveness against target plant(s),
* Duration of control (short-term vs. long-term)
* Human health concerns
* Environmental impacts and mitigation, if needed
* Program costs
* Permit requirements (Federal, state, local).

Review control alternatives in light of these and other site-specific factors. No management program, however, is without some impacts. Decide a course of action to achieve a balance between expected management goals at a reasonable cost and acceptable environmental disruption.

**Action**

*Establish Technical Advisory Group (TAG)*

Establish a scientific peer-review process by creating a committee composed of technical staff from local, state and federal agencies and universities. Participants should include the University of California Cooperative Extension Farm Advisor, the County Agricultural Commissioner, private local Pest Control Advisors and Qualified Applicator, registrants of aquatic herbicides, CDFA Hydrilla Eradication Program, DPR, USDA Aquatic Weed Program and the California Dept. of Fish and Game. This group would provide a discussion of technical issues, including pros and cons, relevant to the issues and courses of action identified by the Citizens Advisory Committee (CAC). Information can be presented to the community for discussion and approval through the public process. Experts can debate the technical issues and avoid making policy.

Specific tasks may include: Yearly scientific evaluation of the program. Prior to start of each season set Red Zones (where no harvesting is allowed) and Yellow Zones (where only hand harvesting is allowed). Re-evaluate Green Zones (Natural Wildlife Areas). Suggest and develop experimental projects. Establish monitoring requirements.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG, USFWS  
**Cost Estimates:** Negligible  
**Potential Funding Source:** departmental budgets  
**Time Frame:** ASAP  
**Benchmark:** Committee selected and meeting  
**Issues:** make-up of group, frequency of meeting, committeemen by agencies, reimbursement for travel
**Action**

*Establish Citizens Advisory Committee*

Through the CLAS (MAP), establish a citizens advisory committee to assist in recommending and coordinating aquatic plant management activities on the lake. This board should be comprised of citizens that represent different interest groups on the lake (i.e. power boating/skiing, sailing, fishing/hunting, aesthetics, environmental, resorts, shoreline homeowners). This separate yet complementary forum from the TAG allows for democratic public participation. The CAC reviews relevant issues and directs the technical discussion of TAG according to identified local needs. The TAG provides the citizens with technical information necessary to make informed choices without being forced to become scientists. After obtaining group consensus on a management scenario, the CAC sets short-term and long-term program priorities and policy. Tasks may also include directing the public outreach efforts.

**Potential Key Players:** UCD, DPW, CAC, CDFA, CDFG, Rimlanders Assoc., Restaurants and Resort Owners Assoc., City Representatives, Public Stakeholders

**Cost Estimates:** Negligible

**Potential Funding Source:** departmental budgets

**Time Frame:** 2003-

**Benchmark:** Committee selected and meeting

**Issues:** make-up of committee, frequency of meeting, subcommittee of CLAS, reestablish MAP Taskforce

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**Identify Lake Zones**

Better understand the aquatic ecosystem of Clear Lake in order to protect the lake’s vitality in terms of recreation, domestic consumption, agricultural use, aesthetic values, fish and wildlife habitat, and commercial uses. Current land use maps should be developed.
In terms of human enjoyment, Clear Lake is a popular place for swimming, boating, and fishing. It offers a variety of economic benefits such as tourism. Its capacity to provide aesthetic enjoyment is immeasurable. Clear Lake provides water for drinking and irrigation both locally and to our downstream neighbors. Equally important, Clear Lake provides habitat and food for all kinds of aquatic life, including fish, waterfowl and other animals.

Desired uses of a water body must be compatible with its capacity to sustain those uses, both human and natural. Under the Water Quality Standards, protected beneficial uses include fish rearing; spawning and harvesting; swimming; boating; navigation; irrigation; wildlife habitat; and domestic, industrial, and agricultural water supply. Clear Lake supports many different desirable uses, which sometimes conflict with each other. The management challenge involves identifying and agreeing on uses that complement each other, and realistically managing for these uses.

**Action**

*Identify present water body use areas.*

Prioritization of the most valuable resources and critical uses of the lake are needed to design and implement activities for maintaining Clear Lake in a healthy condition. Identify the areas of Clear Lake presently employed for beneficial uses. Document most common types of usage. This process should forecast resources and uses over the next five, ten, and 25 years. Use available information in the zoning, wetland, or resource inventory maps. Include:

- Conservancy areas, including habitats that are integral to the lake ecosystem, such as nesting sites, fish rearing or spawning areas, or locations of rare plant communities.
- Boating and boat access areas (launches, ramps)
- Water skiing zones
- Beaches and swimming areas (public, private)
- Fishing areas
- Areas for special aquatic events (e.g., sailing, rowing, poker runs, hydroplane fly-in)
- Parks, picnic areas, nature trails, scenic overlooks
• Irrigation/water supply intakes
• Other shoreline uses (e.g., residential, commercial).

Potential Key Players: CDD, DPW, CAC, CDFA, and CDFG
Cost Estimates: negligible
Potential Funding Source: departmental budgets
Time Frame: present
Benchmark: Information collected in spreadsheet/table
Issues: Staff time, insufficient GIS layers, agreement on uses. Often, the process of identifying and defining zones for each beneficial use on a map of the lake opens the potential for conflict.

Action

Develop a water body usage map:

Overlay the current water body use areas on a map of the lake. This water body usage map shows primary human uses, as well as habitat areas for fish, waterfowl, and other wildlife utilizing the water body. Native American cultural uses of wetland vegetation for basketry.

Potential Key Players: UCD, DPW, CAC, CDFA, CDFG, GIS Subcommittee
Cost Estimates: negligible
Potential Funding Source: Departmental Budgets
Time Frame: in process
Benchmark: Map Completed
Issues: Staff time, insufficient GIS layers, agreement on uses

Action

Develop Control Strategies by Area

Overlay treatment options per areas on a map of the lake. Utilizing water body usage maps habitat areas for fish, and other wildlife, bathymetric and substrate information and hydrilla management areas to develop zones for approved treatment methodologies.

Using the Control Intensity Map, match each control zone (no control, low
control, and high control) with an appropriate control method.

Address following concerns: Will the control option restrict use of the water body after treatment by banning water contact or ingestion (swimming, fishing, drinking or irrigation use)? Does the operation of large machinery or equipment occur at a peak time of recreational use? Does this control option represent a severe safety hazard or interfere significantly with normal use?

Site-specific constraints that might affect use of control method: Does the site have a lot of submerged logs or bottom debris or water intake pipes that would hamper bottom treatments like rotovation or bottom barrier application? Are there many surface obstacles such as docks or buoied areas that could interfere with surface operations of mechanical cutting or harvesting?

Establish:

1. **Green Zones**: No control. Except management activities limited to programmatic control of exotic invasive species (i.e. Hydrilla, Eurasian Water Milfoil, Water Hyacinth) as necessary to protect native habitat.
2. **Red Zones**: Based on CDFA Hydrilla Eradication Program Status, identify areas where no mechanical control, in any form will be allowed.
3. **Yellow Zones**: Areas where limited non-mechanized hand-harvesting will be allowed. Under specified circumstances.
4. **Blue Zones**: Areas within set limit of known municipal potable water intakes where herbicide applications will not be permitted.
5. **Clear Zones**: Areas were all approved and permitted means of aquatic vegetation control are allowable.

**Potential Key Players**: UCD, DPW, CAC, CDFA, CDFG, GIS Subcommittee

**Cost Estimates**: negligible

**Potential Funding Source**: Departmental Budgets

**Time Frame**: in process

**Benchmark**: Map Completed

**Issues**: Need to update during the growing season, as new data becomes available. Limited staff, insufficient GIS layers, agreement on controls, CDFA quarantine limitations. Water intakes no longer public information due to national security concerns. Issues with limited reporting of individual water intake systems around the lake.
Watershed Controls

Watershed influences on lake water quality and macrophyte growth need to be considered within the context of macrophyte control.

As lake and upland development increases the possibility of increased sediment and nutrient inputs to the lake increase as well, which may exacerbate aquatic plant presence. Increased sedimentation and storage of watershed-derived nutrients in the sediment can promote non-native aquatic plants growth such as eurasian watermilfoil and persistence at the expense of native species. Many non-native species can be characterized as opportunistic invaders flourishing in nutrient-rich, fine-textured sediment and quickly forming a canopy, shading out native species. Dense stands of macrophytes like eurasian watermilfoil can, in turn, further promote gradual build-up of incoming sediment loads, providing a mechanism for increasing sediment surface area that can be colonized by macrophytes in a lake (Carpenter 1981; James and Barko 1990). Thus, reducing sediment loading, or its accretion, should be a secondary goal of aquatic plant management.

Another watershed consideration in aquatic macrophyte management is the role that accelerated eutrophication may play in exacerbating the growth of nuisance algae. Increased watershed nutrient loading (primarily phosphorus) in conjunction with development in riparian areas may promote the occurrence of blue-green algae blooms in association with changes in macrophyte community architecture (i.e., reduction in canopy-forming biomass). Surface algal blooms can also have an impact on light penetration, thereby reducing the growth of native macrophyte species, in favor of low light tolerant rapidly growing non-natives. Thus, one problem is being replaced by another due to accelerated eutrophication in conjunction with nuisance macrophyte control. It is recommended that a water quality monitoring program be implemented in conjunction with an aquatic macrophyte control plan.

Action

*Reduce Nutrient Loading*

According to the Clean Lakes Study, 1995: "Accelerated erosion caused by
destabilization of creek channels by gravel mining, road construction, lakeside dredge and fill operations, the shoreline deposition of mine overburden and tailings and similar disturbances is the most important factor causing a doubling of sediment inflow into Clear Lake.

Clear Lake is considered an impaired water body according to the 303d list generated by the State Water Quality Control Board. The county is currently developing a Stormwater plan for NPDES Phase II, Non-Point Pollution Program compliance. A grading ordinance has been in place and is currently being reviewed by a taskforce for possible revision. Continue with the Middlecreek Ecosystem Restoration Project, thereby filtering water inflow from that major watershed.

Watershed management practices, including maintenance practices of shoreline property and sewage disposal issues, should be reviewed and assessed to determine impacts of those processes on aquatic growth.

**Potential Key Players:** DPW, Resource Agencies  
**Cost Estimates:** Covered by other programs  
**Potential Funding Source:** staff and volunteers, grants  
**Time Frame:** present  
**Benchmark:** Stormwater Plan and Grading Ordinance adopted  
**Issues:** Nutrient TMDL due for development

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**Action**

*Coordinate Watershed Planning Efforts.*

Complete Clear Lake Basin Management Plan (CLMP) and continue implementation of recommendations. Coordinate with Clear Lake component of General Plan update. Continue work with volunteer watershed groups (CRMP’s) to improve water quality from their sub-watersheds.

**Potential Key Players:** DPW, Resource Agencies  
**Cost Estimates:** Covered by other programs  
**Potential Funding Source:** staff and volunteers, grants  
**Time Frame:** present
Benchmark: Clear Lake Basin Management Plan, completed

Issues: limited resources

Action

Coordinate Watershed Monitoring Efforts.

Continue coordination within existing agency programs. Seek funding for additional monitoring as needed. The goal of the water quality monitoring program should be to document, over long time scales, changes (if any) in water quality that might be symptomatic of accelerated eutrophication. The program should consider budgetary (i.e., how much is going into the lake, how much is leaving the lake, how much is being stored in the lake) analysis of hydrology, sediments, and nutrients (primarily nitrogen and phosphorus). Major tributary inflows and the discharge should be monitored for flow and water quality to determine loading, discharge, and retention of sediment and nutrients in the lake over an annual cycle. In-lake stations should be monitored at monthly intervals for variables such as temperature, dissolved oxygen, pH, secchi disk transparency, chlorophyll, and total nitrogen and phosphorus.

Continue work with volunteer watershed groups (CRMPS) to develop water quality monitoring in basin streams and Clear Lake.
Data can be compiled in the form of an annual data summary so that year-to-year variations and long-term trends can be evaluated. Sound decisions regarding watershed rehabilitation to improve water quality and promote native macrophyte community persistence can then be made.

**Potential Key Players:** Vector Control, DPW, Resource Agencies  
**Cost Estimates:** Covered by other programs  
**Potential Funding Source:** staff and volunteers, grants  
**Time Frame:** present  
**Benchmark:** GIS Database complete  
**Issues:** Sharing of confidential information, monies for staff, equipment and analysis, quality of data collected by volunteers