'THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE HYDRILLA ERADICATION PROGRAM ANNUAL PROGRESS REPORT 2006

PROTECTING CALIFORNIA'S WATERWAYS

INTRODUCTION

This report covers the progress of the California Department of Food and Agriculture Hydrilla Eradication Program in 2006. After a brief introduction to hydrilla and the program's history, each of its current, eradication projects is described in detail. The Department's annual hydrilla survey of the Sacramento/San Joaquin River Delta is reviewed, as well as our cooperative effort with the Department of Boating and Waterways' remote sensing project.

The Department is the lead agency in California for the eradication of hydrilla[1], in order to protect the state's water resources. The Department administers the Program in cooperation with the local county agricultural commissioners and other federal, state, county, and city agencies, Native American tribes, and private individuals and entities. The Program received additional financial and in-kind support in 2006 from the California Department of Boating and Waterways, California Department of Water Resources, United States Department of the Interior-Bureau of Reclamation, Lake County Department of Agriculture, and Lake County Department of Public Works.

The Department is committed to "early detection and rapid response.'' Detecting hydrilla in an early stage of invasion, when a population is still small, lessens the cost and environmental impact of eradication. Rapid response involves bringing the most effective eradication methods to bear as quickly as possible. Examples of this strategy will follow, and the Department considers this to be one of the keys to the success of the Hydrilla Eradication Program.

THE THREAT OF HYDRILLA

Hydrilla (*Hydrilla verticillata*) is a non-native, aggressive, submerged water weed. Once hydrilla invades an aquatic ecosystem, it drives out all native and introduced aquatic plants, creating a pure stand. Its competitive edge comes from several different mechanisms. For one, hydrilla can grow under lower light conditions than nearly any other species (only 1% of sunlight), allowing it to grow beneath other plants and at greater depths. Second, it can use bicarbonate as a carbon source, as well as the typical source, carbon dioxide. Using bicarbonate increases the alkalinity of the water, inhibiting native species. Third, hydrilla has excellent survival and dispersal through fragmentation. (Seeds, if produced at all, play a very minor role in its spread.) Stem fragments only one inch long can produce entire new plants. Hydrilla also produces special survival structures on the stems (called "turions") and roots (called "tubers"). Turions

[1] California Food and Agricultural Code, Sections 6048 and 7271.

break off their stems in autumn and can drift for long distances before sinking to start a new plant. Each tuber produces a new plant, and a single tuber can lead to the production of several hundred others in the course of one growing season. Tubers can survive for four to seven years in sediment with little water before sprouting, which is the main challenge in eradicating the plant. Fourth, hydrilla grows rapidly on little energy and forms tangled mats that shade other plants. At 93-95 percent water, it creates huge volumes of biomass with very little metabolic investment, thereby doubling its biomass every two weeks in summer conditions. Hydrilla branches profusely as it approaches the water surface, filling the entire water column up to 20 feet deep and shading out other plants. These tangled mats forms have a variety of economic and ecological impacts. Hydrilla grows aggressively in a wide range of water conditions and temperatures, so few habitats are safe from it. As a final competitive edge, hydrilla came to the U.S. without its evolved natural enemies, such as insects and diseases specialized for attacking it.

The potential economic impacts are alarming. Hydrilla mats can reduce the flow of water in canals and ditches up to 85 percent, which could be devastating to California's dependence on moving large amounts of water. Mats also clog and damage water control structures and equipment. In one documented instance, hydrilla blocked intakes at the St. Stephen hydroelectric facility on Lake Moultrie, South Carolina in 1991, forcing the dam to shut down and lose power generation revenue, as well as costing $1.2 million for emergency treatment alone. Hydrilla also impedes boat and ship travel, and increases the risk of drowning. Heavy hydrilla infestations decrease fish stocks and hamper boats, reducing recreation and damaging the economies that depend on it. In one analysis, hydrilla coverage increased 400 percent between 1983 and 1992 on Lake Seminole, Georgia, reducing tourism for an estimated loss of $13 million per year to the local economy.

As for ecological impacts, hydrilla shades out all other plant species, including natives, with its rapid and dense growth, reducing diversity to a single species. Although some birds feed on hydrilla, generally bird populations decline in a heavily infested area. Dense hydrilla infestations increase daily swings in dissolved oxygen and pH, which influences habitat quality and can contribute to eutrophication of aquatic systems by increasing nutrient release from sediments. The dense mass of plant material in the water alters fish habitat quality and food-web relationships, which can lead to changes in fish populations.

Fishermen and some wildlife enthusiasts sometimes argue that hydrilla improves habitat for fish and other wildlife. While it is true that some cover up to 30 to 40 percent of an area, often providing food and shelter for various animals, hydrilla usually expands until it has monopolized nearly every resource. Other species of underwater plants can be just as beneficial for wildlife, without the threat of population explosions.

Hydrilla has two forms, monoecious and dioecious, which is determined by the distribution of male and female flowers among the individual plants. Monoecious forms are more prevalent north of dioecious forms, but both seem to do well in much of California.

HISTORY AND OVERVIEW OF THE PROGRAM

The dioecious[2] form of hydrilla was first identified in Florida in the 1960s, theoretically introduced in the 1950s. This infestation spread rapidly throughout the southeastern states and into Texas and Arizona. The dioecious form first appeared in California in 1976 in a 31-acre man-made lake in Marysville, Yuba County. The monoecious form was first detected in the United States in the Potomac River, near Washington, D.C., in the 1980s. It has since spread into a number of the southern states, into Washington State, and was first found in California in 1993 at an aquatic nursery in Visalia, Tulare County.

In 1977, after the first California hydrilla find, the California Legislature mandated[3] that the Department Secretary initiate a survey and detection program for hydrilla and eradicate it wherever feasible[4]. In 1985, after hydrilla was found in Redding next to the Sacramento River, the Governor of the State of California declared a "State of Emergency" for the eradication of that infestation[5]. In 1994, the Department Secretary also declared an "emergency situation" in regard to the hydrilla infestation discovered that year in Clear Lake[6]. Similar declarations have been issued for most of the current hydrilla infestations[7].

Since 1976, hydrilla has been introduced into California waterways 29 times in 18 counties[8] (not counting detections in plant nurseries). Of these 29 introductions, the Hydrilla Eradication Program has eradicated hydrilla from 19 sites in the following 12 counties: Los Angeles, Monterey, Riverside, San Bernardino, San Diego, San Francisco, Santa Barbara, Shasta, Sonoma, Sutter, Tulare, and Yuba (Table 1, Plate 1). The Hydrilla Eradication Program is currently eradicating[9] hydrilla from 11 locations in the following nine counties: Calaveras, Imperial, Lake, Madera, Mariposa, Nevada, Shasta, Tulare, and Yuba.

Hydrilla has been detected in plant nurseries and aquaculture vendors five times, including twice in 2004. In March 2004, hydrilla was detected in a plant nursery in northern Los Angeles County, and in November, hydrilla was also detected at an aquaculture wholesaler in Alameda County. In each case, the county department of agriculture took the lead on removing all hydrilla plants and plant parts from the infested area, and the Department Pest Exclusion Branch and Hydrilla Eradication Program personnel worked with the vendor to prevent reintroductions.

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[2] The dioecious form of hydrilla has flowers of one sex only on each genetic individual. Monoecious individuals have individual flowers with only staminate or pistillate parts, but these occur on the same plant. Dioecious plants often branch freely near the water surface, forming large submerged mats near the water surface. In contrast, monoecious plants tend to branch freely near the rooting point, producing many stolons and a forest of vertical shoots, which can fill the entire water column with plant material. The genetic or ecological significance of this apparent dimorphism is unknown.

[3] California Food and Agricultural Code Article 9, Section 6048.

[4] A Hydrilla Science Advisory Panel was convened after each hydrilla outbreak. These panels have always found hydrilla eradication to be feasible.

[5] "Proclamation of a State of Emergency," issued by Governor George Deukmejian, October 23, 1985; terminated October 23, 1989.

[6] "Proclamation of a Project Regarding the Eradication of Hydrilla," issued by the Department Secretary Henry Voss, August 12, 1994.

[7] Calaveras, Madera, Mariposa, Nevada, Shasta, and Tulare counties.

[8] The Department considers hydrilla infestations to be separate introductions if they appear more than two or three years apart.

[9] California Code of Regulations, Title 3, Division 4, Sections 3281 and 3410; California Code of Regulations, Section 3962; DEPARTMENT Plant Quarantine Manual, Section 3410.

Plate 1. The "hydrilla hook", a small grappling hook, with hydrilla

Every year, Program crews survey all known infested waterways, and many high-risk lakes[10], ponds, reservoirs, streams, canals, and other waterways in the state. High-risk areas include the Sacramento/San Joaquin River Delta, other high recreational-use water bodies, and waterways within quarantine zones[11]. The surveys generally employ two methods.

1). Working from either the shore or from boats, crew members visually scan the water surface and water column for suspicious plants. 2). They supplement the visual scan by throwing a small grappling hook (Plate 1), which is dragged along the bottom and through the water to snag any long-stemmed vegetation such as hydrilla. Occasionally, divers conduct the surveys[12]. Surveys generally start when the water temperature climbs above 10 degrees C[13] (50 degrees F[14]) in the spring, and water-flows in rivers and creeks have fallen to a safe level. They generally end when water temperatures fall below 10 degrees C in the fall. Active growth of hydrilla occurs between 10 degrees C and 35 degrees C (DiTomaso and Healy 2003, page 102).

The Hydrilla Eradication Program also follows up on all reports from the public on potential new infestations. Two new hydrilla-infested sites were found in 2005, in a pond at the county fairgrounds in Nevada County, and in a small private irrigation pond about six miles south of Grass Valley off Highway 49 (Table 1), but no new hydrilla infestation were found in 2006.

The Hydrilla Eradication Program uses integrated pest management, employing in 2006: manual removal, small scale dredging, biological control, and aquatic herbicides. The aquatic herbicide of choice was a fluridone slow-release pellet formulation[15] applied at 90 to 150 ppb[16], depending upon the size of the water body. Other herbicides used include a copper

[10] High-risk lakes, streams, etc. are those within five miles of Clear Lake, one mile either side of the Sacramento River near the Riverview Golf Course, three miles of the Yuba canal, and one mile of Bear Creek, the west fork of the Chowchilla River, and the Springville ponds.

[11] Quarantine zones are established by declaration of the Department Secretary and are areas within eradication areas that have restrictions as to water use, access, or the intensity of survey.

[12] Surveys are conducted by two methods, visual search of the water column and physical samples. Trained biologists and support staff conduct visual searches to locate individual plants or mats that are visible in the water column or on the water surface. The crews conduct the visual searches from boats, canoes, or kayaks; by wading in shallow streams and lakesides; and by swimming using sight buoys and face masks, depending upon the circumstances. Because visual searches from the surface are sometimes hampered by poor visibility, the program occasionally contracts divers for underwater surveys. Physical samples are taken using a modified grappling hook, usually thrown from a boat or canoe. Personnel trained in identifying hydrilla carefully examine the retrieved plant material. In either case, visual searches or bottom samples, if hydrilla is found, the number of plants or size of the infestation is recorded along with the physical location (by using a global positioning system technology and measured from known landmarks). Representative specimens from new locations are sent to the Department Plant Pest Diagnostic Center, Botany Laboratory for confirmation.

[13] C = Centigrade.

[14] F= Fahrenheit

[15] Sonar® SRP brand, SePRO Corporation.

[16] One ppb = one part per billion = one microgram per liter.

ethylenediamine liquid formulation[17] (applied at one ppm[18]) and a fluridone liquid formulation[19]. In the past, the Program has also used large and small scale dredging bottom lining, burial, and water draw down to dry the hydrosoil, followed by soil fumigation.

Before declaring eradication, Program staff intensively survey and treat an infested site for a minimum of three growing seasons after the last hydrilla detection, followed by a minimum of another three seasons of intensive survey without treatment. The Deparment considers hydrilla eradicated from a site only after a minimum of six years without finding any plants. Longer survey periods may be warranted, depending on the site.

In addition to hydrilla surveys and treatment, the Program monitors aquatic herbicide concentrations in water in order to protect the beneficial use of the state's waters. The Department monitors as policy, and also to comply with the National Pollution Discharge Elimination System (NPDES) General Permit issued by the State Water Resources Control Board. The NPDES is a provision of the Clean Water Act to regulate and protect "waters of the United States" from pollution caused by point sources. This system was extended to aquatic pesticide applications by the United States Court of Appeals for the Ninth Circuit in its decision in *Headwaters, Inc. et al. v Talent Irrigation District*, March 12, 2001. To comply with the NPDES General Permit, the Hydrilla Eradication Program monitors fluridone water concentrations in Clear Lake and in the Riverview Golf Course Ponds in Shasta County; copper water concentrations at Bear Creek in Calaveras County and Clear Lake; diquat concentrations in Island Drive pond in Redding; and triclopyr concentrations in Clear Lake. The Hydrilla Eradication Program also monitors individual treatments to confirm that concentration targets are attained and for public safety. Monitoring done for the NPDES General Permit is published in a separate report.

The status of all current and historical sites in the Hydrilla Eradication Program is summarized in Table 1 and Plate 2.

[17] Komeen® brand, Griffin Corporation.

[18] One ppm = one part per million = one milligram per liter.

[19] Sonar® AS brand, SePRO Corporation.

Plate 2.

California Department of Food and Agriculture
Current Hydrilla Eradication Projects, 2006

Table 1. Status of Hydrilla in California, by County, 1976 – 2006.

COUNTY	YEAR*	DESCRIPTION OF WATERWAY	SIZE	STATUS**
Calaveras	1988	Bear Creek, Units 2 to 11	5 miles	Survey
	1988	Stock Pond	0.5 acres	Active
	1996	Bear Creek, Unit 1	0.75 miles	Active
Imperial	1977	Imperial Irrigation System	270 acres of ponds, 600 miles of canals, drains	Survey, Survey, Active
Lake	1994	Clear Lake	1,440/43,000 acres	Survey
Los Angeles	1980	Eight ponds	2 acres	Eradicated
	1983	One pond	<1 acre	Eradicated
	1985	One pond	<1acre	Eradicated
	2004	One pond (nursery)	<0.5 acre	Eradicated
Madera/ Mariposa	1989	Eastman Lake /Chowchilla River	1800 acres and 26 miles of river	Survey
Monterey	1978	Pond	0.01 acre	Eradicated
Nevada	2004	One pond	0.6 acres	Active
	2005	Two ponds	2.8, 0.1 acres	Active
Riverside	1977	One pond	<1 acre	Eradicated
	1984	One pond	<1 acre	Eradicated
	1985	Three ponds	<1 acre	Eradicated
San Bernardino	1988	One pond	<0.01 acre	Eradicated
San Francisco	1988	One pond	2 acres	Eradicated
San Diego	1977	Lake Murray	160 acres	Eradicated
	1977	One pond	<1 acre	Eradicated
Santa Barbara	1977	One pond	0.12 acre	Eradicated
	1993	One pond	<0.01 acre	Eradicated
Shasta	1985	Seven ponds	133 acres	Eradicated
	1986	Four ponds	23.5 acres	Eradicated
	1994	Two ponds	13 acres	Active
	1996	Four ponds	39 acres	Active
Sonoma	1984	Spring Lake	72 acres	Eradicated
Sutter	1985	One pond	<0.01 acre	Eradicated
Tulare	1993	Three ponds	0.6 acre	Eradicated
	1996	Seven ponds	20 acres	Active
Yuba	1976	Lake Ellis	30.8 acres	Eradicated
	1990	One pond	6 acres	Eradicated
	1997	13 ponds	20 acres	Active
	1997	Canal	3 miles	Active

*Year first detected at a given site.

**Eradicated = No hydrilla found at site in six or more years of intensive survey following the last treatment.
Survey = No hydrilla found at site in last three to six years, intensive surveys continue.
Active = Hydrilla detected within the last three years, an active treatment program continues.

A Loss to the Program

The Integrated Pest Control Branch received a blow on October 17, 2005, when Ross O'Connell, Associate Agricultural Biologist with the Branch, died after a short struggle with lung cancer. Ross loved working on hydrilla, and nothing pleased him more than taking the fight directly to the plants and tubers, which he raked, pulled, dug, and dredged with fierce single-mindedness. Ross worked on the Oregon House project in Yuba County and several other smaller projects in the last several years. He is missed.

2006 SEASON HIGHLIGHTS and LESSONS

1) In California's two major remaining hydrilla infestations at Clear Lake and in the Chowchilla River / Eastman Lake area this was the fourth season without finding plants in either infestation, as well as the first year during which no treatments were made for hydrilla in either project. The Clear Lake crew inspected the lake's entire 100+ miles of shoreline at least once a month from July through October this year. They have found no plants in the lake since June 23, 2003. In the Chowchilla River, 26 miles of the river were originally infested. The Fresno crew carefully searched that entire distance this year and visited some historical hot spots twice. They have found no plants in the river since November 6, 2002, which was the only find of that year. The crew inspected Eastman Lake twice this year. No plants have been found in the lake since 1993. If we make it through two more seasons without plants, we will reach our official threshold for eradication in these two projects.

2) This was the second season with no hydrilla in any of the ponds at the infestation in the fishing resort in Tulare County.

3) There was an instance of hydrilla resurging in one small infestation. No hydrilla had been found since 1999 in the pond in Anderson River Park near Redding, even with intensive surveys by divers in 2004. However, last year the crew began clearing water primrose that was shading the water and interfering with inspections. Perhaps because of this new access to the sunlight, over 100 hydrilla plants emerged this year, most within a period of three weeks. This event illustrates how hydrilla can lay in hiding, to strike when least expected.

4) Program crews spent two weeks assisting UC Davis researchers in ground-truthing an aerial imagery survey for aquatic weeds in the Delta this year, as they have done for the previous three years. The crews visited over 3,200 sites this year, a new record.

5) Jonathan Heintz joined the Program as an Agricultural Biologist. He will be the lead on water monitoring for herbicide residues and the projects in Nevada and Yuba Counties.

6) Biologist Heintz developed a new delivery system for Komeen® (a liquid copper formulation) that permitted treating the canal in the Yuba County infestation continuously for 12 hours or more, as opposed to four hours previously.

7) The Hydrilla Program began a contract with Lars Anderson of the USDA Agricultural Research Service at UC Davis, to support his new Ph.D. student, Tom Barr. Tom's research will be an exploration of possible new control methods for hydrilla, including ultrasonics and electrolysis, new variations of old herbicides, and potential new herbicides. Tom already has some candidates that excite him.

8) The Fresno office's longtime seasonal employee, Sai Vongsackda, took and passed the exam for his Qualified Applicator's Certificate for applying pesticides. The Certificate empowers Sai to apply pesticides, including restricted materials, under his own direction, and to direct applications made by other persons working with him.

9) On about August 6 or 7, thousands of large carp, each two to three feet long, died in Clear Lake due to unknown reasons. Our Program had done no treatments of any kind in the lake by that time. The prevailing winds drove many of the carp into the town of Lakeport, where they rapidly began to rot in the 95+ degree heat. Showing uncommon fortitude, several of our crew helped the city for two days to gather and dispose of the fish.

10) Susan Monheit of our Program carried out a human risk assessment of fluridone associated with the human consumption and handling of tules. Tribes people sometimes eat the tender shoots of tules, and use them to make traditional canoes. The Program sponsored the work to address the concerns of the tribes. The study demonstrated that the risk to human health from fluridone in Clear Lake is exceedingly small. Susan gave a talk about the results in July at a meeting on environmental issues held by the tribes around Clear Lake.

11) This past year Program staff began working with a newly registered aquatic formulation of the herbicide triclopyr. The new product is called Renovate®. Triclopyr is a systemic pesticide, meaning that it moves through a plant once one part of the plant absorbs it. Systemics in general, and triclopyr in particular, are useful for eradicating stubborn perennial species with large, persistent root systems. Water primrose (*Ludwigia* spp.) is one such pest that often interferes with survey and control work. Other available systemic herbicides, such as glyphosate, only provide short-term control or suppression. Although the results on deep-rooted perennials will take a year to judge, preliminary results with the triclopyr look very promising.

12) One of our hydrilla-infested ponds, Hesseltine in Calaveras County, sometimes has trouble with a small floating Mosquito fern scientifically called *Azolla spp*., which can build into a solid mat two or three inches thick. Such conditions completely obscure the water and make inspections very difficult, and such was the case this year. At the suggestion of the manufacturer's representative, we used a liquid formulation of fluridone to treat the azolla, which also served to treat the pond for hydrilla. We stepped up the concentration slightly and achieved excellent control of the azolla after about a month's exposure, which is typical given fluridone's slow mode of action.

13) Rain and snowfall were high in 2006, and the resulting water levels in streams and lakes were, high enough to interfere with the start of work this season in some locations. Surveys were delayed in the Chowchilla River, Eastman Lake and Sacramento and San Joaquin rivers. High flows also limited fluridone treatments to the fishing resort ponds in Tulare County.

14) The Chowchilla River/Eastman Lake Project had an extensive computerized database on its activities going back to 1992, but the data was at risk of being lost. The database was in an old DOS program called DataFlex, and was essentially unusable on anything other than the old original computer on which the system started. Working with a computer-literate seasonal, Program staff was able to download the data as a text file and convert it to Excel spreadsheets, preserving these records for future access.

15) The Integrated Pest Control Branch has thousands of photographic slides going back to the 60s and even earlier. However, the storage and organization of the collection was an ever-worsening problem. This summer a seasonal with the Program, working with the biologists,

began going through the slides, choosing the highest quality and most representative samples. She scanned them into digital images and cataloged them in a computerized weed image database. We estimate that we evaluated about 14,000 slides, and now have approximately 4,000 categorized images in our database.

16) In May and June, a large eradication project for the peach fruit fly occurred in the Fresno area. Two of the Hydrilla Program's seasonals, Jodi DerMinasian and David Espinoza, assisted for several weeks on the project. Both Jodi and David have their Qualified Applicator Certificate for pesticide application, so they were especially valuable for leading treatment crews.

17) Florence Maly of the Program's Fresno office gave a talk about the Chowchilla River / Eastman Lake hydrilla project at the annual conference of the Western Aquatic Plant Management Society in March. The presentation was very well received and Florence was invited to present it at the annual conference of the California Invasive Plant Council in October, and at the annual biologists' meeting of the Department of Fish and Game in spring of 2007.

18) The owner of the fishing resort in Tulare County informed the hydrilla staff that some changes are planned for the property in the future. Ponds 7, 8 and 9 are to be filled in and ponds 5 and 6 deepened. Several of these ponds have had hydrilla in the past. We will be consulting with the owner to learn the details of this activity.

19) Program staff carrying out surveys in the Sacramento/San Joaquin Delta noticed that Carolina fanwort (*Cabomba caroliniana*) seems to becoming more abundant, and was particularly thick at Tower Park Marina. The Carolina fanwort, mixed with Elodea (*Egeria densa*) and Milfoil (*Myriophyllum sibericum*), is causing serious problems for the marina because the weeds are damaging boat propellers and motors. Stands of Yellow iris (*Iris pseudacorus*) also seem to be expanding.

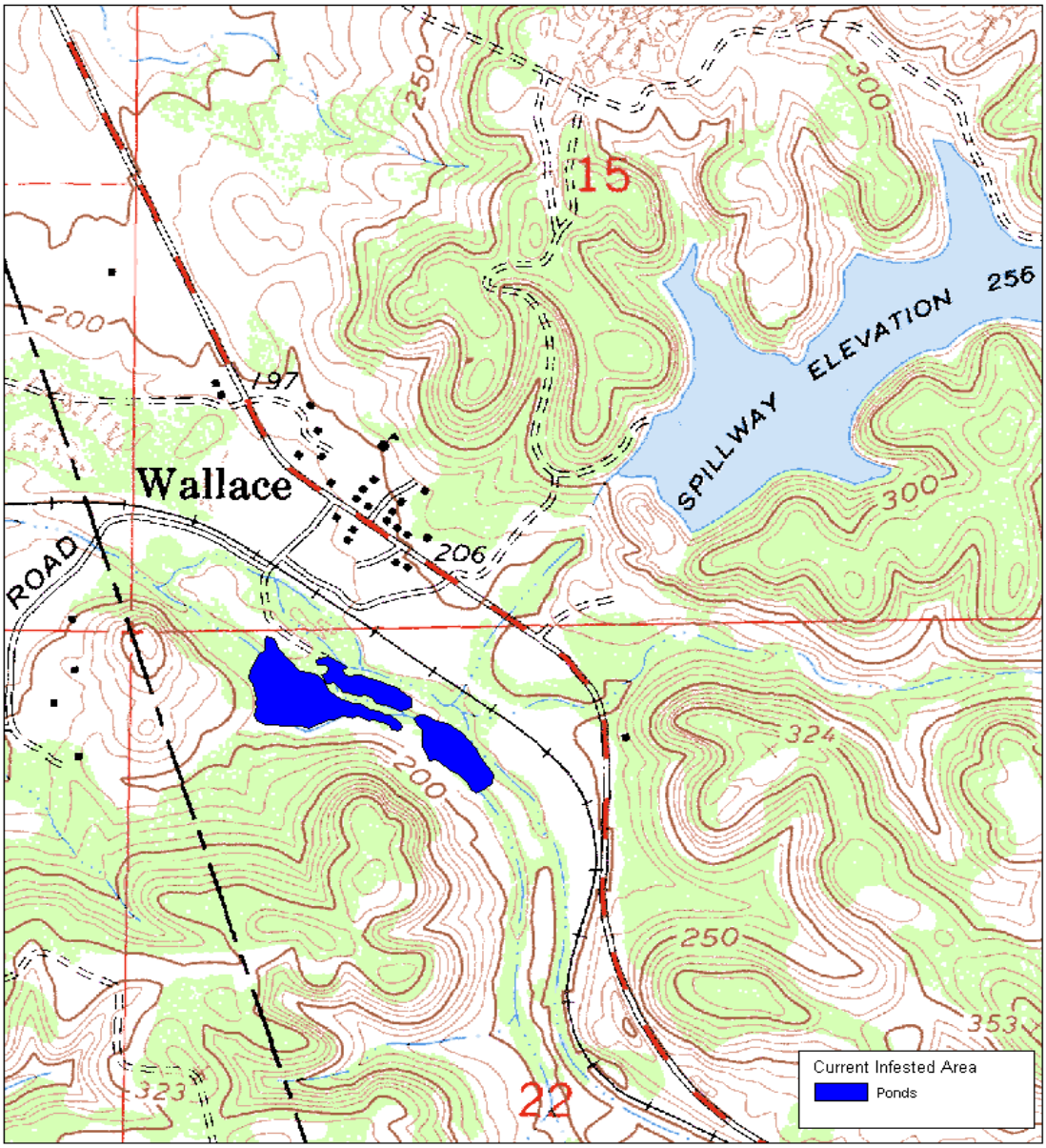
ACTIVE, ON-GOING SURVEY AND ERADICATION PROJECTS IN DETAIL

CALAVERAS COUNTY

Department biologists believe that there have been two separate infestations of dioecious hydrilla in Calaveras County, based on their separation by distance and watershed. The first infestation was detected in May 1988, and was in ponded areas along Bear Creek between the towns of Burson and Wallace, as well as in three isolated ponds (Plate 3). The Calaveras County Hydrilla Eradication Project (Calaveras Project) began soon thereafter. The Project is a cooperative effort between the Department and the Calaveras County Department of Agriculture. The Department convened a Scientific Advisory Panel that made recommendations as to survey, treatment, and public education (Stocker. R.K. and L.W.J. Anderson *et. al.* 1988). The Bear Creek infestations are of particular concern because Bear Creek enters the Sacramento/San Joaquin River Delta at Disappointment Slough in San Joaquin County, only about 26 miles downstream from the Hesseltine pond area (Unit 1), the lowest infested area on the creek.

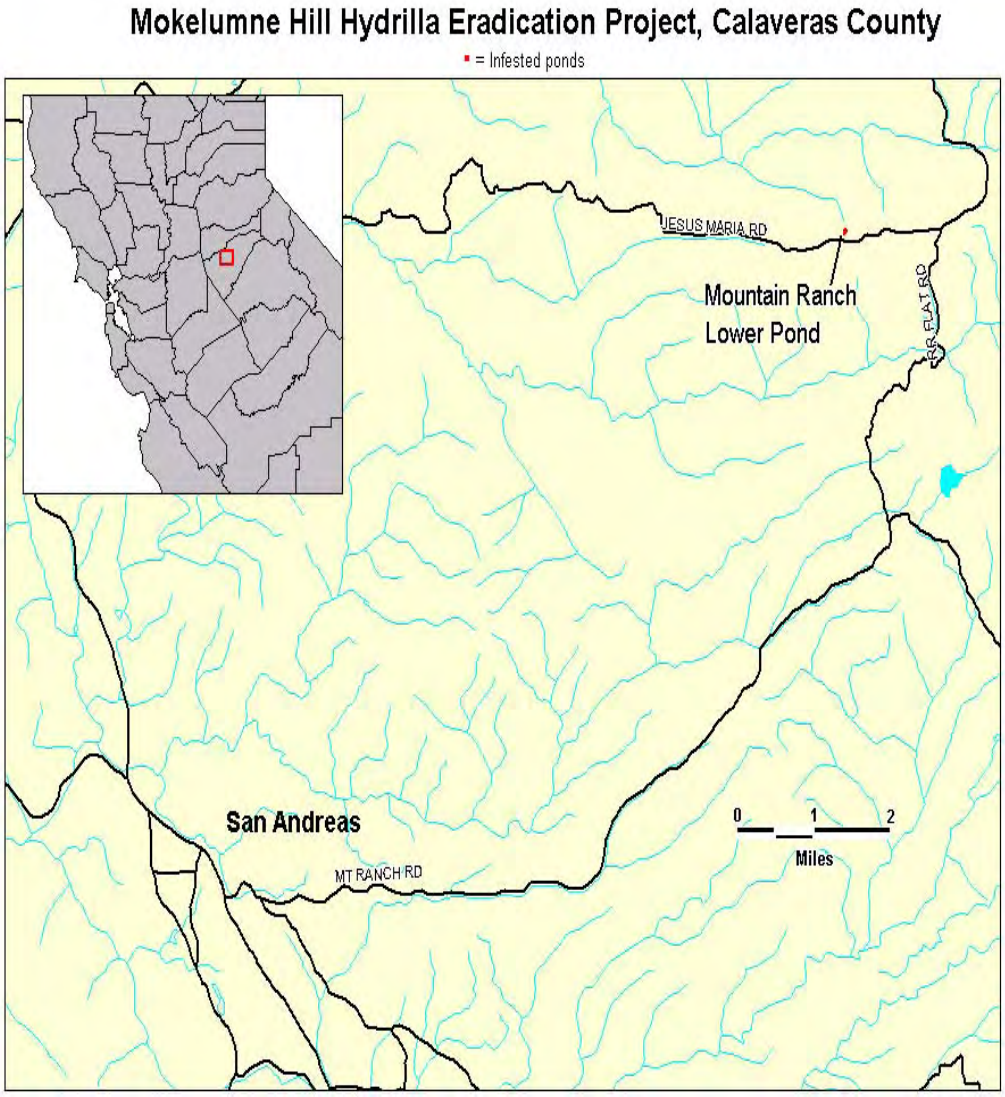
Plate 3.

Bear Creek Hydrilla Eradication Project
Calaveras County



Later in 1988, the Department and Calaveras County survey crews discovered a separate infestation in two ponds located near Mokelumne Hill, about 30 miles from the Bear Creek area (Plate 4). The two Mokelumne Hill ponds are 0.45 and 0.15 acres in size and are used for watering cattle. Six other cattle ponds surround them. The Mokelumne Hill infestation has been particularly troublesome, with hydrilla re-appearing after an absence of one to a few years. Apparently, the tuber bank has been especially resilient. No hydrilla plants have been found in the smaller of the previously infested ponds since 1998, but plants were detected in the larger pond in 2002, 2003, and 2004. No plants appeared in either pond in 2005 or 2006.

Plate 4.



Survey of the Bear Creek Drainage

In order to aid tracking the work on the project, project biologists divided the Bear Creek drainage into 11 management units. Due to the Project's efforts, all of the originally infested isolated ponds and most ponded areas in the Bear Creek drainage project are approaching eradication. Project crews have not detected any hydrilla plants in management units six through 11 of Bear Creek since 1996. They have not detected any hydrilla plants in units three through five (the Perock and Baker ponded areas) since 1998. In addition, no hydrilla has been detected in unit two since July 1999. In 2006, the crews surveyed units two and three on three occasions, unit four once, and unit five twice. All surveys uncovered no hydrilla. No surveys occurred in units six through 11, as these were dry for most of the summer.

In contrast to the above management units that are approaching eradication, the Hesseltine area (Unit 1) is still active because of recent hydrilla detections. Unit one is a series of ponded areas, totaling approximately 10 acres. The main ponded area, (Hesseltine "main pond"), located about one half mile downstream from Unit 2 (Plate 3), is approximately 3.6 acres. The patterns of water flow through the area have been changing in the last several years, which have caused the expectations for the main pond to also alter a few times. Until about 2005, a large leak in an East Bay Municipal Utility District (EBMUD) aqueduct kept water flowing in Bear Creek from about Perock Pond (Unit 3) down, and kept Hesseltine pond from ever drying up. EBMUD repaired the leak in late 2004, causing the areas in Hesseltine pond that once had hydrilla to thoroughly dry out in the 2005 season. Program staff accordingly believed that this particular infestation was most likely doomed. However, the property owner blocked the outlet to the pond during the winter of 2005-06, to try to maintain its volume. With the good rainfalls of that wet season, the water levels in the pond stayed high all through the summer and fall, although the creek completely dried up just upstream and downstream of the pond. With this new development, Program staff returned to the usual survey-and-treat strategy.

In 2004, project crews conducted six surveys of Unit 1 and detected two hydrilla plants (Table 2). The crews surveyed Unit 1 seven times in 2005 and five times in 2006, finding no hydrilla. In 2006, the first survey was conducted on June 6, when the water temperature was 16 degrees C (60 degrees F). The last survey was conducted on October 26; the water temperature was again 16 degrees C. Other aquatic vegetation detected in the Hesseltine ponded area included coontail (*Ceratophyllum* species), Elodea (*Elodea canadensis*), naiad, mosquitofern (*Azolla* species*)*, various pondweeds, watermeal (*Wolffia* species), duckweed, chara, water primrose (*Ludwigia* species), and cattails (*Typha* species). The azolla in particular reached very high densities and began interfering with the surveys for hydrilla.

Table 2. Number of Hydrilla Plants and Tubers Found and Removed from Bear Creek, Calaveras County, 2000 – 2006.

Unit 1 – Hesseltine Ponded Area							
YEAR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Mats	0	0	5	0	0	0	0
Plants	0	10	18	3	2	0	0
Tubers	-	46*	69*	-	2**	0	0

*Most tubers were recovered by dredging operations
**1 plant from tuber, 1 plant from turion.

Treatment of the Infested Management Unit in the Bear Creek Drainage

Since the first hydrilla find in Unit 1 in 1996, Project personnel have treated all find sites with various combinations of physical removal and applications of copper ethylenediamine and/or fluridone herbicide. Areas immediately surrounding locations where plants have been detected in the last three years have been treated with fluridone herbicide, in a quick-release pellet formulation (Sonar PR)® to provide rapid build-up of the herbicide, while still taking advantage of its long residual effectiveness. This year we used Sonar AS®, the liquid formulation, for an even faster elevation of concentrations. There were three applications, on August 23, September 26, and October 26, for a total application of 51.4 ounces of active ingredient, yielding a cumulative application rate of 90 ppb. The fluridone also proved very effective in controlling the problem with azolla.

Survey and Treatment of Mokelumne Hill

Calaveras Project crews surveyed the infested ponds five times in 2006 and each of the nearby ponds four to five times (Plate 4). The first survey was on May 7, when the water temperature was 14 degrees C (58 degrees F). The last survey was on November 7, when the water temperature was 16 degrees C (61 degrees F). In 2004, 10 hydrilla plants were detected in pond three, the main infested pond (Table 3). In 2005 and 2006, no plants appeared. Other aquatic vegetation detected included chara (*Chara* species), nitella, naiad, watershield (*Brasenia schreberi*), coontail, water primrose, American, and curly leaf pondweed (*Potamogeton* species), and algae.

Table 3. Number of Hydrilla Plants and Tubers Found and Removed from the Stock Pond Near Mokelumne Hill, Calaveras County 2000 – 2006.

YEAR	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Mats	0	0	4	0	0	0	0
Plants	0	0	1	22	10	0	0
Tubers	0	0	49	2	24	0	0

The infested pond was treated three times with fluridone quick-release pellets at 30 ppb per treatment, on July 13, August 24, and September 2. In total, 0.6 pounds of fluridone active ingredient were used to treat the pond.

Surveys Outside the Quarantine Zone

Calaveras Project personnel surveyed the following waterways in the vicinity of the Bear Creek infested area in 2006: Comanche Lake and nearby ponds named Trout, Catfish, and Beaver; ponds on the Lockeford Springs Golf Course, and all access points (road crossing areas) of Bear Creek from the Calaveras-San Joaquin County line west to Thornton Road in Stockton, approximately 26 miles. No hydrilla was detected.

FRESNO OFFICE GENERAL DETECTION SURVEYS

The Hydrilla Program crew in Fresno takes care of the Calaveras, Chowchilla/Eastman, and Tulare Springville projects, as well as working on occasion in Imperial County. With the Chowchilla project beginning to taper off, the crew has had more opportunity to expand its detection efforts. Their surveys have carried them to many public water bodies in the central and southern parts of the state (Table 4).

Table 4. 2006 Detection Surveys Conducted by the Fresno Hydrilla Program Staff.

County	Location Name
Amador	Lake Amador, Pardee Reservoir (spot check)
Calaveras	Salt Spring Valley Reservoir, New Melones Lake-Glory Hole Recreation Area (spot check), Lake Wallace, New Hogan Lake (spot check), Camanche Reservoir ponds: Trout pond, Catfish pond, Beaver pond
Fresno	Mendota Wildlife Refuge, Kerckoff Reservoir, Millerton Lake, Pine Flat Lake, Little Panoche Reservoir Wildlife Area
Los Angeles	McDonald's Aquatic Nursery, Castaic Lake and Lower Lagoon
Madera	Berenda Slough, Coarsegold ponds, Corrine Lake, Manzanita Lake
Mariposa	Lake McSwain (spot check), Lake McClure- spot checks at New Exchequer Dam, McClure Point Recreation Area, Barrett Cove Recreation Area, Horseshoe Bend Recreation Area, and Bagby Recreation Area
Merced	Merced Falls, San Luis Reservoir (spot check), O'Neill Forebay (spot check), Los Banos Creek Reservoir (spot check)
Orange	Anaheim Wetlands ponds
Sacramento	Rancho Seco Lake (spot check)
San Joaquin	Mokelumne River State Fish Hatchery, Lake Lodi
Santa Clara	Coyote Lake, Uvas Reservoir, Anderson Lake, Chesbro Reservoir, Calero Reservoir, Almaden Reservoir (spot check), Parkway Lakes, Vasona Lake, Lexington Reservoir, Stevens Creek Reservoir
Stanislaus	Woodward Reservoir, Modesto Reservoir, Dawson Lake (spot check), Basso Bridge fishing access (spot check)
Tulare	Eagle's Nest Resort, pond off Hwy. 190, Kaweah Lake
Tuolumne	New Melones Lake-Tuttletown Recreation Area (spot check), Don Pedro Lake-spot checks at Fleming Meadows, Blue Oaks Recreation area, and Moccasin Point Recreation area, Moccasin Creek State Fish Hatchery

*spot check = access points, public facilities, and nearby shoreline

IMPERIAL COUNTY

Imperial Irrigation District (IID) personnel first detected dioecious hydrilla in Imperial County in June 1977 in the All American Canal. The IID is a gravity-fed irrigation system that delivers water from the Colorado River via the All American Canal through a network of lateral canals, ponds, and reservoirs to farmers' ditches, which in turn water the farms of the Imperial Valley. Drainage canals (drains) then carry the runoff and seepage to the New and Alamo rivers. IID personnel conducted surveys in 1988 and found that the hydrilla infestation covered, to a greater or lesser degree of plant density, 320 canals extending approximately 600 miles, 32 ponds comprising 161 surface acres, and 79 privately owned delivery ditches (farmers' "sides").

The Department, IID, USDA-Animal and Plant Health Inspection Service, California Department of Fish and Game (CDFG), and Imperial County Department of Agriculture formed a cooperative agreement in 1981 to research and develop control and eradication methods for the IID. Between 1981 and 1984, the main control methods were mechanical removal of plant mats and mechanical dredging. In 1984, the IID received permission from the CDFG to stock the west side of the IID (the infested area) with triploid grass carp (*Ctenopharyngodon idella*) (TGC)[20]. The TGC has been the main control and eradication method since that time, supplemented by hand removal of individual plants, sealing of cracks in the canals with epoxy to prevent hydrilla emergence, and mechanical dredging when necessary. The IID stocks the TGC on a yearly basis at a target rate of up to 100 fish per mile for canals infested with aquatic vegetation, and up to 100 fish per acre for ponds infested with aquatic vegetation. In 2006, 5,800 triploid grass carp were stocked in delivery canals (Table 5).

Table 5. The Number of Triploid Grass Carp Stocks and the Number of Hydrilla Infested Canals, Drains (and Farmer's Sides) in the Imperial Irrigation District, Imperial County 2000 – 2006.

YEAR	2000	2001	2002	2003	2004	2005	2006
Number of TGC Stocked	2,432	2,841	2,101	2,822	1,129	3,275	5,800

Survey and Treatment of the Imperial Irrigation District Canals and Associated Waterways

While the IID continues to employ the TGC for control of hydrilla and other aquatic vegetation in the canals (delivery system), the fish cannot be placed in the drains or farmer's sides, where water levels undergo large and rapid changes. Therefore, in 2004, when hydrilla was again detected in the Wildcat Drain (hydrilla was found here in 2002 and 2003) officials from the Department, Imperial County Department of Agriculture, and IID surveyed and mapped the entire drain. A total of 5.1 miles of the drain was divided into 15 units, based on topography.

[20] The biological control agent, the triploid grass carp (*Ctenopharyngodon idella*) (TGC) is used to consume hydrilla and other aquatic vegetation. When used in confined areas, and in adequate stocking rates, the TGC can suppress a population nearly to extinction. However, to prevent establishment of a wild population, the CDFG Code requires that only sterile fish be stocked. (TGC roe is put through a high-pressure treatment that gives each egg a triploid chromosome complement and makes the fish sterile). Nonetheless, the CDFG is concerned that the sterility might not be absolute, so they have tight restrictions on TGC use. According to the CDFG Code, the TGC cannot be deployed in any open water bodies that empty into natural waters of the state (CDFG Code, Sections 6440-6460). Therefore, all use of the TGC must be in areas that are contained with gates and screens, which severely restricts TGC use. Despite this limitation, the use of the TGC can be very effective in ponds and canals where the inlets and outlets can be screened to contain the fish.

Hydrilla was seen in Units 2 through 13. IID personnel removed as much of the hydrilla as possible following the mapping. The crew removed the Hydrilla by hand.

A follow up survey by Department Biologists in October 2005 revealed the continued presence of hydrilla in the Wildcat Drain. Suspicious-looking plants were also seen in another drain, the Wisteria, located southwest of the Wildcat Drain. These plants, however, were not confirmed as hydrilla until November 29. The Wisteria Drain flows into the Greeson Drain, which in turn makes its way to the New River.

In response to these finds, Fresno Hydrilla Project crewmembers and IID workers spent six weeks in the winter of 2005-06 hand-removing all visible hydrilla plants from both drains. Additional sections of the Wildcat, Wisteria, Rice, and Greeson Drains were surveyed and no hydrilla plants were detected.

Hand removal activities were resumed in November 2006, concentrating on the western 0.25 miles of the Wisteria Drain. Large, solid mats of hydrilla and other aquatic plants were removed from the drain in the course of five weeks between November 2006 and mid-January 2007. Plans to conduct a second survey through the infested section and to look at the Wildcat Drain were interrupted in late January by the appearance of the quagga mussel. In 2007, Department and IID officials will resume the implementation of a plan to eradicate these last remnants of hydrilla in Imperial County.

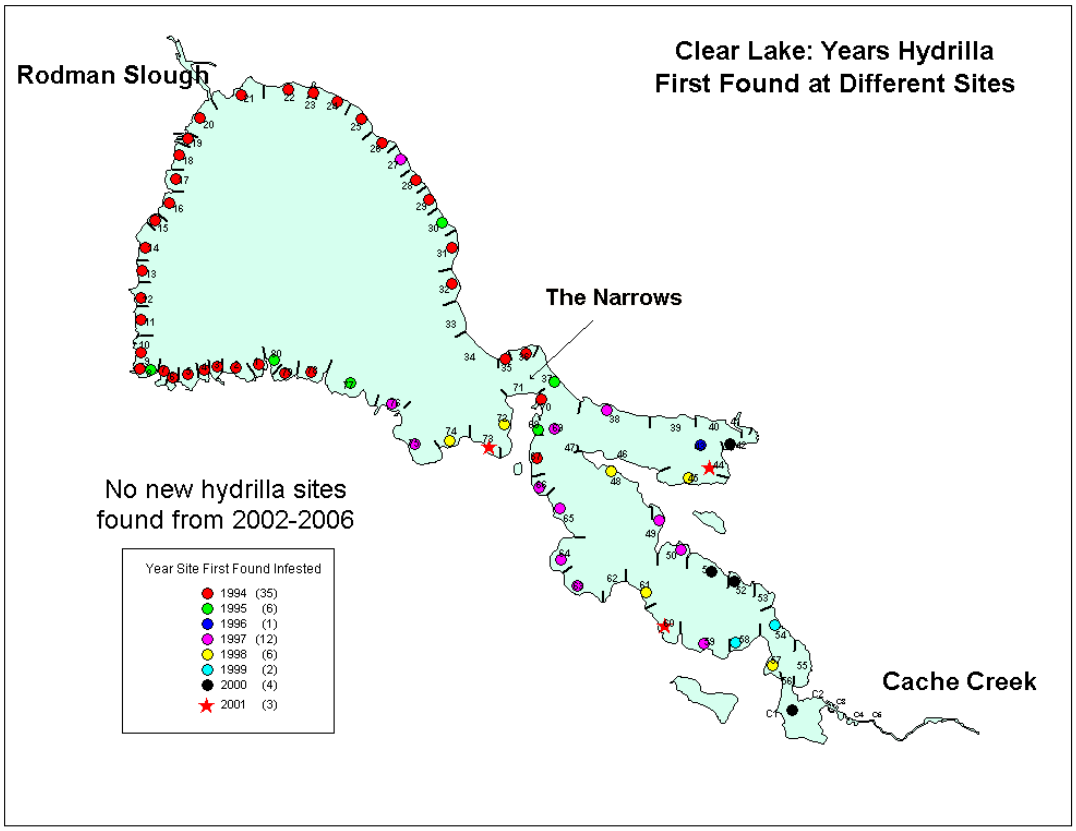
LAKE COUNTY

2006 was the first year since the beginning of the Clear Lake Project that no herbicides were applied for the control of hydrilla. Three growing seasons had passed since the find of the last plant, meeting the criterion for the cessation of treatments.

The Clear Lake Project is a cooperative effort of the Department, the Lake County Department of Agriculture, and the Lake County Department of Public Works. Clear Lake is the largest freshwater, natural lake completely within California's borders[21]. It is almost 22 miles long and eight miles wide, has a surface acreage of approximately 43,000 acres, and has about 100 miles of shoreline (Plate 5). Clear Lake is located roughly 90 miles north of San Francisco. The lake is relatively shallow, with an average depth of approximately 26 feet. Because it is shallow and has winds most afternoons, Clear Lake's waters move and mix significantly, so it does not strongly develop the temperature-based layering (thermocline, stratification) that is typical of most lakes, not even in late summer. Water temperatures range from mid to high 30 degrees C (86 degrees F) in the summer to five to 10 degrees C (40 to 50 degrees F) in the winter. Temperatures are ideal for hydrilla germination and growth from mid-May until mid-October, especially the monoecious form that is in Clear Lake.

[21] Clear Lake is a popular fishing and water sports recreational lake. Clear Lake has often been described as the "Bass Capital of the West." The Lake is host to a number of bass tournaments throughout the year. There are also catfish, crappie, hitch and bluegill in the lake. There is also carp bow hunting.

Plate 5. Map of Clear Lake in Lake County Showing Location of Hydrilla Program Management Units and the Year Hydrilla First Detected in Each Unit.



Hydrilla was first found in Clear Lake on August 1, 1994, during a routine detection survey conducted by personnel from the Department and the Lake County Department of Agriculture. Department and Lake County biologists responded rapidly and applied copper aquatic herbicide to some infested areas within two weeks of the first detection. In addition, the Department, with the cooperation of the Lake County Agricultural Commissioner, put Lake County under quarantine[22]. The Department and Lake County biologists conducted the initial delimiting survey in 1994 and found that 175 to 200 surface acres along the shoreline of the upper arm of Clear Lake were infested (Plate 5). 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 at the upper end of the lake. The Department convened a Scientific Advisory Panel in 1994 (Stocker, R.K. and L.W.J. Anderson *et. al.* 1994), which recommended a survey, treatment, and public education program.

[22] Because of the heavy recreational use of the lake, and the high risk that contaminated recreational equipment, clothing, or vehicles could spread hydrilla plant fragments, tubers, or turions around the Lake, or out of the Lake to nearby ponds, lakes, and streams (particularly Cache Creek), the DEPARTMENT and Lake County restricted movement of watercraft, motors, trailers, fishing gear, and other vehicles and equipment until they were inspected and cleaned of aquatic vegetation at the boat docks and ramps. These restrictions are still in place.

Clear Lake Project personnel divided the lake's shoreline into 86 (originally 80) management units in order to better organize and track eradication efforts (Plate 5). These management units were based upon landmarks for ease of identification; they are not equal in length or area. These management units also vary in width but usually extend about 500 feet from shore toward the center of the lake. In 2003, all of these management units were surveyed and mapped using global positioning system/global information system technology to increase accuracy of herbicide treatments, and to better coordinate aquatic vegetation management activities with the Lake County Integrated Aquatic Vegetation Management Program[23].

Survey of Clear Lake

Surveys within Clear Lake always represented at least 40 percent of the Clear Lake Project's field activities, and that percentage continues to increase as management units reach the three-year criterion for ending treatments. The Project has the goal of at least one survey of every management unit per month during the active hydrilla-growing season. In 2005, project crews conducted 549 surveys of the management units for an average of 6.4 surveys per unit. In 2006, the crews surveyed the management units on an average of once every three weeks, conducting 495 surveys for an average of 5.9 surveys per unit.

No hydrilla plants were detected in 2004, 2005, or 2006 (Table 6). The first survey in 2006 was on May 24 and the last on November 2. The water temperature at the time of the first survey was 20 degrees C (67 degrees F) and was 14 degrees C (58 degrees F) at the time of the last survey. The number of plant finds has continued to decrease every year since the plant population has been low enough to count discrete finds (Plate 6, Table 7). No plants were found in 2005 or 2006, and the last plant found in the lake was on June 23, 2003. The number of management units in which hydrilla was detected has also decreased from a maximum of 54 in 1998 to zero in 2004 through 2006
(Table 6)[24].

Other aquatic plant species detected in Clear Lake in 2006 included coontail, curlyleaf pondweed (*Potamageton crispus*), American pondweed (*P. nodosus*), Illinois pondweed (*P. illinoensis*), Egeria, Elodea, Eurasian watermilfoil (*Myriophyllum spicatum*), sago pondweed (*Stuckenia filiformis*), smartweed (*Polygonum* species), water hyacinth (*Eichhornia crassipes*), spatterdock (*Nuphar luteum*), and spiny, and southern naiad.

[23] The Clear Lake Integrated Aquatic Vegetation Management Program is a permit system to allow the public and Lake County to conduct weed control operations in Clear Lake. The program is operated by the Lake County Department of Public Works.
[24] This does not mean that hydrilla has been eradicated from the management units. It is very possible that new plants are emerging from tubers in the treated units, but that the fluridone herbicide treatments are suppressing their growth.

Plate 6. The Change in Hydrilla Infestation in Clear Lake from Year of First Detection in 1994, to 2006.

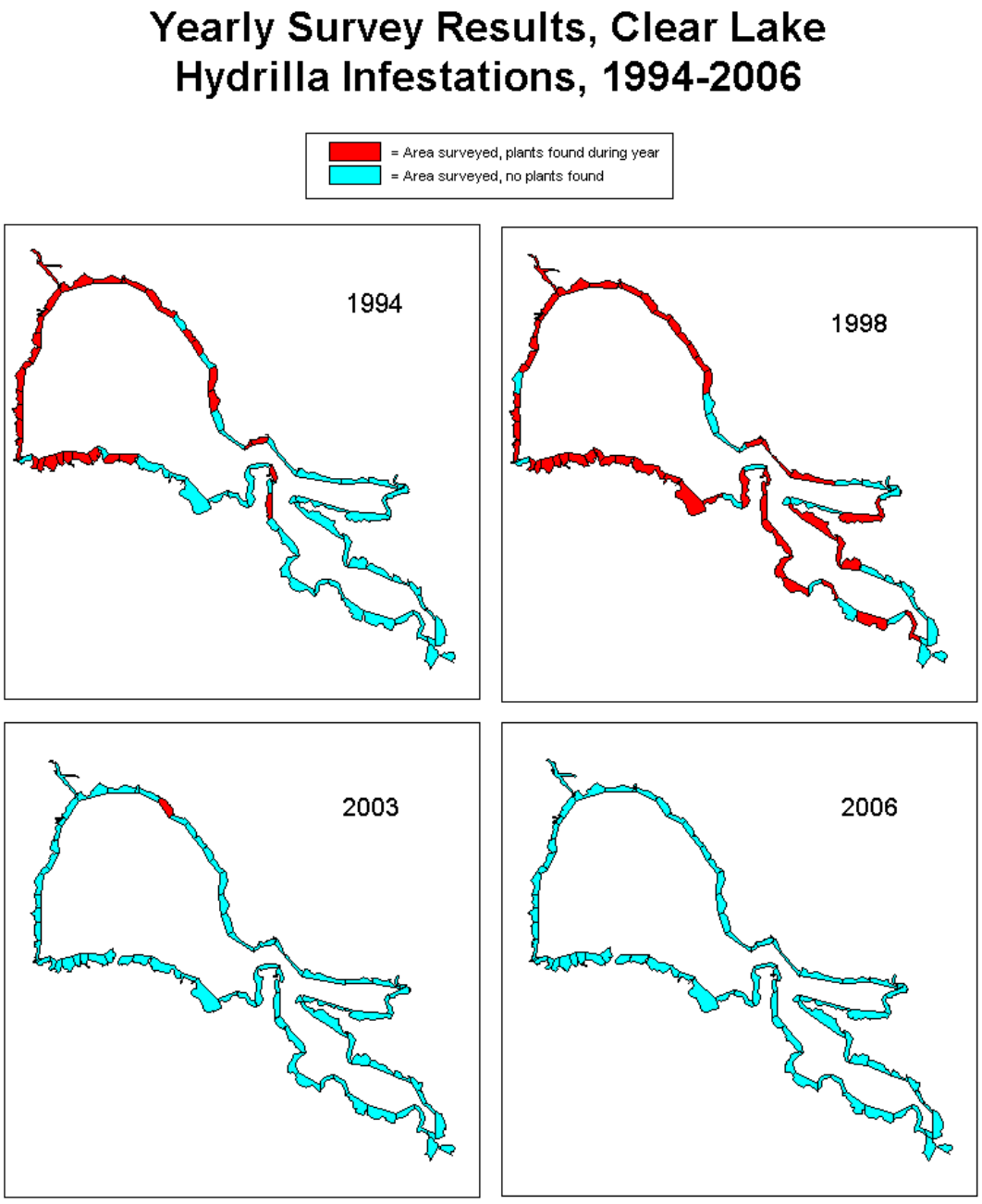


Table 6. Level of Hydrilla Infestation in Clear Lake, Lake County by Number of Infested Management Units* and Number of Finds 2000 to 2006.

YEAR	2000	2001	2002	2003	2004 - 2006
Number of Management Units with "Finds"	31	21	6	1	0
Number of Hydrilla "Finds"	67	41	12	1	0

*The management units were originally defined with reference to natural landmarks for ease of location, survey, and treatment. Management units are not identical in size or shape.

Clear Lake crews survey the center sections of the lake in mid to late summer every year. Mid to late summer was chosen because, if any hydrilla plants were growing in the deeper water sections of the lake, they would have reached near the water surface by this time, and be fairly easy to detect. In 2006, project crews made two center section surveys. No hydrilla has ever been detected in deep-water sections of the lake.

For the management of general aquatic weeds in Clear Lake, the Lake County Department of Public Works has an ongoing program in which they contract with private applicators to control nuisance weeds in high-use areas. These permits require the permittee to identify the location of all proposed treatments, the method of treatment, and any aquatic vegetation present. The Department Agricultural Pest Control Supervisor at Clear Lake approves these permits before treatment can commence. In 2006, there were 89 permits for chemical treatments. None of these permittees have ever reported the presence of hydrilla in the lake.

In addition to surveys, the Clear Lake hydrilla crew also does boat and trailer inspections for hydrilla before and after major fishing and boating events. In 2006, they conducted 180 boat and trailer inspections. No hydrilla was found.

It is important to note that Program managers do not assume that the detection of no plants or plant fragments in Clear Lake in the last three years implies that the lake is free of hydrilla. The true test of the eradication efforts just began this year, with the end of treatments and the beginning of the three-year monitoring phase. Program managers believe that, while large mats of hydrilla would be detected with nearly 100 percent efficiency, small individual plants could escape detection. The Department surveys are very thorough, but no survey system, no matter how intense, can hope to detect with absolute certainty a single small plant amongst the mass of aquatic weeds growing in the entire lake. In addition, program personnel continued to treat known infested areas of the lake with fluridone herbicide in slow release pellets through 2005. The purpose of this herbicide is to eradicate hydrilla plantlets emerging from underground tubers, but it remains in the bottom sediments for an extended period. If the herbicide performs as intended, it eradicates plants when they are small, before they are large enough to be readily detected. Program managers suspect that there are still a significant number of tubers in Clear Lake, and that these tubers could continue to germinate for another three to five years. Without steady suppression with fluridone, any surviving plants will have an opportunity to reveal themselves. The project ceased treatments for hydrilla in 2006, and no treatments will occur until such time as plants appear. Program managers won't probably have a clear idea of the overall effectiveness of the program until the end of next season.

Treatments of Clear Lake

In 2006, the Department used fluridone aquatic herbicide as the eradication method of choice in Clear Lake[25]. No copper aquatic herbicide[26] (Table 7), small-scale dredging or other methods were used, because these methods are used only where plants are actually found. However, these methods may be used in the future if new hydrilla plants are detected.

Table 7. Aquatic Herbicide Used by the Department in Clear Lake, Lake County 2000 – 2006.

ACTIVE INGREDIENT	Copper, pounds					Fluridone, pounds						
YEAR	2000	2001	2002	2003	2004 - 2006	2000	2001	2002	2003	2004	2005	2006
Treated-Acres*	117	62	28	5	0	1,149	1,335	1,440	1,256	520	219	4.5

*Some sites were treated multiple times, but data is expressed as "treated-acres," i.e. one-acre treated multiple times is one treated-acre.

The Clear Lake Project's use of fluridone has decreased in the last several years as a result of a decrease in plant detections (Table 7) and management units reaching the three-year criterion for the end of treatments. In 2005, project treatment crews applied the first fluridone on June 2 and the last on August 4. One hundred and thirty-seven acres were treated with fluridone slow release pellets in 2005, a 90 percent reduction from 2002, the year of maximum treatment. The highest cumulative application rate used in 2005 was 100 ppb, because there were no new infestations detected that year. Visual observations and surveys indicated that the fluridone slow release pellets gave complete control of hydrilla in treated areas.

While no treatments were made for control of hydrilla in 2006, the Project did treat 4.5 acres near Rodman Slough (the inlet stream) with fluridone to maintain an access channel and improve conditions for surveying. As the applications targeted species other than hydrilla, and these species tend to be somewhat less susceptible to fluridone, the treatment protocol was adjusted to address the different objective. There were three applications at two-week intervals beginning August 3, at 75, 25, and 25 ppb, using a total of 8.1 pounds of fluridone active ingredient. The Project also did some control work on water primrose and other emergent vegetation in the area of Rodman Slough and at the State and County Parks, where the plants were growing thickly out over the surface of the water and inhibiting access and visibility. A newly available herbicide promises to improve the returns on this kind of work. This year the

[25] Fluridone slow release pellets have the advantage that they give residual control because they release the active ingredient slowly into the water system. In addition, fluridone slow release pellets are easy to apply and their use concentrates the fluridone near the water: hydrosoil boundary where it controls plants emerging from newly germinated tubers. In general, the Clear Lake Project treatment crews apply fluridone slow release pellets on a two-week schedule, once applications begin in the spring. The treatment zone is a five-acre area around the location of each plant find that has occurred in the previous three years. The standard treatment is seven applications at 20 ppb (calculated to a maximum depth of six feet only) applied on a two-week schedule for a yearly maximum of 140 ppb. The number of applications is decreased to six (120 ppb yearly maximum) in management units in which hydrilla has not been detected the previous year. The number of applications are further decreased to five (100 ppb yearly maximum) in management units in which hydrilla has not been detected in the previous two years (Plate 5). After hydrilla has not been detected for the previous three years, herbicide treatments to that unit cease, but intensive survey continues.

[26] This herbicide is applied on an as-needed basis to achieve rapid destruction of biomass in areas where plants or plant fragments are found. A five-acre area around each plant find is treated with copper ethylenediamine herbicide at one-ppm copper within a few days of any find. Copper ethylenediamine, because it is a contact herbicide, is still the herbicide of choice for rapid dissolution of large plants and mats, and in certain other situations, such as where water might be used for irrigation or where it is not practical to obtain the long contact time required by fluridone.

aquatic product Renovate®, which contains the herbicide triclopyr, became available in California for the first time. Triclopyr has been reported to be very effective on this class of vegetation. In the past, glyphosate (AquaMaster®, Rodeo®) has been one of the few available herbicides, but Hydrilla Program staff has found glyphosate to limit effectiveness on plants like water primrose. In particular, although glyphosate is a systemic herbicide that should act to eradicate the roots, the plants recovered very rapidly from treatments. Triclopyr is also a systemic. The Project applied Renovate® at the minimum rate of two quart per acre of the product, accounting for 14.25 pounds in total of triclopyr. Results were very good to excellent, and there was very little recovery this season. We hope the triclopyr has eradicated the roots better than glyphosate, in which case it should prove much easier to maintain access and visibility in these high-risk areas in the future. The Project will monitor these treatment sites in the future.

Starting in 2000, some management units had been hydrilla free for over three years. Such units were no longer treated after reaching the three-year criterion, though surveys continued. In 2006, there were 70 units that were previously infested, but which are now apparently hydrilla free. None are treated presently[27].

Surveys Outside of the Quarantine Zone

As the time and resources required for making herbicide applications have decreased in Clear Lake, Project crews are able to dedicate more time to surveying surrounding lakes, ponds, streams, and other water bodies, in order to detect any hydrilla infestations in the incipient stage. The crews conduct these surveys because boats, trailers, or other equipment coming from Clear Lake might have carried hydrilla fragments, tubers, or turions to these nearby water bodies. In 2006, project crews surveyed numerous water bodies in the area (Table 8), including Indian Valley Reservoir, Highland Spring Reservoir, Lake Pillsbury, and Blue Lakes in Lake County. In addition, major reservoirs and lakes in Glenn, Napa, and Sonoma counties and Cache Creek in Yolo County were also surveyed. No hydrilla was detected during these surveys, though other aquatic weeds were found, including coontail, sago pondweed, and water primrose.

[27] The Department Hydrilla Eradication Program prohibits the use of mechanical harvesters in areas in which hydrilla has been detected in the previous six years. The prohibited area is a circle of a one-quarter mile radius around each find. The reason for this prohibition is that even the best mechanical harvesters leave numerous plant fragments that could potentially become established thereby spreading the hydrilla infestation.

Table 8. 2006 Detection Surveys of the Clear Lake Hydrilla Eradication Project.

County	Location Name
Mendocino	Blue Lakes, Iron Oak Vineyards, Eel River Watershed, Upper Reservoir Water Treatment, Newell Acres Pond, Testa Vineyard, Beckstoffer Vineyard Pond # 3, Weibel Vineyard, Ruddick Ranch, Ruddick Cunningham Ponds # 1 and 2, Alexi Ranch Vineyards, Waddington Ranch, Ukiah Golf Course, Mendocino College Entrance Pond, Dry Creek, Crow Foot Ranch, Jefson Vineyards, Orrs Creek, Rebo Ridge Ranch, Last Lake, Swan Lake, Koi Lake, North Lake, McDowell Valley Vineyards, Hopper Ranch Vineyards, Fetzer Pond, Vimark Vineyards, Shadow Brook Farms, and 12 other private ponds
Napa	Pope Valley Rd. Pond, Knoxville Valley Rd. Pond, Putah Creek Campground, Berryessa Reservoir, Aetna Springs Golf Course, Kimsey Pond, and three other private ponds
Sonoma	Spring Lake, Lake Ralphine, Gallo Winery Ponds 1, 2, 3, 4, and 5, CDF Fire Station Pond (Lytton Springs Rd), Foppiano Winery Irrigation
Lake	Adams Springs Golf Course, Boggs Lake Preserve, Yogi Bear Jellystone Park, Kelsey Creek Inn, Anderson Spring Swimming Hole, Donnelly Ranch Hwy 175 upper and lower ponds, Rainbow Ranch Hwy 175, Rob Roy Golf Course, Putah Creek, Pomos Creek Ranch, Spring Valley Creek, Buckingham Golf Course
Glenn	Pond at Rd 39 on Hwy 99, Lower and Upper Bidwell Park, Horseshoe Lake, Bidwell Park Golf Course, California Park (Chico), Marler & Family Fish Farm

Public Information and Awareness

Public information and awareness are essential components of the Clear Lake Project. Recreational fishermen, guides and outfitters, fishing tournament organizers, sailors, boaters, and other recreational users of Clear Lake need to know how to prevent the spread of hydrilla in the lake and from Clear Lake to other lakes, streams, ponds, and reservoirs. Since public access to the lake is not restricted, and there are hundreds of access points, public education and awareness efforts must include both traditional and non-traditional outreach venues. Clear Lake Project personnel distributed approximately 1,200 informational pamphlets to businesses and government agencies around Clear Lake.

In 2006, Clear Lake Hydrilla Eradication Project personnel made several presentations to the public about the project. The project was highlighted in a poster at the California Weed Science Society in January, and in a presentation at the Western Aquatic Plant Management Society conference in March. Susan Monheit gave a talk about her work on fluridone in tules at a meeting consisting of the major Native American tribes in Lake County[28]. In addition, several informal discussions of the project occurred at other events during the year.

[28] This consortium is made of representatives from the six Pomo tribes of Native Americans that live near Clear Lake (Big Valley Rancheria, Elem Indian Colony, Habematolel Pomo of Upper Lake, Middletown Rancheria, Robinson Rancheria, and Scott's Valley Band of Pomo Indians).

LOS ANGELES COUNTY

On March 5, 2004, two biologists, one from the Department Pest Exclusion Branch and one from the Los Angeles County Department of Agriculture, detected hydrilla during a routine inspection of an aquatic plant nursery near Reseda, California. A thorough inspection of the site showed that the hydrilla infestation was confined to two tubs of water lilies, and a pond 60 feet long, six feet wide, and 18 inches deep, also containing water lilies.

On May 3, the Department Integrated Pest Control Branch and Pest Exclusion Branch biologists and Los Angeles County biologists drained and cleaned hydrilla from the infested pond and plants. The hydrilla, muck, and other debris were removed to an empty area in the nursery to dry out. All hydrilla tubers and turions were collected and inspected before disposal. A total of approximately 100 hydrilla tubers and turions, mostly turions, were removed from the pond and plants. Based on the size of the hydrilla leaflets, and the length, width, and size of the tubers, project biologists believe the hydrilla was of the dioecious form.

The water lilies that were growing in the infested pond were then cleaned, repotted and replaced in the pond, which was filled with clean water. The pond and plants remained under quarantine by Los Angeles County Department of Agriculture.

A thorough re-inspection by Department and County staff in late July 2006 demonstrated that the infestation had been eradicated.

MADERA AND MARIPOSA COUNTIES

In June 1989, the Department and Madera County Agriculture Department personnel, during a routine survey of aquatic sites in the county, detected dioecious hydrilla in Eastman Lake. Eastman Lake is a 1,800-acre reservoir that belongs to the United States Army Corps of Engineers (USACE) and is used for flood control, irrigation, recreation and wildlife. The survey crews found scattered patches of hydrilla along the northern section of the lake and along the eastern and southeastern shoreline, amounting to 100 infested acres.

During an extensive survey of all known water bodies in the vicinity of Eastman Lake, survey crews detected hydrilla upstream of the lake in the west fork of the Chowchilla River. After a thorough survey, the crew determined that approximately 26 miles of the river were infested. Plant density at different sites ranged from single plants to dense patches.

The Department, Madera County Department of Agriculture, Mariposa County Department of Agriculture, and USACE initiated the Madera and Mariposa Counties Hydrilla Eradication Project (Chowchilla/Eastman Project) in 1989, right after the first detections were made. The Project cooperators issued a quarantine for all of Eastman Lake and for the infested portions of the Chowchilla River, closing the areas to recreational use. Survey crews have not detected hydrilla in Eastman Lake since 1993. As a result, quarantine restrictions have been progressively lifted so that today only the uppermost section near the inlet to the Lake remains under quarantine, where fishing is prohibited. The west fork of the Chowchilla River remains under quarantine, and fishing is prohibited in all management units[29].

[29] In 1989, project leaders divided the lake and river into 38 management units for tracking of survey and eradication activities: The units followed the original property lines and are not the same length or area.

Survey of Eastman Lake

Because hydrilla plants and tubers were detected upstream of Eastman Lake in the Chowchilla River as recently as 2002, surveys of Eastman Lake continue and will continue until the hydrilla is declared eradicated in the river. In 2005, survey crews surveyed Eastman Lake four times by boat and canoe. Some sections of the lake were surveyed twice in 2006, while others were surveyed three times. The first survey of 2006 was on June 30, when the water temperature was 28 degrees C (82 degrees F). The last survey was on October 13, when the water temperature was 20 degrees C (69 degrees F). Other aquatic vegetation detected included chara and algae.

Water levels in the lake remained high throughout the season. The lake elevation, at its lowest point, was a minimum of 50 vertical feet above the level at which the last hydrilla plants were found.

Survey and Treatment of the Chowchilla River

In 2005, project crews conducted between two and three surveys of each management unit along the river. In 2006, the entire river was thoroughly surveyed once, and known hot spots were checked twice. The first survey this year was on June 5, when the water temperature in the river was 20 degrees C (69 degrees F). The last survey was on October 12, when the water temperature was 16 degrees C (61 degrees F). For the fourth year in a row, no hydrilla plants or tubers were detected in any of the 38 management units (Table 9). The last plant in the river was found November 6, 2002, which was the only find of the year, when two plants were found together.

Water conditions in the river were very good this year. High precipitation in the past two rainy seasons raised the water levels in the river and lake quite high this season, to the point where surveys of the river were not safe early in the season. On the other hand, the high flows put water back into parts of the valley bottom that had once had hydrilla but had had no water for several years. The return of water should have provided any residual tubers an opportunity to emerge and yet none appeared, which is very encouraging. Other aquatic vegetation detected in the Chowchilla river included elodea, American pondweed, curly leaf pondweed, water primrose, coontail, duckweed (*Lemna* species), azolla, chara, milfoil, cattail, and algae.

Table 9. Number of Hydrilla Plants and Tubers Found and Removed from the Chowchilla River Project, Madera and Mariposa Counties 2000 – 2006.

Year	2000	2001	2002	2003	2004	2005	2006
Plants	19	5	2	0	0	0	0
Tubers	1,789	23	3	0	0	0	0

Though no hydrilla was detected in 2005, project crews treated the two areas where hydrilla was detected in 2001 and 2002. In 2001, hydrilla plants had been found in Management Unit 2 near Raymond Bridge, and in 2002, plants were found upstream in Management Unit 29. Each area was treated once with fluridone slow release pellets at 90 ppb (parts per billion) each, on July 13. A total of 0.25 pounds of fluridone active ingredient were used in 2005. As 2005 was the third year of treatment with no plants, in 2006 no treatments were made.

Detection Surveys Outside of the Quarantine Zone

Project survey crews surveyed the following water bodies in the Eastman Lake and Chowchilla River area in 2005: Shaver Lake, Clovis Lake, Avocado Lake, Bass Lake, Wildwood pond, a pond in Tivy Valley, and along the Kings River at seven access points. In 2006, the Chowchilla River downstream from Eastman Lake was checked at all access points down to Highway 99. Crews also surveyed Hensley Lake. Surveys were conducted by boat and/or canoe in the lakes and by foot in the river. No hydrilla was detected.

NEVADA COUNTY

Overview of Projects

Hydrilla was found in a pond in a waste transfer station in July of 2004 in Nevada County. In 2005, probably as a result of heightened awareness, two more infestations were found. One infestation was found at the County Fairgrounds in late February, 2005, and a second was found in a small irrigation pond about six miles south of Grass Valley, in late December. For clarity, the infestations will be treated separately.

Waste Transfer Station Fire Control Pond

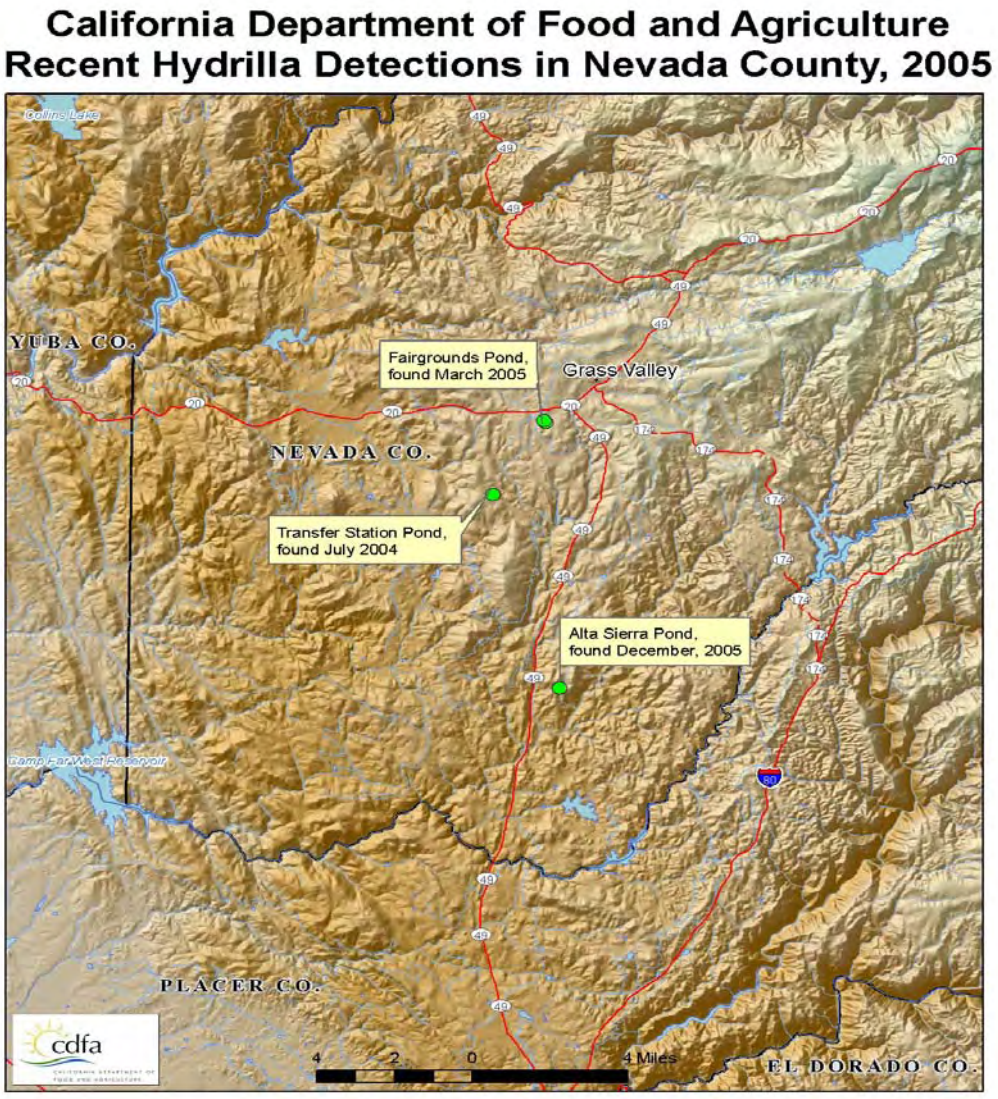
On July 21, 2004, a representative of an aquatic vegetation management company found hydrilla in a fire control pond at the Nevada County Transfer Facility near Grass Valley. The Department and the Nevada County Department of Agriculture then started the Nevada County Hydrilla Project.

Project biologists mapped the pond (Plate 7) within two weeks. Several hydrilla mats were clearly visible in the northeastern third of the pond, including one that was fairly large. The pond is 0.6 acres in area, averages 18 feet deep, and holds one million gallons of water. The pond provides water for fire emergencies and to cool a wood waste chipping operation. The chipping operation requires substantial amounts of water several times a month. The Transfer Facility site itself is a 'no-runoff' site, and is surrounded by a drainage canal and several ponds to capture runoff. Two surveys for threatened and endangered species determined that treating the infested pond would not pose a threat. The frog population in the infested pond proved to be non-native bullfrogs.

The Office of Administrative Law added Nevada County to the listed state hydrilla eradication areas on August 5. On August 23, the Secretary of Agriculture signed the Proclamation of an Eradication Project.

In early August 2004, Department divers free-dived the pond at the northeast end where the hydrilla mats were most visible. Divers reported several inches of sediment at this end of the pond, and recovered several tubers in the sediment. Dr. Lars Anderson of the USDA-ARS also did a pre-treatment survey of the density of the hydrilla infestation. In his samples, there was an average of 2.3±0.7 kilograms of hydrilla dry matter per square meter (Anderson, Lars W.J. 2004 Unpublished data, USDA-ARS Exotic and Invasive Weed Research Unit). The survey also showed that most of the water column was filled with hydrilla, even where it was not clearly visible at the surface.

Plate 7. Map of Hydrilla Infested Pond Currently Known to be Infested in Nevada County.



Survey and Treatment of the Fire Control Pond

The pond was surveyed three times in 2006 by sight and grappling hook. The first survey was on May 20 when the water temperature was 22 degrees C (72 degrees F), and the last was on November 17. No hydrilla was found on any survey. The pond was treated one time, on July 11, to achieve a concentration of 90 ppb, using 1.5 pounds of fluridone active ingredient. Because the pond is isolated and has little flow, a single treatment was warranted.

Nevada County Fairgrounds Pond

On February 22, 2005, a county biologist on a mosquito survey saw plants that he suspected might be hydrilla in the main pond at the County Fairgrounds. He reported his observations to the County Agricultural Commissioner's Office. The Deputy Commissioner, sent a sample to the Department Botany Lab, which confirmed the plant as hydrilla. On February 24, Department

biologists made the first assessment of the pond. On March 23 and 25, the outlet of the pond was screened and the pond and environs carefully surveyed. Raking and visual surveys indicated that the pond bottom was nearly 70 percent covered with hydrilla, but later soil core sampling, taking a four-inch diameter core at each of 29 locations, recovered no tubers and only one fragment of hydrilla. Surveys of the ponds and streams in the area found no other hydrilla locations.

The major function of the pond is the irrigation reservoir for the fairgrounds, but it is also a popular local fishing spot. High-accuracy GPS measured the area of the pond to be 2.75 acres, and the average depth of several boat transects was about 5.5 feet. Most of its water comes from the Nevada Irrigation District flume, which runs through the Fairgrounds near the pond, but during rainstorms, the pond can receive considerable local runoff. The pond was formed by a dam or berm and is not directly in the bed of the local stream system, which leads to Squirrel Creek and the Yuba River. During dry weather, little or no water leaves the pond, but during storms significant amounts can overflow into the local stream. Reference sources indicated that there was an endangered plant in the area, and by June, working with Department of Fish and Game experts and the Department environmental compliance officer; project personnel had found two populations of the Scadden Flat checkermallow, *Sidalcea stipularis*. One population lies uphill of the pond area and away from any influence from it, but the other population lies about ½ mile downstream from the pond. The plants do not reside directly in the stream but do grow in the riparian area nearby. Because of the presence of the checkermallow and the use of the pond water for irrigation, project personnel limit the application rate of fluridone in the pond to 20 ppb at any time. In past practice, this level has proved to not be toxic to even sensitive species of plants, while still controlling hydrilla.

Survey and Treatment of the Fairgrounds Pond

The Project biologist surveyed the pond four times in 2006, the first on May 20 when the water temperature was 22 degrees C (72 degrees F), and the last on November 17, when the temperature was 16 degrees C (61 degrees F). Three plants were found during the surveys. The pond was treated three times with fluridone slow release pellets, on July 11, August 30, and October 17, at 20 ppb per application. The treatment employed a total of 2.8 pounds of fluridone active ingredient.

Valkenburg Lane pond

On December 21, 2005, an employee of the Nevada County Irrigation District, who had attended a training session on recognizing hydrilla, was checking a section of the Nevada County Irrigation canal for another purpose, when he noted suspicious plants in a small irrigation/recreational pond just downhill from the canal. He informed the Nevada County Agricultural Commissioner's office. Agricultural Commissioner Office personnel took a sample and sent it to the Botany Laboratory at the Department Plant Pest Diagnostics Laboratory. The Lab verified the plant as hydrilla, probably dioecious, on December 23. The pond is in within the limits of the town of Alta Sierra. It is about 0.1 acres in area and five to ten feet deep. The pond is formed by a small berm and does not have any significant connection to the local stream system. Its situation also limits local runoff into the pond and any potential overflow.

A group of biologists from the Commissioner's Office and the Department Hydrilla Program visited the pond before the end of the year and found it approximately 95 percent covered with hydrilla. On January 20, 2006, a crew from the Hydrilla Program surveyed all the ponds between the Valkenburg pond and Wolf Creek, and also surveyed the irrigation canal for several

hundred yards both upstream and downstream of the pond. They found no plants. The crew also set up cage screens on the outflow pipe.

Surveys and treatments of Valkenburg pond

Valkenburg pond presented some problems for treatment. The pond was highly infested and stocked with many bass and blue gill, which were of interest to the residents and owner. The fluridone itself is essentially harmless to fish at the treatment concentrations, but dissolved oxygen (DO) concentrations could become a problem. The pond's small size means that it heats up quickly during the summer, and high temperatures drive down DO. The large quantity of plant material could further deplete DO if the plants were eradicated and microorganisms decomposed them over a short period. Even hand removal presented some problems, as it would stir the sediments and possibly encourage fish diseases. After discussion, the Project decided to begin with a lower rate of fluridone while monitoring the DO. As the ambient temperature dropped and DO stabilized, the rate of treatment would increase. As a further precaution, the project Biologist installed a solar powered aeration pump.

The pond responded well to the treatment regime. The Project biologist surveyed the pond four times in 2006, the first on May 20 when the water temperature was 23 degrees C (73 degrees F). He estimated the hydrilla covered approximately 90 percent of the pond at that time. The last survey was on November 17, when the hydrilla covered approximately 15 percent of the pond. The ponds were treated four times with fluridone slow release pellets, on July 11, August 30, October 2, and November 7. The first two applications were at 10 ppb and the last two were at 20 ppb. The treatment employed a total of 1.1 pounds of fluridone active ingredient. With less plant mass in the system now, a more aggressive treatment regime should be possible in 2007. Parrotfeather is a potential problem in the pond, as well as algae such as nitella and chara.

SHASTA COUNTY

The Shasta County Hydrilla Eradication Project (Shasta Project) is a cooperative effort between the Department and the Shasta County Department of Agriculture. The Shasta Project began in 1985 after the dioecious form of hydrilla was detected in seven ponds located next to the Sacramento River. Due to the close proximity of the river and the potential threat to California water systems, the Governor of California issued a "Proclamation of Emergency" to facilitate eradication efforts. Surveyors in 1986 detected hydrilla infestations in four additional ponds. The Department convened a Scientific Advisory Panel in 1986, which recommended a survey, treatment, and public education program (Stocker, R.K. and L.W.J. Anderson *et. al.* 1986). Based on these recommendations, Shasta Project crews chemically treated and filled in with soil four of these 11 ponds. Shasta Project biologists also treated the remaining seven ponds with herbicides for several years. By 2000, surveys showed that no hydrilla plants were detected in these 11 ponds and the Department considers hydrilla to be eradicated at these locations.

However, in 1994, hydrilla was detected in two interconnected ponds in River Park in Anderson, about eight miles south of Redding, and in 1996 it was detected in a pond system at the Riverview Golf Course in Redding (Plate 8). These infestations appear to be unrelated to the previous ones. The Shasta Project initiated a treatment program of aquatic herbicides and manual removal.

Plate 8. Map Showing Infestation at Riverview Golf Course, Redding.

Hydrilla in the Anderson River Park Ponds

The Shasta Project crew detected no hydrilla in the two Anderson River Park ponds from 1999 to 2004, but in 2005 hydrilla returned to one of the ponds. The ponds were surveyed and treated with fluridone in 1999, 2000, and 2001, and were surveyed, but not treated, in 2002, 2003, and 2004, as per the eradication protocol. In addition to surveys from shore and canoe, in 2002 and 2004 the Department contracted a crew of divers from the Shasta County Sheriff's posse to survey the large pond. No plants were found. In 2004, the ponds were surveyed 10 times between May 17 and October 22. Six weeks prior to the last survey date, the Project crew used triclopyr to treat water primrose that was encircling the large pond, to improve visibility and access. The last survey was very intense, and employed a crew in a canoe and a crew of divers. The crew in the canoe surveyed the entire pond by visual inspection and by repeatedly dragging the grappling hook. The divers focused on previously infested areas of the pond, where hydrilla was last detected in 1999. No survey detected any hydrilla. Following the 2004 surveys, the Shasta County Department of Agriculture and the Hydrilla Eradication Program declared the infestation as eradicated in early 2005. Even though the infestation was declared eradicated, Department crews generally continue to occasionally visit previously infested ponds, with decreasing intensity as time passes without finding plants. Unfortunately, in the last week of July 2005, three plants were found in the pond, again demonstrating hydrilla's perverse capacity for surprises. The plants were dredged and the whole pond treated three times with fluridone, each time to achieve a concentration of 30 ppb.

The re-appearance of plants in 2005 re-initiated the complete eradication cycle, beginning in 2006. The hydrilla crew surveyed the ponds 17 times in 2006, and plants continued to emerge. The first survey was on May 31 and the last was on November 15. The crew found plants on several occasions, with the first find netting five plants on May 21. They found two more plants in June, another 11 plants in July 12 more plants in the first two weeks of August, and over 100 plants on August 22. The last find, a single plant, was on September 8. In total, approximately 130 plants appeared.

The crews treated the infested pond with a combination of hand digging, dredging, and herbicides. Between June 2 and August 11, the crews dug and dredged a total of 26 plants. The Program delayed treatments with fluridone, which lasts several months and requires a break in treatment to give the plants an opportunity to make their presence known. The first treatment occurred on August 25, just after the plants made their major flush. Four treatments were made at two week intervals with the fluridone slow release pellets. The first treatment was at 50 ppb, and the remaining three were each at 30 ppb, giving a total rate of 140 ppb for the season. The treatment used a total of 25.9 pounds of active ingredient. On August 23, prior to the first fluridone treatment, the crew treated the part of the pond that had plants with 2.6 pounds active ingredient of copper ethylenediamine complex (Komeen®), at the label rate of 1 ppm. This treatment removes the top growth of the hydrilla, which allows more fluridone to remain and attack newly emerging shoots.

Survey of Riverview Golf Course Ponds

The Riverview Golf Course infestation consists of four interconnected ponds. The most upstream pond is approximately 30 acres in size and is adjacent to but outside the golf course. Project personnel refer to it as “Rother’s pond.” It is fed from a small canal from the Sacramento River. The next three ponds are on the golf course, and are approximately six, two, and one acres, respectively, in surface area. Water returns to the Sacramento River along a small stream leading from the one-acre pond to the levee. The one-acre pond and return stream often go partially or completely dry in the late summer. When Shasta Project crews first surveyed these ponds in 1996, they found the 30-acre pond to be infested in the lower 15 acres, where the infestation ranged from scattered single plants to small clumps. The six-acre pond was moderately to heavily infested, and the two small ponds were heavily infested.

The survey and treatment strategy for the Riverview ponds was different in 2006 from 2004. Rather than beginning treatments early at the beginning of June, they were delayed until late in July. The delay was meant to avoid suppressing the plants during the early part of the growing season, and let them grow large enough to be readily found. There were 15 surveys of Rother’s pond in 2006, beginning on June 12 when the water temperature was 24 degrees C (75 degrees F) and ended on October 20, when water temperatures were 18 degrees C (64 degrees F). The crew found one plant on August 10 and another two on August 11. Surveys used both visual inspection and repeated probes with a grappling hook, from both the shoreline and canoe. The three plants in 2006 compare to 12 plants in 2005 and one plant in 2003 (Table 10). Other aquatic vegetation detected during these surveys included water primrose, Carolina fanwort (*Cabomba caroliniana*), elodea, and egeria.

Table 10. Number of Hydrilla Plants and Tubers Found and Removed from Redding Ponds, Shasta County 2000 – 2006.

	YEAR	2000	2001	2002	2003	2004	2005	2006
Rother's Pond	Plants	1	9	18*	1	0	12	3
	Tubers	0	0	0	0	0	0	0
Riverview Golf Course Ponds 1, 2, 3	Plants	32*	31	10	0	0	0	0
	Tubers	0	0	75**	0	0	0	0

*Estimated from narrative descriptions.
**Dredging operation in 2002 in main infested area; no dredging done in other years.

In 2006, the crew surveyed the six-acre, two-acre, and one-acre ponds six times between June 29 and October 3. The water temperature at the time of the first survey was 24 degrees C (75 degrees F), and was 19 degrees C (66 degrees F) at the final survey. No hydrilla was found in the three smaller ponds. Other aquatic vegetation detected included algae, water primrose, elodea, egeria, and cattail. This is the third year in a row that no hydrilla has been detected in these ponds (Table 10).

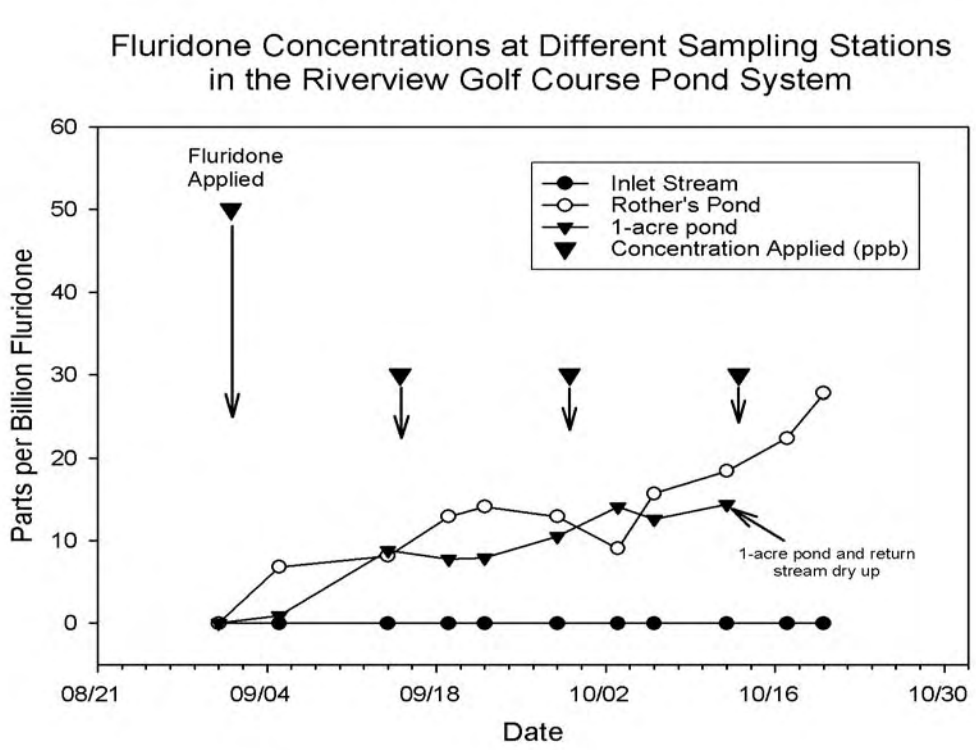
Treatment of Riverview Golf Course Ponds

Because hydrilla was detected in Rother's Pond in recent years, it was treated in 2006 with four applications of fluridone slow release pellets, for a total application rate of 140 ppb[30]. The first application was at 50 ppb and the subsequent applications were at 30 ppb. The applications were at two week intervals beginning on September 1. A total of 73.7 pounds of fluridone active ingredient were applied. The treatment pattern was different from 2005, however. In 2005, the crew treated only the lower, 15-acre originally-infested area. In 2006, the treatment was made to the entire 30-acre pond.

Since the lower three ponds had not had any hydrilla in several years, they were not treated in 2006. In addition, previous experience indicated that fluridone moved readily within an aquatic system, and we suspected that the treatment to Rother's pond would suffice for the lower ponds. Indeed, our water monitoring measurements showed that the treatments of Rother's pond generated adequate fluridone concentrations in the lower ponds (Plate 9).

[30] Rother's Pond is large enough to qualify for a higher total seasonal application rate (150 ppb) than the smaller ponds (90 ppb), as per the Sonar® SRP label.

Plate 9.



Starting in late July and for most of the treatment season, the Riverview Golf Course pumped irrigation water from the Sacramento River in order to avoid using fluridone treated water from Rother's Pond[31].

Survey Inside and Outside the Quarantine Zone[32]

Shasta Project biologists believe that hydrilla has appeared in the Redding area on three separate occasions (1985, 1994, and 1996) and are concerned that it might appear again. Accordingly, they maintain an intensive survey program inside and outside the quarantine zone. The quarantine zone is a corridor one mile wide on either side of the Sacramento River, from the Redding Civic Center to the Red Bluff Diversion Dam. This zone includes 17 ponds, one creek, and 6 sections of the Sacramento River. In 2005 these ponds, creeks and section of river were all surveyed at least twice (the creeks are surveyed between one-half mile above and one-half mile below road crossings, and the river is surveyed at 13 access points). The crew surveyed 31 sites at least one time in 2006. No hydrilla was detected.

Outside the quarantine zone, Shasta Project personnel surveyed another 109 sites at least once in 2006. No hydrilla was detected.

[31] In 1996, the golf course superintendent was concerned that fluridone treated irrigation water might injure the turf or ornamentals on the course. For this reason, Rother's Pond was not treated with fluridone in 1996 in order to avoid any possibility of phytotoxicity. The golf club developed an alternate water source in 1997, and fluridone has been applied to the pond since 1997.

[32] Hydrilla infested counties are "Eradication areas" by California Code of Regulations, Section 3962. "Quarantine zones" are reduced areas within "Eradication areas" and are the specific water bodies in the county where there are restrictions as to water access or use, as per California Code of Regulations, Section 3410.

	Water Body Name
Inside Eradication Zone	City & Tenneys Ponds, Raley's Ponds, Riverbend Golf Course, A.C.I.D. Canal at Rodeo Grounds, Aqua Golf Pond, Ball Boy, Duck Pond, Marina RV Park, River Inn Motel Pond, Sacramento River at Rodeo Grounds boat ramp, Turtle Bay, Village Pond, Churn Creek Golf Course, Gold Hills Golf Course, Palo Cedro Golf Course, Tucker Oaks Golf Course, Lake Redding Golf Course, Sacramento River at Caldwell Park, Sheas Ponds, Allen's Golf Course, Tierra Oaks Golf Course, Sierra Pacific Ponds, Hatchcover Cove, Churn Creek at Dilly Ln., Amigo's, Deschutes Bridge, Gold Leaf Nursery, Balls Ferry to Jelly's Ferry, White Birch Pond, Turtle Bay at east river access at Bechelli Ln, Redding Water Treatment Plant off Placer St.
Outside Eradication Zone	Dutch Girl, Ross Pond, O'Nite Trailer Park Pond, Sacramento River at Bonnyview Boat Ramp, Snag Harbor, Coleman Fish Hatchery, Reading Island, Red Bluff Dam, Rio Vista , Cow Creek at Hwy. 44, Lil Cow Creek, Mary Lake off Pacer St., Bear Creek, Acid Canal & overflow at Emily St. in Anderson, Sherries Water Gardens, Boulder Creek at Boulder Creek School, Boulder Creek at KOA, Boulder Creek at Water Works Park, Rhyolite Pond, Churn Creek at College view, Churn Creek at Girvan, Churn Creek at Hartnell, Churn Creek at Kids Kingdom, Churn Creek at Victor, Churn Creek at River Valley Rd., Salmon Creek, Stillwater at Old Alturas, Acid Canal 2, Bow Rack Creek, Canyon Creek, Cow Creek at Dersch Rd to Sac River, Mental Health Creek, Spring Gulch, Stillwater at Churn Creek, Koi Ponds at Airport Rd., Lake California, Balls Ferry & Ash Creek Rd., Churn Creek at Fountain Circle, Cottonwood Creek, Millville Plains Pond (5), Mistletoe School Pond, Willow Glen Ponds, Canal at Old 44, Churn Creek at Edgewood, Oak Mesa Pond, Plantco Creek, Churn Creek at Echo, Clear Creek Spillway Site, John Steiner Pond, Keswick Boat Ramp, Keswick Dam, Olney Creek, Oregon Gulch, Rock Creek off Iron Mt Rd, Spring Creek off Iron Mt Rd, Westside Aggregate, Ash Creek, Black Butte Rd Ponds off 44 , Churn Creek at Cypress, Hidden Pond, Lack Creek Bridge, 4 Ponds at Hwy 44 & Dersch, Clough Creek, Rainbow Lake Lodge, Shasta College Pond, Park Marina Ponds, South Street Creek, Whiskeytown Lake, Churn Creek at Old Alturas, Levona Pond off Hwy 299 east, McConnell Foundation Pond (3 ponds), River Hills Estates off Hwy 299 east, Grace & Nora Lakes, McCumber Lake, Clear Creek Greenway, Crowley Gulch off Gas Point, Locust Canal, Majestic Oak Pond, Panorama Pond, Phoenix Spa Pond, Creek at Lake and Hill Blvds, Sacramento River upper & lower at Shasta Dam, Fern Creek, Killarc Lake, Crystal Lake, Hat Creek, Kings Creek, Lake Helen at Lassen National Park, Lost Creek, Manzanita Lake, Summit Lake, Arby's Pond, Sacramento RV Park, Lake Britton, Big Lake, Nash Pumpkin Patch, Jones Valley Boat Ramp at Shasta Lake, Black Butte Lake, Sacramento River from S. Bonnyview to Anderson River Park, Sacramento River from Anderson River Park to Rooster's Landing, Stony Gorge Reservoir, Lake Siskiyou, Mt. Shasta Fish Hatchery, Sacramento River at Dunsmuir, Lewiston Lake, Shasta Lake, Trinity Lake, Lone Tree Creek

Public Information and Awareness

Project crews distributed approximately 400 hydrilla brochures to bait shops, marinas, and recreation areas around Lake Shasta in the towns of Redding and Anderson, including the Coleman Fish Hatchery, In addition, the Department Biologist gave a short presentation to the Coleman Fish Hatchery staff on hydrilla identification and the importance of eradication.

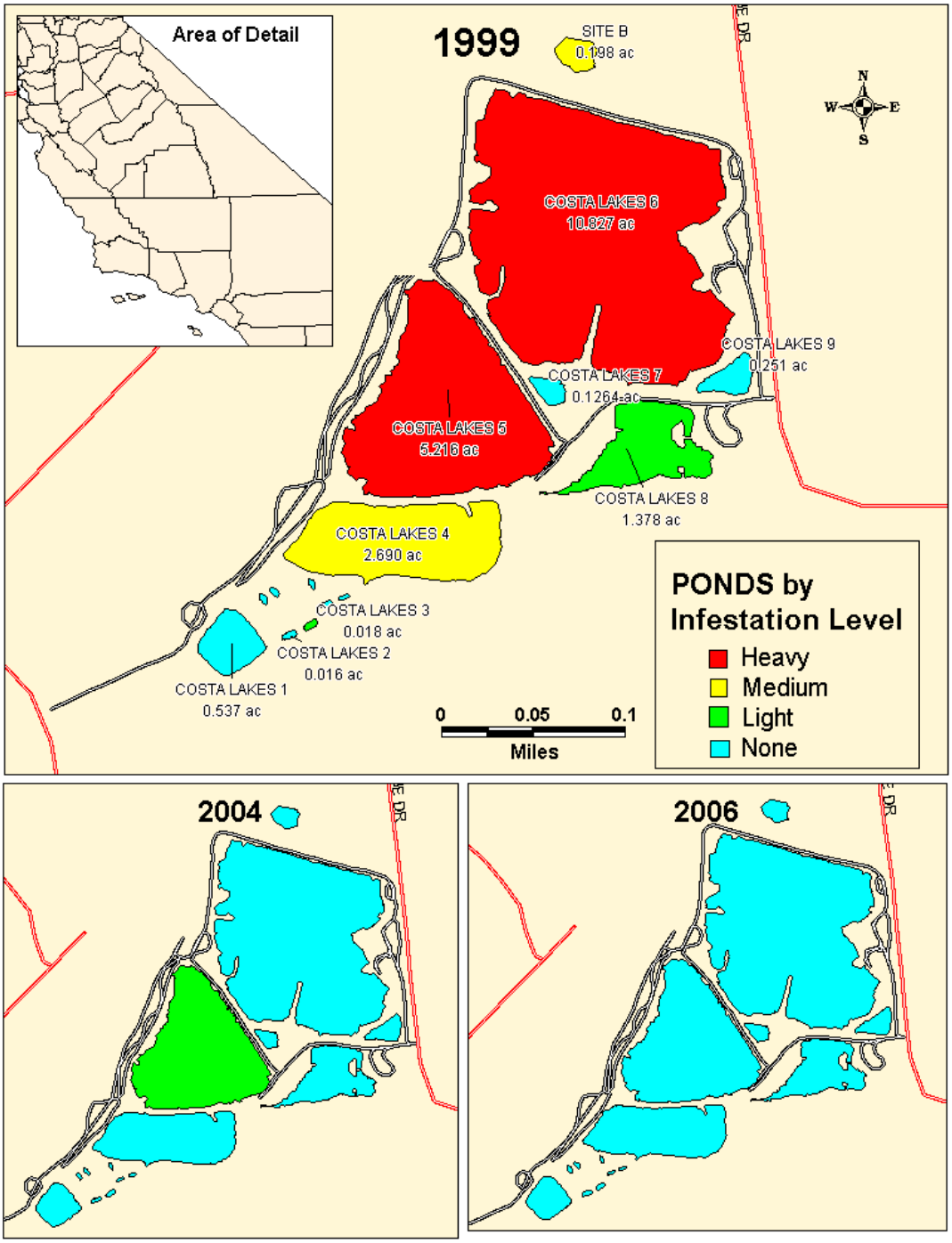
TULARE COUNTY

There have been two separate infestations of hydrilla in Tulare County. In 1993, a Tulare County Department of Agriculture biologist detected monoecious hydrilla in three small ponds that belonged to an ornamental, wholesale nursery near Visalia. The Department and Tulare County biologists, with the cooperation of the owner, emptied the ponds to dry out the hydrosoil and the tubers, and then fumigated the hydrosoil with metam-sodium. The ponds were never refilled with water and remain dry to this day. The Department crews continued to survey these ponds for several years, but no hydrilla was ever found. The Department considers the hydrilla in these ponds to be eradicated.

On October 7, 1996, dioecious hydrilla was detected in a fishing resort southwest of Springville and east of Porterville in Tulare County (Plate 10). This resort is adjacent to the Tule River and is approximately two miles upstream from Lake Success[33]. The Tulare County Hydrilla Eradication Project (Tulare Project), which is a cooperative effort between the Department and the Tulare County Department of Agriculture, began soon thereafter.

[33] Lake Success is a 2,450-acre reservoir managed by the USACE and is used primarily for flood control and agricultural purposes, although it is also popular for recreation.

Plate 10. Map Showing Change in Hydrilla Infestation at the Springville Ponds from the Year of First Detection, 1996, to Current Year, 2006.



Delimitation surveys by project crews determined that five ponds were infested on the resort and one pond was infested on an adjacent, downstream property. The infested ponds ranged in size from 0.02 acres to 10.8 acres with a total surface area of all ponds being 20 acres (Plate 10). The infestations in the ponds ranged from very dense to just a few scattered plants. Four other non-infested ponds were also on the resort's property. Additional ponds have been created since the initial hydrilla detection. Most of these are relatively small (less than 0.1 acre) and are used for fish breeding. There are now a total of 15 ponds on the resort property.

Survey and Treatment of the Springville Ponds

Project crews surveyed all 15 ponds on the resort property and the one previously infested pond off the property between six and nine times in 2005, and between four and eight times in 2006. In 2006, the first survey was on May 26, when the water temperature was 22 degrees C (71 degrees F). The last survey was on November 3, when the water temperature was 18 degrees C (64 degrees F). Originally, in 1996, there were five infested ponds; by 2004, the only pond that had any hydrilla was number five, where 10 mats were found (Plate 10, Table 11). In 2005, nine surveys in that pond detected no hydrilla, and neither did the eight surveys in 2006. Because of high algae and blue-green algae blooms in the pond, the water is quite turbid and visibility is poor. The crew members have developed a technique of cruising the pond while sitting in a kayak with a survey hook tied to one leg. Using this method, they can repeatedly cover the pond, stop quickly when they feel any resistance, and carefully tug on the obstruction. Because of their technique and the soft bottom of the pond, they can often bring up a plant with its root crown intact. Other aquatic vegetation detected in these ponds included curly leaf pondweed, chara, azolla, water primrose, duckweed, spiny naiad (*Najas* species), southern naiad, cattail, and algae.

Table 11. Number of Rooted Hydrilla Plants and Tubers Found and Removed from the Springville Ponds, Tulare County 2000 – 2006.

YEAR	2000	2001	2002	2003	2004	2005	2006
Mats	0	0	0	0	10*	0	0
Plants	9**	37***	0	0	0	0	0
Tubers	1,749***	243***	0	0	0	0	0

*Pond 5 only.
**Ponds 5 and 6.
***Pond 6 only.

Since the project began, the eradication treatments used have included hand removal of plants, copper and fluridone herbicides, and small-scale dredging of tubers. In 2006, water flows through the pond system remained high through almost the entire season, and the crews had the opportunity to make only one herbicide treatment, to a pond with no outflow. Pond 7 was treated on August 15 with 0.25 ounces of fluridone active ingredient, as Sonar AS®, for a rate of 20 ppb. This application eliminated azolla on the pond surface, aiding hydrilla detection efforts.

Surveys Outside of the Quarantine Zone

In 2005 and 2006, Tulare Project crews surveyed two large water bodies in the area of the infested ponds: Lake Success and Lake Kaweah. Surveys were conducted by boat, canoe, and hiking. No hydrilla was detected.

YUBA COUNTY

Yuba County has had three distinct hydrilla infestations: Lake Ellis, Shakey's Pond, and Oregon House. The first two infestations have been eradicated. The earliest infestation was in Lake Ellis, a 31-acre ornamental lake in the center of Marysville. Dioecious hydrilla was found in the lake in 1976, the first occurrence of hydrilla in California. In 1979, Program personnel drew down the lake, removed the hydrosoil, and treated the infested areas with metam-sodium (Vapam®). Six plants re-appeared in 1980 in one small location. Project biologists then treated the entire lake with endothall and copper ethylenediamine complex, with special attention paid to the infested location. By 1981, the lake was free of hydrilla and eradication was declared in 1984. The second infestation in Yuba County was discovered in 1990 in Shakey's Pond. It may have become infested as a result of hand carrying infested plant material to it from Lake Ellis in the 1970s. Hand removal and aquatic herbicide treatments reduced the number of plants in the pond until only one plant was found in 1996, when the pond received three treatments of fluridone. No plants have been found in the pond since 1996, and this infestation is also considered eradicated.

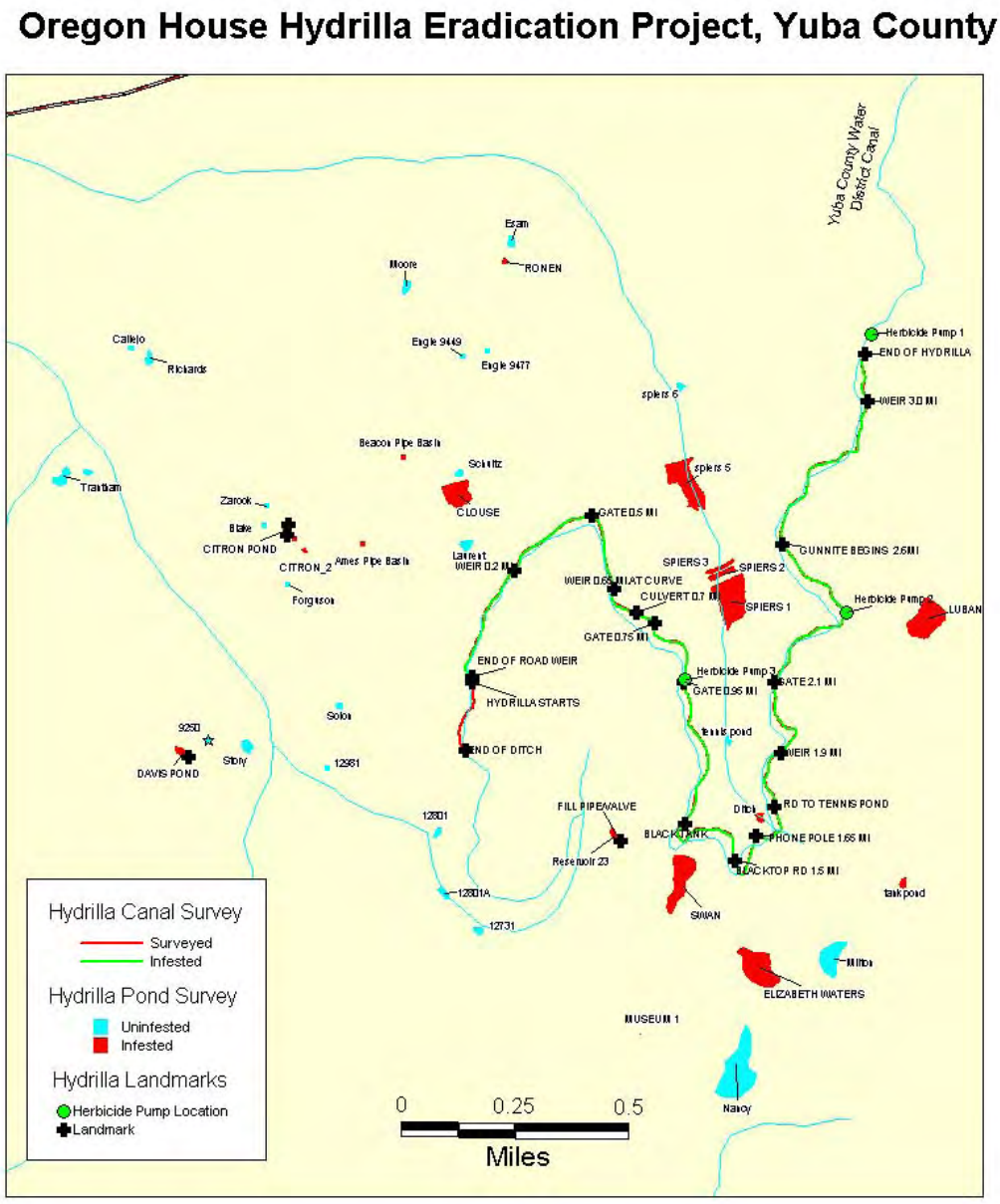
Oregon House: The On-Going Eradication Project

On August 7, 1997, a third infestation of hydrilla was detected in Yuba County near Oregon House (Plate 11), about halfway between Marysville and Grass Valley off Highway 20. A visitor to a nearby winery suspected that hydrilla had infested one of the ponds on the winery and reported it to the Yuba County Department of Agriculture. Yuba County biologists investigated, found hydrilla, and sent a sample to the Department Plant Pest Diagnostics Lab for confirmation. The Department Plant Pest Diagnostics Lab confirmed the specimen to be hydrilla. Scientists at the United States Department of Agriculture, Agricultural Research Service (USDA-ARS) Exotic and Invasive Weed Unit then confirmed it to be the monoecious form of hydrilla.

The Oregon House Hydrilla Eradication Project (Oregon House Project), which is a cooperative effort between the Department and the Yuba County Department of Agriculture, was started after this first detection. Biologists conducted delimitation surveys at the winery and found that a total of five ponds (ranging from 0.15 to 3.0 acres in size and nine to 13 feet deep) and an ornamental fountain[34] were infested (Plate 11). Two of the ponds, Ditch pond and Tank pond, are used to irrigate the vineyard. Project crews then conducted delimitation surveys within a three-mile quarantine zone (around the known infested ponds) and detected additional infestations on three private properties: the Spiers 1, 2, and 3 ponds (3.8, 0.5, 0.4 acres) and the Clouse and Ronen ponds (1.9 and 0.1 acres) (Plate 11). The two smaller Spiers ponds were used for rearing catfish. Another 40 ponds were surveyed and found not to be infested.

[34] The infested water lilies in the ornamental fountain were removed, the hydrilla plants and tubers destroyed, and the water lilies repotted and returned.

Plate 11. Hydrilla Infested Ponds near Oregon House, and Hydrilla Infested Portion of Yuba County Water District Canal.



In 2000, project survey crews on routine surveys detected three additional infested ponds. These were Reservoir 23 (0.25 surface acres), Davis (0.37 acres), and Citron (0.22 acres) ponds (Plate 11). Reservoir 23 is also used for irrigation at the winery.

In 2003, a single hydrilla plant was detected in Spiers pond number 5. This pond had been surveyed multiple times per year since the beginning of the project. Project biologists believe that the most probable route of infestation for this pond was a plant fragment floating down from Spiers pond number 1 via a small creek.

Survey of Ponds Within the Quarantine Zone

In 2006, the project biologist detected hydrilla in two of the three ponds used for irrigation by the winery, Ditch and Reservoir 23 ponds (Table 12). An estimated 100 plants were detected in both ponds. The Ditch pond is directly filled from the Yuba County Water District Canal and is downstream of one of the most heavily infested areas in the canal. No hydrilla was detected in the third pond used for irrigation, Tank pond, though it has been infested in past years. In fact, Reservoir 23 and Tank pond both reversed their status this year. Other aquatic vegetation noted during the surveys included Eurasian water milfoil, and nitella (*Nitella* species) and chara (*Chara* species), both forms of algae.

Of the 11 ponds not used for irrigation, hydrilla was detected in six of them (Table 13). Davis and Ronen ponds had only a few plants, and Spiers 5 had only three plants. Spiers 1 had scattered infestations, at an estimated 75 small spots. Citron pond had a few plants in 2005, but it was heavily covered by mid season in 2006. Similarly, Clouse pond had a few plants in 2005, but over 50 in 2006. Two ponds, Elizabeth and Swan, have not had any detections for at least five years (Table 12). Davis pond had been clear for several years, but produced a few plants this year. These reversals demonstrate why all ponds must be monitored for as long as any hydrilla remains in the canal upstream. Davis, Elizabeth, and Swan were surveyed only once each, in mid-July, while the other ponds were surveyed two or three times, at least one survey occurring late in the season, in early October. Other aquatic vegetation noted during the surveys included nitella and chara, both forms of algae.

Table 12. Presence (+) or Absence (-) of Hydrilla Plants or Tubers in the Yuba Ponds Near Oregon House, Yuba County 2000 – 2006.

Hydrilla Detections (Plants or Tubers) in the Yuba County Ponds									
			YEAR						
Pond Type	Pond Name	Pond Size (Acres)	2000	2001	2002	2003	2004	2005	2006
Irrigation	Ditch	0.2	+	+	+	+	+	+	+
	Reservoir 23	0.3	+	+	+	+	-	-	+
	Tank	0.2	+	+	+	+	+	+	-
Non-Irrigation	Citron	0.2	+	+	+	+	-	+	+
	Clouse	1.9	-	-	+	+	-	+	+
	Davis	0.4	+	-	-	-	-	-	+
	Elizabeth	3.1	+	-	-	-	-	-	-
	Luban	3.0	+	-	+	+	-	-	-
	Ronen	0.1	-	dry	dry	+	-	+	+
	Spiers 1	3.8	+	+	+	+	-	+	+
	Spiers 2	0.5	-	+	dry	dry	+	-	?*
	Spiers 3	0.4	-	dry	dry	dry	-	-	?*
	Spiers 5	3.5	-	-	-	+	-	+	+
	Swan	2.7	-	-	-	-	-	-	-

*? = suspicious-looking plants but could not be hooked for confirmation.

Treatment of Ponds Within the Quarantine Zone

Table 13 gives the details of the season's treatments for the ponds and canals. Most water bodies were treated three times, although a few were treated twice. The irrigation ponds, Ditch and Reservoir 23, were treated with copper, to avoid the damage fluridone might do to irrigated crops. Target concentrations for those treatments were one ppm for each treatment. Most of the non-irrigation ponds were treated with fluridone, and generally to achieve a season total of 90 ppb, which is the label maximum for ponds less than ten acres. The major exception was Citron pond, where the biologist is working with the owner to try to avoid damage to some specimen landscaping plants around the pond. This pond also had a heavy reemergence of hydrilla this year. In addition to the chemical treatments, the biologist developed a cutting rake to mechanically harvest the heaviest part of the biomass. He and a crew harvested three pick-up loads of hydrilla from the 0.2 acre pond during the first week of October, and disposed of the plants in a landfill. Two treatments with diquat, a contact herbicide less toxic to fish than copper, were applied as a follow up. We are pursuing a permit to put grass carp in this pond, as it is an artificial pond and isolated from the local stream system.

Table 13. Treatments to Water Bodies in the Oregon House Eradication Project, Yuba County, 2006.

Water Body	Date Treated	Product	Active Ingredient	Ounces of Active Ingredient	Target Concen-tration	Conc. Unit
Canal*	7/28/2006	Komeen	copper	102.8	1	ppm
Canal**	8/29/2006	Komeen	copper	411.2	1	ppm
Canal	10/3/2006	Komeen	copper	411.2	1	ppm
Citron	8/11/2006	Sonar SRP	fluridone	1.75	30	ppb
Citron	10/10/2006	Reward	diquat	6.3	na	
Citron	10/20/2006	Reward	diquat	6.3	na	
Clouse	8/11/2006	Sonar SRP	fluridone	14.8	30	ppb
Clouse	9/11/2006	Sonar SRP	fluridone	14.8	30	ppb
Clouse	10/13/2006	Sonar SRP	fluridone	14.8	30	ppb
Davis pond	8/11/2006	Sonar SRP	fluridone	2.3	30	ppb
Davis pond	9/11/2006	Sonar SRP	fluridone	2.3	30	ppb
Davis pond	10/13/2006	Sonar SRP	fluridone	2.3	30	ppb
Ditch pond	7/26/2006	Komeen	copper	51.4	1	ppm
Ditch pond	8/11/2006	Komeen	copper	51.4	1	ppm
Ditch pond	9/11/2006	Komeen	copper	51.4	1	ppm
Ditch pond	10/13/2006	Komeen	copper	51.4	1	ppm
Rsvr 23	7/19/2006	Komeen	copper	51.4	1	ppm
Rsvr 23	9/11/2006	Komeen	copper	51.4	1	ppm
Rsvr 23	10/13/2006	Komeen	copper	51.4	1	ppm
Ronen	8/29/2006	Sonar SRP	fluridone	1.55	30	ppb
Ronen	10/13/2006	Sonar SRP	fluridone	3.1	60	ppb
Spiers 1	7/19/2006	Sonar SRP	fluridone	44.8	30	ppb
Spiers 1	8/29/2006	Sonar SRP	fluridone	44.8	30	ppb
Spiers 1	10/13/2006	Sonar SRP	fluridone	44.8	30	ppb
Spiers 2	7/19/2006	Sonar SRP	fluridone	1.92	30	ppb
Spiers 2	8/29/2006	Sonar SRP	fluridone	1.92	30	ppb
Spiers 2	10/13/2006	Sonar SRP	fluridone	1.92	30	ppb
Spiers 3	7/19/2006	Sonar SRP	fluridone	2.27	30	ppb
Spiers 3	8/29/2006	Sonar SRP	fluridone	2.27	30	ppb
Spiers 3	10/13/2006	Sonar SRP	fluridone	2.27	30	ppb
Spiers 5	9/11/2006	Sonar SRP	fluridone	15.35	15	ppb
Spiers 5	10/13/2006	Sonar SRP	fluridone	36	45	ppb

* = 3-hour treatment. ** = 12-hour treatment.

The Yuba County Water District Canal

While surveying the Oregon House area in 1997, the Department and Yuba County biologists found that the lowest 3.1 miles of an 18-mile irrigation canal, owned by the Yuba County Water District, was infested with hydrilla (Plate 11). In addition, two other small water basins, which are used to transfer water from the canal, were also found to be infested (Ames, 0.01 acres, and Beacon, 0.02 acres). The canal is in operation between April and October. The canal is the

headwaters of the entire infestation, thus eradication of the hydrilla in the canal is essential to the success of the entire Oregon House Project.

In 1997, 1998, and 1999, several treatment methods were tried in the canal, with mixed results. Beginning in 2000, Oregon House Project biologists have used a flowing-water copper application method. After a successful preliminary test in mid-summer 2000, they settled on using electric pumps at three stations, one mile apart along the canal, to meter copper ethylenediamine herbicide into the flowing water for four hours. The rate of metering of copper ethylenediamine complex is decreased sequentially from station to station to maintain a one-ppm concentration of copper in the water. Visual observations in 2000 proved this method relatively effective in controlling the hydrilla top growth and the method was adopted. Also in 2000, project biologists started raking[35] the canal, which has proven to be very effective, though labor intensive and time consuming. In 2001, an acetic acid treatment was tried with promising results (Spencer, D and G. Ksander, 2001), although the conditions required for treatment are so exacting that the method is inconvenient.

Survey of the Yuba Water District Canal

Yuba County Project biologists have divided the upper two miles of the canal into management units 50 meters in length starting from the upstream beginning of the hydrilla infestation. There are a total of 65 management units. The canal also includes the two tiny holding basins, Ames and Beacon, which are directly fed by the canal and hold water to be delivered to other properties. Several sections of the canal are lined with gunite. The hydrilla population in these sections is very low.

For the two holding basins, hydrilla plants were detected in Ames in 2003 but not in 2004. The irrigation district also dug out this basin with a backhoe in 2004. However, two plants were found and hand removed in 2005. The Beacon holding pond is gunite lined and was cleaned out of all sediment and hydrilla by project biologists in January of 2002, and no hydrilla has been detected since then. Both basins were inspected twice this year, with no plants found.

Project biologists have noted a decrease in the number of plants and tubers removed from the most highly infested management units over the past couple of years, indicating a continuing decrease in the tuber bank. Table 14 shows the number of tubers removed from the top 10 management units for the past three years. Similar results were found in the other management units. The crews still removed 2,696 tubers in 2005, and 1,175 in 2006. Several units still produced significant numbers, although only units 8 to 10 and 36 to 38 produced more than 100 total plants and tubers. The heaviest producer was unit 38, which produced 260 plants and tubers. Data is missing for earlier years from Unit 38.

[35] The rake method is simply to use a garden rake to sift the sediment in the canal bottom and sides to remove any hydrilla plants, tubers, roots, and root crowns. Screens are placed downstream of the raking operation to catch any floating hydrilla fragments.

Table 14. Number of Tubers Removed from Selected Management Units at the Yuba County Water District Canal.

YEAR	2002	2004	2005	2006
Unit 0	17	0	0	0
Unit 1	0	0	0	0
Unit 2	0	0	0	0
Unit 3	32	0	0	0
Unit 4	347	26	13	0
Unit 5	255	11	1	0
Unit 6	512	25	2	0
Unit 7	263	9	0	0
Unit 8	286	8	4	100
Unit 24	333	12	5	0
Unit 30	136	6	1	0

Dr. David Spencer and Greg Ksander have also been taking core samples along the canal to estimate tuber density, nearly every year since 1998. The tuber density in the core samples was zero tubers per square meter in 2005, as compared to 14 tubers in 2004 and two in the fall of 2003 (Table 15). Fourteen tubers per square meter is a great reduction from 316 tubers in 1998, and about equal to the 13 tubers per meter squared detected in the fall of 2002. As general tuber abundance in the canal falls, the results vary from year to year because the tubers in the canal are very unevenly distributed, and in 2004 they probably hit a few “hot spots”.

Table 15. Tuber Abundance in the Oregon House Irrigation Canal, Yuba County 2000 - 2005. (D.F. Spencer & G.G. Ksander, USDA-ARS, Davis, CA).

YEAR	Fall-2000	Spring-2001	Spring-2002	Fall-2002	Fall-2003	Fall-2004	Fall 2005
Mean Tubers/m²	84	76	28	13	2	14	0
Standard Error	± 21	± 24	± 9	± 5	± 2	± 6	0

In addition to hydrilla, project biologists detected several other aquatic plants in the canal, including elodea, pondweed, sago pondweed, and cattails. In places, the population levels are quite high, making accurate survey difficult and interfering with treatments. There is also a heavy algae load on the plants, which can complicate survey and treatment in mid summer, unless controlled.

Treatment of the Yuba County Water District Canal

In 2006, the project biologist continued to combine raking and physical removal of individual plants with flowing-water copper herbicide treatments. No plants were visible in the canal on its first inspection on May 31, but they were common by the second inspection on July 19. Plants were visible by April 15 in 2005, so they were relatively late this year. During the year, the project biologist removed almost 1,175 tubers and plants from the entire canal.

Three metered copper herbicide applications at one ppm (parts per million) each were made to the canal, on July 28, August 29, and October 4. The project biologist worked on improving the metering system this year, increasing the application period from four hours to a minimum of 12 hours. The previous treatment seemed to becoming less effective in the last couple years, perhaps because of the increasing interference from algae and other water plants. The 12-hour treatment improved the effectiveness, and also began to cut back the heavy populations of other species. In the future, we hope to improve the delivery system to achieve 24-hour application periods maintaining one ppm. A copper monitoring system indicated that the metering system was close to achieving the desired concentration levels, with readings ranging from 0.8 to 1.1 ppm.

SURVEY ONLY PROJECTS

THE SACRAMENTO/SAN JOAQUIN RIVER DELTA SURVEY

Each year since the mid-1980s, the Department personnel have conducted a survey of the Sacramento/San Joaquin River Delta and the lower reaches of the tributary rivers for hydrilla,[36] because hydrilla tubers or plant fragments could be introduced into the Delta by natural or human vectors[37]. The annual survey is conducted in the fall of the year when hydrilla plants would be most visible as they reach the water surface and form dense mats. The presence of other aquatic weeds is also noted. In 2003, through 2006, the Department biologists also assisted scientists from the Center for Spatial Technologies and Remote Sensing at the University of California, Davis, and the Department of Boating and Waterways in developing remote sensing to measure and map aquatic weeds in the Delta, including hydrilla.

Survey of the Sacramento/San Joaquin River Delta

In 2006, Department crews surveyed the Delta for hydrilla during the first two weeks of September. Surveys were conducted by visual inspection of the water column and by sampling

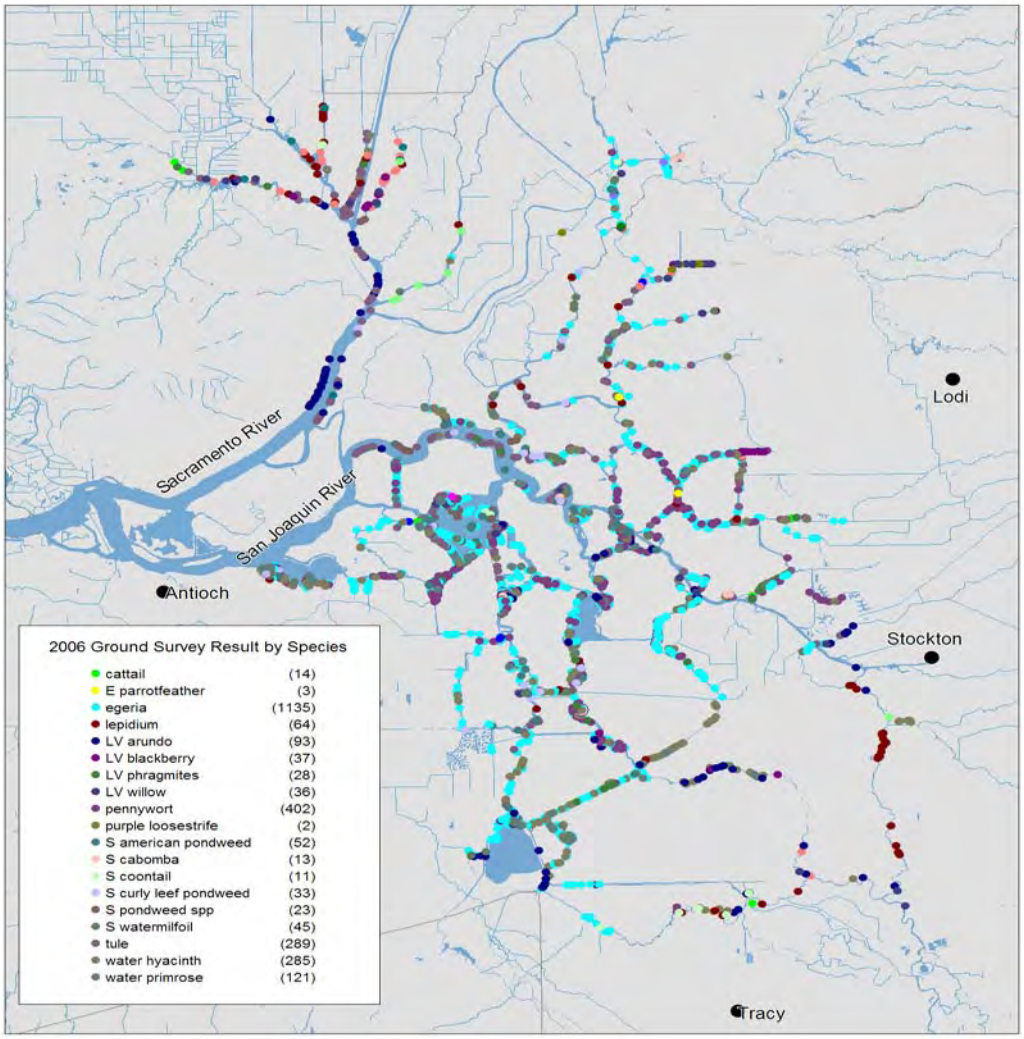
[36] The Sacramento/San Joaquin River Delta is one of the most important sources of fresh water in the State of California. The Delta carries 47 percent of all the runoff water in the state. It provides water for residential, industrial, and agricultural uses in both the north and south state areas. The Delta supports approximately 120 fish species, approximately 750 plant and animal species, and is the largest wetland habitat in the western United States (CALFED Bay-Delta Program 2001). Any blockage of this water-flow by hydrilla would impede navigation, clog water control structures, imperil native plant, fish, and animal life and diversity; and raise the cost of water delivery to users. The annual DEPARTMENT hydrilla survey of the Delta was partially initiated in response to recommendations made by the Scientific Advisory Panel convened in 1988 to consider the hydrilla infestation in Calaveras County (Stocker, R.K. and L.W.J. Anderson *et. al.* 1988).

[37] Plant fragments, tubers, or turions from any active hydrilla infestation in California or elsewhere could potentially infest the Delta. Plant fragments, tubers, or turions could be carried into the Delta by direct hydraulic connection (water-flow) or by way of contaminated boats, boat trailers, boat motors, live wells, trucks, fishing gear, clothing, and other equipment. Of the active hydrilla eradication projects, the closest and most direct hydraulic connection to the Delta is the Hesseltine ponded area in Bear Creek in Calaveras County, which is about 26 miles upstream from Disappointment Slough near Stockton.

submersed vegetation with grappling hooks when needed. Survey teams monitored their progress and position using global positioning system technology. The following areas were surveyed: Disappointment Slough (islands and levee banks), White Slough (islands from Little Potato Slough To Bishop Cut, plus levee banks from Honker Cut to Bishop Cut), Telephone Cut, Bishop Cut, Honker Cut, Little Potato Slough from the Deep Water Channel to White Slough, Fourteen Mile Slough, the east side of the Deep Water Channel, from Fourteen Mile Slough to Disappointment Slough, the Calaveras River up to the University of the Pacific, Buckley Cove, Whiskey Slough, part of Turner Cut and Empire Cut, Smith Canal and Louis Park ramp and park, Pixley Slough and Bear Creek east of Paradise Point Marina, San Joaquin River at Mossdale Crossing ramp, Dos Reis County Park, Peri Park at Highway 4, Taft Park on Walker Slough, Herman and Helen's Marina, Honker Cut Marina, King Island Marina, Tower Park Marina, River's End Marina, east side of Coney Island, Old River from Highway 4 to Connection Slough, Middle River from Union Point to Columbia Cut, Woodward Canal, North Victoria Canal, north and south levee banks of Railroad Cut, Indian Slough, Orwood Cut, Holland Cut from Holland Riverside Marina to north end of Quimby Island, Cruiser Haven, Empire Cut, Turner Cut, Latham Slough, Holland Marina, part of Rock Slough, and Connection Slough. The crews used the following criteria to select areas to survey: areas that appeared to have the most weeds; areas into which tides and wind might push weeds, marinas, boat ramps, and areas that were not as thoroughly covered in the Spectral Analysis project. More emphasis was placed on the marinas and boat ramps than in years past, and more emphasis was made on surveying by foot and in small craft such as canoes, as opposed to motorboats. By surveying from canoes in the backwaters or on foot from the docks, the crews found they were actually able to better look into the water than from the motorboats.

The crews found no hydrilla during the survey, but did find egeria, cabomba, Eurasian water milfoil, water hyacinth, water pennywort, coontail, tules, cattail, water primrose, azolla, and duckweed. Some non-native, aquatic pest plants, such as Egeria, water hyacinth, cabomba, and Eurasian watermilfoil were sometimes in large populations.
The cabomba was particularly thick at Tower Park Marina. The cabomba, mixed with egeria and water milfoil, was causing serious problems for the marina by damaging boat props and motors.

Plate 12. Results of the 2006 Ground Survey to Provide Verification for Aerial Imagery. Results shown for most significant species.



In 2006, the Department again cooperated with the California Department of Boating and Waterways and the Center for Spatial Technologies and Remote Sensing in conducting a remote sensing project to detect, quantify, and map Brazilian waterweed, water hyacinth, and other aquatic weeds in the Delta (Mulitsch et al 2005). The remote sensing method was a hyperspectral sensor imaging system carried by an airplane[38]. Program crews conducted water-based surveys in support of the aircraft survey for two weeks in early and mid June.[39] The water-based surveys consisted of visiting 3,184 sites in the Delta and associated rivers. At each site several parameters were measured including the weeds present (most sites were chosen because they had large solid patches of a weed of interest, though some mixed

[38] The HyMap® system, HyVista Corporation. For more information, see Cocks, T., R. Jennsen, *et. al.* 1998.
[39] Field portable spectrometer by Analytical Spectral Devices.

communities were also used). The submerged aquatic weed of primary interest was Brazilian waterweed (*Egeria densa*); submerged aquatic weeds of secondary interest included common waterweed, cabomba, and Eurasian watermilfoil. The floating aquatic weed of primary interest was water hyacinth. There were several emersed aquatic weeds of secondary interest, including water primrose, pennywort (*Hydrocotyle ranunculoides*), cattails and tules (*Scirpus* species). None of the crews visually detected or sampled any hydrilla at any of the 3,000-plus sample sites.

For both aerial and hand-held systems, the electromagnetic spectrum between 400 and 2,500 nanometers (visible, near-infrared, and short-wave infrared) was divided into 126 bands. Field measurements were geo-referenced using the global positioning system[40]. Data analysis was done by the Center for Spatial Technologies and Remote Sensing (Mulitsch et al 2005). Images were registered (geo-corrected) using United States Geological Survey orthophoto quadrats. Spatial resolution was approximately 3-meter by 3-meter pixels. The aircraft based sensor proved promising for the detection, quantification, and mapping of the water hyacinth, Egeria, and other weeds. For purposes of this report, the preliminary conclusion of the researchers is that it may be possible to resolve submerged aquatic weeds using the technology, when the aquatic environment allows for adequate light penetration into the water column. Therefore, this technology might be of assistance in surveying for hydrilla in the Delta in the future.

SUMMARY AND CONCLUSIONS

2006 was a successful year for the Department Hydrilla Eradication Program. Program biologists continued to reduce the population of hydrilla at the major known, infested sites, and they found no new infestations this year.

The Department Hydrilla Eradication Program has been a cooperative effort since the first discovery of hydrilla in Lake Ellis in Marysville, in 1976. The Governor, Legislature, and the Department recognized the threat hydrilla posed for the State of California and quickly instituted the legal framework needed to eradicate this aquatic, noxious weed. With the operational and technical support of many cooperators, the Department Hydrilla Eradication Program has been successfully conducting survey, eradication, and public education efforts ever since.

Many of the current infestations are approaching eradication. In Clear Lake in Lake County, no hydrilla plants have been found since June of 2003. In addition, no hydrilla plants were detected in Eastman Lake or the Chowchilla River for the fourth year in a row. No hydrilla was detected in the Tulare County infestation, and there were only two infested drains in Imperial County. In addition, plant populations and tuber counts are decreasing in the Yuba County Water District Canal, although there has been some resurgence in several of the associated ponds. No plants were detected for the last two years in Bear Creek in Calaveras County, or in the stock pond near Mokelumne Hill.

Department survey crews continue to guard against new hydrilla introductions. The Department is dedicated to finding any new introductions in California in an early and relatively easy-to-eradicate growth stage. In 2005, thanks to the public outreach and education program, two new finds were located in Nevada County. Department and county biologists began clean up and eradication efforts at all three sites immediately after discovery. Despite visiting well over 200 water bodies this year, the survey crews found no new infestations of the pest.

[40] Trimble® Pro-XRS with less than one-meter accuracy.

The Department and county biologists continue to survey the environmentally sensitive Sacramento/San Joaquin River Delta. Once again, the Department survey crews detected no hydrilla plants in the Delta in 2006. In addition, the Department continues to work with cooperating agencies and researchers to develop new and more efficient survey technologies for hydrilla and other invasive plants in the Delta.

In conclusion, the Department Hydrilla Eradication Program is helping to protect California's waterways by keeping them free of the invasive, noxious, aquatic weed, hydrilla. Continued diligence in survey and public outreach, and rapid response to any new detection is key to the success of this effort. The Department Hydrilla Eradication Program would like to thank its supporters and cooperators for aiding in its success.

COOPERATORS

The Department Hydrilla Eradication Program would like to thank all of its cooperators and supporters in 2006. The Department has received financial support, manpower, regulatory support, and/or technical assistance from the following: the California Department of Boating and Waterways, Center for Spatial Technologies and Remote Sensing, California Department of Water Resources, United States Army Corps of Engineers, United States Department of the Interior-Bureau of Reclamation, United States Department of Agriculture-Animal and Plant Health Inspection Service, United States Department of Agriculture-Agricultural Research Service Exotic and Invasive Weed Research Unit, the Yolo County Flood Control and Water Conservation District, Lake County Department of Public Works, Imperial Irrigation District, Nevada County Transfer Facility, and the Alameda, Calaveras, Contra Costa, Imperial, Lake, Los Angeles, Madera, Mariposa, Nevada, Orange, San Joaquin, Santa Barbara, Shasta, Tulare, Ventura, and Yuba County Agricultural Commissioners.

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