Appendix H. Trail Maps

U.S. Fish & Wildlife Service

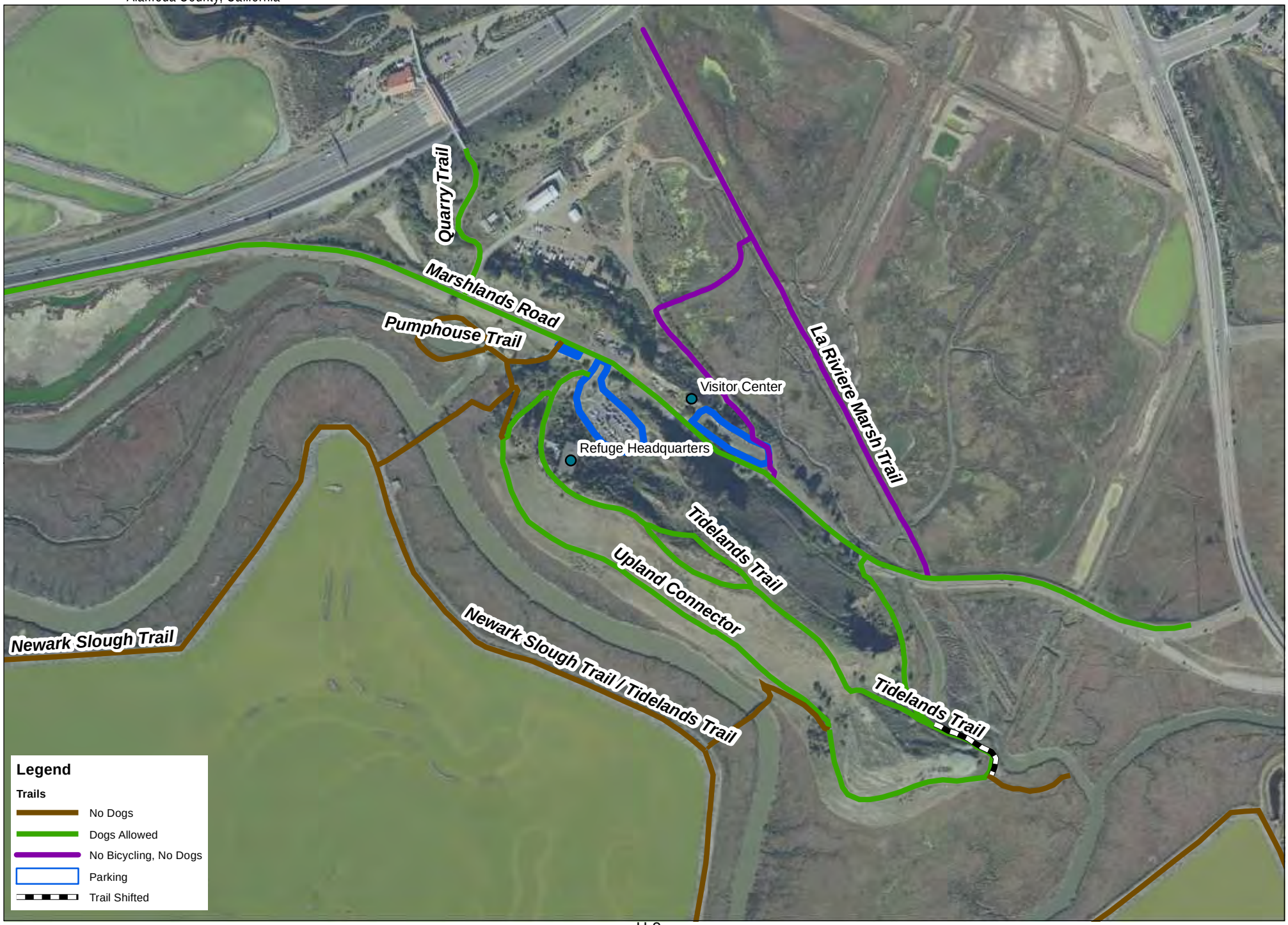
Don Edwards San Francisco Bay National Wildlife Refuge - Newark Unit Trails

Alameda County, California

U.S. Fish & Wildlife Service

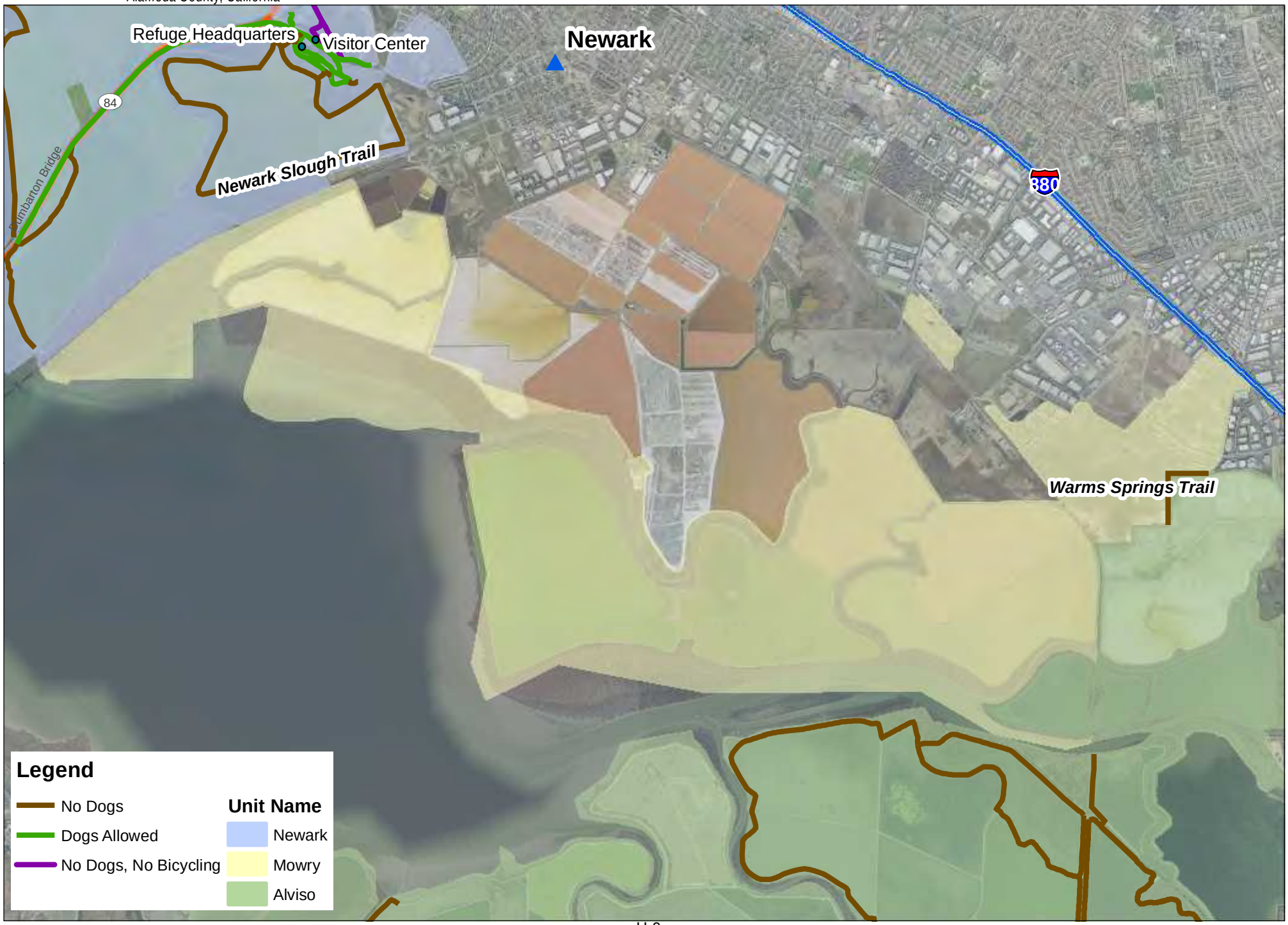
Don Edwards San Francisco Bay National Wildlife Refuge - Newark Unit Trails Inset

Alameda County, California



Don Edwards San Francisco Bay National Wildlife Refuge - Trails in the Mowry Unit

Alameda County, California



Don Edwards San Francisco Bay National Wildlife Refuge - Trails in the Alviso Unit

Santa Clara County, California

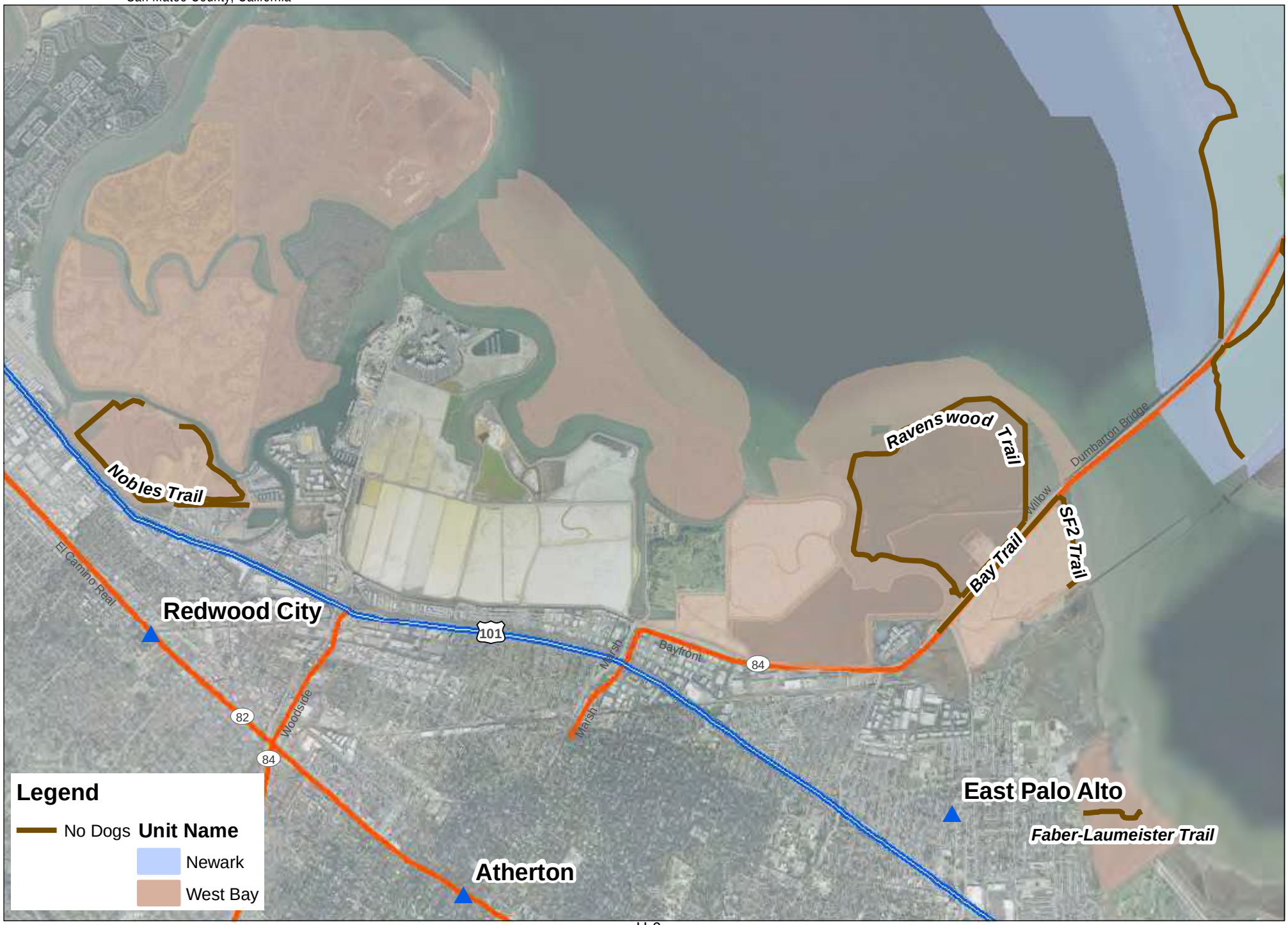
U.S. Fish & Wildlife Service

Don Edwards San Francisco Bay National Wildlife Refuge - Alviso Unit Trails Inset

Santa Clara County, California

Don Edwards San Francisco Bay National Wildlife Refuge - Trails in the West Bay Unit

San Mateo County, California



Appendix I. Mammalian Predator Management Plan

DON EDWARDS SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE PREDATOR MANAGEMENT PLAN

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1) OVERVIEW AND BACKGROUND

During this century, habitat loss and other impacts have caused the near extinction of the California clapper rail (*Rallus longirostris obsoletus*) and the salt marsh harvest mouse (*Reithrodontomys raviventris*) throughout their ranges. Entirely dependent for their survival on very limited and dwindling estuarine habitat, habitat loss and degradation, contaminants, and increased predation levels threaten their existence. Both species nest, rear young, and forage within the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge, Figure 1).

Intensive predation by non-native and urban-subsidized mammals (e.g., rats (*Rattus* spp.), foxes, opossums (*Didelphis virginiana*), and raccoons (*Procyon lotor*)), has been identified as a major factor that limits the reproductive success of the endangered California clapper rail. Although we do not have information on predation levels of salt marsh harvest mice, they are also assumed to be negatively impacted by these same predators, and are therefore incorporated into this document.

The U.S. Fish and Wildlife Service (Service) proposes to increase the endangered California clapper rail population to a Refuge goal of 1.2 rails/ha during the breeding or nonbreeding season, the endangered salt

marsh harvest mouse populations, the threatened western snowy plover (to a Recovery Unit goal of 1.0 chicks fledged per adult male) and other sensitive waterbird populations and nesting success by conducting selective predator (rats, red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), raccoons , striped skunks (*Mephitis mephitis*), opossum, and feral cats (*Felis* spp.) management at selected locations on and adjacent to the Refuge. This will produce a small-scale reduction in the local population of some terrestrial predatory species in localized areas. The purpose of the proposed action is to maximize endangered species' chances for survival both at the Refuge and throughout their ranges. Management actions will be designed to minimize lethal actions and disruption to wildlife. The need for action stems from an immediate and serious threat to the survival of the endangered species due to predation.

The major Refuge purpose is to provide secure habitat (e.g., nesting, feeding, and resting areas) for endangered species and migratory birds. The overall objective of the predator management program will be to provide that secure habitat by selectively controlling and reducing the detrimental impacts of large populations of selected predators. Management of the selected predators is essential to protect and maintain breeding populations of clapper rails, salt marsh harvest mice, western snowy plovers, and colonial nesting birds, such as Caspian terns and Forster's terns.

In spite of all that has been altered in the bay, it is still one of the most important wetland migration areas for shorebirds and other waterbirds between Alaska and Peru. On April 16-18, 1988, PRBO Conservation Science (PRBO) conducted a shorebird census of San Pablo and San Francisco bays. Observers counted 838,000 shorebirds of 28 species. Given the potential for some error, PRBO estimates that between 600,000 and 1,200,000 shorebirds were present on the weekend count. The Observatory conducted a second springtime shorebird survey in April 1989, and observed over 930,000 shorebirds along the tidal mudflats and adjacent wetland areas. A 2006-2008 November high tide roost count of shorebirds throughout San Francisco and San Pablo Bays was about 300,000 (Pitkin and Wood 2011). The majority of these birds were concentrated in south bay. In April of 1990, San Francisco Bay National Wildlife Refuge was designated as a Hemispheric Shorebird Reserve because of the wildlife values this protected habitat provides for shorebird populations.

The Refuge and the San Francisco Bay Bird Observatory (SFBBO), with the assistance of many experienced ornithologists and veteran birders, compiled a checklist entitled Birds of San Francisco Bay and San Pablo Bay National Wildlife Refuges. This list, which includes 281 species, underscores the importance of the San Francisco Bay area as bird habitat and emphasizes the great diversity of birdlife that occurs in the bay. It includes all species that are found in San Francisco Bay and the Delta. It does not include all species that can be found in nearby upland habitats.

The bay area provides habitat for 47 species of mammals. The salt marsh harvest mouse is an endangered species that requires tidal and non-tidal wetlands around the bay for survival (USFWS 1984). The salt marsh wandering shrew, which the Service has been petitioned to list as an endangered species, also inhabits some areas around the bay. The most important marine mammal associated with wetlands within the project boundary is the harbor seal. This species uses tidal salt marshes and mudflats for breeding and hauling-out grounds. The largest haul-out sites in San Francisco Bay are located in the south bay. Other mammals common to the area are raccoon, brush rabbit, big brown bat, Mexican free-tailed bat, gray fox, and California ground squirrel.

San Francisco Bay waters, with the proper control of pollutants, have the potential to support a substantial fishery in the bay area. Salt marshes and shallow water areas provide for larval, young, juvenile, and adult fishes and shellfishes such as shiner perch, top smelt, staghorn sculpin, halibut, striped bass, clams, crabs, mussels, and bay shrimp. Important commercial and sport fishes that utilize deepwater habitats include northern anchovy, starry flounder, striped bass, king salmon, sturgeon, and American shad.

2) THREATS TO THE CALIFORNIA CLAPPER RAIL

The California clapper rail became endangered due to habitat loss and degradation and over-hunting. Over-harvesting by commercial and sport hunting initially contributed to the depletion of the rail population (USFWS 1984). A historic newspaper account from the San Mateo Leader on October 23, 1897, referred to at least 5,000 rails killed in the San Francisco Bay area during a one-week period in 1897. Similar accounts between 1890 and 1910 note individual hunters killing 30 to 50 rails a day. After the enactment of the Migratory Bird Treaty Act in 1913, rails regained much of their abundance in the remaining San Francisco Bay marshes (Bryant 1915, Grinnell and Miller 1944). However, urbanization has led to the eventual diking of most salt marshes of San Francisco Bay, largely for the purposes of salt harvesting, agriculture, and commercial development. Over 90% of the original clapper rail tidal marsh habitat has been lost.

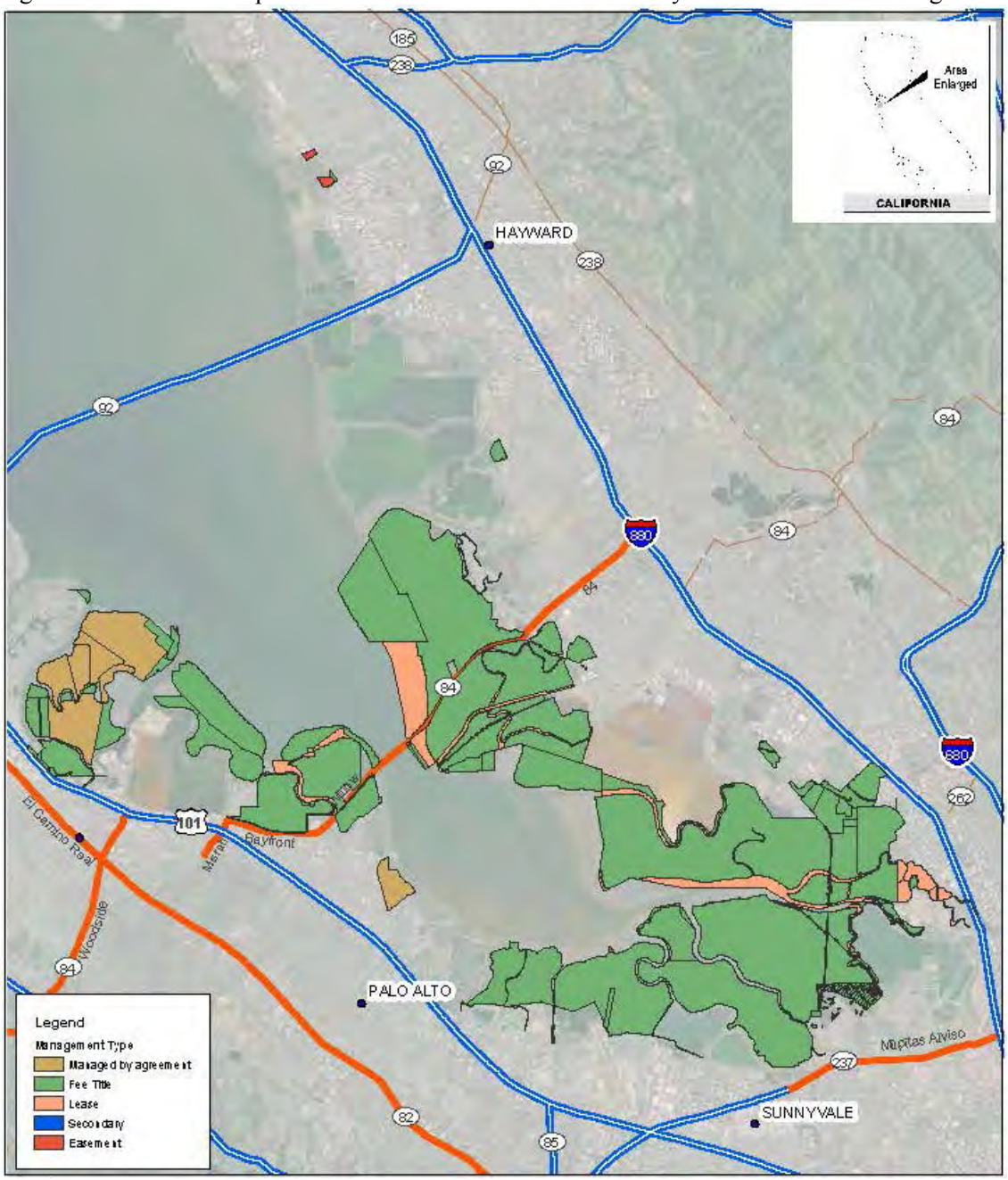
Today, major threats to the survival of the California clapper rail include the historic loss of habitat, marsh conversion, the potential impact of contaminants, and increased predation. To maximize acquisition efforts in a region where land prices are very high, the Service is pursuing cooperative purchases with the California Department of Fish and Game and other entities. In addition large-scale restoration projects such as the South Bay Salt Pond Restoration Project will begin to reverse the trends of habitat loss. Despite an aggressive land acquisition program, and active restoration of tidal salt marsh, recovery will be a slow process. Based on the progress of similar projects, it may take 10 to 20 years or more to recreate healthy salt marsh which would support California clapper rails.

In the extreme southern reaches of San Francisco Bay, tidal salt marsh has been converted to more brackish marshes by the freshwater influence of treated sewage effluent. This conversion has greatly reduced habitat value to endangered species, including the California clapper rail and salt marsh harvest mouse. The Service has worked closely with the regulatory agencies to prevent future tidal marsh conversions and to develop suitable compensation for past conversions.

The Service has investigated the occurrence and potential impacts of contaminants on clapper rails. In a Refuge study, Lonzarich et al. (1990) found elevated levels of mercury and selenium in clapper rail eggs. Organochlorine (pesticide) residues were low and had decreased by 2 to 3-fold since 1975.
A new 3-year study examining potential effects of contaminants in rails began in spring 1991. Biologists investigated factors affecting breeding populations, nest success, movement, and survival in selected Refuge marshes. "Flooding was a minor factor, reducing the number of eggs available to hatch by only 2.3%. Contamination appeared to adversely affect California clapper rail reproductive success. Predation on eggs was a major factor affecting nest success, reducing productivity by a third" (Schwarzbach et al 2006).

One of the primary reasons for the declining population is low annual recruitment of young. Predation of eggs by rats, raccoons, and red foxes, and the predation of adults by red foxes were identified as the primary causes. Other sensitive waterbirds and ground nesting species, including Caspian terns (*Sterna caspia*), Forster's terns (*Sterna forsteri*), and the Federally threatened western snowy plovers (*Charadrius alexandrinus nivosus*) are also being affected.

Figure 1. Land status map of the Don Edwards San Francisco Bay National Wildlife Refuge.



Overview of Mammalian Predation and Clapper Rails Numbers

Refuge studies of clapper rail populations during the breeding season have shown that clapper rails have been subjected to high levels of nest predation by rats, red fox, and raccoons (Harvey 1988, Foerster et al. 1990). In addition, the results of winter high tide surveys for clapper rails indicate the population declined severely from the early to mid-1980s (Harvey 1988, Foerster 1989). The decline accelerated in the late-1980's coinciding with the arrival of the red fox (Harvey 1988, Foerster 1989, Foerster et al. 1990). From a population estimate of approximately 1,500 in the early to mid-1980's, biologists estimated the population of California clapper rails in early 1991 may have been less than 500 individuals (Albertson

and Evens 2000, but the population increased from the mid- to late-90s to an estimated 1,040 to 1,264 individuals (Albertson and Evens 2000). A study conducted from 2005 to 2008 estimated the population at 1,403 to 1,448 individuals (Liu et al 2009).

Clapper rail numbers have not declined uniformly throughout the south bay where the majority of the population is concentrated (Liu et al 2009). Based on winter population surveys, numbers have remained relatively stable in some of the marshes of Palo Alto, on the west side of the Bay. However, rail numbers elsewhere have declined precipitously, particularly in the east side of the south bay in some of the marshes supporting the largest subpopulations of rails. The timing and locations of these declines coincide closely with the arrival, occurrence, and relative abundance of the red fox. For example, prior to 1986 red foxes had never been seen in the salt marshes of San Francisco Bay during winter high tide rail surveys. By the winter of 1990-1991, biologists counted 6-8 individual foxes in Mowry and Dumbarton marshes while conducting rail surveys (Figure 2).

Biologists at the Refuge conducted nighttime spotlight surveys for terrestrial predators within the Refuge during the spring and summer of 1989 and during the spring of 1990. The decline in the rail population is associated with the direct increase in the number of predator sightings during both the breeding season and the non-breeding season (i.e., during winter high tide surveys).

The Service has determined that the red fox is a problem predator of California clapper rails on the Refuge. This is based on Refuge studies, predator surveys, and documentation of incidents where red fox visitation and predation is evidenced, in combination with known red fox foraging patterns and numerous sightings throughout the Refuge. In addition, rat and raccoon depredation of rail nests has been verified in Dumbarton and Mowry marshes (Foerster et al., 1990). Biologists have observed red foxes, rats, and raccoons foraging in Refuge marshes including Dumbarton, Mowry, and Ideal marshes during all tidal conditions, including the peak of extreme winter high tides when rails are very vulnerable to predation.

Gray foxes (*Urocyon cinereoargenteus*) appear to have increased on the Refuge in recent years due to numerous sightings documented in 2010-2011. A gray fox was caught on camera depredating a western snowy plover nest at Eden Landing Ecological Reserve north of the Refuge (Robinson-Nilsen, et al. 2010).

As a defense against predators, clapper rails tend to freeze, depending on their coloration and surrounding dense vegetation for camouflage. Such avoidance behavior appears to work adequately in the presence of coyotes with which clapper rails have evolved and coexisted since long before Europeans' arrival in the area (USFWS and U.S. Navy 1990). This coexistence is evidenced in southern California by the presence of light-footed clapper rails in good numbers in the salt marsh of Upper Newport Bay and Mugu Lagoon, where coyotes are present and red foxes are virtually non-existent (USFWS and U.S. Navy 1990). Foxes are skilled and efficient predators which rely heavily on ambush techniques for hunting. They are known to surplus kill, i.e., kill and cache prey even when not hungry (A. Sargeant, USFWS, pers. comm.), and they have an affinity for eggs which they also cache for future consumption (Kruuk 1964,; Timbergen 1965; A. Sargeant, USFWS, pers. comm.). Clapper rails, which have been known to posture and defend their nests from predators, may easily fall prey to a red fox seeking eggs. Because eggs may be preferred, the adult rail may or may not be eaten after being killed. Defense mechanisms evolved over time by the clapper rail do not appear to be well-suited or effective for defense against newly confronted red fox predation techniques.

There have been no direct observations of red foxes killing or carrying dead California clapper rails on the Refuge. This is not surprising because (1) clapper rails are secretive in nature, few in number, and sparsely distributed on the Refuge; (2) visibility in the marsh is limited by dense vegetation and minimal human access; (3) observation opportunities by skilled biological observers are infrequent; and (4) the vast

majority of fox activity occurs under the cover of darkness. Additionally, obtaining direct and verifiable evidence of red fox predation on clapper rails is difficult because red fox prey items are very difficult to retrieve. Red foxes tend to consume prey away from the capture location in the field and may carry it to well-concealed dens where it is almost completely devoured (Sargeant 1978, Sargeant et al. 1984).

In April 1990, Refuge biologists discovered active red fox dens at the edge of Dumbarton Marsh and in the adjacent Audubon Marsh. They found three California clapper rail carcasses along with a variety of other birds, including mostly waterbirds, at the dens. Red foxes were seen foraging in and along Dumbarton Marsh more frequently in 1990 than in previous years (USFWS, unpubl. data). Furthermore, rail numbers declined by more than 50% in Dumbarton Marsh from January 1990 to January 1991 (Figure 2).

Severe declines were documented in Mowry Marsh (marshes on the north and south sides of Mowry Slough, and north to Newark Slough), located immediately south of Dumbarton Marsh (Figure 1). This marsh traditionally has supported a large subpopulation of rails, second only to Dumbarton Marsh. Harvey (1987) estimated that 140-160 rails resided there in the early to mid-1980s. Winter surveys in 1989-1990 produced a total of 70 rails. Surveys conducted during the following winter (1990-1991) indicated that numbers had dropped by 29%, to 50 birds. Numbers of predators, particularly red foxes, have increased greatly in Mowry Marsh during the same period.

Ideal Marsh is the next salt marsh north of Dumbarton Marsh (Figure 1). It is separated from Dumbarton by a series of active salt ponds, roads, and levees. As many as 80 rails had previously been found in winter surveys in this 138 acre tidal salt marsh. In the early 1980's the breeding population was estimated at 19 rail pairs (Harvey 1988). Surveys conducted more recently indicate that only a few rails remain (peak of 2-3 found during both breeding and nonbreeding season surveys), although the marsh is comprised of tidal salt marsh, dominated by pickleweed and cordgrass. The highest numbers of predators have been observed in this marsh during nighttime spotlight surveys conducted from 1989 to 1991, including red foxes, feral cats, raccoons, and skunks. Many of these predators may be moving into Ideal Marsh from the nearby Coyote Hills Regional Park, where sightings of red foxes and raccoons are frequent (I. Bletz, pers. comm.). Numerous levees provide pathways from such areas directly to Ideal Marsh.

Refuge staff and personnel from the San Francisco Bay Bird Observatory survey nesting colonies of waterbirds annually. In 1990, surveys revealed severe impacts by red foxes on a major Caspian tern (*Sterna caspia*) colony on a levee between salt ponds M4 and M5, southeast of Mowry Slough. As many as 650 adults have used the area for nesting, which has been monitored since 1981. It was one of only five Caspian tern nesting colonies along the central and northern California coast, all of which are in San Francisco Bay, totaling 2818 birds in 1988-1989 (Carter et al. 1990). In early May 1990, red foxes destroyed all Caspian tern nests at this colony. Refuge biologists observed cached (buried) eggs and fox tracks in, and leading to and from, the colony. The terns attempted to re-nest over the next month but the eggs were repeatedly taken by the red foxes. Subsequently, the colony was abandoned and has not returned as of 2012. Two to three red foxes were regularly observed on the levee near the colony during nighttime spotlight surveys.

A mammalian predator management program, targeting the red fox, has been conducted at the Seal Beach National Wildlife Refuge since 1986. The program was initiated in response to an increase in red foxes and a decrease in the nesting success and population size of the endangered California least tern (*Sterna antillarum browni*) and the endangered light-footed clapper rail (*Rallus longirostris levipes*). The predator management program has successfully reduced the number of red foxes and increased the nesting success and population sizes of the two endangered species (USFWS and U.S. Navy 1990). In 1986, light-footed clapper rail breeding numbers had fallen to 10. Predator management was initiated that year and by 1991,

rail numbers had increased to 69, an all-time high for that area since monitoring began in 1979 (C. Houghton, pers. comm.).

A mammalian predator management program, also targeting the red fox has been conducted on Don Edwards since 1993. With predator management, the California clapper rail population increased to an estimated population at 1,403 to 1,448 individuals in 2005-2008 (Liu et al 2009). This plan has been amended to include problem individuals of grey fox and opossums.

Predation is a natural part of a healthy, functioning ecosystem. There are many native predators that potentially could or do prey on California clapper rails, salt marsh harvest mice, and ground-nesting migratory birds. However, this is a selective small-scale effort to reduce intensive predation in localized areas by specific, predators implicated in population declines of endangered species and migratory birds.

In addition to non-native predators, many "suburban native predators" such as raccoons, opossums, foxes, and skunks, that exploit garbage and other human food sources are subsidized in an urban area such as the south bay and can reach unnaturally high density, outcompeting and preying on other native species (Crooks and Soulé 1999).

3) RELEVANCE TO REFUGE PURPOSE AND GOALS

The Refuge was established in 1974 for its "particular value in carrying out the national migratory bird management program," and one of the Refuge's three stated goals is to protect and enhance endangered species populations and their habitats. Listed species have benefited from the management of mammalian predators since 1993, and monitoring results suggest that continued management of selected mammalian predators is necessary to protect and maintain clapper rails, harvest mice and snowy plover breeding populations. This plan has direct bearing on the Refuge's ability to fulfill its purpose and goals.

Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

The Service released a Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California in 2009 (USFWS 2009). This recovery plan is an expansion and revision of the California Clapper Rail and Salt Marsh Harvest Mouse Recovery Plan (USFWS 1984). The recovery plan also encompasses four other threatened and endangered plant species, and 11 species of concern that occur in a variety of tidal marsh habitats. The recovery plan identifies goals, objectives, criteria, and actions needed to recover all focal threatened and endangered species so they can be delisted. The implementation of the predator management plan is consistent with the objectives outlined in the Recovery Plan.

4) MAMMALIAN PREDATOR MANAGEMENT PLAN

The existing Refuge predator management program utilizing a combination of barriers, trapping, and shooting will continue. Lethal controls would only be used when necessary, and as humanely and selectively as possible. This plan is consistent with Refuge and Service goals to increase the populations of the endangered California clapper rail and the salt marsh harvest mouse, the threatened western snowy plovers, and other sensitive waterbird populations, by reducing predation levels through selective predator management within selected locations on and adjacent to the Refuge.

Emphasis would be focused on the removal of rats, red foxes, feral cats, skunks, opossums, and raccoons from areas of highest value to endangered species and colonial nesting birds. Individual grey foxes would be removed in the event that they were determined to be a problem predator in the area where they were

captured, but would not be routinely removed. The use of several capture and removal techniques would allow flexibility in the program and should maximize the effectiveness while minimizing associated costs. Predator barriers would be installed in selected locations as appropriate. The installation and maintenance of physical barriers would continue for as long as the predators threaten the wildlife populations in the area. The trapping or shooting portion would continue for a 5-year period or until rail densities reach a Refuge goal of 1.2 rails/ha as measured over a two-year period during the breeding or nonbreeding season.

All activities are conducted by Refuge staff under the direction of the Refuge biologist. In addition, the Refuge manager may authorize other trained personnel (e.g., U.S. Department of Agriculture -Wildlife Services) to conduct the animal removal efforts. All activities will occur on Refuge property, however, predator management on adjacent properties may be conducted given the approval of the appropriate landowner. Most activities will be conducted away from areas that are in close association with urban developments or areas with high public use.

Trapping, Shooting, And Toxicants

Padded Leg Hold Traps

Non-lethal, padded leg hold traps can be an effective technique on all target species when properly set (Timm 1983). The greatest advantage of this method is that it allows the release, generally uninjured, of non-target species. Traps would be set near areas of high value to endangered species and migratory birds. In addition, trapping would occur along levees and boardwalks (i.e., predator pathways) leading to the high value areas. Adjacent non-refuge lands may be trapped with the approval of the landowner. Because most captures occur at night, traps would be set and checked in the evening and checked and closed at sunrise. Upon capture, all target predators would immediately be euthanized by the most humane means possible that are approved for use. Euthanization would occur by either injection with a commercially available euthanizing solution as approved by the USDA, Wildlife Services or by shooting.

Although not without controversy, euthanasia is a widely accepted form of putting surplus animals to death (USFWS and U.S. Navy 1990). Zoos, animal welfare clinics, animal control facilities, and veterinarians all utilize euthanizing techniques, particularly lethal injection. Steve Graham, Director of the Detroit Zoo, estimated that over 19 million dogs and cats are humanely put to death, i.e., euthanized, each year in the United States (Cassel in USFWS and U.S. Navy 1990). Zoos in Detroit, Michigan, and Sacramento, California and elsewhere around the country, euthanize surplus animals to control populations because there is often no acceptable place to relocate them (Blum, Cassel, and Barbiers in USFWS and U.S. Navy 1990). Deceased animals would be disposed of by cremation or burial. Non-target animals would be released.

The California Department of Fish and Game prohibits the release of non-native species into the wild in California without Fish and Game Commission approval. The Service concurs that it is inappropriate to release potentially destructive species into the wild. Transport of any wild animal within the state requires permits from the California Department of Fish and Game.

Disadvantages of padded leg hold traps include that they are time consuming to set, sets are ruined by rain or standing water, non-target animals may be captured, animals may become trap-wise, and traps must be checked frequently since live animals are held. These traps are not appropriate for rats and feral animals. Removing live animals from these traps can be hazardous.

Predator Calling/Shooting

Authorized personnel would use shotguns and rifles to shoot selected predators. Predator attractant calls such as tape recordings, reed-type calls, or other distress calls would be utilized as appropriate. Opportunistic shooting of target predators would occur in areas away from public use. These methods would only be used in areas of high value to endangered species and migratory birds. The advantages of this technique are that shooting is effective, humane, inexpensive in terms of cost and maintenance, and would pose little threat to humans or non-target species. This would be the most selective method of predator removal. The main disadvantage is the limited shooting range in some areas that are in close proximity to urban development.

Live Traps

Whenever possible, live "box-type" traps would be set in areas near endangered species and migratory bird habitats. The primary advantage of live traps is the ability to release non-target animals. All live traps would be checked daily and target predators would be humanely dispatched. Disadvantages include their limited effectiveness for some species and/or individuals, the repetitive monitoring efforts required because of live animals, and their large size which makes them unwieldy in certain conditions.

Predator Barriers

This plan would involve the use of barriers such as water, fences, or other structures that would physically limit predator movements. The construction of strategically located levee breaks or water barriers would create an impasse for some terrestrial predators. Similarly, an artificial fence may prevent some predator movements into sensitive areas. Fencing or breaks in the levees must not adversely affect endangered species, which it is intended to protect, and must be compatible with other management operations.

Figure 2 contains a conceptualized drawing of a predator fence. The fences may be constructed from locally available materials such as vinyl-coated chain link fence, 1" galvanized poultry netting, or tensar polygrid netting. The fences would be supported by 4" x 4" wooden posts. The top two feet of the fence would be directed at a 45 degree angle to deter climbing. A commercially available perching deterrent would be attached to the tops of all posts to deter predatory birds. An underground barrier may be included with each fence.

The Shorelands Corporation, a private development corporation, has developed and field tested a barrier fence in former salt ponds, proposed to be used in conjunction with the development of a horse racing facility in the Baumberg Tract, (Letter to the Refuge from Mr. John Thorpe, President, Shorelands Corporation, dated August 6, 1990). These former salt ponds are located north of the Refuge, on the east side of South San Francisco Bay. The Shorelands Corporation estimated that it would cost approximately $1,500,000 for the erection of the predator barrier and the installation of public access control structures.

Electric fences also may have limited application in some situations. Electric fencing has been used, with limited success, to protect California least tern colonies in southern California (M. Silbernagle, USFWS, pers. comm.). However, because of the configuration of the remaining tidal salt marshes and the numerous levees leading to the marshes, the installation and maintenance of electric fences would be very labor intensive and costly in this high salinity environment. The electric fences may conflict with the authorized access needs of Cargill Salt.

Disadvantages of the barriers include a limited effectiveness on animals that can swim, dig, climb, or move across mudflats, an increased number of perch sites for avian predators, limitation of areas that can be barricaded because of the physical topography, high installation and maintenance costs, and limitations on breaching or blocking levees because of an existing management agreement with Cargill Salt.

FIGURE 2. Example of a predator barrier fence.

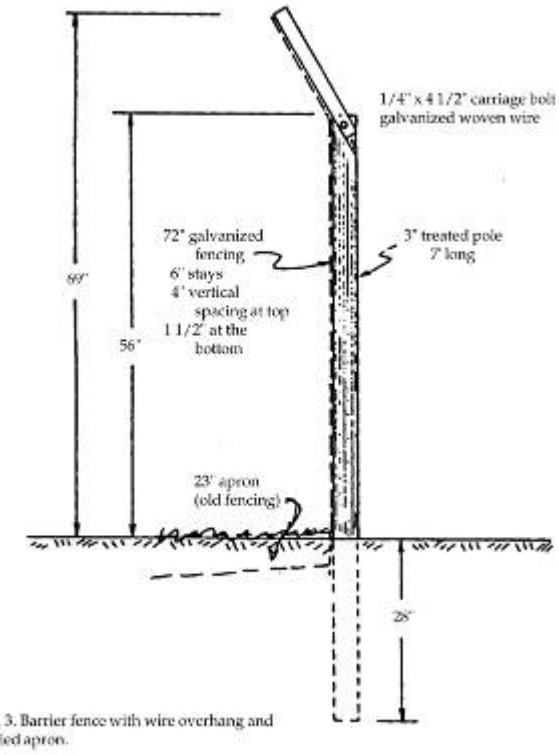


Fig. 3. Barrier fence with wire overhang and buried apron.

5) MAMMALIAN PREDATORS

Red Fox

Red foxes are the most widely distributed carnivores in the world. Two populations of red foxes, one which is native, the other introduced, occur in California (Gould 1980). The Sierra Nevada red fox (*Vulpes vulpes necator*) is native to the Sierra Nevada Mountains in California. This subspecies occurs from Siskiyou County south to Tulare County (Gray 1977, Hall 1981), generally at elevations between 5,000 and 8,400 feet. The Sierra Nevada red fox is listed as threatened by the State of California.

The other subspecies of red fox was introduced into California by hunters or escaped from commercial fox farms (Sleeper 1987) and probably descended from stock introduced from Iowa or Minnesota (Roest 1977). Those occurring in the nearby Sacramento Valley are most like red foxes (*V. v. regalis*) from the northern Great Plains. These alien red foxes now occur in the Sacramento Valley, southern California, and parts of coastal central and northern California.

Prior to late 1986, red foxes had not been observed on the Refuge. Red foxes have been observed in most parts of the south bay and in all habitat types. There have been reports of active dens in several south bay locations since 1987. Dens have been located in grassy uplands, levee banks, and salt marshes among other habitat types. The rapid range expansion of the red fox may be related to its ability to adapt to urbanization and the absence of a higher order predator (e.g., coyote) in the area.

Worldwide reports of red fox abundance vary from a few individuals in many square miles to over 70 red foxes per square mile (Voigt 1987). The highest reported populations have been in an urban area in Great Britain (Voigt 1987). In North America, a breeding density of about two adults per square mile is considered a relatively high population (Sargeant et al. 1984, Voigt 1987). Red fox litter sizes vary from 1 to 10 pups, but average 4 to 7 pups (Samuel and Nelson 1982).

Red fox populations are made up of family groups, usually consisting of a mated pair and offspring (Sargeant 1972, Voigt 1987). Red fox family groups tend to occupy discrete contiguous territories, ranging in size from 1 to 8 square miles, but generally less than 5 square miles (Sargeant 1972, Sargeant et al. 1987, Voigt 1987). Territory size is a function of population size. Territories as small as 25 acres have been recorded in extraordinarily high fox populations in Great Britain (Voigt and MacDonald 1984).

Adult red foxes tend to remain in the same territory for life (Voigt 1987, A.B. Sargeant, USFWS, pers. comm.). Most juvenile males and young females disperse from the parent territories (Storm et al. 1976, Voigt 1987). Dispersal distances are shorter where territories are small, and consequently, population densities are greater (Voigt 1987). Dispersal distances range from less than 10 miles to over 50 miles (Storm et al. 1976, Voigt 1987). Populations grow rapidly in areas where red fox survival is high and dispersal is blocked or inhibited by water or urban barriers (e.g., people, highway traffic, buildings). Dispersal of young red foxes to and from the Refuge is undoubtedly influenced by major roads and flood control channels.

Red foxes are generally nocturnal (Ables 1975), but are often seen during the daytime. Although adult red foxes maintain strong social bonds, they tend to be individualistic in their movements and behavior (Sargeant 1972, Voigt 1987). Adult red foxes tend to travel several miles throughout their territories daily (Sargeant 1972, Voigt 1987). These extensive movements occur even if food is readily available at sites known to the red foxes (A.B. Sargeant, USFWS, pers. comm.). Such daily movements are needed to maintain territory and maximize prey capture opportunities throughout the territory. Thus, as a result of their extensive movement, the likelihood of encounters between red foxes and ground nesting birds increases as red fox abundance increases.

Red foxes require a considerable amount of food to survive. Eighty-seven percent of the ingested energy is used for body maintenance (Vogtsberger and Barrett 1973). Prey consumption by red foxes fed whole prey averaged 5.0 pounds/week for individual adults and 3.0 and 4.2 pounds/week for individual pups at ages of 5-8 weeks and 9-12 weeks, respectively (Sargeant 1978). Sargeant (1978) estimated a typical family of two adults and five pups would require 317 pounds of prey during the 12-week period after whelping.

Red foxes are versatile, highly efficient predators, but they are also capable scavengers (Voigt 1987, A.B. Sargeant, USFWS, unpubl. data). The red fox is known to surplus kill (i.e., kill more prey than it can consume), sometimes on a large scale (MacDonald 1976). Red foxes have diverse food habits, eating mammals, birds, bird eggs, amphibians, reptiles, fishes, insects, worms, refuse, plants, and other items (Ables 1975, Samuel and Nelson 1982, Sargeant et al. 1984, Voigt 1987, A.B Sargeant, USFWS, unpubl. data). There are many cases of ground nesting bird populations being extirpated or sharply reduced by introduced foxes (Blokpoel 1971, Kadlec 1971, Johnson and Sargeant 1977, Drieslein and Bennett 1979, Maccarone and Montevecchi 1981, Petersen 1982, Southern et al. 1985).

Red foxes generally consume mid-size or small prey (e.g., ground squirrels, voles, mice, small birds) in entirety and frequently remove prey from the site of capture before eating it (Sargeant 1978). Food caching of day-old chicks by a 6-week-old red fox was observed by MacDonald (1976). Ducks, and perhaps other prey, generally do not struggle when captured by red foxes (Sargeant and Eberhardt 1975F).

For these reasons it is common for there to be little or no evidence of predation at sites where prey are captured.

Red foxes have a strong attraction for eggs and will take and cache large numbers (Kruuk 1964, Timbergen 1965, A.B. Sargeant USFWS, unpubl. data). Typically a red fox takes all eggs from a nest, one at a time, and discreetly caches each egg nearby (Timbergen 1965, A.B. Sargeant, USFWS, unpubl. data). Cached prey items are well concealed and difficult to find by humans. Generally, no eggs are eaten at the site (A.B. Sargeant, USFWS, unpubl. data). This type of egg predation by red foxes is characterized by little or no nest disturbance. In instances where eggs are difficult to take from nests, a red fox may use its paws to pull eggs out, resulting in some nest disturbance. When eating eggs, red foxes consume little eggshell (A.B. Sargeant, USFWS, unpubl. data). For this reason, and because of their tendency to cache eggs, examination of fecal material, stomach contents, and food remains at dens reveals little about the amount of egg predation by red foxes. Considering these factors, it is extremely difficult to document the magnitude of red fox egg predation.

Matt Klope (U.S. Navy, unpubl. data) found that the diet of red foxes at Point Mugu Lagoon in southern California varied seasonally and consisted primarily of a large number of birds. He also documented red fox predation on California least tern nests. Gary Page (PRBO, pers. comm.) documented the extensive loss of snowy plover nests to red foxes at the Salinas River National Wildlife Refuge and many other areas along Monterey Bay. Feeney (1991) conducted a snowy plover study in and around the Baumberg Tract (former salt ponds in the south bay). She found evidence of red fox predation on a snowy plover nest and observed red fox stalking snowy plover chicks. She observed red foxes taking shorebirds, including an American avocet and dowitcher. Of 29 red fox scat samples examined during this study, 83% by volume was comprised of feathers and avian bones, indicating that the diet of red foxes in the Baumberg salt ponds may consist primarily of birds (Feeney 1991). Meckstroth et al. (2007) found that bird species were the most frequent prey found in the stomachs of red foxes from South Bay (61%), whereas small rodents were most frequent for red foxes from Monterey County (62%).

Due to the implementation of the original mammalian predator management plan on the Refuge, reports and trappings of red fox have decreased by ~2010 (B. Popper, pers. comm.). However, they can still be a predator of concern at a local level and in many of the wetland habitats of greatest importance to endangered California clapper rails, salt marsh harvest mice, and colonial ground nesting birds. Biologists have regularly observed red foxes foraging at night and during the day in tidal salt marshes and along salt pond levees. They have seen foxes swimming in tidal salt marshes and in salt ponds. Moreover, red foxes have been observed stalking small mammals in the refuge tidal marshes during extreme high tides (J.E. Takekawa, pers. comm.). Red foxes are known carriers of a variety of important diseases, presenting a significant public health concern. Viral diseases such as rabies, canine distemper, and infectious canine hepatitis may infect red foxes and be transmitted to native canids (e.g., coyote, kit fox, gray fox) and to dogs. Of the viral diseases, rabies is a significant threat to human health. Red foxes may host bacterial diseases, such as leptospirosis, which can infect dogs and humans. Parasites, such as *Echinococeus multilocularis*, canine heartworm, and sarcoptic scabies, may be transmitted to other canids by red foxes. The transmission of these diseases and parasites by expanding populations of alien red foxes would be detrimental to other canids (D. Jessup, CDFG, pers. comm.).

Raccoon

The raccoon is one of the most widely distributed carnivores throughout California and the United States. Raccoons den in a variety of areas including hollow trees, ground burrows, brushpiles, abandoned buildings, dense marsh vegetation, haystacks, and rock crevices (e.g., riprap along levees). This mainly nocturnal, native mammal is an efficient and opportunistic hunter, displaying omnivorous feeding habits.

The raccoon's diverse diet includes crayfish, fish, small mammals, birds, eggs and young of ground-nesting birds, insects, fruit, nuts, and berries (Jameson and Peters 1988).

Raccoons breed mainly in early spring, but matings may occur from December through June. The gestation period is about 63 days. Most litters are born in April or May, but some late litters may appear in the summer. One litter, averaging 3 to 5 young, is raised per year. Young raccoons are weaned sometime between 2 to 4 months of age. Raccoon populations consist of a high proportion of young animals, with 1/2 to 3/4 of fall populations normally being composed of animals less than one year of age. They may live as long as 12 years in the wild. Family groups of raccoons usually remain together for the first year and the young den for the winter with the adult female. The family then gradually separates during the following spring and the young become independent.

Prior to 1988, raccoons had not been reported as regular inhabitants in many of the salt marshes of South San Francisco Bay. Foerster et al. (1990) identified raccoons as a major clapper rail egg predator in the salt marshes of the San Francisco Bay NWR. Raccoons have also been observed in the salt marshes during the nighttime spotlight surveys conducted by refuge biologists. Snowy plover nests in the Crescent Pond Unit of the Refuge have also been lost to foraging raccoons.

Rats

The Norway rat (*Rattus norvegicus*) is a stocky burrowing rodent, unintentionally introduced to North America by settlers who arrived on ships from Europe. Norway rats are now found throughout the contiguous 48 states. Norway rats burrow to make nests under buildings and other structures, beneath concrete slabs and rock piles, along stream banks and the bay edge, in garbage dumps and any other locations where suitable food, water, and cover are available.

Norway rats will eat nearly any type of available food, including cereal grains, meats, fish, eggs, nuts, and fruit. They are mainly nocturnal, although when populations are high, some individuals may be active during the daylight hours. The average female rat has 4 to 6 litters per year and may successfully wean 20 or more offspring annually. Litters of 6 to 12 young are born 21 to 23 days after conception. Young rats are capable of eating solid food at 2 1/2 to 3 weeks. They become completely independent at about 3 to 4 weeks and reach reproductive maturity at 3 months of age.

Rats have been identified as clapper rail egg predators by several investigators (DeGroot 1927, Applegarth 1938, Harvey 1988, Foerster et al. 1990). They swim readily and biologists at San Francisco Bay NWR regularly observe rats in the salt marshes during the highest winter tides.

Striped Skunks

The striped skunk (*Mephitis mephitis*) occurs over most of the continental United States and is a common resident in portions of the Refuge. Striped skunks are seen regularly by refuge staff during morning and evening hours. Skunks usually nest and rear young in an underground burrow, under debris or buildings. From 4 to 10 young are born in a litter, usually during the spring. Young are independent by early fall.

The normal home range of the skunk is an area 1/2 to 1 1/2 miles in diameter. During the breeding season a male may travel 4 to 5 miles each night. Striped skunks are omnivorous and their diet includes fruits, berries, insects, small reptiles, small mammals, carrion, and eggs (Seymour 1968). They are one of the most important predators of duck eggs in the Prairie Pothole region of the northern Great Plains (Johnson et al. 1989).

Skunks have been observed in tidal salt marshes, along salt pond levees, and in upland habitats on the refuge. Meckstroth et al. (2003) found striped skunks to be the most common predators found in tidal marsh adjacent to urban areas.

Feral cats

Feral cats include domestic cats that have reverted to living in the wild and descendants of domestic cats that breed and live in the wild. Feral cats are predators of small mammals, birds, reptiles, and insects (McMurray and Sperry 1941). Predation by cats may affect endangered and other bird populations in at least two ways: 1) by direct predation on birds and their eggs, and 2) by reducing available alternative prey, causing other predators to shift to other species including those that are endangered. Mammals usually constitute the most important category of prey, while birds contribute as much as 19 percent (Eberhard 1954) to 25 percent (Hubbs 1951) of the stomach contents of feral cats. The importance of birds in the diet of feral cats has been found to vary seasonally. Hubbs (1951) found that birds constituted 25% of the annual diet of feral cats in the Sacramento Valley, but increased seasonally to a high of 70% in June. Most domestic cats appear to be opportunistic hunters. Churcher and Lawton (1989) found that the diets of foraging feral cats consisted of 65 percent small mammals and 35 percent birds. They calculated that at least 20 million birds are killed annually by cats in Britain, and concluded that domestic cats may be a major predator of small birds and mammals in urban and suburban environments. Cats are also reported to regularly prey on larger animals including rabbits, pheasants, and ducks (Hubbs 1951, Liberg 1984) and bird eggs (Hubbs 1951). Moreover, feral cats have been known to kill adult light-footed clapper rails (Zembal and Massey 1988, M. Weitzel, USFWS, pers. comm.). In recent years (~2008-2010) three radio-tagged clapper rails have been found dead outside of feral cat feeding stations in the South Bay (C. Overton, USGS, pers. comm.)

Refuge biologists have frequently observed feral cats foraging in salt marshes, including during the peak of extreme winter high tides, foraging along salt pond levees, and wading at the edge of tidal sloughs. These feral cats are wild and bear little resemblance to domestic pets. The total effect of feral cats on California clapper rails, salt marsh harvest mice, and other wildlife is unknown at this time. The handling of feral animals on Federal lands is governed by parts of 50 CFR 26, 28, and 30.

Gray fox

Gray foxes (*Urocyon cinereoargenteus*) are native predators in the local ecosystem. Diet of the gray fox consists of small rodents, small birds, berries, insects, and fungi. Gray fox have recently been observed foraging in dry salt ponds and along levees and were captured on video depredating a western snowy plover nest (Robinson-Nilsen et al. 2010). Perhaps due to the successful removal of many of the red fox in the area, reports of gray foxes have been increasing in the South Bay, including on the Refuge. In the event that an individual gray fox is determined to be a problem predator, this fox will be removed from sensitive habitat.

Virginia opossum

Virginia opossum (*Didelphis virginiana*) was introduced to California from the east coast and has become well established throughout the state. These nocturnal marsupials are omnivorous and readily fee don birds and their eggs as well as small mammals. Like raccoons, opossums can become numerous in areas where food is supplemented by human food resources, and are a concern in marshes and adjacent to housing and business developments (B. Popper, USDA, pers comm.).

Non-target Terrestrial Predators

Other potential terrestrial predators on the Refuge include California ground squirrel (*Spermophilus beecheyi*), and roof rats (*Rattus rattus*). These species are non-target species and will be released if trapped.

6) CONSULTATION AND COORDINATION WITH OTHERS

In January 1990, a meeting was held at San Francisco Bay NWR to discuss the predator situation (emphasis on the red fox) and possible methods for addressing the situation. The meeting was attended by the Santa Clara Valley Audubon Society, California Dept. of Fish and Game, East Bay Regional Parks District, Golden Gate Audubon Society, Save San Francisco Bay, and San Francisco Bay Bird Observatory. The group discussed the need for action, including the development of the original mammalian predator management plan and environmental assessment. Further meetings were held later in the year with the Humane Society of the United States, the Humane Society of Santa Clara Valley, Ohlone Humane Society, and Peninsula Humane Society.

Resolutions in support of predator management to protect the California clapper rail were passed by The Western Section of the Wildlife Society (an organization of professional wildlife biologists) and the American Ornithologists' Union.

The Service has coordinated development of the plan with the California Department of Fish and Game. Following are California Fish and Game Code sections that relate to control of predatory mammals, including the introduced red foxes.

> Section 2118: Prohibits the importation, transport, possession, or release of live wild animals in California, except under a revocable, nontransferable permit.
>
> Sections 4000-4012: Defines trapping provisions for fur-bearing mammals.
>
> Sections 4150-4154: Defines nongame mammals and control of depredators.
>
> Sections 4180-4181: Defines provisions for controlling depredating mammals and the use of leg-hold traps.

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Appendix J. Avian Predator Management Plan

DON EDWARDS NATIONAL WILDLIFE REFUGE
AVIAN PREDATOR MANAGEMENT PLAN

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1) OVERVIEW

In conjunction with its existing mammalian predator management plan and other wildlife and habitat management plans, the U.S. Fish and Wildlife Service (Service) proposes to implement an avian predator management plan at the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) and adjacent lands. The goal of the plan is to increase the production of the Refuge's population of western snowy plovers (*Charadrius alexandrinus nivosus*, federally listed as threatened) and California least tern (*Sternula antillarum browni,* federally listed as endangered) by selectively removing problem avian predators that pose a threat to snowy plover and least tern adults, chicks, or eggs. The plan will also benefit the federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris*) and California clapper rail (*Rallus longirostris obsoletus*) and other locally nesting bird species.

Removal and deterrence of avian predators will be accomplished by various methods including hazing, relocation, or lethal control. Target predators include California gulls (*Laruscalifornicus*), northern harriers (*Circus cyaneus*), red-tailed hawks (*Buteo jamaicensis*), common ravens (*Corvus corax*) and American crows (*Corvus brachyrhynchos*). Other potential, but less likely target species include peregrine falcons (*Falco peregrinus*), American kestrels (*Falco sparverius*), merlins (*Falco columbarius*), loggerhead shrikes (*Lanius ludovicianus*), Cooper's hawks (*Accipiter cooperii*), sharp-shinned hawks (*Accipiter striatus*), great-horned owls (*Bubo virginianus*), barn owls (*Tyto alba*), and burrowing owls (*Athene cunicularia*).

The development of an overall predator management plan to address the full suite of avian and mammalian predators has been recommended and endorsed by independent researchers. For example, Shuford (2008) recommended that the revised plan place particular emphasize on species of predators, such as the California gull and common raven, which have greatly increased in the South Bay in recent decades (Ackerman et al. 2006, National Audubon Society 2002, Strong et al. 2004a).

2) BACKGROUND

Western Snowy Plover

The Pacific coast population of the snowy plover breeds primarily on coastal beaches over a range that extends from southern Washington to southern Baja California. In 1993, the species was listed as threatened under the federal Endangered Species Act throughout this range. Threats to the snowy plover include habitat loss and human disturbance of nesting grounds. Snowy plovers also suffer from low reproductive success due to high predation levels, often due to artificially inflated predator numbers in a human-modified landscape (USFWS 2007). Significant loss of breeding habitat in southern California has made the state's remaining breeding areas crucial to maintaining a stable snowy plover population. Along the Pacific Coast, the San Francisco Bay (Bay) is the northernmost area supporting over 100 breeding snowy plovers (Page et al. 2000). Historic salt evaporator ponds provide all known nesting habitat for snowy plovers in the Bay area. Recovery goals call for 500 breeding snowy plovers in the entire Bay area and 1.0 fledged chick per male. The area included in the South Bay Salt Pond Restoration Project (of which the Refuge is a part) will manage habitat for 250 breeding snowy plovers (USFWS 2007, USFWS and CDFG 2007). Restoration efforts of the South Bay Salt Pond Restoration Project will decrease the area of dry, seasonal pannes available for nesting snowy plovers (USFWS and CDFG 2007). This smaller footprint will concentrate snowy plover nests, thus increasing the need for effective avian predator management and more intensive snowy plover habitat management.

Region-wide, snowy plover avian nest predators include American crows, common ravens, gulls, northern harriers, falcons, owls, and herons (USFWS 2007). Locally, documented predators of concern are California gulls, northern harriers, common ravens, and red-tailed hawks (Robinson- Nilsen et al. 2010). Nest success in the South Bay has decreased from ~84% in 2004 and 2005 to 58% in 2006, 49.4% in 2007, 54% in 2008, 59% in 2009 and 41% in 2010 due mostly to predation (Robinson-Nilsen et al. 2010). Because there is usually no sign of

predation other than missing eggs at depredated nests, we have traditionally had no way of identifying predators. However, as of August 2009, the San Francisco Bay Bird Observatory (SFBBO) has documented predations using a nest camera set up on snowy plover nests in the South Bay. Nest cameras have identified red-tailed hawks, northern harriers, common ravens, and California gulls as nest predators along with a single instance each of gray fox (*Urocyon cinereoargenteus*) and ruddy turnstone (*Arenaria interpres*); Robinson-Nilsen et al. 2010).

In 2008, a flock of California gulls roosting in an area with snowy plover nests corresponded to a wave of predation on nests and the disappearance of snowy plover chicks (Robinson et al. 2008).

Robinson et al. (2007) documented a harrier taking a snowy plover nest on one occasion and a chick in another. Northern harriers have been suspected of contributing significantly to a zero fledge rate at the Salinas River NWR in 1999 as observations of harriers at the Salinas Refuge coincided with periods of snowy plover chick loss (USFWS 2007). Removal of targeted individual northern harriers corresponded in timing to an increase in nesting success at California Dept. of Fish and Game's Eden Landing Ecological Reserve that is also part of the South Bay Salt Pond Restoration Project area (Robinson et al. 2007).

California Least Tern

The historic breeding range of the least tern extended along the southern California coast between Santa Barbara and San Diego, with some nesting sites documented as far north as the San Francisco Bay and as far south as southern Baja California. Today, the breeding range is limited to San Francisco Bay and a few areas along the coast from San Luis Obispo County to San Diego County. The least tern population has declined due to human encroachment and destruction of nesting habitat. Human disturbance related to dredging and development have reduced nesting habitat on beaches and mudflats. Due to a lack of beach for nesting, many remaining least tern colonies now nest on more terrestrial areas away from the ocean, making them more vulnerable to predation by mammals and avian species that are well-suited to a human-modified landscape. The least tern's fishing grounds have also been severely impacted by dredging, development and pollution (USFWS 1980). Depending on the year, there are 3-6 least tern colonies in the San Francisco Bay, with Alameda Point the largest colony with >300 breeding pairs in 2009 (USFWS unpub data); only two other Bay area colonies had >20 breeding pairs (Marschalek 2008). Service recovery goals call for the establishment of four colonies in the Bay area with at least 20 breeding pairs and 1.0 fledged chick per pair (USFWS 1980). Restoration efforts of the South Bay Salt Pond Restoration Project will increase the number of islands available for nesting least terns in the South Bay. These islands may also be used by competing species, including California gulls, increasing the need for effective avian predator management.

Marschalek (2008) reported 39 and Marschalek (2009) reported 45 species as possible, suspected, or documented predators of least terns. The most reported predators were avian species. The most common avian predators were gulls, peregrine falcons, common ravens, great blue herons (*Ardea herodias*), American kestrels, as well as burrowing owls and great horned owls.

At the Alameda colony, fencing and predator management limit predation, particularly in respect to mammals. In 2006, common ravens and gulls were suspected to have taken 2-10 eggs and burrowing owls took at least 26 adults and 15 chicks (Euing 2007). In 2007, four verified kills were made by red-tailed hawks, peregrine falcons and northern harriers, and 25 other verified kills by unknown avian predators (USFWS, unpublished data). In 2008, peregrine falcons, northern harriers, red-tailed hawks, common ravens, American crows, and logger-head shrikes were documented predators on eggs, chicks or adults (Marschalek 2009). In 2009, local nesting families of peregrine falcons and red-tailed hawks continued to depredate eggs, chicks, and adults at Alameda Point. American crows also depredated eggs at this colony, while California gulls, American kestrels and Cooper's hawks were also seen in the vicinity of the colony. In 2012, one male American kestrel was responsible for the loss of over 200 chicks within the colony (USFWS, unpublished data). In addition, a newly re- established California gull colony was present near the least tern colony in 2010 although no fledglings were produced presumably due to predation by western gulls (*Larus occidentalis*, USFWS, unpub. data).

Least tern nests in a newly establishing colony in Eden Landing Ecological Reserve in 2008 were depredated after a large number of California gulls roosted in the immediate area (Robinson et al. 2008). In 2009, a northern harrier was caught on camera depredating a newly hatched least tern nest (Robinson-Nilsen et al. 2009).

Least terns at Hayward Regional Shoreline abandoned a newly established colony in 2005 and again in 2006 after California gulls established a roosting site on an adjacent island and depredated the least tern colony (Riensche 2007). The following year, least terns established 15 nests, but only fledged four young after an increase of gulls on an adjacent island. Active predator management in 2007 and 2008 allowed least terns to produce 49 and 70 fledglings respectively (Schacter et al. 2008). In 2009, this colony had 80 least tern nests, producing ~65 fledglings with very active predator management (D. Riensche, pers. comm.). Avian predators on this colony included California gulls, peregrine falcons, and American crows with northern harriers, red- tailed hawks, and common ravens suspected as predators (Marschalek 2009).

California Clapper Rail

California clapper rails were historically abundant in all tidal salt and brackish marshes in the San Francisco Bay area (Cohen 1895), as well as in the larger tidal estuaries from Marin to San Luis Obispo counties. California clapper rails are now restricted almost entirely to the marshes of the San Francisco Bay Estuary where the only known breeding populations occur, where they exist in disjunct populations (USFWS 2009 and references listed therein). The breeding period of the California clapper rail extends from late February or early March into August. Clapper rails require an intricate network of sloughs to provide invertebrates and escape routes from predators, particularly for flightless young (Taylor 1894, Adams 1900, DeGroot 1927, Evens and Page 1983, Foerster et al. 1990, Evens and Collins 1992). The small natural berms along tidal channels provide elevated nesting substrate with relatively tall vegetation, such as Grindelia stricta (gumplant).

According to the Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2009), predation pressures on clapper rails must be reduced in order to downlist the California clapper rail to threatened status. Thus they recommend that a predator management plan be developed and implemented at all sites with significant predation issues.

Reproductive success of the California clapper rail is low, with hatching success estimated at 19-43% (Harvey 1988, Foerster et al. 1990, USFWS unpub. data). Predation was reported to account for a third of the lost eggs. Known avian predators on clapper rails and their eggs include great blue herons, red-tailed hawks, peregrine falcons, northern harriers, barn owls, great horned owls, short-eared owls (*Asio flammeus*), and common ravens. Numbers of native avian species (common ravens, American crows, California gulls) have increased above historical levels due to the increased availability of human food resources and nesting opportunities associated with the human activities. Other species, such as the northern harrier, can no longer forage in upland habitats due to urban development and their foraging activities are concentrated in wetland areas USFWS 2009 and references listed therein).

Common ravens, peregrine falcons, and red-tailed hawks nest in electrical towers and buildings and forage in nearby marshes. The peregrine falcon has increased locally in recent years as a result of peregrine falcon recovery actions. Hunting intensity and efficiency by avian predators is increased by electric power transmission lines, towers, and boardwalks, many of which cross through tidal marshes and provide otherwise-limited hunting perches (USFWS 2009). These predation impacts are greatly intensified by a decrease in high marsh and high tide cover in marshes (Sibley 1955, Evens and Page 1986).

Salt Marsh Harvest Mouse

The salt marsh harvest mouse is generally restricted to saline or saline/brackish areas in the San Francisco Bay, San Pablo Bay, and Suisun Bay area. No historical records exist of its abundance or distribution in the estuary to use as a baseline, however the salt marsh harvest mouse probably occupied most of the pickleweed-dominated marshes and high marsh zones of San Francisco Bay, San Pablo Bay, and the Suisun Marsh prior to the significant marsh reclamation of the 1840s. Habitat loss leading to fragmentation of the populations, non-native species invasions, and insufficient escape habitat are major threats to this species. In the South Bay, this species is currently limited to existing fringe tidal marshes and diked marshes. Larger populations likely exist in the few, larger marshes that remain in the South Bay (for example: Calaveras Point Marsh, Bair Island, Greco Island, Mowry Slough, and other sites)(USFWS 2009 and references listed therein).

Although little is known about predation impacts to salt marsh harvest mice, predation related to flooding is an important factor (Johnston 1957, Fisler 1965, USFWS 2009). During high winter tides great blue herons, great egrets (*Ardea alba*), snowy egrets (*Egretta thula*), ring-billed gulls, California gulls, northern harriers, white-tailed kites (*Elanus caeruleus*), American kestrels, short-eared owls and other avian predators can be seen taking small mammals from the upper edges and flooded areas of marshes. Clapper rails also occasionally take small mammals (Terres 1980, Josselyn 1983, Meanley 1985). Salt marsh harvest mice depend on dense vegetation cover for predator protection. Flooded vegetation exposes mice

and other small mammals to predation. Unnatural predation is thought to exist in some marshes where salt marsh harvest mice are concentrated into narrow pickleweed zones due to surrounding habitat loss (USFWS 2009).

Existing predator management efforts in the South San Francisco Bay and adjacent areas

The Refuge's mammalian predator management plan was written in 1991, in response to low reproductive success rates of the California clapper rail as well as other ground nesting species, including snowy plovers. It integrates a variety of techniques, including the removal of mammalian predators, primarily non-native red foxes (*Vulpes vulpes*), feral cats (*Felis catus*), skunks (*Mephitis mephitis*), and raccoons (*Procyon lotor*) by USDA Wildlife Services and the installation of predator barriers such as fencing or water (USFWS 1991).

Currently, USDA Wildlife Services implements avian predator management at Salinas River National Wildlife Refuge in the Monterey Bay area (USFWS 2002), at Eden Landing Ecological Reserve, an important snowy plover breeding site in the South San Francisco Bay (CDFG 2000) and at the Alameda least tern colony for the Dept. of the Navy (Euing 2007). Avian predator removal in other areas provides us with insight into the efficacy of such plans on the reproductive success of snowy plovers and least terns.

Salinas River National Wildlife Refuge and the Monterey Bay area

The Salinas River National Wildlife Refuge implemented an experimental avian predator management plan in 1999. After implementation, snowy plover nesting success increased to an all-time high of 70%. Based on the results of the 3-year experimental plan at the Salinas River NWR and surrounding Monterey Bay areas, the Service and its cooperators concluded that avian predation was adversely affecting snowy plover reproductive success at the three study sites, and that removal of problem avian predators was an effective strategy for reducing predation-related mortality and increasing fledge rates. Avian predators at Salinas River NWR include northern harriers, red-tailed hawks, common ravens, American crows, American kestrels, and loggerhead shrikes. The avian predator management plan is now incorporated into the Salinas River NWR Comprehensive Conservation Plan.

Salinas River NWR avian predator management is concentrated immediately prior to and during the snowy plover breeding season (March–September). Management strategies are implemented on the Refuge and on adjacent public or private properties with consent of the landowner. Individual non-corvid predators determined to be a threat to snowy plovers are trapped, banded, and relocated (>150 miles away) as possible. A combination of live-trapping techniques are used, including bal-chatri traps, dho gaza nets, bow nets, net launchers with bait, pole traps, pigeon/starling harnesses, padded jaw-leg holds, cage traps and lures. Hazing or lethal control is used on rare occasions when necessary, for example, when repeated trapping attempts have failed and there is an immediate threat to snowy plovers. The decision to lethally remove an avian predator is determined on a case-by-case basis, and based on the degree of threat, the breeding phase of the snowy plovers, professional judgment of the situation, and knowledge regarding the species involved. Lethal methods include euthanasia

and shooting, and are implemented as humanely and selectively as possible. If a problem raven or crow is found on the Refuge, it is controlled lethally.

Additional measures to discourage avian predator use of snowy plover breeding areas include attaching spikes to signs and removing abandoned posts which serve as perches. Salinas River NWR and its cooperators continue to monitor snowy plovers to determine hatch and fledge rates as well as adult survivorship and population size. In addition, avian predators on the Refuge and adjacent lands are monitored, recording species observed and their behavior and habits (USFWS 2002).

Alameda National Wildlife Refuge (proposed; Dept. of the Navy property)

Predation is the major cause of breeding failure at most least tern colony sites in California. Due to the limited availability of suitable nesting habitat and the colonial nature of terns, breeding least terns tend to concentrate in high numbers, making them especially vulnerable to predators. Avian predator management on Alameda maintains high least tern breeding success and is conducted on adjacent properties in cooperation with the Navy. Avian predators at Alameda include northern harriers, red-tailed hawk, common ravens, American crows, American kestrels, peregrine falcons, logger-headed shrikes, barn owls, great horned owls, and burrowing owls.

Discouraging avian predators from the area by preventative measures is the first option. Tarmac areas are maintained free of vegetation to discourage predators, to provide least tern roosting habitat, and to maintain unobstructed views needed for predator detection by least terns. Adjacent areas are mowed to maintain vegetation height below six inches during least tern nesting season in order to attract avian predators away from the least tern colony.

Power poles and other structures (e.g. fences, buildings, poles) have been removed or modified that provide predator perches. Buildings and other potential habitat are inspected for nesting predators before least tern nesting season and predator nests that are close to the colony are removed. The use of outside lighting is restricted near the colony site to prevent attraction of predators to the area at night.

Nonlethal methods are used whenever possible, including box-type traps, soft-catch padded leghold traps, hazing, egg oiling, Bal-chatri traps, pole traps, Dho gazo nets, bow nets, pigeon harnesses, effigies, and lures. Avian predators that pose an immediate threat to the least tern colony and cannot be humanely live-trapped will be taken by humane lethal methods, which may involve shooting or euthanasia. The decision to lethally remove an avian predator is determined on a case-by-case basis, after taking into account the degree of threat, breeding phase of the terns, type of predator, resident versus migratory status of predator, and professional knowledge of the situation and species involved.

Peregrine falcons that depredate the tern colony or cause impacts to tern productivity are hazed and/or removed according to the special protocols developed by the Santa Cruz Predatory Bird Research Group. American kestrels are live-trapped and removed. Northern harriers and red-tailed hawks may be hazed, live-trapped and removed, lethally removed, have their eggs oiled,

or young relocated where their proximity is determined not to threaten the colony. Active burrowing owl burrows are monitored for signs of least tern predation.

Any gull nests on the least tern colony site are removed. Individual gulls that become predators on terns or threaten the colony are lethally removed. Avian predator presence and activities are monitored prior to and during the nesting season (USFWS 1999). In 2010, the Service and SFBBO added artificial eggs to California gull nests on paved areas adjacent to the least tern colony to reduce clutch size. However, this colony was unsuccessful due to western gull predation, thus the results of this experiment is unknown. Plans to oil California gull eggs in 2011 were postponed as the colony failed to return to nest.

Eden Landing Ecological Reserve (California Dept. of Fish and Game)

CDFG conducts predator management to reduce predation of the federally listed California clapper rail, western snowy plover, salt marsh harvest mouse, and species of concern in the Eden Landing Ecological Reserve (which is a part of the South Bay Salt Pond Restoration Project).

As part of their predator management, avian predators such as corvids and other predators determined necessary are removed by trapping, capture or shooting. Avian predator presence and activities are monitored prior to and during the nesting season by SFBBO. Landscape changes have been made to reduce the number of perches in the area as well as the placement of oyster shells on the pond bottoms to provide camouflage for snowy plover nests and chicks (Robinson-Nilsen et al. 2009).

3) AVIAN PREDATOR MANAGEMENT PLAN

In order to increase reproductive success of listed species, the Refuge, in cooperation with the SFBBO and USDA Wildlife Services, propose an avian predator removal plan on the Refuge and lands adjacent to the Refuge beginning in 2013. The purpose of the plan is to document the effects of avian predator removals and deterrents on the nesting success of snowy plovers, least terns and other nesting species, and to assess the efficacy of removing avian predators in the region.

Avian predator management may occur year-round but will be concentrated immediately prior to and during the breeding season (March–September). Management strategies included in this plan will be implemented within the Refuge, and with the consent of the appropriate agency or landowner, on adjacent public and private properties. Under the avian predator management plan, the Refuge and its cooperators will continue to monitor snowy plovers and least terns to determine reproductive success rates as well as population size. Clapper rail numbers will continue to be assessed per standardized methods (see http://www.prbo.org/cms/663#clra). In addition, avian predators on the Refuge and adjacent lands will be monitored; information recorded will include species observed and their behavior and habits.

Only permitted and authorized agencies or individuals will implement predator management actions; all activities will be conducted in a humane manner, under the direction of the Refuge and in close coordination with SFBBO or other qualified organization. Management actions

will be carried out by USDA Wildlife Services, or other such qualified agencies or individuals. Refuge personnel and their cooperators may assist with efforts. Non-lethal techniques will be used whenever possible, including hazing, trap and release, and the use of effigies and emetics.

There is a long history of trapping raptors safely and releasing them for research and rehabilitation around the world. We only use traps that have been approved in a Migratory Bird permit issued by the Migratory Bird Division of the Service. Biologists will observe any birds captured by trapping methods prior to release to insure the bird is healthy and uninjured. All birds are banded prior to release to monitor birds in case they return.

The decision to lethally remove an avian predator will be determined on a case-by-case basis, and will be based on the degree of threat, the breeding phase of the snowy plovers and least terns, professional judgment of the situation, and knowledge regarding the species involved. Lethal methods may include trapping, euthanasia and shooting, and will be implemented as humanely and selectively as possible. Shooting will be conducted only by personnel trained and certified in firearm safety. In order to avoid human safety hazards, shooting will take place only when members of the public are not in the area.

Control of mammalian predators will continue as described in Appendix I.

The Refuge and its cooperators will continue to explore avian predator management alternatives that will protect the snowy plover, clapper rail, harvest mouse and least tern while minimizing disturbance to native avian predators. There is particular interest in developing management techniques that would permit problem predators to remain on the Refuge but would prevent them from hunting in nesting areas, such as the use of larger oyster shell plots to provide camouflage to nesting snowy plovers. Additional measures to discourage avian predator use of listed species habitats will include continuing to attach metal spikes to signs on the Refuge and removing abandoned posts on the Refuge, both of which serve as perching sites. Other potential plans include creating snowy plover and least tern nesting habitat farther from nesting habitat of northern harriers, and the removal of nests (active and inactive) from power towers to preclude corvid and red-tailed hawks from nesting. To reduce the suitability of nesting substrate for California gulls, the Refuge may attempt to smooth existing levees and remove vegetation and woody debris in target areas (Blokpoel and Tessier 1992). The Refuge may also explore the use of emetics to reduce the appeal of bird eggs to corvids, raptors and gulls in a method known as conditioned taste aversion (Avery et al. 1995).

Our overall tiered approach to working with avian predators on endangered and threatened species is outlined below.

1. Remove perches from area before nesting season begins. Modify levees to preclude California gulls from nesting (i.e. by removing boards and smoothing levees).
2. Remove existing nests on power towers and other structures before raptors and ravens begin using them for the season.
3. Place dummy eggs with an emetic in an effort to condition resident avian predators to avoid predation on eggs.
4. If nesting on towers or other structures has begun, oil eggs to prevent hatching (most raptors, excluding sensitive species-see below) or remove nests and eggs (ravens). If

chicks are present, place raptor chicks in a wildlife rehabilitation facility; remove ravens.

5. Trap and release adult raptors if individuals are hunting in the nesting area of endangered and threatened species. All trapped birds will be banded to determine if and when they return to the area.
6. Lethally remove adults if all other methods fail to protect endangered and threatened species.

4) GOALS OF THE AVIAN PREDATOR MANAGEMENT PLAN

The goals of the avian predator management plan are to:

- Maintain a 3-year average population of 125 breeding snowy plovers on the Refuge. This number will be included in the management of 250 snowy plovers as part of the South Bay Salt Pond Restoration Project, in addition to the snowy plovers that use the Eden Landing Ecological Reserve.

- Maintain a 3-year average productivity of at least 1.0 fledged chick per snowy plover male.

- Establish a colony of 20 breeding least tern adults on at least one colony on the Refuge, after restoration of islands in ponds of the South Bay Salt Pond Restoration Project.

- Maintain a 3-year average productivity of at least 1.0 fledged chick per least tern breeding pair.

- Thru predator monitoring, reduce predation pressure on California clapper rails to a level below at which it negatively affects long-term population persistence for 5 consecutive years.

- Reduce individual problem avian predators in localized areas. Problem predators are defined as individuals of species known to prey on listed species which are exhibiting hunting behavior in nesting areas.

The plan is being developed to support the Refuge's management objective of recovering and maintaining a stable snowy plover population; the numerical targets reflect the best available data on the numbers of individuals necessary for a self-sustaining snowy plover population. With the implementation of the South Bay Salt Pond Restoration Project, the Refuge will be creating least tern nesting habitat; this predator management plan would protect any least tern colonies that are attempting to establish in these new areas on the Refuge (USFWS and CDFG 2007). In addition, depredation of California clapper rail and salt marsh harvest mice by avian predators would be reduced, as identified in the Draft Marsh Recovery Plan (USFWS 2009).

The avian predator management plan is designed to operate in concert with existing management efforts, including the Eden Landing Ecological Reserve predator management plan (CDFG 2000) and efforts by the Navy at Alameda Point (Euing 2007).

a) Steps to Achieve Goals

Conduct avian predator management plan

- Determine if removal of avian predators results in increased snowy plover hatch and fledge rates.

- Determine if removal of avian predators results in the successful establishment of one or more least tern colonies on the Refuge in suitable restored habitat.

- Determine the effects of removing avian predators on the avian predator population dynamic in the area where the removal occurred (ie. did another avian predator move into the area? If so, did it become an effective predator?).

- Compare before and after predator management plan data to identify a positive correlation between avian predator removal and nesting success and/or colony establishment.

SFBBO and the Refuge will monitor snowy plovers to determine hatch and fledge rates, as well as population size in the South Bay. SFBBO will also monitor avian predators at these locations. They will record what avian predator species are using these sites and note their behavior. Nest monitoring of other nesting species such as American avocets (*Recurvirostra americana*) and Forster's terns (*Sterna forsteri*) by SFBBO and USGS will also provide information on the efficacy of this plan.

Criteria to continue with avian predator management:

- An increase in snowy plover hatch rate.

- The establishment of one successful least tern colony in suitable restored habitat.

- An increase in the hatch rate of adjacent nesting species such as avocets and terns in the event that more data are required than can be collected from snowy plovers.

- An increase in numbers of Clapper rails or salt marsh harvest mice in selected marshes.

b) Monitoring and Coordination

SFBBO is the primary snowy plover and avian predator monitor for Eden Landing Ecological Reserve and the Refuge. Christina Donehower is currently the Science Coordinator and is responsible for documenting avian predator presence both by direct monitoring and in compiling data submitted to SFBBO by volunteers and field crews.

Cheryl Strong, Refuge, is responsible for overseeing the snowy plover project at the Refuge and is the main contact for the South Bay Salt Pond Restoration Project. She will be contacted

by SFBBO or USDA Wildlife Services regarding predator management efforts on the Refuge. Rachel Tertes or Joy Albertson, Refuge biologist and supervisory biologist for the Refuge complex, respectively, are secondary contacts. Eric Mruz, the Refuge Manager, can be contacted if others are not available.

Brian Popper is wildlife biologist for USDA Wildlife Services and supervises the predator removal efforts in the South Bay. John Krause is the wildlife biologist and manager of the Eden Landing Ecological Reserve (CDFG).

c) Species Specific Protocols

Common ravens and American crows

Numbers of American crows and common ravens (corvids) have increased in the San Francisco Bay and central California coast over the past several decades, and are positively associated with human population density (Marzluff and Angell 2005). Crows and ravens have increased in the Bay area (National Audubon Society 2002) and are becoming increasingly significant as nest predators on snowy plovers. Along the Pacific Coast, nest predation by corvids is a major cause of nest failures (Leibezet and George 2002). Of 63 nests in 2005 in Oregon, corvid predation accounted for 22 nest failures, by comparison with 14 failures due to mammalian or unknown predators (Lauten et al. 2006). In Santa Barbara, American crows were the most frequent predator on snowy plover nests and on experimentally placed quail eggs (Lafferty et al. 2006). At Point Reyes ravens have consistently been the most significant nest predator, accounting for 69% of predation events over five years and destroying ~50% of all nests (Hickey et al. 1995). In northern California, ravens are the single most significant predator limiting snowy plover reproduction (USFWS 2007). Snowy plovers in Point Reyes National Seashore declined 32% from 1986-2000 largely because of nest predation by ravens (Point Reyes National Seashore, unpub. data). In 2007, a common raven was seen taking a snowy plover nest in the South Bay and in 2009, SFBBO filmed a raven depredating a plover nest with a nest camera (Robinson et al. 2007 and Robinson-Nilsen et al. 2009). While current hazing efforts at local landfills may also help to reduce the number of ravens in the South Bay in the long-term, more immediate, targeted action is warranted. Potential methods to control corvids include:

1. Behavioral modification including the use of effigies and distress calls on site to deter use of the immediate area. This method was used successfully at the Refuge's Environmental Education Center in 2008 by USDA Wildlife Services to deter crow use of a newly-seeded restoration area. Plastic effigies were placed on the site and hawk and/or owl calls were played when the crow flocks were present in order to get them to mob. After mobbing, crow distress calls were played. The flock of crows eventually landed in nearby trees and then flew away from the site. While the effigies remained on the site, the crows did not return. However, they did return once the effigies were removed.

2. Lethal control of corvids hunting over endangered species habitats, including the use of traps and calls as allowable by law.

3. Removal of nests in PG&E towers or other structures near nesting colonies of snowy plovers and least terns or over tidal marsh. This has been done successfully in the past in the Eden Landing area in cooperation with USDA Wildlife Services and PG&E.

4. Use of conditioned taste aversion to "teach" local corvids that eggs are not palatable. This is a non-lethal method that has been used successfully in resident populations and may help to reduce the predation pressure on nesting terns and plovers.

California gulls

California gulls are common in the South Bay where three large and various small breeding colonies exist. California gull colonies have been growing at an exponential rate in the South Bay, from <200 in 1982 to over 49,000 in 2009 (Figure 1; Strong et al. 2004a, Robinson-Nilsen et al 2009). At snowy plover nesting sites, observations of California gulls coincided with periods of snowy plover chick and nest loss and least tern nest loss in 2008 (Robinson et al. 2008). In 2008, the Refuge created nesting habitat by drawing down water in Alviso pond A12. While this was successful in creating nesting habitat for American avocets and Forster's terns and at least one snowy plover pair, an influx of California gulls into the pond in June reduced nesting success and very few birds nested here the following year (USGS, unpub data). Ackerman et al. (2006) documented California gulls as an important predator of shorebird eggs in the South Bay, and a major predator of American avocet chicks. Avian predators accounted for 46% and mammalian predators for 54% of egg loss in avocets. California gulls were responsible for 33% of avian predation and 15% of total nest predation of avocets documented by cameras (Ackerman et al. 2006).

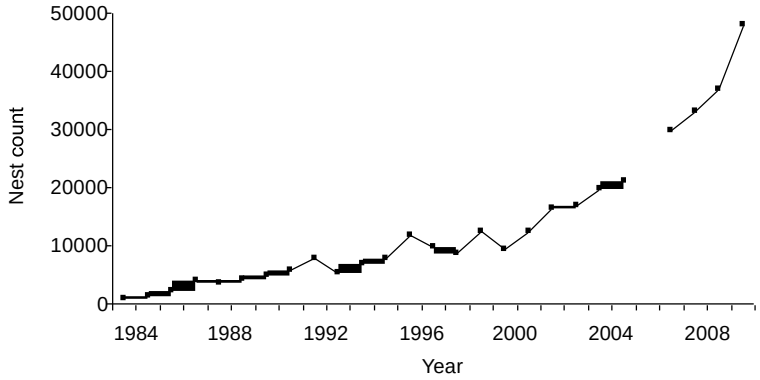
California gulls are also important predators of snowy plover nests in the interior at Mono Lake (Page et al. 1983).

During winter surveys of California clapper rails at extreme high tides, biologists have seen gulls, mainly California and ring-billed (*Larus delawarensis*), foraging in salt marshes in groups of usually 10–50 individuals and taking rodents, including harvest mice (Joy Albertson pers. comm.) adding to the effect of mammalian predation pressure on harvest mice.

While current hazing efforts at local landfills may help to reduce the number of California gulls nesting in the South Bay in the long-term (SFBBO unpub data), more immediate, targeted action is required to protect resources in the short term. California gulls pose an increasing threat to breeding snowy plovers and other ground-nesting birds because they not only depredate nests and chicks, but can also take over and trample nesting habitat and crush eggs (see references in USFWS 2007). The South Bay Salt Pond Restoration Project displaced California gulls from their current largest nesting colony in 2010 (pond A6), adding more displacement pressure on other nesting species (Shuford 2008) and subsequently other nearby colonies grew in size. Increases in non-breeding California gulls along Coastal California and the first recorded breeding of this species on the Farallon National Wildlife Refuge in 2008 add to this concern

over displacement and predation in the region (G. Page, PRBO and G, McChesney, USFWS, pers. comm.).

Figure 1. Numbers of nesting California gulls in the South San Francisco Bay, 1982-2008.



The goal for the California gull population is to limit the spread of new colonies into sensitive areas and remove "specialist" individuals that learn to prey on eggs and nests. Potential methods to control California gulls include:

1. Non-lethal control (using vehicle harassment, use of noise makers, lasers, starter pistols, arm waving and shouting, and pyrotechnics where feasible).

2. Locating nests and oiling of eggs where individuals pose the highest threat to snowy plovers or least terns and marsh species. The destruction of nests or eggs has been used frequently to control gulls by reducing attendance of adults at colonies and suppressing breeding success. Treatment of intact eggs (such as by oiling) to prevent hatching generally keeps gulls from relaying in the same season if the adults continue to incubate. However, this method is resource intensive and may not be effective in the long-term (Shuford 2008 and references therein).

3. Lethal removal of "specialist" gulls that hunt over endangered species habitats, eating eggs and/or young (Guillemette and Brousseau 2001). Shooting adult gulls has had limited success in controlling population numbers, but can be effective when it selectively targets specific problem gulls (such as chick- specialists). Shooting can also be effective when it focuses on removal of relatively few individuals nesting on small islands (Shuford 2008 and references therein).

4. To reduce the suitability of nesting substrate for California gulls in certain areas, the Refuge will work to smooth levee surfaces, remove vegetation and woody

debris and grade levees to remove irregularities. Early-season use of heavy equipment to frequently grade, disk, or drag a boom over flat areas has proven effective in preventing ring-billed gulls from building their nests (Blokpoel and Tessier 1992).

5. To reduce the availability of food, the Refuge has been working with local landfills. The largest landfill (Newby Island; City of San Jose 2007) is currently undertaking intensive gull abatement procedures to limit foraging on the landfill. In addition, preliminary efforts to create a covered area where food waste will be composted may help to reduce available anthropogenic food waste to gulls at Newby Island (R. King, pers. comm.). To be effective overall, it is crucial that intensive gull abatement programs be concurrently and continuously operational at all of the large landfills located adjacent to the South bay (Tri-Cities and Newby Island), and possibly also at landfills in other areas around the Bay. Given the gulls' tendency to habituate to any harassment techniques these will need to be varied and monitored over time to ensure their effectiveness (Shuford 2008 and references therein).

Red-tailed hawks and northern harriers

Red-tailed hawks nest in power towers and other structures around the South Bay, often adjacent to endangered species habitats. USGS nest camera data have found that red-tailed hawks were the most frequent nest predators on American avocets and black-necked stilts (*Himantopus mexicanus*) (23% of all predation events on avocets; Ackerman et al 2006). SFBBO has also captured red-tailed hawks on camera depredating snowy plover nests (Robinson-Nilsen et al. 2009). Red-tailed hawks appear to have increased slightly overall in the Bay area according to Christmas Bird Count results, particularly in the more urban count circles of the Bay area (National Audubon Society 2002).

Northern harriers are listed as a species of special concern in California, largely due to moderately reduced numbers within California caused by habitat loss, and the potential for human-induced threats to moderately reduce the population over the next 20 years (Davis and Niemela 2008). However, in the Bay area Audubon Christmas Bird Count data from 1955 to 2002 indicates that numbers of harriers counted per party hour from two local counts adjacent to the South Bay plover nesting habitat have increased (the Hayward-Fremont and Palo Alto counts; National Audubon Society 2002 summarized in Strong et al. 2004b). In addition, Breeding Bird Survey indices show a slight increase in harriers, 1968-2007 (Sauer et al. 2008). Although both of these data sets must be interpreted with caution, mammalian predator management and wetland restoration in the Bay area may currently be benefiting this marsh-nesting species.

Development has limited upland habitats where northern harriers can forage. The increase in tidal marsh due to the South Bay Salt Pond Restoration Project will increase the amount of nesting habitat for northern harriers, but may also increase the tidal marsh prey base for this species (such as voles and other mammals that use tidal marsh). Thus as the restoration project progresses, northern harriers may rely less on hunting over some endangered species habitats.

Potential methods to control red-tailed hawks and northern harriers include:

1. Non-lethal control (using vehicle harassment, use of noise makers, arm waving and shouting, and pyrotechnics where feasible).

2. Finding of nests and oiling of eggs in selected areas where individuals pose the highest threat to endangered species.

3. Use of conditioned taste aversion to "teach" local raptors that eggs are not palatable. This is a non-lethal method that has been used successfully in resident populations and may help to reduce the predation pressure on nesting terns and plovers.

4. Removal of nests in PG&E towers near endangered species habitats.

5. Trap and relocate problem individuals of this species.

6. Lethal control of individuals hunting over endangered species habitats will be considered as a last resort.

Other species

Peregrine falcons, American kestrels, great-horned owls, barn owls, burrowing owls, loggerhead shrike, merlin, cooper's hawks, and sharp-shinned hawks.

While these species are not considered to be an immediate threat to the persistence of endangered species in the Bay area, there is a potential for individuals of these species to become specialists that hunt over nesting areas, eating eggs and/or chicks. Individuals of these species will be dealt with on a case-by-case basis, and only removed if deemed to be a serious threat to a listed species.

We will harass (using vehicle harassment, use of noise makers, arm waving and shouting, and pyrotechnics) or lethally remove any predator listed above documented hunting over endangered species habitats. Specific protocols for certain special status predators are outlined below.

Peregrine falcons

Peregrine falcons have recently been delisted from the U.S. Federal List of Endangered and Threatened Wildlife. Due to their current listing as a Federal Bird of Conservation Concern, more specific protocols are given for peregrines. In recent years, a family of peregrine falcons have nested on the Bay Bridge adjacent to the Alameda Point least tern colony and appear to have become specialists that hunt over nesting colonies, eating eggs and/or chicks. However, as with all species listed above, individuals will be controlled on a case-by-case basis, and only if deemed to be a serious threat to a listed species.

Deter peregrine falcon from nesting area

1. USDA Wildlife Services will coordinate observation time to determine if peregrine falcon is a regular visitor of the area, and if the bird visits on a schedule.

2. If peregrine falcon is a first-time or regular visitor, USDA Wildlife Services will use a variety of methods as appropriate to harass but not harm peregrine falcon. These methods may include vehicle harassment, use of noise makers, arm waving and shouting, and pyrotechnics.

Trapping peregrine falcons

1. Trapping will be used as a last resort. The decision to trap will be made on a case-by-case basis, after evaluating such things as nesting phenology, size of colony, percent of terns present, and any additional factors deemed pertinent.

2. SFBBO or another qualified individual may need to observe peregrine falcon to determine status, such as breeding adult, fledgling, floating adults.

3. USDA Wildlife Services will have the lead to capture peregrine falcon using approved methods, determined by State and Federal permits. SFBBO or another qualified individual may assist.

4. USDA Wildlife Services will inform Refuge before trapping attempt and keep them informed of progression of trapping. Refuge or other qualified individual will pick up trapped peregrine falcon within one day of trapping.

5. Refuge will take the lead in banding and releasing any bird caught under these protocols. SFBBO or another qualified individual may assist with banding, transport and release of the peregrine falcon at a distance from the Refuge, such as Goose Lake or Salton Sea in California. Landowners' permission will be obtained for release sites.

6. Peregrine falcons will not be held in captivity for more than 2 days, unless peregrine falcon requires rehabilitation for injuries, etc. All peregrines will be color-banded per regulations before release.

<u>American kestrels</u>

Although considered stable over most of its North American range, American kestrels have declined in the Bay area according to Christmas Bird Count data from the past fifty years, likely due to increased urbanization and lack of cavity sites for nesting (National Audubon Society 2002, Smallwood and Bird 2002).

Because of local concern for this species, the Refuge will relocate, rather than lethally remove individual "problem" kestrels on a case-by-case basis. This was done in 2009 and 2012 with a male kestrel from the Alameda area; Wildlife Services captured these birds and released them out of the area (B. Popper, pers. comm.). If that is not possible, an individual may be lethally removed.

<u>Great horned owls</u>

This species appears to adapt remarkably well to habitat change as long as nest sites are available (Houston et al. 1998). Although not well-covered in these types of surveys, great horned owls appear to have declined in the Bay area according to Christmas Bird Count data from the past fifty years (National Audubon Society 2002). Great horned owls are suspected predators at snowy plover nesting sites in Oregon (Lauten et al. 2008) and are known to predate piping plovers, including adults (Murphy et al. 2003). Great horned owl tracks were found next to a near-fledgling least tern at Seal Beach in 2009 (C. Collins, pers comm).

Management recommendations in Houston at al. 1998 indicate that individuals that prey on endangered species may need to be removed. If individuals are seen perched near the colony they will be harassed away from the sites. If owl predation is confirmed, then attempts will be made to locate the nesting and/or roosting site of the individual and it will be live-trapped and released off site. If that is not possible, it may be lethally removed.

Burrowing owls

Burrowing owls are listed as a species of special concern in California and as a Federal Bird of Conservation Concern due to moderately reduced numbers within the state caused by habitat loss and the potential for human-induced threats to greatly reduce the population over the next 20 years (Gervais et al. 2008). Burrowing owls have increased on Breeding Bird Survey routes in California 1968-2006 (Sauer et al. 2008), but this may be largely due to increased numbers in agricultural areas especially the Imperial Valley in southern California (Gervais et al. 2008). In the Bay area, this species is declining and indeed has been extirpated from some locations (Klute et al. 2003 and references listed therein). Because of concern for this species, the Refuge will relocate, rather than lethally remove individual "problem" owls on a case by case basis. This has worked successfully in the past, where burrowing owls have been removed from the Farallons National Wildlife Refuge where they were predating ashy storm-petrel adults and chicks (*Oceanodroma homochroa*, J. Albertson, pers. comm.). Reduction of burrowing owl predation is one of the key management recommendations for ashy storm-petrels on the Farallons National Wildlife Refuge (Carter et al. 2008). The ashy storm petrel is also designated a species of special concern in California and as a Federal Bird of Conservation Concern and is recognized by the IUCN as Endangered (Carter et al. 2008, Birdlife International 2004). One burrowing owl was also removed from Alameda Point where in 2006, the owl took ~26 least tern adults and 15 chicks (Euing 2007). In both cases, burrowing owls were successfully relocated.

5) RELEVANCE TO REFUGE PURPOSE AND GOALS

The Refuge was established in 1974 for its "particular value in carrying out the national migratory bird management program," and one of the Refuge's three stated goals is to protect and enhance endangered species populations and their habitats. Listed species have benefited from the management of mammalian predators since 1993, but recent monitoring results suggest that management of selected avian predators is also necessary to protect and maintain clapper rails, harvest mice and snowy plover breeding populations as well as potential least tern nesting colonies that may establish on the Refuge as part of the South Bay Salt Pond Restoration Project. The new plan has direct bearing on the Refuge's ability to fulfill its purpose and goals.

6) JUSTIFICATION

The avian predator management plan will result in localized reductions in numbers of some avian predator species around the Refuge. In most years, an estimated 2–10 individuals per species, or fewer will be affected, and impacts on individual birds will be minimized by the use of humane and selective techniques. Populations of avian predators using grassland and riparian habitats will not be affected.

Without effective predator management, losses of chicks and adults of the Clapper rail, snowy plover, least terns and loss of salt marsh harvest mice will continue to threaten the recovery of these listed species. With management, including avian predator management, the Refuge snowy plover population is expected, at a minimum, to maintain its current size of approximately 125 breeding adults. Snowy plover reproductive success is expected to increase to 1.0 fledglings per male per year. With the avian predator management plan, we may be able to establish at least one least tern colony of 20 adults, with a fledging success rate of 1.0 fledglings per pair per year in the South Bay on newly created habitat as part of the South Bay Salt Pond Restoration Project. Numbers of tidal marsh dependent species should also increase due to both predator management and restoration efforts.

7) COLLABORATORS AND CONTACTS

This plan will be implemented in cooperation with the following agencies and organizations.

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Appendix K. Mosquito Management Plan

DON EDWARDS SAN FRANCISO BAY

NATIONAL WILDLIFE REFUGE

FINAL MOSQUITO MANAGEMENT PLAN

Prepared by: _____ Date: 9/25/12

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1 Introduction

This Plan has been prepared to provide guidance for when and how mosquito-borne virus surveillance and response should be implemented on the Don Edwards San Francisco Bay National Wildlife Refuge (Refuge). Mosquito management is particularly important on this Refuge because of the proximity of the Refuge's coastal wetlands to urban development. Mosquito management activities occur throughout the San Francisco Bay region where a large (over 7 million) human population occurs and a long history of mosquito management and documented mosquito-borne disease transmission to humans and wildlife exists. The Refuge lies within the jurisdiction of three mosquito abatement districts (MADs): Alameda County Mosquito Abatement District, Santa Clara County Vector Control District, and San Mateo Mosquito and Vector Control District.

This Plan for the Refuge is one of several step-down management plans to be developed concurrent with the Don Edwards San Francisco Bay NWR Comprehensive Conservation Plan (CCP). The CCP provides a general discussion of mosquito management on the Refuge, while the Plan provides specific details about the mosquito-borne disease management actions proposed for the Refuge. The potential effects on the environment of current and future mosquito management activities are addressed in the CCP/Environmental Assessment (EA).

The objectives of this plan are to:

- Provide guidelines on the surveillance of mosquitoes and of mosquito-borne viruses on the Refuge;
- Provide the Service and MADs with a decision support system for mosquito control activities that is consistent with Refuge purposes, the mission and goals of the Refuge System, DOI and Service policy, while minimizing public health risk (i.e., mosquito-borne diseases) from Refuge-produced or harbored mosquitoes;
- Outline the roles and responsibilities of stakeholders involved with mosquito-borne virus surveillance and response.

1.1 Guiding Principles

Wildlife Conservation

We allow populations of native mosquito species to exist unimpeded unless they pose a specific human or wildlife health threat. We recognize that mosquitoes are a natural component of most wetland ecosystems, and that they also may represent a threat to human and wildlife health.

Compatibility with Refuge Purposes

We only allow mosquito management methods that are appropriate (603 FW 1) and compatible (603 FW 2) with refuge purpose(s) and the mission of the Refuge System, and that comply with all applicable Federal laws, policies, and regulations.

Maintenance of Biological Integrity, Diversity and Environmental Health

We manage mosquitoes in such a way as to meet our statutory obligations to protect the biological integrity of refuges while meeting our policy obligations and our social obligation to protect the health and well-being of the human communities surrounding refuges. Mosquito management strategies and the altered ecological communities that may result can potentially impact the biological integrity, diversity, and environmental health of refuge lands that we must maintain under the Administration Act and 601 FW 3.

Public Health Protection

Although the fundamental goal of the Refuge System is wildlife conservation, we are committed to protecting the public from refuge-based mosquitoes that present a threat to human health. We manage such health threats using methods that we determine are appropriate refuge uses and compatible with the purpose(s) of the refuge and the mission of the Refuge System. We may make exceptions to this if, under the emergency provision of the Administration Act, it is necessary to temporarily suspend, allow, or initiate a mosquito management activity in a refuge to protect the health and safety of the public or a fish or wildlife population. Because mosquito-borne pathogens in equines and humans represent similar risks to public health, appropriate measures we take to protect human health from these diseases would also offer similar protection to equines.

Integrated Pest Management
In partnership with the MADs, we will apply IPM principles to manage mosquito-borne disease threats on the Refuge. These principles will serve as the foundation for management strategy development and assessment. Ongoing mosquito population and mosquito-borne pathogen monitoring in addition to specific action thresholds generate the criteria that implement mosquito management measures. IPM employs a variety of mosquito control methods that include habitat management, biological control agents, and pesticide application. Best management practices (BMPs) for mosquito control have been developed for the Coastal Region Mosquito and Vector Control Districts (2001) and are a significant component of this plan (See Appendix K2). These BMPs can be used to lower the production of mosquitoes and reduce the need for chemical treatment, without significantly disrupting the ecological character, habitat function, or wildlife use of managed wetlands.

2 Coordination with Mosquito and Vector Control Districts

An annual meeting will be held in November to discuss mosquito activities for the past year and any proposed wetland and mosquito management changes or issues for the upcoming season. Annual meetings will also allow for any changes that may need to be adopted as a result of changing environmental conditions or new treatment methods and pesticides. The following is a list of topics that should be covered:

Service:

- Staff introduction/changes
- Acquisition changes
- Pest management policy changes
- Summary of current wetland restoration and management program
- Proposed enhancement or restoration projects
- Current wildlife populations & status as related to mosquito management locations
- Listed species monitoring, including known locations of nests
- Techniques to minimize disturbance to wildlife

MADs:

- Staff introduction/changes
- Mosquito policy changes
- Renewal of Special Use Permits
- Revisions to any Memorandums of Understanding or Agreements
- Summary and map of mosquito production areas
- Summary and map of mosquito monitoring and management activities, including method of access and mileage/feet of tidal marsh accessed
- Updated Pesticide Use Proposals (PUPs) and label information
- Submittal and/or review of Pesticide Use Reports (PURs) of the previous year
- Proposed changes to mosquito management program

- Current mosquito and disease information
- Listed species monitoring, surveillance, and report of sightings
- Techniques used to minimize disturbance to wildlife
- Results of relevant mosquito research projects
- Proposed mosquito reduction projects

The Refuge staff coordinates annually with local MADs to allow the monitoring and, if necessary, control of mosquitoes on the Refuge to minimize public health risks from mosquito-borne diseases . Wetland management BMPs for proactive mosquito control are regularly used by the Refuge. These include, but are not limited to, water management techniques, and maintenance and improvement of water control structures. Refuge staff coordinates closely with the MADs on timing of irrigations, flood-up schedules, and communication of any problems with unplanned flooding.

In addition, PUPs developed cooperatively with the MADs, are reviewed by Service IPM specialists, and if approved, are issued along with a SUP that identifies conditions under which specific mosquito control activities can be conducted. Conditions specified in these documents include: products approved for use; application methods, rates, and timing; maximum number of applications allowed per season; measures to be taken to avoid sensitive areas; and annual reporting requirements for MADs. PUPs will be generated annually; SUPs will be generated biennially. PURs must be submitted by the MADs by the end of each calendar year to report type, amount, and location of pesticide used on the Refuge.

3 Regional/Local History of Mosquito Control and Associated Health Threats

Due to its climate and topography, California has a history of serious arboviral disease problems. Historic documents concerning mosquitoes and mosquito-borne diseases in California focus on the presence of malaria and large nuisance populations of mosquitoes affecting the first immigrants and settlers. The most severe mosquito disease and pest outbreaks of the 1800s occurred in the Central Valley of California (Fontaine 1980).

When California became one of the first states to launch mosquito control in early 1900s, the project was not for disease control, but to abate severe nuisance infestations of salt-marsh mosquitoes in the San Francisco Bay Area that were adversely affecting development (Fontaine 1980, Peters 1966). During this period, environments characterized by native estuarine and riverine systems were rapidly being altered or replaced by new irrigation systems, mining operations, and diked tidelands for agriculture (e.g., transition from tidal to seasonally flooded and shallow open water environments). These alterations expanded existing habitat for mosquitoes and likely altered mosquito population diversity and abundance in the region. The first campaigns to control mosquitoes were funded mainly by subscriptions from private individuals (Gray and Fontaine 1957, Fontaine 1980). Support for the creation of governmental control units and expenditure of public funds was not supported by public health agencies but came from real estate developers who were losing profits due to a perceived “excessive prevalence” of salt marsh mosquitoes (Gray and Fontaine 1957). In 1915, the real estate lobby introduced a bill to provide for the organization of mosquito abatement districts in the State Legislature. The law passed and was incorporated into the State Health and Safety Code that serves as the legal authority under which most mosquito control work is performed (Gray and Fontaine 1957). The first district organized was the Marin County District in December 1915. Other Bay area districts formed after 1920 (Gray and Fontaine 1957).

Since establishment in 1915 and through the 1940s, the MADs of the San Francisco Bay region relied heavily upon physical controls to manage mosquitoes (Gray and Fontaine 1957, Woodworth 1915). Controls included ditching, levee building, and the installation of culverts. The Districts owned and rented heavy equipment and employed engineers, inspectors and laborers to accomplish their mission

(Alameda Co. MAD 1992). Chemical controls (distillate and crude oils) were also used during this period to prevent larvae and pupae from reaching adult stages (Woodworth 1915).

During World War II, a fear of the return of large numbers of military personnel infected with mosquito-borne diseases stimulated the legislature in 1945 to provide special funds for mosquito control by the State Department of Public Health (Gray and Fontaine 1957). The program was oriented toward better control of pest mosquitoes, and of the vector of viral encephalitis, *Culex tarsalis* (Gray and Fontaine 1957). The traditional pre-World War II methods were largely suspended and mosquito control programs became increasingly dependent on routine spraying of (dichlorodiphenyltrichloroethane) DDT (Fontaine 1980). By 1954, the major pest and vector mosquitoes developed a resistance to DDT and led to use of organophosphorous compounds (Fontaine 1980). During the late 1960s and 1970s, the Bay Area Districts began to implement Integrated Pest Management programs to counter-attack the development of insecticide resistance by some species of mosquitoes, and to address the environmental concerns of pesticides (Alameda Co. MAD 1992). District employees began to select control methods appropriate to each source of mosquitoes and the use of mosquito-eating fish became an integral part of mosquito control programs (Alameda Co. MAD 1992).

By the mid-1980s most districts in the Bay area had replaced the majority of chemical controls materials with biorational methods that are relatively non-toxic and have fewer ecological side-effects. Principle biorational materials used today are *Bacillus thuringiensis* var. *israelensis* (B.t.i.), *Bacillus sphaericus* (B.s.), and methoprene which is an insect growth regulator.

Today, at least 18 known arboviruses have been recovered in California. Western equine (WEE) and St. Louis encephalitis (SLE) viruses are endemic and continue to represent significant public health threats throughout the state. Making the situation worse, a new cast of emerging pathogens has entered the California and national scene. Leading that list are important international arboviral diseases such as dengue, Venezuelan equine encephalitis, and West Nile virus (WNV). WEE tends to be most serious in very young children, whereas elderly people are most at risk to SLE and WNV (CA Dept. of Health Services 2003). WEE and WNV can cause serious diseases in horses and emus, and WNV kills a wide variety of endemic and imported birds. The top 4 species of birds affected by WNV are, American Crows, Western Scrub-Jays, Yellow-billed Magpies, and Steller's Jays.

From 1990 through 1999, 82 cases of arbovirus diseases were diagnosed in California and comprised <1% of patients hospitalized with acute encephalitis (Trevejo 2004). WEE and SLE viruses, both of which can be transmitted by mosquitoes, are important causes of encephalitis in California residents. Since the 1960s, incidence of WEE and SLE has decreased significantly in California although sporadic cases are still reported (Trevejo 2004).

Since introduction to North America in 1999, WNV has now reached California, and is transmitted to humans by infected mosquitoes. Mosquitoes become infected with WNV when they feed on the blood of infected birds. The recent spread of the WNV to the Bay Area, and the increased number of vectors possible for WNV, has led to increases in mosquito monitoring and control activities by regional MADs to ensure public health and safety. California reporting for WNV dates back to 2005. There has been 16 reported human case of WNV in Santa Clara County since 2005; four reported human cases for Alameda County since 2005; and one reported human case of WNV in San Mateo County since 2005 (http://www.westnile.ca.gov, accessed June 27, 2012). Table 1 summarizes information on WNV cases in the three counties where the Refuge is located.

Table 1. Cases of West Nile Virus by County, 2005-2011.

County	Human cases	Dead birds	Mosquito samples	Sentinel chickens	Squirrels
Alameda					
2011	-	-	-	-	1
2010	1	1	-	-	-
2009	-	10	1	-	-
2008	1	12	1	-	1
2007	-	19	1	-	1
2006	1	41	9	-	2
2005	1	48	8	-	n/a
San Mateo					
2011	-	-	-	-	-
2010	-	-	-	-	6
2009	-	1	-	-	-
2008	-	2	-	-	-
2007	-	2	-	-	1
2006	-	7	-	-	2
2005	1	10	-	-	n/a
Santa Clara					
2011	1	36	16	-	1
2010	-	32	10	-	6
2009	-	14	14	-	2
2008	1	13	1	-	-
2007	4	83	10	-	6
2006	5	224	9	1	2
2005	5	144	3	-	n/a

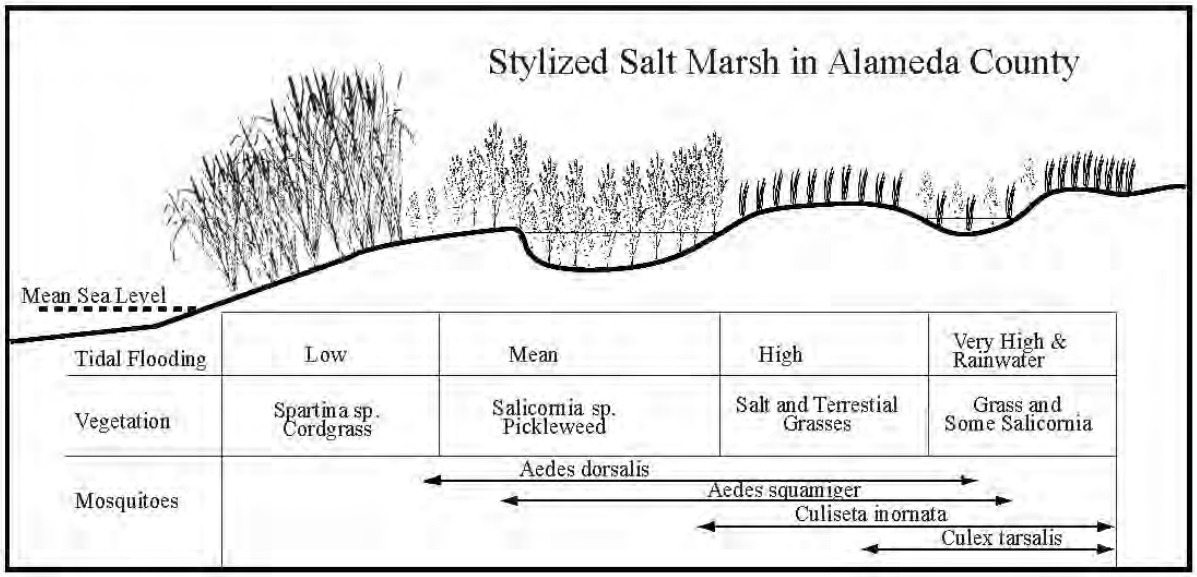
Source: http://westnile.ca.gov/, accessed on 6/27/12

4 Mosquito Biology

Mosquitoes are dipteran insects with aquatic immature stages and an aerial adult stage. They have four aquatic larval stages (instars) plus an aquatic pupal stage. The adult emerges from the pupal stage onto the surface of the water, expands its wings, hardens its exoskeleton, and flies off. Depending on seasonal and environmental conditions and the particular mosquito species involved, it generally takes from four days to up to a month for a mosquito to complete its life from developed egg to early adult stage (CDPH 2008). In general, as ambient temperature increases, the number of days required from hatching to emergence as an adult decreases. Although some species of mosquitoes (e.g., *Culex tarsalis, Aedes squamiger*), are capable of long flights from the aquatic habitat, the mosquito problem created by a wetland will generally be inversely proportional to its distance from concentrations of human and domestic animal populations.

There are six species of mosquitoes frequently found breeding on the Refuge: *Aedes dorsalis, Aedes squamiger, Aedes washinoi, Culex erythrothorax, Culex tarsalis,* and *Culiseta inornata*. Due to the variety of breeding habits of these species, mosquito larvae can be found year round on the Refuge. *Aedes* mosquitoes are floodwater species. They lay their eggs singly on dry vegetation, and they hatch after a flooding episode. *Culex* and *Culiseta* mosquitoes require standing water on which to deposit their eggs. Figure 1 is a depiction of a typical salt marsh and the habitat types where immature marsh mosquito species are found. Many of the species' habitats overlap.

Figure 1. Marsh Mosquito Habitat Types.



***Aedes squamiger* (Winter salt marsh mosquito)**. Larvae develop in rainwater that collects in salt marsh depressions between November and March. Eggs are laid in these depressions during the spring. They hatch in winter when flooded by rainwater. Larvae develop over the winter to emerge in mid-March. Adults are relatively long-lived, sometimes lasting through May or June. Females disperse inland along streams and then spread out into surrounding residential neighborhoods to seek a blood meal. These mosquitoes can fly 20 miles or more from the larval source. Most of the control effort occurs during the winter. It is the only species found on the Refuge that produces a single generation per year. Control is by physical modifications to the marshes and by spraying with biologically-based larvicides. They are aggressive biters and known carriers of both WNV and California Group Encephalitis viruses.

***Aedes dorsalis* (Summer salt marsh mosquito)**. This species is found year round in tidal salt marsh areas but is most common after summer high tides. This species uses many of the same marsh habitats as *A. squamiger*, as well as intertidal marshes. Numerous generations can be produced from flooding tides between April and October. The eggs are laid in the marsh and hatch when the marsh is filled by high tides. Control is by application of biorationals and physical modifications. Adults are very aggressive, fly moderate distances, and are capable of producing very high numbers of service requests near marsh areas, especially in large grassy areas such as schools and parks. *A. dorsalis* females are aggressive biters capable of dispersing 15 miles or more from their larval source. They can harbor WNV, WEE, and SLE as well as California Group Encephalitis viruses.

***Aedes washinoi* (Woodland pond mosquito)**
This mosquito is produced in depressions that fill with water. Eggs are laid on the mud and organic material along the edges of receding water in these areas. Adults are generally present in the early spring, are very aggressive, and may be found in large numbers. Most of the control effort on this species is by use of biorational materials. Although not considered a marsh mosquito, this species is found near marshy areas that flood with rainwater. This species is found mostly near the entrance to the visitor's center at the Refuge.

***Culex erythrothorax* (Tule mosquito)**
Larvae usually live in permanent or semi-permanent sources of water which contain large stands of cattails or tules. They are extremely sensitive to vibration and dive quickly so detecting them when they are immature is difficult. Adult females feed equally on mammals and birds; they will feed on humans in

the shade. *Culex erythrothorax* can become a major pest to human and other vertebrates that reside near their breeding habitats. This mosquito has been found naturally infected with SLE, WEE, and WNV. Although immature individuals have never been collected on the Refuge, adults have been collected in carbon dioxide-baited traps.

***Culex tarsalis* (Encephalitis mosquito)**. This species breeds in almost any type of flooded pool, including salt marsh, if the salt content does not exceed 1.0 percent. Multiple generations are produced between February and November in rainwater impounds in pickleweed marsh. This mosquito is an efficient vector of WNV, WEE and SLE (California Mosquito-Borne Virus Surveillance and Response Plan 2011, Appendix K8). These viruses are maintained in wild bird populations. Breeding of this species in areas occupied by large populations of migratory birds near dense human population centers is of particular concern to public health.

***Culiseta inornata* (Winter marsh mosquito)**. This species rests during the summer and becomes active in the fall after the first rains. This species breeds in almost any ground depression, but seems to excel in habitats favored by *A. squamiger*. Females lay eggs on the surface of rain-filled ponds in the fall, and many generations can be produced in a single season (October through May). This mosquito bites at dusk in the fall and spring and is moderately aggressive, quite large, and may reach very high numbers. *Culiseta inornata* are very noticeable to the public because of their size and activity. Adults tend to stay within 1 – 2 miles of their larval source. This species is generally found close to temporary fresh water sources. Most of the control is by using biorational materials. They are capable of transmitting WNV and feed preferentially on mammals.

4.1 Mosquito Abundance in Refuge Habitats

Mosquito abundance on the Refuge is generally in and around brackish, standing water bodies with a range of plant diversity that are exposed to different levels of tidal waters. Characteristics of elevated mosquito production areas include shallow swales within the marsh plain (4-6 feet NGVD29) that hold water for extended periods following high tides and precipitation, and a lack of tidal channels that permit drainage. These characteristics, in combination with emergent vegetation, encourage mosquito production. Sedimentation has reduced the efficacy and longevity of historic ditching efforts (by MADs) to increase tidal flushing in some areas. In addition to the above characteristics, these sites generally exhibit poor habitat quality for estuarine wildlife and plants, including threatened and endangered species, relative to other tidal marsh areas of the Refuge.

Mosquitoes are also in areas of the Refuge that are not exposed to tides (e.g., vernal pools), but where rainwater provides the habitat for larval development. Immature mosquitoes are not uniformly distributed, but are aggregated in clumps or pockets protected from predators. Mosquito production occurs in areas where standing water accumulates in depressions among the vegetation. During the winter months and into the early spring a combination of rainwater and tidal influence create an accumulation of water in upland areas. In the summer, high tides cause flooding in areas where drainage is inadequate. See the above graphic "Stylized Salt Marsh in Alameda County."

District mosquito control technicians focus on sampling mosquitoes in these areas by dipping the shoreline vegetation and progressing outward to isolated tufts of emergent vegetation in standing water. Water that accumulates in cracks on the floor of old salt pans also provides a sheltered environment for larvae.

5 Threat Criteria

This section presents the process to be followed in making determinations regarding to what extent mosquito management should occur on the Refuge and how and when specific mosquito management

activities should be undertaken. Effective mosquito control results in the removal of a high percentage of one or more target species, although usually temporarily. Such control efforts can also result in direct and indirect adverse effects to one or more non-target species. The altered ecological communities that may result from mosquito control activities can impact biological integrity and diversity through disruptions in food webs and other ecological functions. Therefore, the decision to control mosquitoes and at what level requires careful evaluation.

The potential threat posed by the presence of WNV and/or other pathogens in mosquitoes within the Refuge must be assessed. These health threat determinations will be based on the criteria depicted in Table 2 and a phased approach will be used to treat mosquitoes occurring on the Refuge. Threat level determinations will include the risk rating described in the California Mosquito-Borne Virus Surveillance and Response Plan (Response Plan) (Appendix K8).

The Response Plan was developed to provide a semi-quantitative measure of virus transmission risk that could be used by local agencies to plan and modulate mosquito risk reduction measures. Various risk factors, including ecological dynamics, are rated on a scale of 1 to 5, based on their average status over at least five non-epidemic years in a specific region. A value of 5 represents conditions indicative of a high risk of human infection with a mosquito-borne virus.

Table 1 in the Response Plan provides worksheets for assessing risk of WEE, SLE, and WNV transmission. Average risk values for a normal season range from 1.0 to 2.5, emergency planning from 2.6 to 4.0, and epidemic conditions from 4.1 to 5.0. The Risk Assessment prepared by the MADs will be used in conjunction with the Health Threat criteria listed in Table 2 to assess treatment needs. Threat levels one through four correspond to a normal season with a value between 1.0 and 2.5. Threat Level 5 corresponds to emergency planning and would have a risk rating between 2.6 and 4.0.

As proposed, mosquito management on the Refuge will be consistent with an integrated pest management (IPM) approach to mosquito control. IPM is a sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks. When practical, the approach may include compatible actions that reduce mosquito production and do not involve pesticides.

In some locations, mosquito production may be influenced by current site conditions. For example, historical human activities along the upper edges of a salt marsh complex may have altered the natural drainage patterns, creating areas where ponding now occurs during higher spring tides or after a significant rain event. In these situations, an integrated approach to mosquito management involving habitat manipulation and/or restoration and enhancement could provide benefits related to reducing the area available on the refuge for mosquito production.

Restoration of wetlands to tidal influence may not result in complete control of mosquito populations, resulting in the need for mosquito monitoring, disease surveillance, and the potential application of pesticides. Application of pesticides would be approved based on the phased approach outlined below. The principle goal of a phased approach to mosquito management is to minimize adverse effects to Refuge resources while addressing legitimate human and wildlife health concerns, as well as complying with Service regulations and policies. The Plan proposes a phased-response to mosquito management and control that is consistent with Service and California guidelines. Because the occurrence of arboviruses and other human health issues resulting from mosquitoes vary by Refuge location, the phases of mosquito management to be implemented on the Refuge would vary through time.

Except during high risk disease situations where there is a need to take action quickly, full consideration must be given to the integrity of non-target populations and communities when considering compatible

habitat management and pesticide uses for mosquito control. Mosquito control procedures must also be consistent with IPM strategies and existing pest management policies of the Department of the Interior and the Service (517 DM 1, 569 FW 1, and 30 AM 12). Even during high risk disease situations, proven mosquito-borne disease presence on or within flight range of the Refuge is required to warrant substantial intervention (e.g., the use of adulticides). Additionally, appropriate pesticide review (i.e., approval of the use of a pesticide through the PUPs process) must be completed, although this review will be expedited so that any necessary intervention measures will not be delayed. Such pesticide treatments for adult mosquito population control on Refuge lands will only be allowed when local, current data have been collected and indicate that refuge-based mosquito populations are contributing to a human or wildlife mosquito-borne disease health threat.

The proposed phased approach to mosquito management is dependent upon continued communication and cooperation among the Service, the local mosquito abatement districts, and the appropriate state and local public health agencies. As described in *Chapter 2*, communication is essential to the success of the Plan. Therefore:

- The districts will coordinate all activities with the Refuge Manager.
- The districts will meet annually with Refuge staff to review the activities and results of the previous year and discuss the monitoring and possible control plans for the upcoming year.
- A Refuge SUP will be prepared biennially for the districts that will include all appropriate BMPs presented in the Mosquito Management Plan, as well as special conditions related to location, timing, extent of mosquito monitoring, and stipulations for carrying out mosquito control, should it be warranted, under the guidance of the approved PUPs.
- Prior to each year's mosquito breeding season, the districts field staff will meet with Refuge staff to go over field protocols for avoidance and minimization of take to any trust resources including migratory birds and listed species and their habitats.
- At the beginning of the mosquito breeding season, the districts will provide a general schedule of seasonal activities and refuge locations to the Refuge Manager. If activities are proposed that significantly differ from the schedule, particularly accessing endangered species habitat, we request that the districts notify the Refuge Manager at least two business days prior to accessing the Refuge.
- Access to sensitive wildlife areas (i.e., endangered species habitat) is preferred by foot; use of ATV or ARGOs will be coordinated with the Refuge staff prior to entry in these areas.

Although the districts would have the lead for monitoring, disease surveillance, and pesticide applications, evaluation of monitoring data and approval for each management action would be the responsibility of the Refuge. This approach, which requires the Refuge Manager to oversee the mosquito management program, process PUPs, prepare biennial SUPs, and comply with legal mandates (e.g., NEPA, Refuge Improvement Act) and Service policies (e.g., Compatibility, Appropriate Use), is necessary to ensure that the conditions for compatibility are met and the program is implemented so as to avoid or minimize effects on Refuge resources.

Because of the nature of mosquito-borne diseases, as well as the limited information available regarding the effects of these diseases on wildlife of the Refuge, this approach focuses on the implementation of a mosquito management program to protect human health. The table below describes the phased response thresholds that the San Francisco Bay NWR Complex has adopted for its refuges, based on guidance from the Service's Interim Guidance for Mosquito Management on National Wildlife Refuges (2005). Further detail on each phase and individual district threshold requirements are described below and in Table 3.

Table 2. Health Threat Criteria for Mosquito Management on the Refuge.

Threat Level	Condition	Response
1	No documented existing health threat[1]. Mosquito management issues have not been reported or identified by the appropriate public health authority[4] or vector control district(s).	Monitoring and surveillance of areas surrounding the Refuge to inform management actions on the Refuge. Remove/manage artificial breeding sites such as tires, tanks, or similar debris/containers. Consult with MADs when planning wetland enhancement or restoration projects.
2	Potential human or wildlife (incl. threatened and endangered species) health threat[1] (presence of vector spp., historical health threat, etc.), as documented by appropriate public health authority(ies) or vector control district(s).	Response as in threat level 1, plus: allow compatible monitoring and disease surveillance. Consider compatible non-pesticide management options to reduce the potential for above-normal mosquito production (e.g., restore/enhance tidal marsh hydrology).
3	Mosquito larvae threshold exceeded for human and/or wildlife health[2] on the Refuge as determined by standardized monitoring. Documented potential human or wildlife health threat (historic health threat, presence of vector species).	Response as in threat level 2, plus: allow compatible site-specific application of larvicide in areas with above average mosquito populations, as determined by monitoring. Conduct post larvicide monitoring to determine efficacy.
4	Mosquito larvae have begun to reach last instar stages or pupate reducing the efficacy of larvicides. Mosquito larval and pupal population thresholds[2] exceeded on the Refuge. Mosquitoes produced by the Refuge pose a health threat[1,4] as determined by the appropriate public health authority(s).	Response as in threat level 3, plus: if appropriate, increase the intensity and frequency of larvicides, allow compatible site-specific use of pupacides in areas with above average mosquito populations, determined through monitoring to be beyond control with larvicides. Increase monitoring and disease surveillance. Conduct post larvicide and pupacide monitoring to determine efficacy.
5	Mosquito-borne disease is documented on the Refuge or within flight range of vector mosquitoes on the Refuge. Risk Assessment rating is at least 2.6[3]. High risk for mosquito-borne disease (imminent risk of serious human disease or death, or an imminent risk of serious disease or death to populations of wildlife) within communities surrounding the Refuge has been documented by the appropriate public health authority[4].	Response as in threat level 4, plus: Consider site-specific adulticiding in areas with above average mosquito populations as determined by monitoring. Conduct post adulticide monitoring to determine efficacy.

[1]An adverse impact to the health of human or wildlife populations from mosquito-borne disease identified and documented by Federal, State, and/or local public health authorities. Health threats are locally derived and are based on the presence of endemic or enzootic mosquito-borne diseases, including the historical incidence of disease, and the presence and abundance of vector mosquitoes. Health threat levels are based on current monitoring of vectors and mosquito-borne pathogens.
[2]See Table 3.
[3]Risk Assessment is calculated by considering several factors as determined by California Mosquito-Borne Virus Surveillance and Response Plan (Appendix K8).
[4]Appropriate public health authority(s) is a Federal, State, or local public health or wildlife management authority with jurisdiction inclusive of Refuge boundaries and/or neighboring public health authorities.

Threat Level 1

In Threat Level 1, an existing health threat has not been identified and mosquito management issues have not been reported or identified by the appropriate public health authority or MADs. To avoid any possible mosquito management issues, artificial mosquito breeding habitat throughout the Refuge, such as tires, open containers, and other equipment or objects that pool water where mosquitoes may breed, should be eliminated.

The Refuge would consult with the MADs when wetland enhancement or restoration projects are being planned on the Refuge. Consultation would allow Refuge staff and the MADs to identify potential issues or opportunities related to mosquito production and management in the future. Monitoring and surveillance of mosquito abundance and disease prevalence in areas similar and near the Refuge would be conducted by the MADs which would inform the potential for mosquito management needs on the Refuge.

Threat Level 2

In Threat Level 2, the Refuge Manager is contacted by the appropriate public health authority(ies) or MAD(s) regarding a potential human health threat posed by mosquitoes harbored or produced on the Refuge. The Service recognizes human health threats typically include the presence of a vector species and historical incidence of mosquito-borne disease in the local area. Some areas may already be operating under Threat Level 2 if they have had historical and recurring presence of mosquito-borne disease. In response, Refuge staff may allow compatible mosquito population monitoring and disease surveillance by the MADs on the Refuge. The initial step to developing a proactive prevention and management program for mosquitoes is to determine mosquito species presence and abundance on refuge lands, and to identify potential or documented vectors of mosquito-borne diseases that represent a potential human health threat. In addition to a species list of mosquitoes, the survey or inventory should determine locations on the Refuge being used for breeding and/or resting mosquitoes (harboring). Monitoring and surveillance activities should be well-documented and presented to Refuge staff by the MADs.

In order to avoid or minimize the use of pesticides, habitat management practices or wetland enhancement/restoration projects that improve wildlife habitat and reduce seasonal abundance of larval and adult mosquitoes should be implemented where possible.

Refuge staff and visitors would be informed of an increased health threat associated with mosquito-borne disease activity. Personal protection measures such as wearing mosquito repellant would be recommended to staff and visitors.

Threat Level 3

If non-pesticide attempts to reduce mosquito populations are unsuccessful or are not feasible and mosquito larvae thresholds have been exceeded, application of larvicides would be considered. Locations and types of larvicide treatments would be based on standardized methods as described in *Chapter 8*. The preferred larvicide treatments are biorationals (biological agents) B.t.i. and B.s. because of their limited non-target effects (Appendix K3, K4). Other larvicides treatments (e.g., methoprene) would be the second preferred method for larvicides control. Post larvicide monitoring would be conducted to determine efficacy.

Table 3. Larval and Pupal Mosquito Thresholds for Alameda, Santa Clara, and San Mateo Mosquito and Vector Control Districts

Species	Common Name	Most Common Habitats	Distance to Populated Area	Larval/Pupal Threshold	Notes
Aedes dorsalis	Salt marsh mosquito	Salt marshes	0 meters - 5 miles	≥1 per 10 dips	High Pest Significance
Aedes squamiger	Winter salt marsh mosquito	Salt Marshes, Reclaimed Marshes	0 meters - 10 miles	≥1 per 10 dips	High Pest Significance
Aedes washinoi	Woodland pool mosquito	Temporary Woodland Pools	0 meters - 5 mile	≥1 per 10 dips	High Pest Significance

Culex erythrothorax	Tule mosquito	Lakes and Ponds Associated with Tules	0 - 500 meters	≥1 per dip	High Pest Significance, Vector of Encephalitis, WNV
Culex tarsalis	Encephalitis mosquito	Creeks, Marshes, Temporary Pools, Roadside Ditches, Fresh Water	0 meters - 5 miles	≥1 per 10 dips	Moderate Pest Significance, Vector of Encephalitis, WNV
Culiseta inornata	Winter salt marsh mosquito	Marshes, Temporary Pools, Roadside Ditches	0 meters - 1 mile	≥1 per dip	High Pest Significance

Threat Level 4

If appropriate, the intensity and frequency of larvicides would be increased. Larvicides (B.t.i. or B.s., and methoprene) are only effective on mosquitoes during early instar stages (up to the fourth) and do not control pupae. If developing mosquitoes have reached the last instar stages or have pupated, then we would consider site-specific pupacides in areas with above average mosquito populations (determined through monitoring). Because pupacides can negatively affect all invertebrates that require surface air (e.g., act as surfactants), the use of these pesticides should be carefully considered. For this reason, pupacides (Agnique) would only be used if large numbers of mosquitoes are considered an immediate threat to human health and thresholds developed by the appropriate public agency have been exceeded (there is active transmission of mosquito-borne disease from Refuge based mosquitoes or within flight range of vector mosquito species present on the Refuge). Post larvicide and pupacide monitoring would be conducted to determine efficacy and any adverse impacts.

Threat Level 5

In this threat level, mosquito-borne disease activity has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge. A risk of serious mosquito-borne human disease or death has been documented by the appropriate public health authority. Disease surveillance determines that there is a high risk for mosquito-borne disease within the vicinity of the Refuge. For example, pathogen presence in mosquito pool(s), wild birds, sentinel chicken flock(s), horses, or humans has been documented within the flight range of vector mosquito species present on the Refuge. These conditions would trigger consideration of a more aggressive treatment strategy, including the use of adulticides. If larvicide and/or pupacide treatments fail, pyrethrin-based adulticides would be considered for use on the Refuge to suppress populations of infected mosquitoes and interrupt epidemic virus transmission. Because the efficacy and effects of adulticides are variable, adulticides should not be applied broadly without site-specific data indicating a need for control.

Further, the use of adulticide would be considered in relation to the most current version of the Mosquito-borne Virus Risk Assessment in the California Mosquito-borne Virus Surveillance and Response Plan (Appendix K8). The MADs would be required to include a risk assessment as part of their request to apply adulticides. The risk assessment evaluates a number of factors including environmental conditions, species presence, virus infection rate, sentinel chicken seroconversion, dead bird presence, and human cases to determine whether adulticide should be considered. We would only consider application in areas where a pathogen is present on the Refuge that can be effectively treated while minimizing non-target effects, especially to threatened and endangered species. However, specific areas treated and the extent of treatment would vary from year to year depending on mosquito populations and environmental conditions.

In order to limit human contact with adulticides, visitors would not be allowed in those parts of the Refuge that are being treated with adulticides. Information about treatment scheduling, location, and pesticide would be posted on the Refuge website, at the Refuge Headquarters, and at the treatment location. Post adulticide monitoring would be conducted to determine efficacy and any adverse impacts.

In summary, application of adulticides on the Refuge would require the following steps:

- Prior approval from the National IPM Coordinator via an approved Pesticide Use Proposal
- The MAD must present the Refuge Manager with data supporting presence of a arboviral disease on the Refuge or within flight range of the vector mosquito species on the Refuge, including a Risk Assessment in the region
- The MAD must provide the Refuge Manager with types/quantities of adulticides proposed and locations
- If beneficial, the MAD should conduct simultaneous application of larvicides with the adulticide application to prevent future adult outbreaks

Control strategies are selected to minimize their impact on the environment while maximizing the degree of control. The method used is based on the criteria above as well as:

- Habitat type
- Water conditions
- Cost and feasibility
- Site accessibility

The efficacy of adulticiding is dependent upon a number of factors. First, the mosquito species to be treated must be susceptible to the insecticide applied. Some District mosquitoes are resistant or more tolerant to some adulticides, thus affecting the selection of the chemical. Adulticides are applied by hand-held units when applied to limited areas, or by truck mounted sprayers when applications are made on a larger scale.

Each chemical application has its own set of conditions that determine success or failure. The application must be at a dosage rate that is lethal to the target insect and applied with the correct droplet size. The most common form of adulticiding is ultra-low volume (ULV). Typically with ground applications, vegetated habitats may require up to three times the dosage rates that open areas require. This is purely a function of wind movement and its ability to sufficiently carry droplets to penetrate foliage. Environmental conditions may also affect the results of adulticiding. Wind determines how the ULV droplets will move from the spray equipment into the treatment area. Conditions of no wind will result in the material not moving from the application point. High wind, a condition that inhibits mosquito activity, will disperse the insecticide too widely to be effective. Light wind conditions (<10 mph) are the most desirable because they move the material through the treatment area and are less inhibiting to mosquito activity.

ULV application is avoided during hot daylight hours because thermal conditions will cause the small droplets to quickly rise and become completely ineffective on the adult mosquitoes. Generally, applications are made at night, when a thermal inversion is present, keeping the material near to the ground.

6 Monitoring Mosquito Populations

6.1 Immature Stage Mosquito Monitoring at the Refuge

Immature –principally larval stage– sampling will be conducted to monitor and gauge mosquito population levels. Routine surveillance occurs on a monthly, biweekly, or sometimes weekly schedule depending on season, habitat and other factors and conditions. Mosquito management activities are depicted generally through maps in Appendix K9. Monitoring consists of driving on levees to access points in the marsh, then walking into the marsh to sites where there is water present. Alternatively, some monitoring sites will require boat access through slough channels (i.e., Bair Island).
Monitoring involves approximately four to five people cover a unit on foot, searching for larvae. They collect samples and return them to the laboratory for identification. The average number of immature mosquitoes per dip is recorded for each section of the parcel, along with the species found. Sampling is done with standard 1-pint dippers. The dipper has a cup of molded plastic attached to either a telescoping aluminum handle or a hardwood dowel. The length of dipper handles can vary from 3-4 feet for obtaining shoreline samples to 4-6 feet for sampling hard to reach areas. Immature mosquito population estimates are obtained by averaging the number of larvae or pupae collected in several dips. Boat access will be permitted in some areas of the Refuge (e.g., Bair Island) with seasonal restrictions on access or based on known locations of listed species. Samples are examined in the field or laboratory for the abundance, species, and life-stage of mosquitoes present. This information is compared to historical records and used as a basis for treatment decisions.

6.2 Adult Stage Mosquito Monitoring at the Refuge

Collecting adult mosquitoes on or near the Refuge signals the movement of adults off the Refuge to feeding sources (human populations). Adult mosquito population monitoring information is generally used to determine whether to apply treatment for adult mosquitoes off the Refuge. Adult mosquito populations may be monitored on the Refuge through carbon dioxide-baited traps, New Jersey light traps, and landing rates. The mosquitoes are attracted to the trap by the sublimation of dry ice into carbon dioxide gas (CO_2), which simulates the exhaled respiratory gasses of birds and mammals. The trap consists of a central 6-inch diameter plastic cylinder housing a battery-driven motor and 2-blade fan. The trap is suspended below an insulated container filled with dry ice. A mesh bag is attached to the bottom of the cylinder to collect the mosquitoes. Mosquitoes attracted to the CO_2 are drawn in through the top of the trap and forced downward by the fan into the collection bag. Female mosquitoes thus collected are identified to species and counted. Samples are quantified as the number of females collected per trap-night. Traps require one day to set and access the next day to collect any specimens.

The New Jersey light trap is used in fixed locations where 110-volt electrical service is available. These traps consist of a 25 watt light bulb (the attractant) and a fan which are connected to a timer. During dusk, evening hours, and dawn, the trap is functioning and collecting night-flying insects into a jar that contains a pesticide strip. Jars are changed weekly. These traps are limited in that trap results are over a one week period, mosquitoes are killed when they enter the jar (rendering them useless for WNV testing), and different mosquito species show different levels of attraction to light sources, with mosquitoes in the genus *Aedes* showing the least attraction. Most significantly, these traps become less efficacious in areas of greater population density because of competing light sources. All traps will only be used in upland locations to protect sensitive habitat, when there is standing water on the Refuge, generally fall through spring.

Landing rates are also used as a supplementary method for measuring adult mosquito activity. The technique involves counting the number of mosquitoes that land on a person within a given amount of time. Landing rates are particularly effective for monitoring salt marsh mosquitoes, which readily bite during daylight hours. This method is used as a direct observation of the number of host-seeking

mosquitoes present. This information is used to supplement carbon dioxide-baited traps in the decision to apply treatment for adult mosquitoes generally off Refuge.

7 Disease Surveillance Activity

Disease surveillance is conducted year round. A variety of methods will be used on and off the Refuge to detect disease presence.

Dead wildlife. Testing of dead wild birds and squirrels is used to detect WNV in the area. This is the most sensitive method of detecting the presence of WNV and is usually the first indication of the presence of virus. Unlike WEE and SLE, this virus kills birds and affects tree squirrels. Moreover, it can be detected readily in their tissues. Birds in the corvid family (crows, ravens and jays) and raptors are especially susceptible. However, the virus has also been detected in shorebirds and waterfowl. Submission of dead birds and squirrels by the public is also solicited by the MADs. Residents are directed to call the California Department of Public Health's West Nile Virus hotline if they find a dead bird or squirrel ((877) WNV-BIRD). This information is conveyed to the MADs, which collects the bird or squirrel and submits it for testing.

Mosquito pools. MADs will collect live mosquitoes to test for the presence of a virus. Live trapping of mosquitoes will be permitted in upland areas of the Refuge (e.g., the Refuge's Environmental Education Center in Alviso, Inner Bair Island, and the Refuge's headquarters). Light traps are not used for adult mosquito disease surveillance because collected mosquitoes are killed upon entering the trap rendering them useless for virus detection. Host-seeking adult mosquitoes will be collected with carbon dioxide-baited traps. Carbon dioxide traps are portable battery-operated traps used to collect adults of nearly all species. The traps use dry ice –frozen CO_2- as the attractant, and adults are captured in a mesh bag. These traps are left out for a single night and picked up the following day, so adult mosquitoes are still alive and useful for virus testing. Traps sites will be selected by MAD staff, and usually require hanging on trees, large bushes or other structures. Open, wind-swept areas are typically avoided when setting traps. The trapping will assess taxonomy, abundance, and disease presence. Mosquito traps in the surrounding community of the Refuge will also inform potential disease presence on the Refuge. Although not on Refuge lands, it is believed that some of the mosquitoes collected in theses traps are produced by sources on the Refuge.

Sentinel Chickens. Sentinel chickens are an indirect way of monitoring for the presence of virus in the mosquito population. Chickens are maintained in outdoor cages where they are exposed to host-seeking mosquitoes. If bitten by an infected mosquito, these birds will develop an immune response. Blood samples are taken from the chickens bi-weekly to every two weeks to test for exposure to WNV, WEE, or SLE. Flocks of chickens are currently located in each of the counties where the Refuge is located. No sentinel flocks are maintained on the Refuge. Chickens have been used for many years to monitor mosquito populations in California for WEE and SLE. This method has not proven to be an effective early warning system for detecting WNV.

8 Treatment Options

MADs of the San Francisco Bay region employ an Integrated Pest Management approach to mosquito control that emphasizes permanent solutions such as wetland restoration, mechanical control of water levels or exchange, and/or includes the use of biorationals and larvicides (Appendix K2. Statement of Best Management Practices and Proposed Monitoring Plan for Coastal Region Mosquito and Vector Control Districts).

8.1 Habitat Enhancement/Restoration

Habitat enhancement and restoration can not only benefit wildlife, but benefit mosquito management as well. The Refuge is actively managing the South Bay Salt Pond Restoration Project (SBSPRP), the largest tidal wetland restoration project on the West Coast. When complete, the restoration will convert 15,100 acres of former commercial salt ponds at the south end of San Francisco Bay to a mix of tidal marsh, mudflat, managed pond, open water, and other wetland habitats. The Refuge is also in the process of restoring former salt evaporator ponds on the Bair Island complex to tidal habitats. The objectives of the proposed project are: (1) to restore 1,400 acres of high quality tidal marsh habitat, mudflat/aquatic habitat, and uplands habitat; (2) maximize the function and values of tidal marsh habitats in a timely manner in order to provide habitat for endangered species and other native wildlife; and (3) enhance the public's appreciation and awareness of the unique resources of Bair Island. Both projects will improve tidal circulation to marsh habitat which will reduce mosquito control efforts.

New water control structure in 2011 in New Chicago Marsh will allow for increased tidal flows through the diked marsh and will increase the habitat value for the salt marsh harvest mouse and other tidal marsh species. The new water management capability will also lead to less standing, stagnant water and therefore reduce mosquito habitat.

8.2 Physical Controls

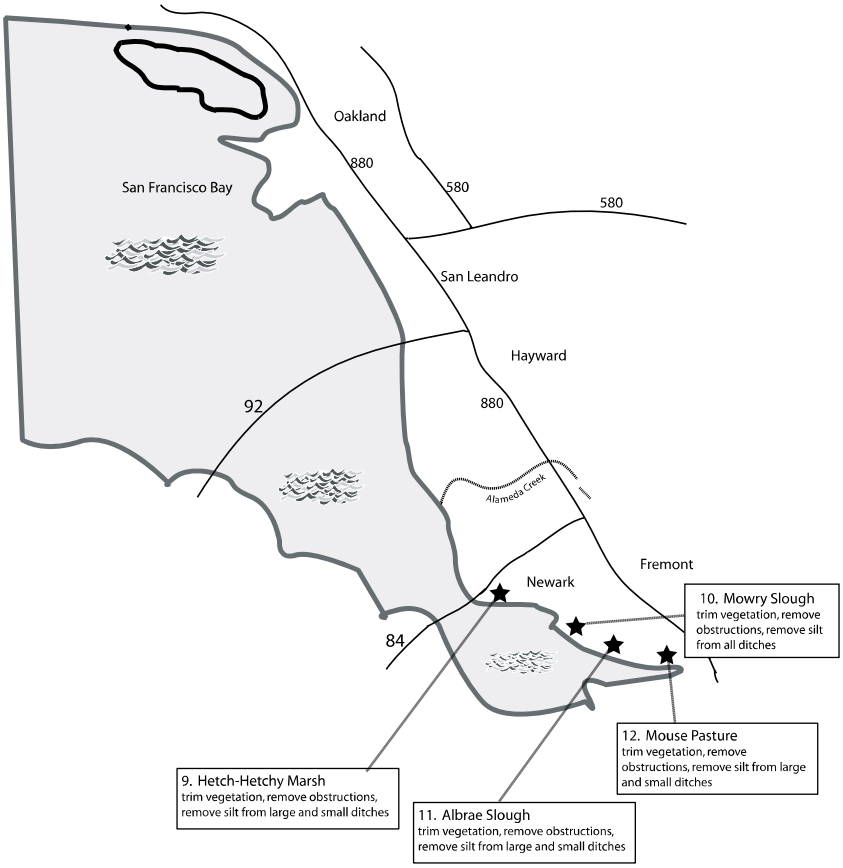
Physical controls that will also be coordinated between the Refuge and the MADs to reduce mosquito production include vegetation control and ditching.

Ditching

In the 1990s the Alameda MAD created ditches using a speed scavel ditcher and tractor to facilitate drainage and/or allow access of larvivorous fish in marshlands. Now hand ditching is used to maintain existing ditches and create minor ditches. Most of this type of ditching is to trim vegetation and keep small ditches open to tidal flow and keep access open for fish to move within the marsh. Hand ditching is done using shovels, rakes, pitch forks, hoes, machetes and power weed cutters. This is a low impact type of ditching. Personnel, typically a group of no more than eight employees, walk to the site, spoils are spread by hand and removed vegetation is spread away from the ditch. Such work is only done on the parts of the existing ditch system that need maintenance. Ditching activities only take place between the months of September to January in order to avoid peak nesting seasons for the California clapper rail. All ditching work is subject to a permit issued by the U.S. Army Corp of Engineers (ACE), in cooperation with the San Francisco Bay Conservation and Development District and the San Francisco Bay Regional Water Quality Control Board.

Currently the Alameda MAD conducts ditching activities in four locations on Refuge property: Hetch-Hetchy Marsh, Mowry Slough, Mouse Pasture, and Albrae Marsh/Pintail Marsh. The current ACE permit allows the Alameda MAD to maintain up to 2,150 linear feet at Hetch-Hetchy, 8,000 linear feet at Mowry Slough, 3,775 linear feet at Mouse Pasture, and 16,000 linear feet at Albrae Marsh/Pintail Marsh. In 2010/2011 the Alameda MAD performed maintenance on a combined total of 5,524 linear feet of ditches in these four areas. Figure 2 shows the areas ditching activities occur on Refuge property.

Figure 2. Ditching Activities on the Refuge in Alameda County



8.3 Biological Controls (B.s. and B.t.i.)

When physical controls are not enough and larval mosquito populations exceed thresholds, the use of biological controls will be used. Because there is a historical presence of disease in the Refuge area, use of biological controls will be permitted. There are two types of biological controls currently permitted for use on the Refuge: B.s. and B.t.i. Control strategies among the MADs differ based on district size, budget, available equipment, product efficacy, and restrictions on difference control materials/methods. New control products will be considered based on their effects compared to those products identified in this plan. Current control products used by the MADs are listed in Table 4, 5, and 6.

***Bacillus sphaericus* (B.s.)**

Description: *Bacillus sphaericus* is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments that is a common mosquito larvicide. The endotoxin destroys the insect's gut by a process similar to that of B.t.i. However, it is active against a narrower spectrum of mosquito species. Species in the genera *Aedes* and *Ochlerotatus* have lower susceptibility to B.s. and MAD field tests have shown that commercially available formulations of B.s. are not effective against the saltmarsh species *A. squamiger*. There are three formulations currently permitted for use on the Refuge: VectoLex WDG, VectoLex CG, VectoLex WSP. Formulations are generally broadcast by hand.

Product name: VectoLex CG, VectoLex G Granules, VectoLex WDG, VectoLex WSP

Advantages: B.s. is another bacterial pesticide with attributes similar to those of B.t.i. The efficacy of this bacterium is not affected by the degree of organic pollution in larval development sites and it may

actually cycle in habitats containing high densities of mosquitoes, reducing the need for repeated applications.

Barriers to use: Like B.t.i., B.s. must be consumed by mosquito larvae and is therefore not effective against non-feeding stages such as late instar larvae or pupae. B.s. is also ineffective against mosquitoes in the genus *Aedes*. Toxicity of B.s. to mosquitoes is due to a single toxin rather than a complex of several molecules as is the case with B.t.i. Development of resistance has been reported in other countries, where the material has been applied for extended periods of time. Knowing the stage and species present can increase the effectiveness of this material, restricting it to sources containing susceptible species. Development of resistance can be overcome by rotating B.s. with other mosquitocidal agents described in this document.

Impact on water quality: B.s. is a naturally occurring bacterium and is environmentally safe. It leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, B.s. is unlikely to have any measureable effect on water quality. There are no established standards, tolerances, or EPA approved tests. Other naturally occurring strains of this bacterium are commonly found in aquatic habitats.

***Bacillus thuringiensis var. israelensis* (B.t.i.)**

Description: *Bacillus thuringiensis israelensis* is an organism that produces a resting stage or spore whose walls contain five different microscopic protein pro-toxins packaged inside one larger protein crystal. The gut of mosquito larvae is unique in that it is an extremely alkaline environment (the stomach of vertebrate animals is acidic). When the crystal is ingested by mosquito larvae, the five proteins are released in the alkaline environment of the larva's gut. The five proteins are then converted into five different toxins by specific enzymes present in the gut of larvae. Once converted, these toxins work to destroy the gut wall. This leads to paralysis and death of the larvae.

Both liquid and granular formulations of B.t.i. are permitted for use on the Refuge. There are several formulations currently permitted for use on the Refuge: VectoBac G, VectoBac 12AS, Teknar HP-D, VectoBac WDG, Bactimos pellets, and Summit B.t.i. Briquettes. These formulations are appropriate for aquatic environments. Formulations are applied by ground (backpack spray, herd seeder, hand, low-volume spray, boom spray) via foot, all-terrain vehicle (ATV), ARGO, or applied aerially by helicopter.

Product names: Vectobac 12AS, Vectobac G, VectoBac WDG, Bactimos pellets, Teknar HP-D, Summit B.t.i Briquettes

Advantages: B.t.i. is highly target-specific and has been found to have significant effects only on mosquito larvae and closely related insects (e.g., black flies and midges). It is available in a variety of liquid, granular, and pelleted formulations, which provide some flexibility in application methods and equipment. B.t.i. has no measureable toxicity to vertebrates and is classified by the EPA as "Practically Non-Toxic" (i.e., Caution). B.t.i. formulations contain a combination of five different proteins with a larger crystal. These proteins have varying modes of action and synergistically act to reduce the likelihood of resistance developing in larval mosquito populations.

Barriers to Use: To be effective, *Bacillus* insecticides must be ingested by the mosquito larvae during feeding. Therefore, applications must be carefully timed to coincide with periods in the life cycle when larvae are actively feeding. Pupae and late fourth stage larvae do not feed and therefore will not be controlled by B.t.i. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of B.t.i. during very cold periods. High organic conditions also reduce the effectiveness of B.t.i. Therefore it is not feasible to use this material in sources with a high concentration of decaying organic material.

The cost per acre treated is generally higher for B.t.i. than for surface films. B.t.i. is used extensively by the MADs when appropriate, but other products may be used when later stages of mosquitoes are present.

Impact on water quality: B.t.i. contains naturally produced bacterial proteins generally regarded as environmentally safe. It leaves no residue and is quickly biodegraded. At the application rates used in mosquito control programs, B.t.i. is unlikely to have any measureable effect on water quality. There are no established standards, tolerances, or EPA approved tests. Other naturally occurring strains of this bacterium are commonly found in aquatic habitats.

Information on B.t.i. and B.s. treatments done in the Alameda County portion of the Refuge can be found in the attached document "Five Year History of Materials Applied at DESFBNWR" (Alameda County MAD). Vernal pools and diked or poor quality tidal marshes are primarily treated with B.t.i. products. Highly vegetated areas are most effectively treated with granular formulations that can penetrate the dense canopy. Occasionally an ARGO, Polaris ATV, or 4 wheel drive truck equipped with an intellispray reel is used to treat a source. An ARGO has been used to treat South Marsh-Munster, Stevenson Field, and Newark Golf Course. There are no known California clapper rails in these areas. The majority of ARGO usage at Stevenson Field is in the area under the Pacific Gas & Electric towers which is not part of the Refuge. The Polaris ATV would be permitted for use in designated non-sensitive areas of the Bailey Ranch Vernal Pools/Warm Springs area. No vehicle contact is made with the actual pools; the Polaris is used to circumnavigate the pool to effect treatment. At the Newark Golf Course the intellispray rig is frequently used for treatments. Two people are need to operate the reel, one to spray and another to guide the hose.

Table 4. Pesticides permitted for use on the Refuge in 2012 for Alameda County.

Trade Name	Type	Rate & Unit	Method	Equipment	Applications per year
VectoLex CG	Larvicide, B.s.	20 lbs./acre	Hand	Hand broadcast	Not to exceed 10
VectoLex WDG	Larvicide, B.s.	1.50 lbs./acre	hand	Hand broadcast	Not to exceed 10
VectoLex WSP	Larvicide, B.s.	50 ITUs/mg	hand	Hand broadcast	Not to exceed 10
VectoBac 12AS	Larvicide, B.t.i.	16 oz./acre	Backpack Spray, Low-Volume Spray, Aerial	ATV, Helicopter	Not to exceed 20
VectoBac G	Larvicide, B.t.i.	10 lbs./acre	Hand, Herd Seeder, Aerial	ATV, Helicopter	Not to exceed 20
Altosid Liquid Concentrate SR-20	Larvicide, Methoprene	1 oz./acre	Backpack, Boom Spray, Aerial	ATV, Helicopter	Not to exceed 10
Altosid Pellets WSP	Larvicide, Methoprene	10 lbs./acre	Hand	ATV	Not to exceed 10
Altosid XR Extended Residual Briquettes	Larvicide, Methoprene	35 lbs./acre	Hand	ATV	Not to exceed 10
Altosid Briquettes	Larvicide, Methoprene	4.90 lbs./acre	Hand	ATV	Not to exceed 10
Altosid XR-G	Larvicide, Methoprene	20 lbs./acre	Hand	Hand-held	Not to exceed 10
Mosquito Larvicide GB-1111 (Clarke)	Larvicide, oil	640 oz./acre	backpack spray, boom spray	ATV, truck	Not to exceed 5
Agnique MMF	Pupacide, Monomolecular film	128 oz./acre	backpack spray, boom spray	ATV, Truck	Not to exceed 2
Pyrenone 25-5	Adulticide,	0.87 oz./acre	Backpack Spray, boom	ATV	Not to exceed 2

	Pyrethrin		spray		

Table 5. Pesticides permitted for use on the Refuge in 2012 for San Mateo County.

Trade Name	Type	Rate & Unit	Method	Equipment	Applications per year
VectoBac 12AS	Larvicide, B.t.i.	32 oz./acre	Backpack Spray, Boom Spray, Low-Volume Spray, Aerial	ATV, Helicopter	Not to exceed 20
VectoBac G	Larvicide, B.t.i.	10 lbs./acre	Hand, Herd Seeder	Truck	Not to exceed 20
Teknar HP-D	Larvicide, B.t.i.	0.16 oz./acre	Backpack Spray, Boom Spray, Low-Volume Spray	Truck	Not to exceed 20
VectoBac WDG	Larvicide, B.t.i.	0.44 lbs./acre	Backpack Spray, Boom Spray, Low-volume Spray	ATV	Not to exceed 20
Altosid Liquid Concentrate SR-20	Larvicide, Methoprene	1 oz./acre	Backpack Spray, boom Spray, Low-Volume Spray, Aerial	ATV, helicopter	Not to exceed 20
Altosid Liquid Larvicide Mosquito Growth Regulator	Larvicide, Methoprene	4 oz./acre	Backpack Spray, boom Spray, Low-Volume Spray, Aerial	ATV, helicopter	Not to exceed 20
Altosid Pellets WSP	Larvicide, Methoprene	5 lbs./acre	hand	ATV	Not to exceed 20
Altosid XR-G	Larvicide, Methoprene	20 lbs./acre	hand	Hand broadcast	Not to exceed 20
Mosquito Larvicide GB-1111 (Clarke)	Larvicide, oil	640 oz./acre	backpack spray, boom spray	ATV, Truck	Not to exceed 5
Agnique MMF	Pupacide, Monomolecular film	128 oz./acre	backpack spray, boom spray	ATV, Truck	Not to exceed 2
Pyrenone 25-5	Adulticide, Pyrethrin	0.87 oz./acre	Backpack Spray, boom spray	ATV	Not to exceed 2

Table 6. Pesticides permitted for use on the Refuge in 2012 for Santa Clara County.

Trade Name	Type	Rate & Unit	Method	Equipment	Application per year
VectoLex CG	Larvicide, B.s.	20 lbs./acre	hand	Hand broadcast	Not to exceed 10
VectoLex WDG	Larvicide, B.s.	1.50 lbs./acre	hand	Hand broadcast	Not to exceed 10
VectoLex WSP	Larvicide, B.s.	50 ITUs/mg	hand	Hand broadcast	Not to exceed 10
VectoBac 12AS	Larvicide, B.t.i.	32 oz./acre	Backpack Spray, Boom Spray, Low-Volume Spray, hand, Aerial	Truck, Helicopter	Not to exceed 10
VectoBac G	Larvicide, B.t.i.	10 lbs./acre	Hand	Truck	Not to exceed 10
Teknar HP-D	Larvicide, B.t.i.	16 oz./acre	Backpack Spray, Boom Spray, Low-Volume Spray, Hand	Truck	Not to exceed 10
Bactimos pellets	Larvicide, B.t.i.	8 lbs./acre	Hand	Truck	Not to exceed 10
Summit B.t.i. Briquettes	Larvicide, B.t.i.	7000 ITUs/mg	hand	Hand broadcast	Not to exceed 10
Altosid Pellets WSP	Larvicide, Methoprene	5 lbs./acre	hand	Hand broadcast	Not to exceed 10
Altosid XR-G	Larvicide,	20 lbs./acre	hand	Hand broadcast	Not to exceed 10

	Methoprene				
Altosid Briquettes	Larvicide, Methoprene	4.90 lbs./acre	Hand	ATV	Not to exceed 10
Altosid XR Extended Residual Briquettes	Larvicide, Methoprene	35 lbs./acre	Hand	ATV	Not to exceed 10
Altosid Liquid Larvicide Mosquito Growth Regulator	Larvicide, Methoprene	4 oz./acre	Aerial, Backpack Spray, Low volume spray, boom spray, hand	Helicopter, truck	Not to exceed 10
Altosid Liquid Concentrate SR-20	Larvicide, Methoprene	1 oz./acre	Aerial, Backpack Spray, Low volume spray, boom spray, hand	Helicopter, truck	Not to exceed 10

8.4 Other Controls, Including Chemical Controls

When biological controls fail to manage larval and pupal mosquito populations below threshold levels, other controls may be considered. Larvicides, pupacides, adulticides that would be permitted for use include methoprene, Golden-Bear-1111, Agnique, and Pyrenone 25-5. Adulticides would be permitted only as a last resort, and with proof of mosquito-borne disease on the Refuge. Control strategies among the MADs differ based on district size, budget, available equipment, product efficacy, and restrictions on difference control materials/methods. New control products will be considered based on their effects compared to those products identified in this plan. Current control products used by the MADs are listed in Table 4, 5, and 6.

8.4.1 Larvicide

Methoprene

Description: Methoprene is a true analogue and synthetic mimic of a naturally occurring insect hormone called juvenile hormone (JH). JH is found during aquatic life stages of the mosquito; in other insects, it is most prevalent during the early instars. As mosquito larva mature, the level of JH steadily declines until the fourth-instar molt, when levels are very low. This is considered a sensitive period when all the physical features of the adult begin to develop. Methoprene in the aquatic habitat can be absorbed on contact and the insect's hormone system becomes imbalanced. When this happens during the sensitive period, the imbalance interferes with fourth-instar larval development. One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. For these and perhaps other reasons, methoprene is considered an insect growth regulator (IGR).

Product names: Altosid briquettes, Altosid Liquid Larvicide, Altosid pellets, Altosid SBG, Altosid XR briquettes, Altosid XRG

Advantages: Methoprene can be applied as liquid or solid formulation or combined with B.t.i or B.s. to form a "duplex" application. Methoprene is a desirable IPM control strategy since affected larvae remain available as prey items for the rest of the food chain. This material breaks down quickly in sunlight, and when applied as a liquid formulation it is effective for only 3-5 days. In the briquette form, methoprene can persist in a source for either 30 or 150 days, depending upon the product. The availability of different formulations provides options for treatment under a wide range of environmental conditions. Studies on non-target organisms have found methoprene to be nontoxic to vertebrates and most invertebrates at concentrations used by mosquito control. It can be used for mosquito control in sources of water that are consumed by humans.

Barriers to Use: Methoprene products must be applied (or present, if using a slow release formula) to the late fourth instar and/or pupal stages of mosquitoes. It is not effective against other life stages.

Monitoring for effectiveness is more challenging since mortality is delayed. Bringing samples of larvae in treated source water into the lab to observe normal or abnormal development is the best way to gauge if the treatment was effective. The use of methoprene may result in the delay of development of adult vernal pool crustacean, which may reduce the number of resting eggs (cysts) that are formed before vernal pools dry (Lawrenz 1984). Because of the effects of methoprene on vernal pool crustacean and a lack of information on how long the agents remain in the soil, methoprene will not be permitted for use in vernal pools at any time, in either wet or dry conditions.

Several formulations of methoprene are permitted for use on the Refuge: Altosid Pellets WSP, Altosid Briquettes, Altosid XR Extended Residual Briquettes, Altosid XR-G, Altosid Liquid Concentrate SR-20, and Altosid Liquid Larvicide Mosquito Growth Regulator. These formulations are both liquid and pellet forms. Formulations are applied by ground (hand, ATV, backpack sprayer, boom sprayer, low-volume spray) or aerially by helicopter. Methoprene is typically applied in one of two ways. The liquid form can be mixed with liquid B.t.i. to form a duplex which is applied in moderate to lightly vegetated areas. Any species of mosquito can be targeted. The second form, a pellet, is used to pretreat heavily vegetated areas that will be flooded by high tides, prime locations for *A. dorsalis* production.

8.4.2 Pupacide

When larvicide treatment fails, pupacide treatments may be considered. Golden Bear-1111 and Agnique Monomolecular Film will be permitted for use.

Surface Oils and Films

Description: Surface oils and films are applied to mosquito breeding sites to kill mosquito larvae and pupae. This oil produces a visible sheen on the water surface. This pesticide acts as a film preventing larvae, pupae, and emerging adult mosquitoes for obtaining oxygen at the water surface. Golden Bear-1111 is a "napthenic oil" (petroleum-based) applied only in closed water sources (e.g., ponds) and not in tidal waters. Depending on the product, the film may remain on the water's surface from a few hours to a few days.

Product Names: Golden Bear Oil (GB1111)

Advantages: These materials are efficacious in eliminating pupae. Treatments are simplified due to the spreading action of the surfactant across the water surface and into inaccessible areas. These surfactants are considered "practically nontoxic" by the EPA.

Barriers to Use: The drawback of using oils in habitats where natural enemies are established is that all surface-breathing insects, particularly mosquito predators, are similarly affected. GB1111 forms a visible film on the water surface. As a general rule, surfactants are used only after alternative control strategies have been considered and ruled ineffective. Ideally, surfactants should not be used in a rich macro-invertebrate habitat such as vernal pools. Surface oils are sometimes the only feasible choice in cases where the material must have the ability to spread on water.

Monomolecular Film (Poly (oxy-1,2-ethanediyl), α-Isooctadecyl-ω-hydroxyl)

Description: *Monomolecular Film (MMF)* is a non-ionic surfactant that has an alcohol base. The film produced by MMF reduces the surface tension of the water making mosquito larvae and pupae unable to attach, thus causing them to drown. Emerging adult mosquitoes or midges are unable to fully emerge and will drown. The film produced by MMF is not visible on the water surface and should not be used in areas that are subject to unidirectional winds greater than 10 mph or where surface water overflow or runoff is an issue. MMF is applied only in closed water sources (e.g., ponds) and not it tidal waters. Depending on the product, the film may remain on the water's surface from a few hours to a few days.

Product Names: Agnique MMF

Advantages: Agnique MMF is efficacious in eliminating pupae. Agnique forms an invisible monomolecular film that is visually undetectable. Treatments are simplified due to the spreading action of the surfactant across the water surface and into inaccessible areas. It is considered "practically nontoxic" by the EPA. Agnique is labeled "safe for use" in drinking water.

Barriers to Use: The drawback of using Agnique MMF in habitats where natural enemies are established is that surface-breathing insects, particularly mosquito predators, are similarly affected. As a general rule, Agnique MMF is used only after alternative control strategies have been considered and ruled ineffective. Ideally, it should not be used in a rich macro-invertebrate habitat such as vernal pools. Agnique MMF is sometimes the only feasible choice in cases where the material must have the ability to spread on water. However, this material is not very effective.

8.4.3 Adulticide

Natural pyrethrins (pyrethrum) are extracted from chrysanthemum flower heads, mainly *Chrysanthemum cinerarnaefolium*, grown commercially in parts of Africa and Asia. The six pyrethrins are esters of three cyclopentenolone alcohols: Pyrethrolone, cinerolone, and jasmolone combined with either chrysanthemic acid or pyrethric acid.

Synthetic pyrethroids may be effectively applied at much lower rates of active ingredient per acre. The synthetic pyrethroids are mimics of natural pyrethrum, a botanical insecticide. However, pyrethroids are not permitted on the Refuge at this time due to their impacts on non-target species.

Natural pyrethrum, sold under several trade names, is registered in California, but is used sparingly due to higher cost. Pyrethrins are the only adulticide permitted for use on the Refuge at this time. Only one formulation is allowed: Pyrenone 25-5, and only under extreme conditions such as presence of a mosquito-borne disease threat.

Pyrenone 25-5 is a California-registered natural pyrethrin formulation. Pyrenone 25-5 contains 5% pyrethrin and 25% piperonyl butoxide. Pyrenone 25-5 is applied as a ultra-low volume (ULV) spray via backpack sprayer or boom spray on an ATV with a dosage per acre of typically 0.87 oz./acre (equivalent to 0.0027 lbs. of pyrethrins and 0.0135 pounds of piperonyl butoxide per acre).

Pyrenone 25-5 is labeled for use by government mosquito control programs controlling mosquitoes on residential, industrial, recreational and agricultural areas as well as swamps, marshes, overgrown waste areas and pastures where adult mosquitoes occur.

9 Mosquito Control Treatment Effects

Under this plan, the MADs would conduct mosquito monitoring and surveillance, mosquito control through application of pesticides (i.e., larvicides, pupacides, and adulticides). Tables 4-6 summarize the pesticides that are currently permitted for use on the Refuge under this plan. Biological controls and chemicals allowed under this plan include B.s., B.t.i., methoprene, monomolecular films (Agnique, GB-1111) and pyrethrins (in conditions with an imminent mosquito-borne virus disease threat only).

9.1 Effects on non-target organisms

9.1.1 Vegetation

Impacts to vegetation could occur during access (on-foot, ARGOs) within tidal marsh to conduct mosquito management. The use of mechanized vehicles that traverse wetland areas (ARGOs and ATVs) have a much greater impact on vegetation than foot access, including the trampling and crushing of plants.

B.t.i. has practically no acute or chronic toxicity to vascular plants (USEPA 1998) (Appendix K5). The application of other pesticides, including adulticides, are not likely to adversely affect vegetation directly because the pesticides used for mosquito control are not known to harm plants. Pyrethrins are not expected to affect plants because the sodium channel mechanism of action for pyrethrins does not indicate that pyrethrins would be toxic to plants (USEPA 2006).

9.1.2 Other Invertebrates

Monitoring and surveillance activities are not expected to adversely affect non-target invertebrate populations. Biological and chemical treatment of mosquito populations on the Refuge has the potential to adversely affect non-target invertebrates and these are described below.

How reductions in certain invertebrate populations as a result of repeated pesticide applications would impact specific invertebrate-plant interactions (e.g., pollination) within tidal marsh and vernal pools of the Refuge are not known. However, because most pollinators do not have an aquatic lifecycle stage, it is likely that pollinators would not be affected by larvicide and pupacide application. Pollinators may be affected by adulticides which are broadcast in liquid form at ultra-low volume, but use of adulticides would only be used under extreme conditions and in limited areas. Moreover, application of adulticiding would occur during the evening which limits the target population primarily to mosquitoes and when generalist pollinators are not active.

The effect on local populations of invertebrate species over time with periodic and continued use of B.t.i. is inconclusive, but potential for negative effects is a possibility (Appendix K3, K4, and K5). Host range and effect on non-target organisms indicates that B.t.i. is relatively specific to the Nematocera suborder of Diptera, in particular filter-feed mosquitoes (Culicidae) and blackflies (Simuliidae) (Glare and O'Callaghan 1998). B.t.i. is pathogenic to some species of midges (Chironomidae) and Tipulidae, although to a lesser extent than mosquitoes and biting flies and is not reported to affect a large number of other invertebrate species (Glare and O'Callaghan 1998). B.t.i. concentration may be important with regard to effects on nontarget organisms. Of particular concern is the potential for B.t.i. to kill midge larvae (family Chironomidae). Chironomid (non-biting midge) larvae are often the most abundant aquatic insect in wetland environments and form a significant portion of the food base for other wildlife (Batzer et al. 1993; Cooper and Anderson 1996; Cox et al. 1998). Reduced invertebrate populations as a result of food web effects (e.g., reduction of nematoceran, Diptera) have been shown in studies of B.t.i. (Hershey et al. 1998). However, current surveys indicate abundance of aquatic invertebrates in vernal pools receiving mosquito control with B.t.i. and B.s. (I. Loredo, pers. comm.). See *9.1.7 Threatened and Endangered Species,* for more information on VPTS.

Because methoprene is a juvenile hormone (JH) mimic and all insects produce JH, there is concern about potential adverse effects on non-target aquatic insects when this pesticide is used for mosquito control (Appendix K6). As with B.t.i., there is concern regarding potential negative effects on chironomid larvae due to their importance in food webs. As with any pesticide, toxicity is a factor of dose plus exposure. At mosquito control application rates, methoprene is present in the water at very small concentrations (4-10 parts per billion, initially). With regard to exposure, chironomid larvae occur primarily in the benthos, either within the sediments and/or within cases constructed of silk and detritus. Thus, there may be differences with regard to exposure to methoprene between chironomid and mosquito larvae, the latter occurring primarily in the water column. The published literature on the effects of methoprene to chironomids is not as extensive as that for B.t.i. However, there is evidence for potential toxicity to chironomid and other aquatic invertebrates from methoprene treatments. In summary, there is evidence for significant adverse non-target effects from methoprene even when applied at mosquito control rates.

Monomolecular films (Agnique, GB-1111) are potentially lethal to any aquatic insect that lives on the water surface and requires periodic contact with the air-water interface to obtain oxygen (USFWS 2004).

The film interferes with larval orientation at the air-water interface and/or increases wetting tracheal structures, thus suffocating the organism. As the film spreads over the water surface, the treatment tends to concentrate the larvae, which may increase mortality from crowding stress (Dale and Hulsman 1990).

Under this plan, only pyrethrins (natural adulticides) could be applied when there is high risk of mosquito-borne disease (*Chapter 5*, *Threat Level 5*). Pyrethrins are known to cause acute toxicological effects to benthic invertebrates at rates used for mosquito abatement (USEPA 2006). Because pyrethrins are broad-spectrum insecticides, they are potentially lethal to most insects, including both terrestrial and benthic forms. All adulticides are very highly toxic to aquatic invertebrates in low concentrations (e.g., 1 ppb) (Milam et al. 2000). Because most adulticides can be applied over or near water when used for mosquito control, there are risks to aquatic invertebrates from direct deposition and runoff of the pesticides.

9.1.3 Fish

Mosquito monitoring and surveillance activities are not expected to adversely affect fish because these activities do not occur within open sub-tidal waters of the Refuge (e.g., sloughs, channels, open bay) and are not expected to adversely affect water quality (e.g., turbidity, dissolved oxygen). Negative effects on fish populations are not expected from proposed larvicides and pupacides (USEPA 1998, Appendix K3 and K4). B.t. is practically non-toxic to fish (Appendix K5). However, the application of adulticides has the potential to adversely affect fish populations (Gunasekara 2005). Pyrethroids are considered highly toxic to fish and invertebrates (Appendix K4 and K7).

The frequency of conditions that would require use of adulticides on the Refuge has been rare over the past few decades. This pattern suggests that future use of adulticides in discrete areas of the Refuge is unlikely, but if occurred, the frequency and scope of application is not likely to cause significant adverse effects to fish and invertebrate populations. To reduce impacts to fish, adulticides will only be permitted in upland areas and interior water bodies. They will be applied away from open water and navigable slough channels to reduce impacts to fish. Application would only occur during low tides to avoid potential impacts to fish that may move into the tidal marsh plain during higher high or extreme tides.

9.1.4 Reptiles and Amphibians

Reptiles are known to occur within both tidal and seasonal wetland areas of the Refuge. Amphibians are likely to occur in seasonal wetland and fresh water areas of the Refuge, including California tiger salamanders (CTS) in the vernal pool units (see *9.1.7*, *Threatened and Endangered Species*). Pesticide effects on reptiles and amphibians may occur through reductions in insects that serve as food source (Hoffman et al. 2008), and through direct individual effects from pesticide application or from trampling of individuals or habitat (e.g., access via ARGOs and ATVs). Methoprene may affect, but is not likely to adversely affect CTS, through the reduction of direct food sources (Rexrode and Jones 2011). With regard to adulticides, direct chronic effects have been found for the San Francisco garter snake from application of labeled rates of permethrin (synthetic pyrethroid, Hoffman et al. 2008). While this species does not occur on the Refuge, these findings suggest other reptiles may incur direct chronic effects. Aquatic organisms (e.g., tadpoles, CTS) may be highly sensitive to pyrethrins and use of the compound near water bodies or waterways must be carefully evaluated prior to its application (Gunasekara 2005). Because mosquito control is applied directly to vernal pools, CTS may be directly affected. The Refuge has monitored these populations for more than ten years. The effects of pesticides on CTS are unknown at this time. However, refuge surveys over the last several years indicate that there is continued, long-term presence of CTS in these pools. Only trained personnel and limited vehicle use (with restrictions) will be permitted near vernal pools in order to limit impacts to dispersing California tiger salamanders.

9.1.5 Birds

Impacts to birds that use the Refuge may occur during access for mosquito monitoring, surveillance and control, as well as the application of pesticides. There are three federally listed bird species that inhabit

the Refuge: the California clapper rail (*Rallus longirostris obsoletus*), the western snowy plover (*Charadrius alexandrinus nivosus*), and the California least tern (*Sterna antillarum browni*). These species are covered in *9.1.7*, *Threatened and Endangered Species*. There are many other bird species listed as Species of Special Concern by the California Department of Fish and Game that occur on the Refuge.

Birds may be temporarily flushed as a result of ground access via foot or mechanized vehicle, although birds will most likely return to roosting sites once operations have ceased in the area. It is anticipated that disturbance to most birds is likely to be low as a result of regular communication between the Refuge and the MADs on known nesting sites and other sensitive habitat locations, and limitations on marsh access in areas with nesting birds. However, repeated travel over the same areas creates paths through the marsh that increases access for predators.

B.t.i. has practically no acute or chronic toxicity to birds (USEPA 1998, Appendix K3 and K4). There is the potential for B.t.i. to kill midge larvae (family Chironomidae). Chironomid (non-biting midge) larvae can be abundant in wetlands and form a significant portion of the food base for other wildlife, including birds (Batzer et al. 1993; Cooper and Anderson 1996; Cox et al. 1998). As with B.t.i., there is concern regarding potential negative impacts to chironomid larvae from methoprene. Some studies have suggested methoprene impacts to other organisms that may form part of the food base for birds. McKenney and Celestial (1996) noted significant reductions in number of young produced in mysid shrimp at 2 ppb. Sub-lethal effects on the cladoceran, *Daphnia magna*, in the form of reduced fecundity, increased time to first brood, and reduced molt frequency have also been observed at lower concentrations of methoprene (Olmstead and LeBlanc 2001). Methoprene showed no toxicity to slight toxicity to birds at high concentrations and repeated exposure (Appendix K3 and K6, USEPA 2001). Monomolecular film is not known to cause direct chronic or acute avian toxicological effects to birds (Appendix K4). But monomolecular films are potentially lethal to any aquatic insect that lives on the water surface or requires periodic contact with the air-water interface to obtain oxygen (Appendix K3 and K4).

Pyrethrins are not considered toxic to birds (Milam et al. 2000, USEPA 2006) when applied at labeled rates. However, non-target effects to birds from pesticide application may occur as a result of reduced food base (e.g., Chironomid invertebrates). There is uncertainty with regard to pyrethrins, which have been shown to have no impact on large-bodied arthropods, but have been shown to reduce invertebrate populations, especially among small-bodied arthropods (Boyce et al. 2007).

Conversely, significant mosquito production and absence of mosquito control may negatively affect bird populations. Although mosquitoes themselves are a part of estuarine ecosystems, they are known vectors of disease, including diseases that cause harm to humans and wildlife (e.g., WNV). Mosquito-borne diseases such as WNV have shown to be lethal to wildlife. As of 2011, 326 bird species have been listed in the Center for Disease Control WNV avian mortality database (http://www.cdc.gov/ncidod/dvbid/westnile/birdspecies.htm, accessed May 2, 2011). The list includes wildlife that inhabit tidal marsh such as waterfowl, grebes, heron, egrets, cormorants, songbirds (wrens, yellowthroats, song sparrows), and rails (clapper rail, Virginia rail, common moorhen, American coot).

9.1.6 Mammals

Impact to mammals that use the Refuge may occur during the monitoring, surveillance and control of mosquitoes, as well as the application of pesticides. The federally endangered salt marsh harvest mouse (*Reithrodontomys raviventris haliocoetes*) occurs throughout tidal marsh of the Refuge and is addressed below. Adverse impacts to salt marsh mammals may occur as a result of marsh access via foot or mechanized vehicles for mosquito management activities. Vehicle effects on habitat include compacted soil and destroyed vegetation (Bias and Morrison 1993). In addition, repeated vehicle travel over the same areas creates paths through the pickleweed that increases access for predators. Vehicle travel can also disrupt daily activity (e.g. movements) of small mammals and has the potential to cause mortality of

individuals. Past and current aerial imagery from a variety of sources show visible paths where mechanized vehicles have traversed the marsh. In addition, boat, ARGO and foot travel can flush harbor seals which are particularly sensitive during the pupping season. Important seal haul out location exist in Corkscrew Slough (Bair Island), Calaveras Point and Mowry Slough.

The use of larvicides and pupacides for the purpose of mosquito management are not likely to directly affect native mammal populations of the Refuge (USEPA 1998). Adverse effects on mammals from B.t.i., methoprene, and monomolecular films are not expected (Appendix K3 and K4) when applied according to the label instructions. Extensive acute toxicity studies indicated that B.t.i. is virtually innocuous to mammals (Siegel and Shadduck 1992). These studies exposed a variety of mammalian species to B.t.i. at moderate to high doses and no pathological symptoms, disease, or mortality were observed. Methoprene is not considered toxic to mammals (Appendix K3, K4, and K6). Impacts to the mammalian community as a result of reduced invertebrate populations are not expected because many small mammal species that inhabit wetlands of the Refuge are herbivorous (invertebrates are not a primary component of their diet). Insectivorous species such as shrews (e.g., *Sorex ornatus*) do occur in wetlands of the Refuge, and reduced arthropod populations may impact food availability for these species. Impacts to fish-eating harbor seals could occur if population-level effects to fish occur through the use of adulticides directly in waters and slough channels (see *9.1.3, Fish*, above).

Under this plan, the use of pyrethrin pesticides on the Refuge is only permitted under specific conditions. Oral exposure of pyrethrins could occur through consumption of plants or plant parts that have been sprayed (ground-based application). A terrestrial exposure model showed no acute or chronic risks to mammal or bird species (USEPA 2006).

Conversely, significant mosquito production and absence of mosquito control may negatively affect mammal populations. Although mosquitoes themselves are a part of estuarine ecosystems, they are known vectors of disease, including diseases that cause harm to humans and wildlife (e.g., WNV). Mammals known to be infected by WNV include horses, bats, chipmunks, skunks, rabbits, and squirrels.

9.1.7 Threatened and Endangered Species

Vernal pool tadpole shrimp

The endangered vernal pool tadpole shrimp (VPTS) (*Lepidurus packardi*) occur in discrete habitats on the Refuge (e.g. Warm Springs) and spend their entire life cycle within the pools. Because mosquito control (B.t.i., B.s.) is applied directly to vernal pools, VPTS may be directly affected. Generally, these pesticides are not expected to affect aquatic invertebrates such as VPTS (Appendix K3), but detailed effects of pesticides on VPTS and CTS are unknown at this time. Other pesticides will not be permitted for use in the vernal pools. The Refuge has monitored these populations for more than ten years. These refuge surveys indicate continued, long-term presence of VPTS and CTS in these pools. Also, MAD staff would be required to receive training in order to access vernal pool areas.

Steelhead

The federally threatened Central California Coast steelhead (*Oncorhynchus mykiss*) has the potential to occur on the Refuge. Impacts to the steelhead are the same as those listed in *9.1.3, Fish*.

It is not anticipated that larvicides and pupacides will impact steelhead. The frequency of conditions that would require use of adulticides on the Refuge has been rare (last application was in 2006 at Outer Bair Island), suggesting that future use of adulticides in discrete areas of the Refuge is unlikely, but if occurred, the frequency and scope of application is not likely to cause significant adverse effects to fish and invertebrate populations. To reduce impacts to steelhead, adulticides will only be permitted in upland areas and interior water bodies. They will be applied away from open water and navigable slough channels to reduce impacts to fish. Application would only occur during low tides to avoid potential impacts to fish that may move into the tidal marsh plain during higher high or extreme tides.

North American green sturgeon
The federally threatened Southern Distinct Population Segment of North American green sturgeon (*Acipenser medirostris*) has the potential to occur on the Refuge, but is an infrequent visitor. Impacts to the North American green sturgeon are the same as those listed in 9*.1.3*, *Fish*.

It is not anticipated that larvicides and pupacides will impact the North American green sturgeon. The frequency of conditions that would require use of adulticides on the Refuge has been rare (last application was in 2006 at Outer Bair Island), suggesting that future use of adulticides in discrete areas of the Refuge is unlikely, but if occurred, the frequency and scope of application is not likely to cause significant adverse effects to fish and invertebrate populations. To reduce impacts to the North American green sturgeon, adulticides will only be permitted in upland areas and interior water bodies. They will be applied away from open water and navigable slough channels to reduce impacts to fish. Application would only occur during low tides to avoid potential impacts to fish that may move into the tidal marsh plain during higher high or extreme tides.

California tiger salamander
The federally threatened Central California Distinct Population Segment of the California tiger salamander (*Ambystoma californiense*) occurs in the Warm Springs sub-unit of the Refuge. California tiger salamanders occur in vernal pool habitats. The larvae develop in the vernal pools and ponds in which they are born, but California tiger salamanders are otherwise terrestrial and typically spend the dry summer and fall months in the burrows of small mammals. California tiger salamanders could be adversely affected by mosquito monitoring, surveillance, or control due to crushing from access on foot or by mechanized vehicles. Motor vehicles would be restricted to established roads and berms in vernal pool areas. Use of larvicides and pupacides (methoprene, monomolecular films, and adulticides are not permitted in vernal pool areas) may have an indirect adverse effect on the California tiger salamander by reducing the availability of invertebrate prey. California tiger salamanders could also be adversely affected as described under the *Reptiles and Amphibians* section, 9*.1.4*. Also, MAD staff would receive training to access vernal pool areas.

California clapper rail
The endangered California clapper rail forages, roosts and nests in tidal marsh channels where mosquito management could occur. Mosquito monitoring, surveillance, or control could adversely affect these species. Walking and especially ATV or ARGO driving in the marsh has the potential to disturb California clapper rails as well as crush nests, eggs, or chicks. Also, repeated travel over the same areas creates paths though the marsh that increases access for predators. Like other birds, as described in 9*.1.5*, *Birds,* mosquito control pesticides are not likely to have direct affects to California clapper rails. Instead, California clapper rails may be impacted indirectly by reduced invertebrate prey base as a result of adulticiding. However, this is a rarely used pesticide. It is not known what affect the frequent use of larvicides and pupacides in tidal marsh habitat would have on the invertebrate prey base of California clapper rails.

California least tern
The endangered California least tern forages in sloughs and large channels within the areas affected by this plan. However, they are more often found foraging in the Bay or in managed ponds, and are not likely to be adversely affected by mosquito monitoring, surveillance, or control if best management practices are followed (e.g., avoiding nesting areas). If population-level impacts to forage fish occur, then California least terns could be negatively impacted (see 9*.1.3*, *Fish*).

Western snowy plover

The Pacific Coast population of the western snowy plover is federally listed as threatened. Western snowy plovers may occasionally forage in areas affected by this mosquito management plan. However, they do not nest in areas affected by this plan, and are more likely to forage on mudflats or along tidal channels at low tide. Therefore they are not likely to be adversely affected by mosquito monitoring, surveillance, or control if the best management practices are followed. If population-level impacts to invertebrate prey occur, then western snowy plovers could be negatively impacted (See 9*.1.2*, *Other Invertebrates* and 9*.1.5*, *Birds*).

Salt marsh harvest mouse
The federally endangered salt marsh harvest mouse (SMHM) occurs throughout tidal marsh of the Refuge. Adverse impacts to SMHM and other wetland mammals may occur as a result of marsh access via foot or mechanized vehicles for mosquito management activities. According to observations, vehicle effects on habitat include compacted soil, destroyed vegetation, and documented the destruction of at least one salt marsh harvest mouse nest (Bias and Morrison 1993). In addition, repeated vehicle travel over the same areas creates paths through the pickleweed that increases access for predators. Lastly, they reported that vehicle travel can disrupt daily activity (e.g. movements) and has the potential to cause mortality of individual SMHM.

Contra Costa goldfield
Impacts to the federally endangered Contra Costa goldfields (*Lasthenia conjugens*) are the same as those listed in 9*.1.1*, *Vegetation*. Contra Costa goldfields generally begin to appear in April, and can be easily trampled and crushed by mechanized vehicles. Trucks and ARGOs would be restricted to established roads and berms in vernal pools areas. Only small, all-terrain vehicles will be permitted near vernal pools. Refuge staff will advise MAD staff on areas appropriate for motor vehicles. Only trained staff will be allowed to access vernal pools on foot in order to limit impacts to goldfields. Foot access by trained personnel is not expected to have a significant impact on Contra Costa goldfields. Contra Costa goldfields may also be indirectly affected by MAD staff spreading non-native plant species by foot within the listed plant's habitat.

Most pollinators do not have an aquatic lifecycle stage, making it unlikely that pollinators would be affected by larvicide and pupacide application. Adulticide is not permitted in vernal pool areas, making it unlikely that Contra Costa goldfield pollinators would be affected by adulticide.

10 Stipulations and Best Management Practices for Mosquito Monitoring, Surveillance, and Control

In order to minimize adverse effects to habitat and wildlife, the following best management practices will be required in all areas of the Refuge accessed for monitoring, surveillance, and control of mosquitoes.

General Stipulations

- The MADs will be required to minimize the use of pesticides (e.g., choosing less toxic materials, using smaller quantities of more toxic chemicals, conducting fewer applications) and continually investigate formulations and compounds that are least damaging to fish and wildlife (including invertebrate) populations.
- Each MAD will be required to review the past year's Pesticide Use Proposals and submit any changes in the pesticides or formulations of pesticides that they expect to use in the upcoming year. This information will be made available at or before the time of the annual meeting.
- New products will not be applied without prior Refuge approval.
- Mosquito control will be authorized on a biennial basis by a SUP. The SUP conditions will stipulate that all mosquito control work will be carried out under the guidance of pre-approved PUPs.

- Pesticides will be applied according to pesticide label instructions and per habitat type.
- Aerial mosquito control application is encouraged over ground-based application methods.
- Aerial mosquito control applications will avoid low level flight over water to access or exit the Refuge as possible, thus minimizing bird disturbance.
- Application of larvicides and pupacides will be discouraged during high tide events in order to avoid impacts to tidal marsh species.
- Unless permitted by the Refuge Manager, pesticide application should not occur within 100 feet of major natural sloughs and channels that can disperse into navigable waterways and open water.
- Application of pesticides will be informed by monitoring of mosquito vector populations and surveillance indicating location of disease prevalence.
- MADs will adapt methods to reduce ecological risk to the environment (e.g., boom height, droplet size, application rate) as new information on ecological risk and avoidance measures are identified by appropriate regulatory agencies.
- To reduce the spread of non-native invasive plants all construction equipment, vehicles and personnel gear will be cleaned of seeds, soil or plant material before arriving on site.
- Oil and other hazardous material spill contingency plans must be implemented.
- Marsh vegetation is to be hand mowed and removed down to the bare ground before dredging occurs to prevent harm to the salt marsh harvest mouse.
- Areas of marsh vegetation that are submerged in water do not need to be mowed before dredging occurs.
- Before excavation occurs, crews must walk ahead of the equipment and haze mice out of vegetation.
- When clearing vegetation from an area, begin mowing from the center of the area to be cleared and work toward the edges to avoid trapping mice in remaining patches of vegetation.
- Mowed vegetation should be cleared from the area and stockpiled for later re-use if possible.
- A final report on activities will be provided by MADs by the end of the treatment year. MADs will provide dates of mosquito sampling and treatment, mapped locations and methods of sampling/treatment sites, species of mosquito and their population indices/frequencies.

Motor Vehicle Operation:

- Mechanized vehicles will only be allowed on levees and existing roads unless approved by the Refuge Manager.
- Techniques for approved ARGO operations are such that limit impact, including: slow speeds; slow, several point turns; and using existing levees or upland to travel through sites when possible.
- Access along tidal channels and sloughs is restricted in order to reduce impacts to vegetation used as habitat by wildlife (e.g., nesting and escape habitat).
- MADs are required to attend Refuge-approved training on measures to avoid impacts to wetland wildlife and in identification of sensitive species.
- Aerial pesticide (larvicide or pupacide) application is encouraged over ground-based application methods in areas with endangered species.
- Boat access to Corkscrew Slough, Calaveras Point and Mowry Slough will be limited to the center channel during the harbor seal pupping season, March 15-June 15 to prevent flushing of pups from their mothers.

Endangered Species Habitat:

- Inspections and treatments will be primarily performed on foot, when possible.
- Aerial pesticide (larvicide or pupacide) application is encouraged over ground-based application methods in areas with endangered species.

- Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed access from February 1 to July 15 in areas that are inhabited by California clapper rails without authorization of the Refuge Manager.
- Access (via foot or mechanized vehicle) to seasonal pond habitats for the purpose of mosquito management would not be allowed access from March 1 to September 15 in areas used by nesting snowy plovers without authorization of the Refuge Manager.
- Trucks and ARGOs would be restricted to established roads and berms in vernal pools areas. Only small, all-terrain vehicles will be permitted near vernal pools. Refuge staff will advise MAD staff on areas appropriate for motor vehicles. Only trained staff will be allowed to access vernal pools on foot in order to limit impacts to dispersing California tiger salamanders.
- MAD staff will avoid driving and stepping on Contra Costa goldfields. Refuge staff will provide a map of known Contra Costa goldfield sites and MAD staff will avoid driving in these areas during Contra Costa goldfield germination (coincides with vernal pool draw down) and blooming period.
- Methoprene, monomolecular films, and adulticides will not be permitted for use in the vernal pool areas.

Use of Pyrethrins:

- Use of adulticides must meet the following criteria: (1) when mosquito-borne disease incidence has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge and (2) when there are no practical and effective alternatives to reduce a mosquito-borne, disease-based health threat.
- Adulticides must be approved for use by the Service's National IPM Coordinator.
- The application of pyrethrins must be limited to reduce impacts to habitat and wildlife (i.e., during the time period when there is a mosquito-borne virus detected on or in mosquito flight range of the Refuge, or high risk to public health was documented), but sufficient to ensure effective mosquito control.
- The application of pyrethrins should occur at an ultra-low volume (according to pesticide label instructions and per habitat type).
- If beneficial, the MAD should conduct simultaneous application of larvicides with the adulticide application to prevent future adult outbreaks.
- Application would only occur during low tides to avoid impacts to fish that may move into the tidal marsh plain during high tides.
- The application of pyrethrins should occur only where monitoring and surveillance data justify its use (e.g., incidence of mosquito-borne disease).
- Refuge staff and visitors must be notified prior to adulticide treatments. Information about treatment scheduling, location, and type of pesticide must be posted by the MADs in areas where treatments would occur when those areas could be accessible to Refuge staff or the public.
- The application of pyrethrins should occur only in specific, discrete areas where monitoring data justify its use.
- Pyrethrins will not be permitted for use in the vernal pool areas.

GLOSSARY

Adulticide. Killing adult mosquitoes or a pesticide that kills adult mosquitoes.

Arbovirus. Arthropod-borne virus. A viral disease carried and transmitted by mosquitoes or other arthropods.

Biological Integrity. Biotic composition, structure, and functioning at genetic, organism, and community levels comparable with historic conditions, including the natural biological processes that shape genomes, organisms, and communities. (See 601 FW 3 for more information on biological integrity.)

BMPs. Best management practices

CWA. Clean Water Act (33 U.S.C. 1251-1387)

Environmental Health. Composition, structure, and functioning of soil, water, air, and other abiotic features comparable with historic conditions, including the natural abiotic processes that shape the environment. (See 601 FW 3.)

Enzootic. A relatively consistent prevalence of disease in animals. The term is comparable to endemic, but refers to animals.

EPA. Environmental Protection Agency.

ESA. Endangered Species Act (16 U.S.C. 1531-1544).

Health Threat. For the purposes of allowing mosquito control on a particular refuge, the threshold of a "documented existing health threat" will be met when a positive virus (WNV, WEE, etc.) detection is made in humans, dead birds, mosquito pools, sentinel chickens, or horses in the vicinity of the Refuge, within the same county, and within the same annual mosquito season.

Integrated Pest Management (IPM). A sustainable approach to managing pests by combining biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks.

Larvicide. Killing mosquito larvae, or a pesticide that kills mosquito larvae.

MAD. Mosquito Abatement District

Mosquito-borne disease. An illness produced by a pathogen that mosquitoes transmit to humans and other vertebrates. The major mosquito-borne pathogens presently known to occur in the United States that are capable of producing human illness are the viruses causing eastern equine encephalitis, WEE, St. Louis encephalitis, West Nile encephalitis/fever, LaCrosse encephalitis, and dengue, as well as the protozoans causing malaria.

NEPA. National Environmental Policy Act (42 U.S.C. 4321-4347).

NMFS. National Marine Fisheries Service.

Non-target Organisms. Species or communities other than those designated for population control.

NPDES. National Pollutant Discharge Elimination System established by section 402 of the

NWRS. National Wildlife Refuge System.

Public Health Authority. A Federal, State, and/or local agency that has health experts with training and expertise in mosquitoes and mosquito-borne diseases and that has the official capacity to identify health threats and determine health emergencies.

PUP. Pesticide Use Proposal.

Pupacide. A pesticide that kills the pupal stage of mosquitoes.

PUR. Pesticide Use Report.

Refuge-Based Mosquitoes. Mosquitoes that are produced within, or occur on, a refuge.

Service. United States Fish and Wildlife Service.

Service-Authorized Agent. A contractor, cooperating agency, cooperating association, refuge support group, volunteer, or other party working on a refuge on behalf of the Service to help achieve the refuge purpose(s) or NWRS mission.

SLE. Saint Louis Encephalitis.

Surveillance (mosquito-borne disease). Activities associated with detecting pathogens causing mosquito-borne diseases, such as testing adult mosquitoes for pathogens or testing reservoir hosts for pathogens or antibodies.

ULV. Ultra-low volume.

Vector. An organism, such as an insect or tick, that is capable of acquiring and transmitting a disease-causing agent, or pathogen, from one vertebrate host to another, or the act of transmitting a pathogen in such a manner.

WEE. Western Equine Encephalitis.

WNV. West Nile Virus.

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APPENDIX K1. USFWS Interim Guidance for Mosquito Management on National Wildlife Refuges

In Reply Refer To:
FWS/ANRS-NR-WR/020301

Memorandum

To: Regional Directors, Regions 1-7
Manager, California/Nevada Operations Office

From: Director

Subject: Interim Guidance for Mosquito Management on National Wildlife Refuges

A draft policy on mosquito management for the National Wildlife Refuge System is expected to be released for public comment within the next few months. In the interim, and while the draft policy is undergoing public review, the attached document has been prepared to provide refuges with a Systemwide, consistent process for addressing mosquito management issues.

Because refuges with existing mosquito management programs have already begun the process for the current season, there will be a 6-month transition period during which these refuges should review their existing programs to ensure consistency with this guidance. Refuges with no current mosquito management program should follow the attached guidance when health threats from refuge-based mosquitoes are identified.

Mosquito management on national wildlife refuges can be a very controversial issue. The Service is committed to protecting the health of humans, wildlife, and domestic animals while maintaining our statutory and policy obligations for wildlife conservation.

For additional information, please contact Michael Higgins at (410) 573-4520.

Attachment

Cc: 3238-MIB-FWS/Directorate File
3238-MIB-FWS/CCU
3251-MIB-FWS/ANRS
670-ARLSQ-FWS/ANRS-DNRS
670-ARLSQ-FWS/ANRS-CPP
570-ARLSQ-FWS/ANRS-NR
570-ARLSQ-FWS/ANRS-NR-WR File
570-ARLSQ-FWS/ANRS-NR-WR Staff (Higgins)

FWS/ANRS-NR-WR:MHiggins:kem:2/22/05:703-358-2043
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NATIONAL WILDLIFE REFUGE SYSTEM
MOSQUITO MANAGEMENT GUIDELINES FOR 2005

With the spread of West Nile virus across the country, national wildlife refuges (NWRs) may come under increasing pressure to manage refuge-based mosquitoes (mosquito populations that are bred or harbored within refuge boundaries). In addition to West Nile virus, there may be other human or wildlife health concerns from refuge-based mosquitoes. The following document provides refuges with guidance in addressing mosquito-associated health threats in a consistent manner. Generally, refuges will not conduct mosquito monitoring or control, but these activities may be allowed under special use permits. When necessary to protect the health of a human, wildlife, or domestic animal population, we will allow management of mosquito populations on National Wildlife Refuge System (Refuge System) lands using effective means that pose the lowest risk to wildlife and habitats. In summary, the guidance provides for the following:

- Mosquito management can occur only when local and current monitoring data indicate that refuge-based mosquitoes are contributing to a human, wildlife, or domestic animal health threat.

- Refuges may use compatible nonpesticide options to manage mosquito populations that represent persistent threats to health.

- Refuges will collaborate with Federal, State, or local public health authorities and vector control agencies to identify refuge-specific health threat categories. These categories will represent increasing levels of health risks, and will be based on monitoring data.

- Management decisions for mosquito control will be based on meeting or exceeding predetermined mosquito abundance or disease threshold levels that delimit threat categories.

- In the case of officially determined mosquito-borne disease emergencies, we will follow the guidelines described in this document. Monitoring data are still required to ensure that intervention measures are necessary.

- All pesticide treatments will follow Service and Department of the Interior pest management and pesticide policies. In an emergency, the pesticide approval process can be expedited.

- Refuges must comply with Federal statutes and Service policies by completing the appropriate documentation prior to mosquito management activities taking place.

MOSQUITO MANAGEMENT GUIDANCE FOR 2005

Although the National Wildlife Refuge System (Refuge System) does not engage in mosquito control activities directly, under certain circumstances we will allow State or local vector control agencies to conduct mosquito control on refuge lands when it is necessary to protect the health and safety of humans, wildlife, or domestic animals.

In the management of the Refuge System, we will allow populations of native mosquito species to function unimpeded unless they cause a wildlife and/or human health threat. This interim guidance recognizes that mosquitoes are a natural component of most wetland ecosystems, but may also represent a threat to human, wildlife, or domestic animal health. When necessary to protect the health and safety of the public or a wildlife or domestic animal population, we will allow management of mosquito populations on Refuge System lands using effective means that pose the lowest risk to wildlife and habitats. Except in cases of officially determined health emergencies, any method we use to manage mosquito populations within the Refuge System must be compatible with the purpose(s) of an individual refuge and the Refuge System mission, and must comply with applicable Federal laws such as the Endangered Species Act. Compatible habitat management and pesticide uses for mosquito control must give full consideration to the integrity of nontarget populations and communities. They must also be consistent with integrated pest management strategies and with existing pest management policies of the Department of the Interior (Department) and the Service. We will allow pesticide treatments for mosquito population control on Refuge System lands only when local, current mosquito population monitoring data are collected and the data indicate that refuge-based mosquito populations are contributing to a human, wildlife, or domestic animal health threat.

Mosquito-Associated Health Threats on National Wildlife Refuges

A mosquito-associated health threat is defined as an adverse impact to the health of human, wildlife, or domestic animal populations from mosquitoes. A health threat determination will be made by the appropriate Federal, State, or local public health authority that has the expertise and the official capacity to identify human, wildlife, or domestic animal health threats. Documentation of a specific health threat on a refuge by a Federal, State, or local public health agency must be based on local and current mosquito population and/or mosquito-borne disease monitoring data.

A health emergency indicates an imminent risk of serious human disease or death, or an imminent risk to populations of wildlife or domestic animals. A health emergency represents the highest level of mosquito-associated health threats. Health emergencies will be determined by Federal, State, or local public health authorities and documented with local and current mosquito population and disease monitoring data.

Addressing Health Threats from Refuge-Based Mosquitoes

Prior planning to address mosquito-associated health threats and emergencies is strongly encouraged. Refuges where health threats have been documented (see below) are encouraged to

work collaboratively with Federal, State, or local public health authorities and vector control agencies to develop integrated pest management (IPM) plans for monitoring and potentially managing refuge mosquito populations. Development of such plans (Exhibit 1) is particularly important for refuges currently lacking a mosquito monitoring/management program, but where a potential health threat has been identified by public health authorities. These refuge-specific IPM plans will outline the conditions under which monitoring and mosquito population management would occur (exhibit 1). Development of a mosquito management IPM plan during a health emergency is not appropriate; refer to the section below that addresses emergency procedures.

Nonpesticide Options and Best Management Practices for Mosquito Control

When necessary to protect human, wildlife, or domestic animal health, we will reduce mosquito-associated health threats using an integrated pest management (IPM) approach, including, when practical, compatible, nonpesticide actions that reduce mosquito production. The procedures described in this section may be considered long-term options to reduce persistent mosquito-associated health threats. Except in officially determined health emergencies, any procedure we use to reduce mosquito production must meet compatibility requirements as found in 603 FW 2 and must give full consideration to the safety and integrity of nontarget organisms and communities, including federally listed threatened and endangered species.

- For native or nonnative species of mosquitoes, we will remove or otherwise manage artificial breeding sites such as tires, tanks, or other similar debris/containers, where possible, to eliminate conditions that favor mosquito breeding regardless of health threat conditions.

- When enhancing, restoring, or managing habitat for wildlife, we will consider using specific actions that do not interfere with refuge purposes or wildlife management objectives to reduce mosquito populations. Examples include water-level manipulation that disrupts mosquito life cycles, including timing and rate of flood-up and drawdown of managed wetlands, and/or vegetation management to discourage egg laying by mosquitoes. Except when determined appropriate during human or wildlife health emergencies, we prohibit habitat manipulations for mosquito management that conflict with wildlife management objectives, such as draining or maintaining high water levels inappropriate for other wildlife.

- We will consider the introduction of predators for mosquito management only if we can contain such introductions. Such introductions must have demonstrated efficacy, have been evaluated by the refuge with respect to potential adverse impacts to nontarget organisms and communities, not interfere with the purpose(s) of the refuge or other refuge management objectives, and not adversely affect federally listed species. We must have appropriate procedures in place for all species introductions to ensure that we do not release other species with the desired introductions. Any introduction of a nonnative predator requires a compatibility determination, a written plan for containment of the introduced species to the desired location(s) and, if applicable, an Endangered Species Act (ESA), section 7(a)(2), consultation examining the evaluation of potential effects of

the introduced predator on federally listed threatened or endangered species. In compliance with Executive Order 13112, we will not authorize any activities likely to cause or promote the introduction or spread of invasive species (see 601 FW 3).

Monitoring Mosquito Populations

We recognize the importance of monitoring mosquito populations to document species composition and estimate their size and distribution because this information is used to make integrated pest management decisions. We will allow compatible monitoring of mosquito populations on Refuge System lands by State/local public health authorities or vector control agencies.

The goal of mosquito monitoring is to detect relative changes in population sizes that can indicate an increased risk to human, wildlife, or domestic animal health (see section on action thresholds below). In addition, adult mosquitoes collected with certain traps can be tested for the presence of pathogens. Mosquito abundance data is recorded by the manner in which the mosquitoes are collected. The standard tool for monitoring larval and pupal mosquito populations is a long-handled 500 ml "dipper". The tool is dipped at several locations within a mosquito breeding habitat and the number of larvae and pupae recovered is recorded. The density of mosquitoes within a specific habitat is recorded as the average number per dip. Adult mosquitoes are collected with a number of different portable or semi-permanent traps, and abundance is usually recorded, by species, as number of individuals per trapping period. Although some vector control agencies use the number of biting mosquitoes landing on a human subject per minute to assess mosquito abundance, this technique is not recommended on refuges due to the increased risk of the subject acquiring a mosquito-borne pathogen.

We will allow compatible monitoring of larval and adult mosquito populations on refuges under special use permits (SUPs) issued by individual refuges. To avoid harm to wildlife or habitats, access to traps and sampling stations must meet the compatibility requirements found in 603 FW 2 and may be subject to refuge-specific restrictions. Where federally listed species are present, monitoring methods must undergo an ESA, section 7(a)(2), consultation in order to determine whether or not such monitoring programs will adversely affect the listed species.

Mosquito-Borne Disease Monitoring

The purpose of mosquito-borne disease monitoring is to detect the presence of mosquito-borne pathogens and estimate the relative intensity of disease transmission over time. The data collected in such monitoring is used to estimate health risks to humans, wildlife, or domestic animals, and to make mosquito management decisions based on the level of risk. The ultimate goal in mosquito-borne disease monitoring is to detect disease activity prior to any human infection. Early detection of pathogenic activity, combined with up-to-date mosquito population monitoring, can allow for timely intervention measures to occur and thus potentially lessen the impact of disease on humans, wildlife, and domestic animals.

Federal and/or State/local public health and wildlife management authorities can use documentation of previous or current mosquito-borne disease activity near the refuge to identify

a potential health threat. We will obtain mosquito-borne disease activity information from State/local public health authorities.

Refuge personnel will note dead or sick wildlife during their routine outdoor activities. In most cases, this will only involve passive surveillance for affected wildlife. Refuges will identify a facility that will test dead or sick wildlife for mosquito-borne pathogens. This may be a State or local laboratory or the National Wildlife Health Center. Refuge personnel will receive instruction on proper procedures for safely collecting, handling, shipping, or disposing of potentially infected wildlife (refer to guidelines developed by the National Wildlife Health Center: http://www.nwhc.usgs.gov/research/west_nile/wnv_guidelines.html). If wildlife specimens from a refuge test positive for mosquito-borne disease, we will provide these results to the State/local public health authorities, State fish and wildlife agencies, and the refuge supervisor immediately.

State/local public health authorities or vector control districts will generally be responsible for other disease surveillance methods, such as monitoring disease activity in reservoir hosts for pathogens or antibodies, and collecting adult mosquito samples using live traps and testing them in same-species pools for virus. These activities must meet the compatibility requirements of 603 FW 2, and we must authorize the activities. We discourage using caged sentinel chickens on refuges for reservoir host surveillance due to the risk of spreading disease to wild birds.

Individual refuges may allow compatible disease surveillance activities under SUPs or other agreements. To avoid harm to wildlife or habitats, access to traps and sampling stations must meet the compatibility requirements found in 603 FW 2 and may be subject to refuge-specific restrictions. Where federally listed species are present, monitoring methods must undergo an ESA, section 7(a)(2), consultation in order to determine whether or not such monitoring programs will adversely affect the listed species.

Risk Assessment

The first step in addressing mosquito management on a refuge is notification by the appropriate Federal, State, or local public health authority of a potential mosquito-associated health threat. Federal and/or State/local public health authorities with expertise in mosquitoes and mosquito-borne disease will identify and document a potential mosquito-associated human health threat and notify the refuge manager. Appropriate documentation may include species-specific larval or adult mosquito monitoring data from the refuge or areas adjacent to the refuge that indicate an abundance of species known to vector one or more endemic/enzootic diseases or otherwise adversely impact human health. For refuges with current mosquito monitoring programs, such documentation should already be in place. For refuges without an ongoing mosquito or disease monitoring program, documented mosquito-borne disease activity near the refuge would also identify a health threat (refer to section below on emergencies, if applicable). The identification and documentation of a potential mosquito-associated health threat does not necessarily imply a need to manage mosquito populations, but may indicate the need to initiate on-refuge monitoring (if not already underway) and contingency planning should mosquito management become necessary.

Health threat determinations will be made at the local level, based on the historical incidence of mosquito-borne health threats and current, local monitoring of mosquito populations and disease activity. When a potential health threat has been documented, we will work with local, State, or Federal public health authorities with expertise in mosquito-borne disease epidemiology to identify refuge-specific categories of mosquito-associated human health threats based on monitoring data. Where local or State public health expertise in mosquito-borne disease epidemiology is lacking, we will consult with the Department of Health and Human Service's Centers for Disease Control and Prevention (CDC) to develop these categories. Health threats lie along a continuum in potential severity from secondary infection of mosquito bites to lethal infection by a mosquito-borne pathogen. Health threat categories will reflect increasing severity and risks to health (table 1).

Federal and/or State/local public health authorities with jurisdiction inclusive of refuge boundaries will make actual mosquito-associated human health threat level determinations using current local monitoring data and take the appropriate response(s) developed for that threat category (table 1). We will also respond appropriately to determinations made by neighboring State/local public health authorities. Mosquito-associated wildlife health threat determinations will be made by wildlife health experts from Federal or State wildlife agencies.

Action Thresholds

We expect mosquito-associated health threat levels to vary over time and space. In general, the health threat levels can be expected to be relatively static, changing only when monitoring data indicate significant changes in mosquito populations and/or disease activity. When monitoring data indicate an increasing risk to human and/or wildlife health, health threat levels may be increased (table 1). Action thresholds are mosquito population levels and/or levels of disease activity that, once reached, indicate an increased health risk and trigger additional response. We will establish numerical action thresholds in collaboration with Federal and/or State/local public health authorities and vector control agencies.

Mosquito abundance action thresholds represent mosquito population levels that may require intervention measures or more intense surveillance. It is important to consider the limitations of such numerical action thresholds, especially in the context of minimizing disease transmission. Thresholds are developed considering many factors which include, but are not limited to, those listed in table 2. Unfortunately, very few scientifically-determined estimates of mosquito abundance have been defined as threshold values for any mosquito species in the context of limiting disease transmission. Vector control agencies usually develop threshold values for their own immediate use based on years of experience. However useful such values are for limiting human annoyance from biting mosquitoes, these values often cannot be practically validated with respect to being accurate thresholds of disease transmission. Thus, in the absence of scientifically-determined threshold data, there will necessarily be some subjectivity in establishing numeric thresholds for mosquito abundance.

The factors identified in table 2 can be used as a guide in establishing numeric thresholds collaboratively with public health authorities and vector control agencies. When establishing mosquito abundance thresholds in the context of mosquito-borne disease, it is appropriate to

consider the current and historical incidence of disease and the vector potential of the species. Also note that numerical thresholds can be raised or lowered depending upon current conditions (e.g., environmental conditions, abundance of mosquito predators, presence of pathogens; see table 2).

Thresholds will be species specific (or species-group specific) for larval, pupal, and adult mosquito vectors and reflect the potential significance of a particular species or group of species in to a particular health threat. For example, mosquito vector species known to be important in the transmission cycle of a disease may have a lower action threshold than species with lesser transmission roles. We will implement intervention measures only when current mosquito population estimates, as determined by current mosquito monitoring data, meet or exceed action thresholds.

Treatment Options

Mosquito population management will be based on the level of health threat identified. The appropriate response to a health threat will be based on the level of severity and risk associated with that particular threat (table 1).

We will choose treatment based on our pest management policy (30 AM 12). We will base the choice on, in order of preference: human safety and environmental integrity, effectiveness, and cost. We will use human, wildlife, and/or domestic animal mosquito-associated health threat determinations combined with refuge mosquito population estimates to determine the appropriate refuge mosquito management response (table 1). Where federally listed threatened or endangered species are present, we will use ESA, section 7(a)(2), consultation information to assist in the decision-making process.

We will consider allowing pesticide treatments to control mosquitoes on Refuge System lands after we evaluate all other reasonable IPM actions (see above). We will determine the most appropriate pesticide treatment options based on monitoring data for the relevant mosquito life stage. We will use current monitoring data for larval, pupal, and adult mosquitoes to determine the need for larvicides, pupacides, and adulticides, respectively. We will allow the use of adulticides only when there are no practical and efficacious alternatives to reduce a health threat. We will not allow pesticide treatments for mosquito control on Refuge System lands without current mosquito population data indicating that such actions are warranted. We require an approved pesticide use proposal (PUP) prior to application of a pesticide to Refuge System lands.

Emergency Procedures

Federal, State, or local public health authorities may officially identify a mosquito-borne disease human health emergency based on documented disease activity in humans, wildlife, or domestic animals. A human health emergency indicates an imminent risk of serious human disease or death. Public health authorities may request pesticide treatments to Refuge System lands to decrease mosquito vector populations and lower the health risk to humans. Refuges with ongoing mosquito monitoring programs should have addressed potential emergency situations

and appropriate responses within those documents. Refuges without an ongoing monitoring program should immediately contact their refuge supervisor and Regional IPM coordinator in the event of an emergency and review the steps listed below. Even in emergency situations, we will only allow pesticide treatments for mosquito population control on Refuge System lands when local and current mosquito population monitoring data are available and the data indicate that refuge-based mosquito populations are contributing to a human and/or wildlife health threat. In the context of a mosquito-borne disease emergency, appropriate documentation would include identification of infected mosquitoes or abundant populations of vector species within refuge boundaries. In mosquito-borne disease emergency situations, we will undertake the following:

- If no mosquito population data are available for the refuge, we will request (or undertake, if applicable) short-term (24 hours or less) monitoring of adult and/or larval mosquito populations on the refuge to ensure that intervention is necessary.

- We will complete and submit a pesticide use permit (PUP) to the Regional IPM coordinator and Washington Office IPM coordinator, if applicable, for emergency review. Actual use of any pesticide will be contingent on current mosquito population monitoring data indicating intervention with pesticides is warranted. However, in an emergency we will not wait for monitoring results to initiate the PUP process, and we will expedite the review of PUPs.

- If there is no site-specific National Environmental Policy Act (NEPA) documentation for the proposed emergency intervention measure(s), contact the Regional NEPA coordinator for guidance (see below).

- If federally listed species are present and an ESA, section 7(a)(2) consultation has not been completed for the potential intervention measures, we will contact the local Ecological Services (ES) office for recommendations (see below).

- We will notify refuge employees and visitors of the increased human health risk and provide information for personal protection against mosquito-borne disease. Where appropriate, we will consider restricting or closing all or part of the refuge to visitors and restricting outdoor activities of employees.

- If monitoring data indicate that intervention with pesticides is warranted, we will prepare an SUP for pesticide application(s), in which we may identify pertinent conditions and restrictions on pesticide application activities to ensure compatibility.

- Following pesticide applications, we will require (or undertake, if applicable) additional mosquito population monitoring to assess the efficacy of the pesticide treatment(s).

Communication and Conflict Resolution

It is important to develop a communication plan with public health and vector control agencies, particularly in regard to addressing emergencies. Timely communication at the outset of an emergency will speed any necessary response. Contact information should be shared among

agencies, and refuges should have the necessary contact information of appropriate Service personnel to expedite any needed compliance documentation (see below).

Mosquito management on NWRs can be a very controversial issue, especially with regard to applying pesticides to control mosquito populations. Developing health threat categories and establishing action thresholds in collaboration with public health and vector control agencies can be a difficult process. This may be especially true in establishing mutually-agreed upon action thresholds, where the science is often lacking and the numbers become somewhat subjective. In cases where agreements cannot be reached, we will work with the public health and vector control agencies to identify third-party agencies or individuals with appropriate expertise in mosquito biology and vector-borne disease ecology for further guidance.

Compliance Documentation

The following statutes and policies may be relevant to mosquito management activities on refuges. In most cases, proper documentation must be in place prior to any mosquito management occurring.

A. National Environmental Policy Act (NEPA) (42 U.S.C. 4321-4347).

(1) Categorical Exclusions. Under most circumstances, we can categorically exclude monitoring and surveillance activities under existing Department NEPA procedures for data collection and inventory (516 DM 2, appendix 1.6; and 516 DM 8.5B(1), see 516 DM 2, appendix 2, for exceptions to categorical exclusions). In addition, some habitat management actions as described above may be categorically excluded. If a proposed refuge mosquito management activity qualifies as a categorical exclusion, refuges should document that determination by preparing an environmental action statement (EAS). We generally cannot categorically exclude intervention measures such as pesticide applications for mosquito-borne health threats.

(2) Environmental Assessments. Refuges that have completed the NEPA process for mosquito management should ensure that they addressed the environmental consequences of potential intervention measures for mosquito-associated health threats. Refuges that have not completed the NEPA process for mosquito management should prepare an environmental assessment (EA) if they can reasonably expect to need intervention measures (e.g., pesticide applications). You may reasonably expect intervention measures if the State/local public health agency has documented a potential health threat from refuge-based mosquitoes. In a nonemergency situation, when a State/local public health agency documents a potential threat, you must complete an EA with the appropriate finding (such as a finding of no significant impact (FONSI)) prior to any substantial intervention activities. You must consider local conditions in an EA. When assessing the potential environmental effects of pesticide applications, consider such factors as the spatial and temporal extent of the treatment, the toxicity and specificity of the proposed pesticide(s) to fish and wildlife populations, the persistence of the proposed pesticide(s), and the alternatives to the proposed action (e.g., different pesticides, using larvicides versus adulticides, compatible habitat management). To minimize potential impacts, identify and document restricted areas and activities in an EA.

(3) Emergencies. In a health emergency, you may need to take immediate intervention measures without completing a NEPA review. If such measures cannot be categorically excluded, contact the Regional NEPA coordinator who will consult with the Council on Environmental Quality (CEQ) for guidance. The CEQ may require follow-up documentation once the emergency has passed. Once an emergency has passed, you must complete proper NEPA documentation that addresses future mosquito management activities on the refuge.

B. Endangered Species Act (16 U.S.C. 1531-1544). Comply with ESA, section 7(a)(2), for listed species. You should complete this prior to an emergency. In order to complete consultation in a timely manner, please submit consultation documents at least 135 days prior to proposed mosquito management activities. Note that the Department pesticide use policy (517 DM 1) and the Department/Service pest management policy (30 AM 12) do not allow for adverse impacts to listed species from pesticides. Should a health emergency occur prior to the completion of an ESA, section 7(a)(2), consultation, contact the local ES office for recommendations. An "after-the-fact" consultation may be required once the emergency has passed.

C. Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 136 *et seq*.). On Service lands, we may only use pesticides that are registered with the Environmental Protection Agency. We must apply them according to the pesticide label directions.

D. Compatibility Determination (50 CFR 26.41 and 603 FW 2). We must complete a compatibility determination before allowing surveillance and intervention activities to be undertaken by an outside agency. However, we may waive this requirement in a health emergency involving humans, wildlife, and/or domestic animals. In health emergencies involving wildlife, we will consult with the State fish and wildlife agency. In health emergencies involving domestic animals, we will consult with the State Agricultural Department.

E. Pest Management and Pesticide Use Policies (516 DM 1 and 30 AM 12). Follow all Department and Service pest management and pesticide use policies. Before applying any pesticide to Refuge System lands, you must have a PUP reviewed and approved by the appropriate Regional or National IPM coordinator. The National IPM coordinator must approve the use of all adulticides. We can expedite PUP approvals in a health emergency. If an outside agency conducts pesticide applications, as will usually be the case, we require an SUP, memorandum of understanding, or other agreement. The agreement will detail the justification for pesticide applications, identify the specific areas to be treated, and list any restrictions or conditions that must be followed before, during, or after treatment.

Table 1. Example of Mosquito-Borne Disease Health Threat and Response Matrix

Current Conditions		Threat Level	Refuge Response
Health Threat Category[1]	**Refuge Mosquito Populations[2]**		
No documented existing or historical health threat/emergency	No action threshold	**1**	Remove/manage artificial mosquito breeding sites such as tires, tanks, or similar debris/containers. Allow compatible monitoring.
Documented historical health threat/emergency	Below action threshold	**2**	Response as in threat level 1, plus: evaluate compatible nonpesticide management options to reduce mosquito production.
	Above action threshold	**3**	Response as in threat level 2, plus: allow compatible site-specific larviciding of infested areas as determined by monitoring.
Documented existing health threat (specify multiple levels, if necessary; e.g., disease found in wildlife, disease found in mosquitoes, etc.)	Below action threshold	**4**	Response as in threat level 2, plus: increase monitoring and disease surveillance.
	Above action threshold	**5**	Response as in threat levels 3 and 4, plus: allow compatible site-specific larviciding, pupaciding, or adulticiding of infested areas as determined by monitoring data.
Officially determined existing health emergency	Below action threshold	**6**	Maximize monitoring and disease surveillance.
	Above action threshold	**7**	Response as in threat level 6, plus: allow site-specific larviciding, pupaciding, and adulticiding of infested areas as determined by monitoring.

[1] Health threat/emergency as determined by Federal and/or State/local public health or wildlife management authorities with jurisdiction inclusive of refuge boundaries and/or neighboring public health authorities.

[2] Action thresholds represent mosquito population levels that may require intervention measures. Thresholds will be developed in collaboration with Federal and/or State/local public health or wildlife management authorities and vector control districts. They must be species and life stage specific (see text).

Table 2. Factors to be considered in establishing thresholds for use of larvicides/pupacides/adulticides to control mosquitoes to address human health threats.

Factor	Description	Consideration
Mosquito species	Mosquito species vary in the following: their ability to carry and transmit disease; flight distances; feeding preference (birds, mammals, humans); seasonality; and type of breeding habitat	These factors should be considered when establishing adult and larval thresholds. Often the species and biology of the mosquito will be more important in developing thresholds than the relative abundance.
Proximity to human populations	The distance from potential mosquito habitat on NWRs to population centers (numbers and density).	The potential to produce large numbers of mosquitoes in close proximity to population centers may result in less tolerance or lower thresholds for implementation of mosquito control on NWRs.
Weather patterns	Prevailing wind patterns, precipitation, and temperatures.	Prevailing wind patterns that carry mosquitoes from refuge habitats to population centers may require lower thresholds. Inclement weather conditions may prevent mosquitoes from moving off-refuge resulting in higher thresholds.
Cultural mosquito tolerance	The tolerance of different populations may vary by region of the Country and associated culture and tradition.	In many parts of the Country, mosquitoes are accepted as a way of life, resulting in higher mosquito management thresholds. NWRs in highly populated areas may require lower thresholds because of the intolerance of urban dwellers to mosquitoes.
Adults harbored, but not produced, on-refuge	Refuge provides resting areas for adult mosquitoes produced in the surrounding landscape.	Threshold for mosquito management on the refuge should be high with an emphasis for treatment of mosquito breeding habitat off refuge.
Spatial extent of mosquito breeding habitat	The relative availability of mosquito habitat within the landscape that includes the refuge.	If the refuge is a primary breeding area for mosquitoes that likely affect human health, threshold may be lower. If refuge mosquito habitats are insignificant in the context of the landscape, thresholds may be higher.

Factor	Description	Consideration
Natural predator populations	Balanced predator-prey populations may limit mosquito production.	If refuge vertebrate and invertebrate prey populations are adequate to control mosquitoes, threshold for treatment should be high.
Type of mosquito habitat	Preferred breeding habitat for mosquitoes is species- specific.	Because breeding habitat is species-specific, thresholds for each species to initiate control should be correlated with appropriate habitat types.
Water quality	Water quality influences mosquito productivity.	High organic content in water may increase mosquito productivity, lower natural predator abundance, and may require lower thresholds.
Opportunities for water and vegetation management	Management of water levels and vegetation may reduce mosquito productivity.	Thresholds for treatment should be higher where mosquitoes can be controlled through habitat management.
Presence/absence of vector control agency	Many areas do not have adequate human populations to support vector control. In addition, resources available for mosquito management vary among districts.	Thresholds for management may be much higher or non-existent in areas without vector control.
Accessibility for monitoring/control	Refuges may not have adequate access to monitor or implement mosquito management.	Thresholds will probably be higher for refuges with limited access that will require cost- prohibitive monitoring and treatment strategies.
History of mosquito borne diseases in area	Past monitoring of wildlife, mosquito pools, horses, sentinel chickens, and humans have documented mosquito-borne diseases.	Thresholds in areas with a history of mosquito-borne disease(s) will likely be lower.

EXHIBIT 1

Outline: Integrated Pest Management Plan for Mosquito Associated Threats on Refuges

I. Health Threat Determination.

A. Describe the communication process and identify points of contact and their contact information for Federal and/or State/local public health authorities, vector control districts, and recognized experts in vector ecology, epidemiology, public health, and wildlife health. Identify agency with public human health authority and personnel with medical training regarding the epidemiology of mosquito-borne diseases that has the official capacity to make a human health determination.

B. Elaborate on regional/local history of mosquito associated health threat(s). Identify endemic and enzootic mosquito-borne diseases.

C. Determine health threat using criteria in table 1 based on documentation from Federal or State fish and wildlife agency health experts, Federal and/or State/local public health authorities, and/or public health veterinarians employed by the appropriate public health authorities that refuge-based mosquitoes threaten human, wildlife, or domestic animal health.

1. Off-refuge (or on-refuge, if available) mosquito surveillance summary data (species and abundance).

2. List of mosquito species present, enzootic/endemic diseases they may vector, and any other potential adverse impacts to health they may have.

II. Monitoring Mosquito Populations (developed in cooperation with Federal/State/local public health authorities, vector control agencies, and State fish and wildlife agencies).

A. Identify the purpose and goals of monitoring on the refuge.

B. Identify who will be conducting the monitoring on the refuge and their contact information.

C. Identify when monitoring will be conducted.

1. Routine, seasonal; or

2. Monitoring only when threat level is elevated (identify triggers for monitoring).

D. Description of monitoring protocols.

1. Larval and pupal mosquito monitoring and breeding habitat inventory and mapping.

(a) Objective(s)
(b) Method(s).

(c) Sampling locations and numbers of samples/location.
(d) Frequency of sampling.
(e) Processing/identification of samples (species, larval stage).

2. Adult mosquito monitoring.

(a) Method(s) of sampling (e.g., traps, landing counts).
(b) Sampling locations and frequency of sampling.
(c) Processing/identification of samples.

3. Post-treatment monitoring: Monitoring should continue after any treatment to determine efficacy.

E. Reporting.

1. Refuge receives copies of all monitoring data concerning refuge.

2. Refuge shares annual habitat management plans, if applicable, with public health or vector control agency.

F. Restrictions/Stipulations: Identify any restrictions/stipulations on monitoring activities (e.g., access, vehicle use, sensitive species or habitats, time of day, etc.) to ensure compatibility.

III. Surveillance of Mosquito-Borne Disease (developed in cooperation with Federal/State/local public health authorities, vector control agencies, and State fish and wildlife agencies).

A. Identify the purpose and goals of surveillance.

B. Identify who will be conducting surveillance on or near the refuge and their contact information.

C. Identify when surveillance will be conducted.

1. Routine, seasonal surveillance; or

2. Surveillance only when threat level is elevated (identify triggers for surveillance).

D. Description of surveillance protocols.

1. Disease monitoring.

(a) Objective(s).
(b) Method(s).
(c) Monitoring locations.
(d) Wildlife testing facility (for dead or sick wildlife found on the refuge).

2. Disease activity notification procedures between public health agency, State fish and wildlife agency, and refuge (these procedures are developed cooperatively).

3. Post-treatment monitoring: Surveillance should continue after any treatment to determine efficacy.

E. Restrictions/Stipulations: Identify any restrictions/stipulations on surveillance activities (e.g., access, vehicle use, sensitive species or habitats, time of day, etc.).

IV. Treatment Options (developed in cooperation with Federal/State/local public health authorities, and vector control agencies, and State fish and wildlife agencies using stepwise approach, table 1).

A. Identify and categorize refuge-based mosquito species or species groups based on role in transmission cycle(s) of enzootic/endemic diseases and other impacts to human, wildlife, or domestic animal health.

B. Identify species-specific larval, pupal, and adult mosquito vector action threshold levels that reflect the importance of vector species in identified health threats (see table 2).

C. Identify health threat levels and describe potential intervention measures for each level (table 1). Include non-pesticide and pesticide intervention options.

D. Complete NEPA process, as necessary, to examine potential environmental effects of potential intervention measures. In an emergency, contact the Regional NEPA coordinator for guidance.

E. Complete ESA, section 7, consultation for potential impacts to endangered species from intervention measures.

F. Identify specific pesticides or other management actions to use at specific threat levels based on NEPA and ESA, section 7, analyses.

G. Unless it is an emergency, complete a compatibility determination for intervention measures.

H. Follow Service pesticide use and permitting procedures, and attach approved pesticide use proposal (PUP) and special use permits (SUP).

1. Complete PUP.

2. Submit PUP to Regional IPM coordinator. In an emergency, contact Regional pest management coordinator (and national IPM coordinator, if applicable) to expedite PUP approval.

3. Prepare SUP or other agreement for agency conducting intervention measures, outlining specific actions to be taken (when, where, how) and describing any restrictions, stipulations, or other conditions on such actions.

APPENDIX K2. Statement of Best Management Practices and Proposed Monitoring Plan for Coastal Region Mosquito and Vector Control Districts

Statement of Best Management Practices and Proposed Monitoring Plan for Coastal Region Mosquito and Vector Control Districts

Alameda County Mosquito Abatement District
Contra Costa Mosquito and Vector Control District
Marin-Sonoma Mosquito and Vector Control District
Napa County Mosquito Abatement District
Santa Clara County Vector Control District
San Mateo Mosquito Abatement District
Solano County Mosquito Abatement District

FOR WATER QUALITY ORDER NO 2001-12-DWQ STATEWIDE GENERAL NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR DISCHARGERS OF AQUATIC PESTICIDES TO WATERS OF THE UNITED STATES (GENERAL PERMIT) NO. CAG990003

BACKGROUND

Mosquito and vector control districts (MVCD) within the jurisdiction of the San Francisco Bay Region (2) Water Quality Control Board, are seeking coverage under the General Permit as "public entities" that apply aquatic pesticides for vector and weed control in waters of the United States. As provisioned by the State Water Resources Control Board (SWRCB) Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California, MVCD are allowed categorical exemptions from meeting priority pollutant/objectives for public health pest management. Although the administrations of the MVCD vary between special, independent, and dependent districts, the underlying health and safety statutory mandates and requirements are one and the same (California Health and Safety Code, Division 3).

While various mosquito larvicides used by the MVCD (Table 1) are directly applied to water bodies with the purpose and intent of killing mosquito larvae, extensive research has indicated that little or no lasting environmental impacts are imparted. Currently used aquatic pesticides (*Bacillus thuringiensis israelensis*, *B. sphaericus* and *methoprene*) degrade rapidly in the environment, thus the areal extent and duration of residues may be considered negligible. When integrated with other strategies including vegetation management, surface acting agents, and predatory mosquitofish, these aquatic pesticides constitute safe and effective best management practices (BMP).

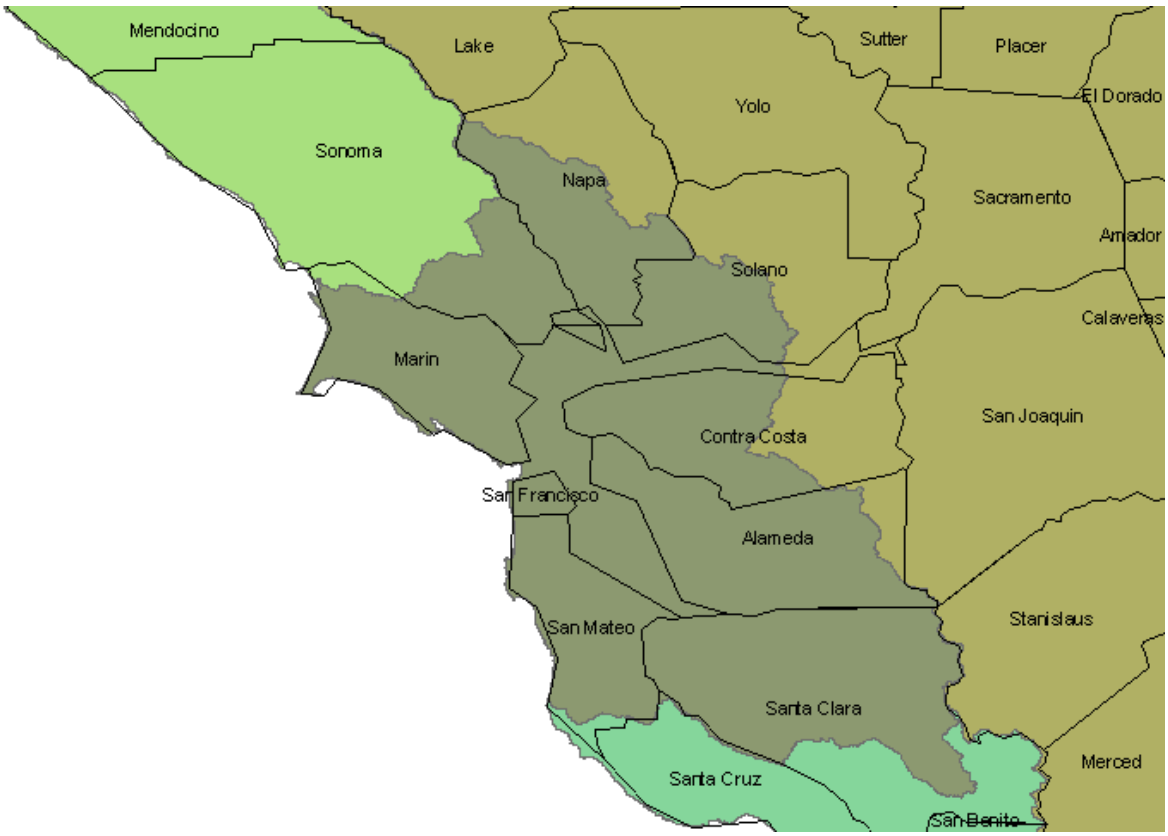
Similarly, a limited use by MVCD of herbicides, glyphosate and sulfometuron methyl (Table 1) is largely restricted to Napa County. These compounds are probably not reaching Waters of the U.S. since they are used on the berms of wastewater channels and ponds and are not applied directly to water.

This document presents and discusses the BMPs of the MVCD and proposes a monitoring plan as a requisite to the General Permit. The MVCD are confident that currently-established practices are very much environmentally safe due to the use of non-toxic or less toxic alternatives and proven BMP systems. Additionally, the aquatic pesticides are applied at rates sufficiently low to leave the physical parameters of the environment (i.e., temperature, salinity, turbidity and pH) unchanged. Therefore, the MVCD are proposing broad exemptions to General Permit requirements that are presented and justified below.

Statement of Best Management Practices

INTRODUCTION

The MVCD in the S.F. Bay Region (see map below) are some of the oldest organized programs of mosquito control in North America, most have been in existence since the early 1900's. These districts were formed (pursuant to California Health and Safety Code Sections 2200-2280) by local citizens and governments to reduce the risk of vector-borne disease or discomfort to the residents of San Francisco Bay area. This includes vector-borne diseases such as mosquito-borne encephalides and malaria. Vector control districts are indirectly regulated by the Department of Pesticide Regulation (DPR). Supervisors and applicators are licensed by the California Department of Health Services (CDHS). Pesticide use by vector control agencies is reported to the County Agricultural Commission (CAC) in accordance with a 1995 Memorandum of Understanding among DPR, CDHS, and the CACs for the Protection of Human Health from the Adverse Effects of Pesticides and with cooperative agreements entered into between DHS and vector control agencies, pursuant to Health and Safety Code section 116180.



Map of San Francisco Bay Water Quality Control Region with counties.

Mosquito and vector control districts in the coastal region have all implemented Best Management Practices (BMP)s based on the philosophy of integrated pest management (IPM). The basic components of the programs are: (1) surveillance of pest populations, (2) determination of treatment thresholds, (3) selection from a variety of control options including physical, cultural, biological and chemical techniques (4) training and certification of applicators and (5) public education.

1. MOSQUITO SURVEILLANCE

Surveillance of pest populations is essential for assessing the necessity, location, timing and choice of appropriate control measures. It reduces the areal extent and duration of pesticide use, by restricting treatments to areas where mosquito populations exceed established thresholds. The 54 mosquito species known in California differ in their biology, nuisance and disease potential and susceptibility to larvicides. Information on the species, density, and stages present is used to select an appropriate control strategy from integrated pest management alternatives.

A. Larval Mosquito Surveillance

Surveillance of immature mosquitoes is conducted by MVCD staff assigned to zones within "districts". These technicians maintain a list of known mosquito developmental sites and visit them on a regular basis. When a site is surveyed, water is sampled with a 1 pint dipper to check for the presence of mosquitoes. Samples are examined in the field or laboratory to determine the

abundance, species, and life-stage of mosquitoes present. This information is compared to historical records and used as a basis for treatment decisions

B. Adult Mosquito Surveillance

Although larval mosquito control is preferred, it is not possible to identify all larval sources. Therefore, adult mosquito surveillance is needed to pinpoint problem areas and locate previously unrecognized or new larval developmental sites. Adult mosquitoes are sampled using standardized trapping techniques (i.e., New Jersey light traps, carbon dioxide-baited traps and oviposition traps).

Mosquitoes collected by these techniques are counted and identified to species. The spatial and seasonal abundance of adult mosquitoes is monitored on a regular basis and compared to historical data.

C. Service Requests

Information on adult mosquito abundance from traps is augmented by tracking mosquito complaints from residents. Analysis of service requests allows district staff to gauge the success of control efforts and locate undetected sources of mosquito development. All MVCD conduct public outreach programs and encourage local residents to contact them to request services. When such requests are received, technicians visit the area, interview residents and search for sources that may have been missed. Residents are asked to provide a sample of the insect causing the problem. Identification of these samples provides information on the species present and can be helpful in locating the source of the complaint.

2. PRE-TREATMENT DECISION-MAKING

A. Thresholds

Treatment thresholds are established for mosquito developmental sites where potential disease vector and/or nuisance risks are evident. Therefore, only those sources that represent imminent threats to public health or quality of life are treated. Treatment thresholds are based on the following criteria:

- Mosquito species present
- Mosquito stage of development
- Nuisance or disease potential
- Mosquito abundance
- Flight range
- Proximity to populated areas
- Size of source
- Presence/absence of natural enemies or predators
- Presence of sensitive/endangered species

B. Selection of Control Strategy

When thresholds are exceeded an appropriate control strategy is implemented. Control strategies are selected to minimize potential environmental impacts while maximizing efficacy. The method of control is based on the above threshold criteria but also:

- Habitat type
- Water conditions and quality
- Weather conditions
- Cost
- Site accessibility
- Size of site and number of other developmental sites

3. CONTROL STRATEGIES

A. Source Reduction

Source reduction includes elements such as, physical control, habitat manipulation and water management, and forms an important component of the Coastal Region MVCD IPM program.

B. Physical Control

The goal of physical control is to eliminate or reduce mosquito production at a particular site through alteration of habitat. Physical control is usually the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces the need for chemical applications.

Historically (circa 1903), the first physical control efforts were projects undertaken to reduce the populations of salt marsh mosquitoes in marshes near San Rafael. Two years later, similar work was undertaken in the marshes near San Mateo. Networks of ditches were created by hand to enhance drainage and promote tidal circulation. Since then, various types of machinery have been used since then to create ditches necessary to promote water circulation. In recent years, a number of environmental modification projects have been undertaken in collaboration with the U.S. Fish and Wildlife Service (USFWS) to reduce potential mosquito developmental sites and enhance wildlife habitat. Re-circulation ditches allow tidewater to enter the marsh at high tide and drain off at low tide. Water remaining in the ditch bottoms at low tide provides habitat for mosquito-eating fish. These projects have reduced the need to apply chemicals on thousands of acres of salt marsh in the San Francisco Bay.

Physical control programs conducted by the MVCD may be categorized into three areas: "maintenance", "new construction", and "cultural practices" such as vegetation management and water management.

Maintenance activities are conducted within tidal, managed tidal and non-tidal marshes, seasonal wetlands, diked, historic baylands and in some creeks adjacent to these wetlands. The following activities are classified as maintenance:

* Removal of sediments from existing water circulation ditches

* Repair of existing water control structures
* Removal of debris, weeds and emergent vegetation in natural channels
* Clearance of brush for access to streams tributary to wetland areas
* Filling of existing, non-functional water circulation ditches to achieve required water circulation dynamics and restore ditched wetlands.

The preceding activities are included within the permits required by U.S. Army Corps of Engineers (USACE) and San Francisco Regional Water Quality Control Board (SFRQWB) (Waste Discharge) and coordinated by the California DHS. Additional agencies involved include the Coastal Conservancy and San Francisco Bay Conservation and Development Commission.

New projects, such as wetland restoration, excavation of new ditches, construction of new water control structures, all require application by individual districts directly to the USACE. Currently, few districts in the coastal region have the resources available to initiate new physical control projects. Instead, most districts try to work with landowners to manage their lands in a manner that does not promote mosquito development. Coastal region MVCD staff review proposals for wetlands construction to assess their impact on mosquito production. The districts then submit recommendations on hydrological design and maintenance that will reduce the production of mosquitoes and other vectors. This proactive approach involves a collaborative effort between landowners and MVCD. Implementation of these standards may include cultural practices such as water management and aquatic vegetation control.

C. Biological control

Biological control agents of mosquito larvae include predatory fish, predatory aquatic invertebrates and mosquito pathogens. Of these, only mosquitofish are available in sufficient quantity for use in mosquito control programs. Natural predators may sometimes be present in numbers sufficient to reduce larval mosquito populations. Biological control is sometimes used in conjunction with selective bacterial or chemical insecticides.

Mosquitofish (*Gambusia affinis*)

The mosquitofish, *Gambusia affinis*, is a natural predator of mosquito larvae used throughout the world as a biological control agent for mosquitoes. Although not native to California, mosquitofish are now ubiquitous throughout most of the State's waterways and tributaries, where they have become an integral part of aquatic food chains. They can be stocked in mosquito larval sources by trained district technicians or distributed to the public for stocking in backyard ornamental ponds and other artificial containers.

Advantages: The use of mosquitofish as a component of an IPM program may be environmentally and economically preferable to habitat modification or the exclusive use of pesticides, particularly in altered or artificial aquatic habitats. Mosquitofish are self-propagating, have a high reproductive potential and thrive in shallow, vegetated waters preferred by many mosquito species. They prefer to feed at the surface where mosquito larvae concentrate. These fish can be readily mass-reared for stocking or collected seasonally from sources with established populations for redistribution.

Barriers to Use: Water quality conditions, including temperature, dissolved oxygen; pH and pollutants may reduce or prevent survival and/or reproduction of mosquitofish in certain habitats. Mosquitofish may be preyed upon by other predators. They are opportunistic feeders and may prefer alternative prey when available. Introduction of mosquitofish may modify food chains in small-contained pools and have potential impacts on endemic fish and shrimp in such situations. Some wildlife agencies suspect mosquitofish may impact survival of amphibian larvae through predation. Recent research has shown no significant impact on survival of the threatened California red-legged frog (Lawler et al. 1998), but mosquitofish have been shown to negatively impact the survival of the California tiger salamander (Leyse and Lawler 2000).

Impact on water quality: Mosquitofish populations are unlikely to impact on water quality.

Solutions to Barriers: Strict stocking guidelines adopted by MVCD restrict the use of mosquitofish to habitats such as artificial containers, ornamental ponds, abandoned swimming pools, cattle troughs, stock ponds, etc. . . . where water quality is suitable for survival and sensitive or endangered aquatic organisms are not present. Fish are generally stocked at population densities lower than those required for effective mosquito control and allowed to reproduce naturally commensurate with the availability of mosquito larvae and other prey. Guidelines prevent seasonal stocking in natural habitats during times of year when amphibian larvae or other sensitive species/life stages may be present.

Natural predators: aquatic invertebrates

Many aquatic invertebrates, including diving beetles, dragonfly and damselfly naiads, backswimmers, water bugs and hydra are natural predators of mosquito larvae.

Advantages: In situations where natural predators are sufficiently abundant, additional mosquito control measures including application of pesticides may be deemed unnecessary.

Barriers to Use: Predatory aquatic invertebrates are frequently not sufficiently abundant to achieve effective larval control, particularly in disturbed habitats. Most are generalist feeders and may prefer alternative prey to mosquito larvae if available and more accessible. Seasonal abundance and developmental rates often lag behind mosquito populations. Introduction or augmentation of natural predators has been suggested as a means of biological control, however there are currently no commercial sources since suitable mass-rearing techniques are not available.

Solutions to Barriers: The presence and abundance of natural predators is noted and taken into account during the larval surveillance process. Conservation of natural predators, whenever possible, is achieved through use of highly target-specific pesticides including bacterial insecticides, with minimal impacts on non-target taxa.

Impact on water quality: As predatory invertebrates represent a natural part of aquatic ecosystems, they are unlikely to impact water quality. There are no established standards, tolerance, or EPA approved tests for aquatic invertebrate populations.

Fungal pathogens (*Lagenidium giganteum*)

Product name: Laginex

Lagenidium giganteum is a fungal parasite of mosquito larvae. It is highly host-specific; other aquatic organisms are not susceptible and there is no mammalian toxicity. Unfortunately, the effectiveness of this pathogen has proven to be extremely variable due to stringent environmental requirements for growth and development of the fungus. Although commercial formulations (aqueous suspension) of this pathogen have been produced, severe limitations on its availability, shelf life and handling, as well as inconsistent results have prevented its integration into mosquito control programs in California.

Advantages: Use of fungal pathogens as part of an integrated pest management program may reduce the need for use of conventional insecticides. *Lagenidium* may recycle naturally in certain habitats, providing long-term larval reducing the need for repeated applications.

Barriers to Use: Commercial availability is uncertain. Because it contains living fungal mycelium the material has a very limited shelf life and is difficult to handle and apply. It is also very sensitive to environmental conditions (i.e., pH, salinity, and temperature), which makes its effectiveness highly variable.

Solutions to Barriers: *Lagenidium* is not currently in routine use in Coastal Region mosquito control programs due to problems with availability and reliability of control.

Impact on water quality: *Lagenidium* is a naturally occurring biological control agent At a typical application rate of 10 oz of active ingredient (mycelium) per acre it is unlikely to have any detectable effect on water quality. There are no established standards, tolerances or EPA approved tests for *Lagenidium*.

D. Bacterial insecticides

Bacterial insecticides contain naturally produced bacterial proteins that are toxic to mosquito larvae when ingested in sufficient quantity. Although they are biological agents, such products are labeled and registered by the Environmental Protection Agency as pesticides and are considered by some to be a form of Chemical Control.

Bacillus thuringiensis var. *israelensis* (BTI)

Product names: Acrobe, Bactimos pellets, Teknar HP-D, Vectobac 12AS, Vectobac G, Vectobac TP.

Advantages: BTI is highly target-specific and has been found to have significant effects only on mosquito larvae, and closely related insects (e.g., blackflies and some midges). It is available in a variety of liquid, granular and pelleted formulations that provide some flexibility in application methods and equipment. BTI has no measurable toxicity to vertebrates and is classified by EPA as "Practically Non-Toxic" (Caution). BTI formulations contain a combination of five different

proteins within a larger crystal. These proteins have varying modes of action and synergistically act to reduce the likelihood of resistance developing in larval mosquito populations.

Barriers to Use: Bacterial insecticides must be fed upon by larvae in sufficient quantity to be effective. Therefore applications must be carefully timed to coincide with periods in the life cycle when larvae are actively feeding. Pupae and late 4th stage larvae do not feed and therefore will not be controlled by BTI. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of BTI during the cooler months. High organic conditions also reduce the effectiveness of BTI. Cost per acre treated is generally higher than surfactants or organophosphate insecticides.

Solutions to Barriers: An increased frequency of surveillance of larvae ensures that bacterial insecticides can be applied during the appropriate stages of larval development to prevent adult mosquito emergence.

Impact on water quality: BTI contains naturally produced bacterial proteins generally regarded as environmentally safe. It leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, BTI is unlikely to have any measurable effect on water quality. There are no established standards, tolerances or EPA approved tests. Other naturally occurring strains of this bacterium are commonly found in aquatic habitats.

Bacillus sphaericus (BS)

Product names: Vectolex CG, Vectolex WDG

Advantages: BS is another bacterial pesticide with attributes similar to those of BTI. The efficacy of this bacterium is not affected by the degree of organic pollution in larval development sites and it may actually cycle in habitats containing high densities of mosquitoes, reducing the need for repeated applications.

Barriers to Use: Like BTI, BS must be consumed by mosquito larvae and is not is therefore not effective against nonfeeding stages such as late 4th instar larvae or pupae. BS is also ineffective against certain mosquito species such as those developing in saltmarshes, seasonal forest pools or treeholes. Toxicity of BS to mosquitoes is due to a single toxin rather than a complex of several molecules as is the case with BTI. Development of resistance has been reported in Brazil. Thailand and France in sites where BS was the sole material applied to control mosquitoes for extended periods of time.

Solutions to Barriers: Information obtained from larval surveillance on the stage and species of mosquitoes present can increase the effectiveness of this material, restricting it use to sources containing susceptible mosquitoes. Development of resistance can be delayed by rotating BS with other mosquitocidal agents.

Impact on water quality: BS is a naturally occurring bacterium and is environmentally safe. It leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, BS is unlikely to have any measurable effect on water quality. There are no established

standards, tolerances or EPA approved tests. Other naturally occurring strains of this bacterium are commonly found in aquatic habitats.

E. Chemical Control

Methoprene

Product Names: Altosid briquets, Altosid liquid larvicide, Altosid pellets, Altosid SBG, Altosid XR briquets, Altosid XRG

Advantages:

Methoprene is a larvicide that mimics the natural growth regulator used by insects. Methoprene can be applied as liquid or solid formulation or combined with BTI or BS to form a "duplex" application. Methoprene is a desirable IPM control strategy since affected larvae remain available as prey items for predators and the rest of the food chain. This material breaks down quickly in sunlight and when applied as a liquid formulation it is effective for only 3 to 5 days. Methoprene has been impregnated into charcoal-based carriers such as pellets and briquettes for longer residual activity ranging up to 150 days. The availability of different formulations provides options for treatment under a wide range of environmental conditions. Studies on nontarget organisms have found methoprene to be nontoxic to vertebrates and most invertebrates when exposed at concentrations used by mosquito control.

Barriers to Use: Methoprene products must be applied to larval stage mosquitoes since it is not effective against the other life stages. Monitoring for effectiveness is difficult since mortality is delayed. Methoprene is more expensive than most other mosquitocidal agents. Methoprene use is avoided in vernal pools. There may be toxicity to certain nontarget crustacean and insect species.

Solutions to Barriers: Surveillance and monitoring can provide information on mosquito larval stage present, timing for applications and efficacy of the treatments.

Impact on Water Quality: Methoprene does not have a significant impact on water quality. It is rapidly degraded in the environment and is not known to have persistent or toxic breakdown products. It is applied and has been shown to be effective against mosquitoes at levels far below those that can be detected by any currently available test. Methoprene has been approved by the World Health Organization for use in drinking water containers.

Surfactants

Product Names: Golden Bear 1111, Agnique MMF

Surfactants are "surface-acting agents" that are either petroleum or isostearyl alcohol-based materials that form a thin layer on the water surface. These materials typically kill surface-breathing insects by mechanically blocking the respiratory mechanism.

Advantages: These materials are the only materials efficacious for reducing mosquito pupae since other larviciding strategies (i.e., methoprene, BTI and BS) are ineffective to that life stage. Agnique forms an invisible monomolecular film that is visually undetectable. Treatments are simplified due to the spreading action of the surfactant across the water surface and into inaccessible areas. These surfactants are considered "practically nontoxic" by the EPA. Agnique is labeled "safe for use" in drinking water.

Barriers to Using: The drawback of using oils in habitats where natural enemies are established is that surface-breathing insects, particularly mosquito predators, are similarly affected. GB1111 forms a visible film on the water surface.

Solutions to Barriers: As a general rule, surfactant use is considered after alternate control strategies have been ruled out or in habitats that are not supporting a rich macro-invertebrate community (i.e., manmade sites).

F. Cultural Practices

Wetland design criteria were developed and endorsed by DHS and the San Francisco Bay Conservation and Development Commission in 1978 as part of the Suisun Marsh Protection Plan under California State Assembly Bill 1717. These criteria have been sent to various governmental agencies and private parties involved in the planning process for projects having the potential of creating mosquito breeding problems. Guidelines for the following source types are included in the above marsh protection plan and may be considered cultural control techniques:

* Drainageway construction and maintenance practices
* Dredge material disposal sites
* Irrigated pastures
* Permanent ponds used as waterfowl habitat
* Permanent Water impoundments
* Salt marsh restoration of exterior levee lands
* Sedimentation ponds and retention basins
* Tidal marshes
* Utility construction practices

The MVCD also provide literature and education programs for homeowners and contractors on elimination of mosquito developmental sites from residential property. These sources include rain gutters, artificial containers, ornamental ponds, abandoned swimming pools, tree holes, septic tanks, and other impounded waters.

Water Management consists of techniques to control the timing, quantity and flow rate of water circulation in managed wetlands to minimize mosquito development. MVCD have established guidelines for water management based on information from University of California Agricultural Extension Service (UCAES). Districts provide these guidelines to property owners to promote proper irrigation techniques for pastures, duck clubs and other wetlands to reduce mosquito development. Some MVCD operate structures such as tide gates that control water levels in marshes to minimize mosquito production.

G. Vegetation Management

Vegetation Management consists of the removal of vegetation within mosquito developmental sites to promote water circulation, increase access of natural predators such as fish or provide MVCD staff access for surveillance and treatment operations. Vegetation management is achieved either through recommendations to the landowner or by the use of hand tools and the application of selective herbicides.

Vegetation management, one aspect of physical mosquito control, is an effective long-term control strategy that is occasionally employed by MVCD. This methodology utilizes water management, burning, physical removal, and chemical means to manage vegetation within mosquito developmental sites. The presence of vegetation provides harborage for immature and adult mosquitoes by protecting them from potential predators as well as the effects of wind and wave action, which readily cause mortality. Vegetation reduction not only enhances the effects of predators and abiotic factors, but also reduces the need for chemical control. Several factors can limit the utilization of vegetation management. These include: sensitivity of the habitat, presence of special status species, size of the site, density and type of vegetation, species of mosquito and weather.

A. Burning

This technique is used to achieve effective mosquito control where the density of unwanted vegetation precludes the use of other methodologies. Burning requires a permit, and coordination with local fire agencies and the Bay Area Air Quality Management District. This strategy is limited to manmade impoundments and fallow farm lands. Factors limiting the use of this technique include weather, the limited number of approved burn days, and proximity of human habitation. As a general rule, burning is a last resort and not a primary method.

B. Physical Removal/Mowing/Trimming

Physical removal of vegetation is used to clear obstructed channels and ditches to promote water circulation, effectiveness of predators and improve access for mosquito control personnel to enter mosquito developmental sites. Ditches and channels can be cleared with a variety of tools ranging from shovels and small pruners to weed whackers and large mechanized equipment. Most removal activities performed by MVCD utilize small hand tools. This is the most frequently employed management technique once all necessary permits have been obtained and it is performed in all types of habitats. Unfortunately, its effectiveness is temporary and labor intensive, and therefore requires routine maintenance on an annual or at least biennial basis. Other limiting actors include cost, the presence of sensitive species or habitats and the limited time period that MVCD are allowed to perform the activity for many types of mosquito developmental sites.

C. Chemical

Chemical control of vegetation occurs only in man-made habitats such as impoundments, channels and ditches. Both pre- and post-emergent herbicides are used, with strict attention given to label

requirements, weather conditions, potential for runoff and drift, and proximity of sensitive receptors such as special-status species, sensitive habitats, livestock, crops, and people. Routine intensive surveys are conducted to address many of these factors. Most MVCD use little or no herbicides. For those that do, two types of herbicides are currently in use. These are: glyphosate based (Roundup and Rodeo) and sulfonylurea based (Oust).

Chemical name: Glyphosate

Product names: Roundup, Rodeo, Gallup, Landmaster, Pondmaster, Ranger, Touchdown, and Aquamaster

Advantages: Glyphosate based herbicides are not applied directly to water, but along the levee tops and margins of wastewater ponds, channels, ditches and access roads as post-emergence herbicides. These are non-selective, low-residual herbicides used to control weeds and low-growing brush. These materials come in a variety of formulations, allowing for flexibility of use and application. MVCD in recent years have only used the Roundup, Rodeo and Aquamaster formulations (Aquamaster being the registered replacement for Rodeo). Glyphosate acts in plants by inhibiting amino acid synthesis. Roundup (41% of the isopropylamine salt of glyphosate with surfactants) and Aquamaster (53% of the isopropylamine salt of glyphosate without surfactants) are applied from March through October for spot control of weed growth. Both of these materials are also occasionally used to control growth of poison oak, blackberry vines and non-native aquatic weeds such as Spartina and peppergrass that would prevent access, impede water flows or out-compete native vegetation in sensitive habitats.

Barriers to using: Landowners are notified before glyphosate is applied to any site and applications are timed with their operations. Furthermore, to prevent large, tall stands of dead vegetative material, applications must be timed so that weed growth is minimal. Weather conditions, specifically wind and rainfall, also affect timing and application of glyphosate based products. The proximity of food crops and sensitive habitats must also be considered.

Solutions to barriers: Intensive surveillance in and around target sites ensures that nontargets are not affected. Coordination with landowners and appropriate regulatory authorities verifies that reasonable and acceptable applications occur.

Impact on water quality: In water, glyphosate is strongly adsorbed to suspended organic and mineral matter and is broken down primarily by microorganisms. Its half life in pond water ranges from 12 days to 10 weeks (Extoxnet).

Chemical name: Sulfometuron methyl, chemical class sulfonylurea

Product names: Oust Weed Killer and DPX 5648

Advantages: Sulfometuron-methyl is a broad spectrum, general use category III pesticide that is classed by the US EPA as slightly toxic (acute oral LD50 in rats and mallards greater than 5,000 mg/kg, acute dermal LD50 in rabbits greater than 2000 mg/kg and acute inhalation LC50 in rats greater than 5.3 mg/L). This herbicide can be applied either pre- or post-emergence for the control

of a wide variety of grasses and broadleaf weeds and acts by stopping cell division in the growing tips of roots and stems. Sulfometuron-methyl is readily broken down in animals (half-life in rats shown to be 28-40 hours) with no environmental bioaccumulation having been detected or reported. Furthermore, this pesticide is rapidly degraded in water and is broken down in soil by microorganisms, chemical action of water (hydrolysis) and sunlight. No teratogenic, mutagenic or carcinogenic effects have been detected or reported.

Barriers to using: Because sulfometuron-methyl is non-selective, this compound may affect non-target aquatic and terrestrial plant species. This herbicide also does not bind strongly to soil and is slightly soluble in water.

Solutions to barriers: Intensive surveillance in and around target sites ensures that sensitive receptors are not affected. Furthermore, coordination with landowners and appropriate regulatory authorities verifies that reasonable and acceptable applications occur. No applications occur where there is a potential for unwanted runoff.

Impact on water quality: The reported half-life for sulfometuron-methyl in water varies from 24 hours to more than two months depending on factors such as light, pH, dissolved oxygen and amount of vegetation present. In well aerated acidic water, this herbicide is broken down very quickly (Extoxnet). Due to the nature and condition of the application sites (principally wastewater ponds) it is not likely that use of this herbicide poses any threat to sensitive habitats or drinking water.

H. ORGANOPHOSPHATES (OP)

While all districts in the San Francisco bay area have used organophosphates in the past, nearly all have stopped using these products. Some districts have not used OP's for over 14 years. Mosquito and vector control agencies that operate under the California Health and Safety Codes may utilize those materials registered as mosquito larvicides under the Federal Fungicide, Insecticide, and Rodenticide Act. Such materials used in accordance with label instructions are allowed by law. However, as a result of heightened concern over environmental impacts and worker health and safety, most of the districts have voluntarily eliminated their use. Organophosphate use will probably be reserved for emergency use against disease outbreaks and epidemics.

4. TRAINING AND CERTIFICATION

All MVCD applicators must be certified to apply public health pesticides. The CDHS Vector-Borne Disease Section administers certification training and testing. All mosquito control personnel applying pesticides or overseeing the application of pesticides must obtain a Vector Control Technician certificate number. The Mosquito and Vector Control Association of California provides training materials and exams are conducted by the CDHS. All certificate holders must maintain continuing education credit in at least two and as many as four subcategories. Category A (Laws and Regulations) and category B (Mosquito Biology) is mandatory for all certificate holders and requires 12 and 8 continuing education units (CEU) respectively, in a two year period. Category C (Terrestrial Invertebrate Control) and Category D (Vertebrate Control) are optional both with 8 hours of CEU per two-year cycle.

Individual districts conduct a number of in-house educational and safety programs to increase the expertise of the operational staff. Ultimate decisions regarding the need for and application of pesticides rest on the field staff based on information acquired from surveillance data. Decisions to apply a particular product are made in accordance to each California Environmental Quality Act (CEQA) documentation including threshold levels and other information regarding habitat type, distance from populated areas, and water quality data. Training opportunities to accumulate CEU credits are made available by the MVCAC regional committees that develop training programs fine-tuned to the local ecology and unique problems of the region. Training programs are submitted to the MVCAC state training coordinator for approval and then to the California Department of Health Services for final approval. Thirty-six hours of CEU credits are offered each two-year cycle.

5. OVERSIGHT

Members of the MVCAC operate under the California Health and Safety Code and the California Government Code (reference Division 1, Administration of Public Health, Chapter 2, Powers and Duties; also Part 2, Local Administration, Chapter 8, State Aid for Local Health Administration; Division 3, Pest Abatement, Chapter 5, Mosquito Abatement Districts or Vector Control Districts, Sections 2200 - 2910). In addition, members of the MVCAC that are signatories to the California Department of Health Services Cooperative Agreement (Pursuant to Section 116180, Health and Safety Code) are required to comply with the following:

1. Calibrate all application equipment using acceptable techniques before using; maintain calibration records for review by the County Agricultural Commissioner (CAC).

2. Maintain for at least two years, pesticide use data for review by the CAC including a record of each pesticide application showing the target vector, the specific location treated, the size of the source, the formulations and amount of pesticides used, the method and equipment used, the type of habitat treated, the date of the application, and the name of the applicator.

3. Submit to the CAC each month a Pesticide Use Report on Department of Pesticide Regulation form PR-ENF-060. The report shall include the manufacturer and product name, the EPA registration number from the label, the amount of pesticide used, the number of applications of each pesticide, and the total number of applications, per county, per month.

4. Report to the CAC and the CDHS, in a manner specified any conspicuous or suspected adverse effects upon humans, domestic animals and other non-target organisms, or property from pesticide applications.

5. Require appropriate certification of its employees by CDHS in order to verify their competence in using pesticides to control pest and vector organisms, and to maintain continuing education unit information for those employees participating in continuing education.

6. Be inspected by the CAC on a regular basis to ensure that local activities are in compliance with state laws and regulations relating to pesticide use.

Other agencies such as local fire departments, California Department of Fish and Game, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and others have jurisdiction and oversight over our activities. We work closely with these agencies to comply with their requirements.

Public Education

An integral part of the MVCD BMP is to provide information to the public to assist them in resolving their pest problems. Specialized staff at the MVCD provide public outreach in the form of presentations to schools, utility districts, homeowner associations, county fairs, home and garden shows, as well through the media such as newspaper, television, and radio. Information is provided on biological, physical and cultural control methods (i.e., BMPs) that property owner and managers can use to preclude or reduce mosquitoes and other disease and nuisance pests within their jurisdictions.

Proposed Monitoring Plan for S.F. Bay Region Mosquito and Vector Control Districts

INTRODUCTION

Mosquito and vector control districts (MVCD) within the San Francisco Bay Region (2) are seeking regional coverage under the General Permit for discharges of aquatic pesticides to surface waters. The monitoring plan is presented in this document to the Regional Water Quality Control Board and shall be implemented as approved. Implementation of nontoxic or least toxic control alternatives within a BMP program eliminates the need for water quality and chemical residue monitoring. Microbial larvicides, thin-film larvicides and methoprene are justifiably exempted from such requirements.

Characterization of Pesticide Application Projects by Region MVCD

Types of sources treated

Activities of the MVCD are directed toward control of mosquitoes in their aquatic, larval stage. This approach allows control activities to be concentrated in localized areas using least toxic materials. Adult mosquitoes may occasionally be targeted for control, such as in the case of disease outbreaks. However, this approach requires the use of more potent pesticides applied over a greater area and is therefore avoided whenever possible.

There are 19 species of mosquitoes in the coastal region (Table 2) that vary in their seasonality and the type of sources in which their larvae develop (Table 3). Mosquitoes are generally weak swimmers and cannot survive in waters with substantial flow or surface disturbance due to wind action. Therefore, larval development is largely restricted to small bodies of still water. The timing and location of pesticide applications follows seasonal changes in distribution of water sources. Many times heavy populations of immature mosquitoes are found in still shallow water

containing dense emergent vegetation. Species vary in their tolerance to salinity, degree of organic pollution and temperature extremes.

Climate and Seasonality

The San Francisco Bay Area has a mild, Mediterranean climate, with the preponderance of rain deposited during winter months (November through May). The climate and seasonal patterns of rainfall in this area influence the distribution of mosquitoes and hence the timing and location of pesticide applications. The mild climate of this area allows mosquitoes to develop throughout the year. However, the mosquito species and type of source targeted varies seasonally. For example, creeks and waterways that have substantial flow during winter months are only treated in summer after the water has receded into scattered, isolated pools. Similarly, mosquitoes are generally flushed out of storm drains during winter months. These sources are typically treated only during the summer. In contrast, seasonal wetland such as saltmarshes, require treatment from fall through spring. In summer months the rainwater deposited in low areas disappears and mosquitoes are no longer able to survive. Tables 2 and 3 include information on the seasonality of mosquito species and their development sites.

PESTICIDES USED AND ASSESSMENT OF IMPACTS ON BENEFICIAL USE

Pesticides used by MVCD fall into the 4 categories: bacterial larvicides, methoprene, surfactants (surface-acting agents) and herbicides. Table 1 summarizes the amount of these products applied annually by each district in the region. The accompanying document "Technical Review" provides a detailed review of available literature on nontarget effects.

A. Bacterial Larvicides

Bacterial insecticides consist of the spores of certain species of bacteria containing naturally produced proteins, which are toxic to mosquito larvae when ingested in sufficient quantities. Although they are biologically-derived agents, products containing them are labeled and registered by the Environmental Protection Agency (EPA) as pesticides and are considered by some to be a form of chemical control.

1. *Bacillus thuringiensis* var. *israelensis* (BTI)

Advantages: BTI is highly target-specific and has been found to have significant effects only on mosquito larvae, and closely related insects (e.g. blackflies and midges). It is available in a variety of liquid, granular and pellet formulations, providing some flexibility in application methods and equipment. BTI has no measurable toxicity to vertebrates and is classified by EPA as "Practically Non-Toxic" (Caution). BTI formulations contain a combination of five different proteins within a larger crystal. These proteins have varying modes of action and synergistically act to reduce the likelihood of resistance developing in larval mosquito populations.

Barriers: Bacterial insecticides must be fed upon by larvae in sufficient quantity to be effective. Therefore applications must be carefully timed to coincide with periods in the life cycle when

larvae are actively feeding. Pupae and late 4th stage larvae do not feed and therefore will not be controlled by BTI. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of BTI during the cooler months. The presence of high concentrations of organic material in treated water also reduces the effectiveness of BTI. Cost per acre treated is generally higher than surfactants or organophosphate insecticides.

Solutions to Barriers: Increasing the frequency of surveillance for larvae can ensure that bacterial insecticides are applied during the appropriate stages of development to prevent adult mosquito emergence.

Impact on water quality: BTI contains naturally produced bacterial proteins that are generally regarded as environmentally safe. Naturally occurring strains of this bacterium are ubiquitous in aquatic habitats. BTI leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, this product is unlikely to have any measurable effect on water quality. There are no established standards, tolerances or EPA approved tests for this material.

Product names: Acrobe, Bactimos pellets, Teknar HP-D, Vectobac 12AS, Vectobac G, Vectobac TP.

Formulations and dosages There are five basic BTI formulations available for use: liquids, powders, granules, pellets, and briquets. Liquids, produced directly from a concentrated fermentation slurry, tend to have uniformly small (2-10 micron) particle sizes, which are suitable for ingestion by mosquito larvae. Powders, in contrast to liquids, may not always have a uniformly small particle size. Clumping, resulting in larger sizes and heavier weights, can cause particles to settle out of the feeding zone of some target mosquito larvae, preventing their ingestion as a food item. Powders must be mixed with an inert carrier before application to the larval habitat, and it may be necessary to mix them thoroughly to achieve a uniformly small consistency. BTI. granules, pellets, and briquets are formulated from BTI primary powders and an inert carrier. BTI. labels contain the signal word "CAUTION".

BTI is applied by MVCD as a liquid or sometimes bonded to an inert substrate (i.e.: corn cob granules) to assist penetration of vegetation. Application can be by hand, ATV, or aircraft. Persistence is low in the environment, usually lasting three to five days. Kills are usually observed within 48 hours of toxin ingestion. As a practical matter, apparent failures are usually followed with oil treatments.

BTI LIQUIDS. Currently, three commercial brands of BTI liquids are available: Aquabac XT, Teknar HP-D, and Vectobac 12AS. Labels for all three products recommend using 4 to 16 liquid oz/acre in unpolluted, low organic water with low populations of early instar larvae (collectively referred to below as clean water situations). The Aquabac XT and Vectobac 12 AS (but not Teknar HP-D) labels also recommend increasing the range from 16 to 32 liquid oz/acre when late 3rd or early 4th instar larvae predominate, larval populations are high, water is heavily polluted, and/or algae are abundant. The recommendation to increase dosages in these instances (collectively referred to below as dirty water situations) also is seen in various combinations on the labels for all other BTI. formulations discussed below.

BTI liquid may also be combined with the Altosid Liquid Larvicide discussed earlier. This mixture is known as Duplex. Because BTI is a stomach toxin and lethal dosages are somewhat proportional to a mosquito larvae's body size, earlier instars need to eat fewer toxic crystals to be adversely affected. Combining BTI with methoprene (which is most effective when larvae are the oldest and largest or when you have various, asynchronous stages of one or more species) allows a district to use less of each product than they normally would if they would use one or the other. Financially, most savings are realized for treatments of mosquitoes with long larval development periods, asynchronous broods or areas with multiple species of mosquitoes.

BTI CORNCOB GRANULES. There are currently two popular corncob granule sizes used in commercial formulations. Aquabac 200G, Bactimos G, and Vectobac G are made with 5/8 grit crushed cob, while Aquabac 200 CG (Custom Granules) and Vectobac CG are made with 10/14 grit cob. Aquabac 200 CG is available by special request. The 5/8 grit is much larger and contains fewer granules per pound. The current labels of all B.t.i. granules recommend using 2.5 to 10 lb./acre in clean water and 10 to 20 lb./acre in dirty water situations.

2. *Bacillus sphaericus* (BS)

Advantages: BS is another bacterial pesticide with attributes similar to those of BTI. The efficacy of this bacterium is not affected by the degree of organic pollution in larval development sites and it may actually cycle in habitats containing high mosquito densities reducing the need for repeated applications.

Barriers: Like BTI, BS must be consumed by mosquito immatures and is therefore not effective against nonfeeding stages such as late 4th instar larvae or pupae. BS is also ineffective against certain species of mosquitoes such as those developing in saltmarshes, seasonal forest pools or treeholes. Toxicity of BS to mosquitoes is due to a single toxin rather than a complex of several molecules as is the case with BTI. Development of resistance has been reported in Brazil, Thailand and France where BTI was used as the sole control method for extended periods of time.

Solutions to Barriers: Information obtained from larval surveillance on the stage and species of mosquitoes present can increase the effectiveness of this material, restricting its use to sources containing susceptible mosquitoes. The development of resistance can be delayed by rotating BS with other mosquitocidal agents.

Impact on water quality: At the application rates used in mosquito control programs, BS is unlikely to have any measurable effect on water quality. It is a naturally occurring bacterium and like BTI, occurs naturally in most aquatic environments. There are no established standards, tolerances or EPA approved tests for BS.

Product names: Vectolex CG, Vectolex WDG

Formulations and dosages VECTOLEX CG. VectoLex-CG is the trade name for the granular formulation of *B. sphaericus* (strain 2362). The product has a potency of 50 BSITU/mg (*Bacillus sphaericus* International Units/mg) and is formulated on a 10/14 mesh ground corn cob carrier. The VectoLex-CG label carries the "CAUTION" hazard classification. VectoLex-CG is intended

for use in mosquito breading sites that are polluted or highly organic in nature, such as dairy waste lagoons, sewage lagoons, septic ditches, tires, and storm sewer catch basins. VectoLex-CG is designed to be applied by ground (by hand or truck-mounted blower) or aerially at rates of 5-10 lb./acre. Best results are obtained when applications are made to larvae in the 1st to 3rd instars. Use of the highest rate is recommended for dense larval populations

B. Methoprene

Advantages: Methoprene is a larvicide that mimics the natural growth regulator used by insects. Methoprene can be applied as liquid or solid formulation or combined with BTI or BS to form a "duplex" application. Methoprene is a desirable IPM control strategy since affected larvae remain available as prey items for predators and the rest of the food chain. This material is breaks down quickly in sunlight and when applied as a liquid formulation is effective for only 24 hours. Methoprene can be impregnated into charcoal-based carriers such as pellets and briquettes for longer residual activity ranging from 30 to 150 days. The availability of different formulations provides options for treatment under a wide range of environmental conditions. Studies on nontarget organisms have found methoprene to be nontoxic to all vertebrates and most invertebrates when exposed at concentrations applied for control of mosquitoes.

Barriers: Methoprene products must be applied to mosquitoes at the larval stage, since it is not effective against the other life stages. Monitoring for effectiveness is difficult since mortality is delayed. Methoprene is more expensive than most other mosquitocidal agents. Use is restricted in vernal pools and certain other aquatic habitats where red-legged frogs are unlikely to occur.

Solutions to Barriers: Surveillance and monitoring can provide information on the stage of mosquito immatures present, so that timing of applications can maximize efficacy of the treatments.

Impact on Water Quality: Methoprene does not have a significant impact on water quality. It is applied and has been shown to be effective against mosquitoes at levels far below those that can be detected by any currently available test approved by the EPA. Studies on nontarget organisms have shown methoprene to be nontoxic to all vertebrates and most invertebrates when exposed at concentrations applied for control of mosquitoes.

Product Names: Altosid Liquid Larvicide, Altosid Single Brood Granule, Altosid Pellets, and Altosid Briquets, Altosid Extended Release Briquets XR . .

Formulations and dosages. s-Methoprene is a very short-lived material in nature, with a half-life of about two days in water, two days in plants, and ten days in soil (Wright 1976 in Glare & O'Callaghan 1999, La Clair et al 1998). The manufacturer has developed a number of formulations to maintain an effective level of the active material in the mosquito habitat (0.5-3.0 parts per **billion** = ppb[1]; (Scientific Peer Review Panel 1996)) for a practical duration, thus minimizing the cost and potential impacts associated with high-frequency repeat applications. Currently, five s-methoprene

[1]Note that this concentration is measured in parts per **billion**, and is equivalent to 0.0005 to 0.003 ppm (parts per **million**) when comparing application rates and toxicity studies.

formulations are sold under the trade name of Altosid. These include Altosid Liquid Larvicide (A.L.L.) and Altosid Liquid Larvicide Concentrate, Altosid Briquets, Altosid XR Briquets, and Altosid Pellets. Altosid labels contain the signal word "CAUTION".

ALTOSID LIQUID LARVICIDE (A.L.L.) & A.L.L. CONCENTRATE. These two microencapsulated liquid formulations have identical components and only differ in their concentrations of active ingredients (AI). A.L.L. contains 5% (wt./wt.) s-Methoprene while A.L.L. Concentrate contains 20% (wt./wt.) s-Methoprene. The balance consists of inert ingredients that encapsulate the s-Methoprene, causing its slow release and retarding its ultraviolet light degradation. Maximum labeled use rates are 4 ounces of A.L.L. and 1 ounce of A.L.L. Concentrate (both equivalent to 0.0125 lb. AI) per acre, mixed in water as a carrier and dispensed by spraying with conventional ground and aerial equipment. In sites which average a foot deep, these application rates are equivalent to a maximum active ingredient concentrations of 4.8 ppb, although the actual concentration is substantially lower because the encapsulation does not allow instantaneous dissolution of all of the active ingredient into the water.

Because the specific gravity of Altosid Liquid is about that of water, it tends to stay near the target surface. Therefore, no adjustment to the application rate is necessary in varying water depths when treating species that breathe air at the surface. Cold, cloudy weather and cool water slow the release and degradation of the active ingredient as well as the development of the mosquito larvae.

ALTOSID BRIQUETS. Altosid Briquets consist of 4.125% s-methoprene (.000458 lb. AI/briquet), 4.125% (wt./wt.) r-methoprene (an inactive isomer), and plaster (calcium sulfate) and charcoal to retard ultra violet light degradation. Altosid Briquets release methoprene for about 30 days under normal weather conditions and, as noted earlier, this means that the concentration of AI in the environment at any time is much lower than the value calculated from the weight of material applied. The recommended application rate is 1 Briquet per 100 sq. ft. in non-flowing or low-flowing water up to 2 feet deep. Small sites with any mosquito genera may be treated with this formulation. Typical treatment sites include storm drains, catch basins, roadside ditches, ornamental ponds and fountains, cesspools and septic tanks, waste treatment and settlement ponds, transformer vaults, abandoned swimming pools, and construction and other man-made depressions.

ALTOSID XR BRIQUETS. This formulation consists of 2.1% (wt./wt.) s-methoprene (.00145 lb. AI/briquet) embedded in hard dental plaster (calcium sulfate) and charcoal. Despite containing only 3 times the AI as the "30-day briquet", the comparatively harder plaster and larger size of the XR Briquet change the erosion rate allowing sustained s-methoprene release for up to 150 days in normal weather. The recommended application rate is 1 to 2 briquets per 200 sq. ft. in no-flow or low-flow water conditions, depending on the target species. Many applications are similar to those with the smaller briquets, although the longer duration of material release can also make this formulation economical in small cattail swamps and marshes, water hyacinth beds, meadows, freshwater swamps and marshes, woodland pools, flood plains and dredge spoil sites.

ALTOSID PELLETS. Altosid Pellets contain 4.25% (wt./wt.) s-methoprene (0.04 lb. AI/lb.), dental plaster (calcium sulfate), and charcoal in a small, hard pellet. Like the Briquets discussed above, Altosid Pellets are designed to slowly release s-methoprene as they erode. Under normal weather conditions, control can be achieved for up to 30 days of constant submersion or much

longer in episodically flooded sites (Kramer 1993). Label application rates range from 2.5 lbs. to 10.0 lbs. per acre (0.1 to 0.4 lb. AI/acre), depending on the target species and/or habitat. At maximum label application rates, as with the Briquets, the slow release of material means that the actual concentration of active ingredient in the water never exceeds a few parts per billion.

The target species are the same as those listed for the briquet and liquid formulations. Listed target sites include pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, flood plains, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other man-made depressions, ornamental pond and fountains, flooded crypts, transformer vaults, abandoned swimming pools, construction and other man-made depressions, tree holes, storm drains, catch basins, and waste water treatment settling ponds.

ALTOSID XR-G. Altosid XR-G contains 1.5% (wt./wt.) s-methoprene. Granules are designed to slowly release s-methoprene as they erode. Under normal weather conditions, control can be achieved for up to 21 days. Label application rates range from 5 lbs. to 20.0 lbs. per acre, depending on the target species and/or habitat. The species are the same as listed for the briquet formulations. Listed target sites include meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other natural and man-made depressions.

G. Surfactants

Surfactants are "surface-acting agents" that are either petroleum-based or isostearyl alcohol agent that form a thin layer on the water surface. These materials typically kill surface-breathing insects by blocking the respiratory mechanism.

Advantages: These materials are the only materials efficacious for reducing mosquito pupae since other larviciding strategies (i.e., methoprene, BTI and BS) are ineffective to that life stage. Agnique forms a monomolecular film that is visually undetectable. Treatments are simplified due to the spreading action of the surfactant across the water surface and into inaccessible areas. These surfactants are considered "practically nontoxic" by the EPA. Agnique is labeled "safe for use" in drinking water.

Barriers to Use: The drawback of using oils in habitats where natural enemies are established is that surface-breathing insects, particularly mosquito predators, are similarly affected. GB1111 forms a visible film on the water surface.

Solutions to Barriers: As a general rule, surfactant use is considered after alternate control strategies or in habitats that are not supporting a rich macro-invertebrate community.

Product Names: Golden Bear 1111, Agnique MMF

Formulations and dosages

MOSQUITO LARVICIDE GB-1111 (GOLDEN BEAR 1111). This product, generally referred to as Golden Bear 1111 or simply GB-1111, is a highly-refined petroleum based "napthenic oil" with very low phytotoxicity and no detectible residual products within days after application. Volatility is very low ("non-volatile" according to the MSDS), and environmental breakdown presumably results primarily from natural microbial degradation into simple organic compounds. The label for GB-1111 contains the signal word "CAUTION". GB-1111 contains 99% (wt./wt.) oil and 1% (wt./wt.) inert ingredients including an emulsifier. The nominal dosage rate is 3 gallons per acre or less. Under special circumstances, such as when treating areas with high organic content, up to 5 gallons per acre may be used.

GB-1111 provides effective control on a wide range of mosquito species. Low dosages (1 gallon per acre) of oil work slowly, especially in cold water, and can take 4 to 7 days to give a complete kill. Higher dosage rates are sometimes used (up to 5 gallons per acre) to lower the kill time. It is typically applied by hand, ATV, or truck. Aerial application is possible for large areas, but is not routine.

AGNIQUE: Agnique is the trade name for a recently reissued surface film larvicide, comprised of ethoxylated alcohol. According to the label, Agnique has very low vertebrate toxicity; an average persistence in the environment of 5-14 days at label application rates; and no toxic breakdown products, skin irritation, carcinogenicity, mutagenicity, or teratogenicity has been reported. Because of its similar mode of action and effectiveness against pupae, Agnique can be used as an alternative to Golden Bear 1111, especially in sites where the moderate temporary sheen associated with GB-1111 might be objectionable. Because the application rate of Agnique is much lower than that of Golden Bear, this potential shift would not include an increase in volume of materials applied.

Overall assessment of existing or potential impacts of mosquito control pesticides on beneficial use

All of the materials currently in routine use by MVCD can be considered "less toxic" or "least toxic" according to US EPA toxicity data (Fig. 1).

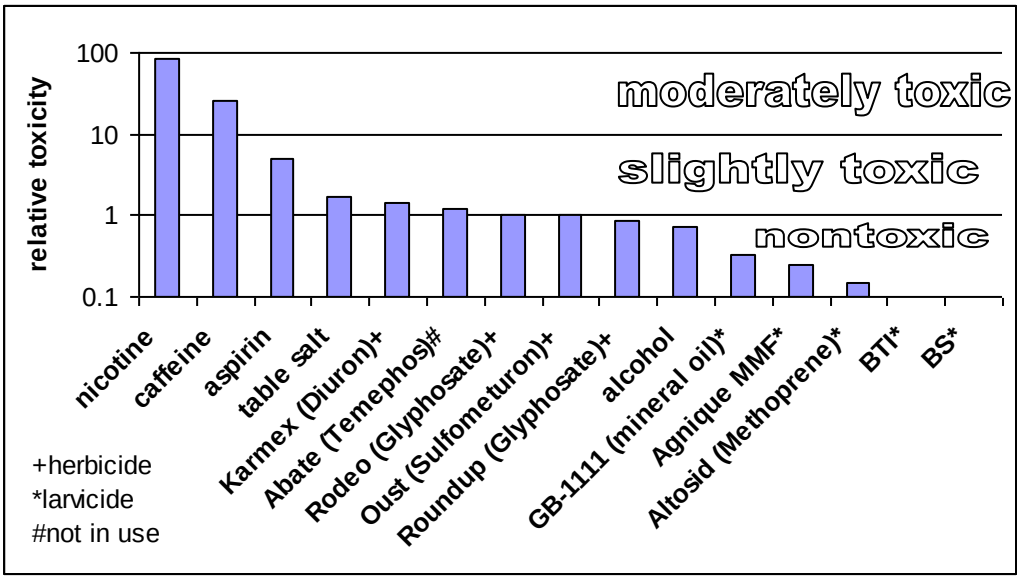


Fig. 1. Relative toxicities of pesticides used by mosquito and vector control programs, based on rat LD50 data from product labels, in comparison with some common household chemicals.

Relevance of water quality analyses for the demonstration of full restoration following project completion:

Mosquito control "projects" are ongoing and do not have a specific duration or date of completion, since the goal is to prevent mosquito populations from exceeding specific injury levels rather than to eradicate them. As in the above "Statement of BMP", surveillance of larval sources is conducted on a continuous basis and treatments are applied as necessary to prevent significant nuisance or disease risks to the public. The materials used routinely in mosquito control programs are applied at extremely low dosages relative to the volume of the habitat, are inherently less-toxic or least-toxic materials (Fig. 1) and are not known to have measurable impacts on water quality. However, existing water quality conditions may have significant impacts on the selection and efficacy of control methods applied (see BMP). Alternative control methods such as physical control (manipulation of drainage, tidal flow etc.) may have significant effects on water quality (salinity, hardness etc) as they can change the hydrodynamics of the entire habitat. The goal of these activities is to enhance water circulation, which directly reduces mosquito production while improving habitat values for natural predators of mosquito larvae. Large-scale physical control projects require individual permits from the U.S. Army Corps of Engineers and the San Francisco Bay Conservation and Development Commission (BCDC), which review potential impacts prior to approval. Documentation of our existing BMP may be considered a "demonstration of full restoration" since it prevents impacts to water quality and makes restoration unnecessary.

b. Relevance of parameters suggested by the water board

The less-toxic control methods and materials used by our programs are designed not to produce measurable impacts on the water quality parameters generally monitored under NPDES permits. Therefore, monitoring of these parameters would represent an added cost while not providing significant benefits to the public or the environment. Parameters normally monitored under NPDES include the following:

i. **Dissolved oxygen**: Materials used in mosquito control are applied at volumes of several ounces (methoprene) to less than 10 gallons (surfactants) per acre of active ingredient. At these dosage rates it is extremely unlikely there would be any measurable effects on dissolved oxygen.

ii. **Temperature**: Materials used in mosquito control are generally applied at or near ambient environmental temperature. At the dosage rates used in mosquito control it is extremely unlikely there would be any measurable effects on water temperature.

iii. **pH**: Materials used in mosquito larval control are not strongly acidic or basic as this could damage application equipment. At the application rates used in mosquito control they are extremely unlikely to have a measurable effect on pH.

iv: **Turbidity**: Turbidity, particularly due to suspended organic material, may influence the selection or efficacy of materials used in mosquito control. At the application rates used in our programs, these materials are extremely unlikely to have a measurable effect on turbidity.

v: **Hardness**: Materials used in mosquito control do not have a high mineral. At the dosage rates used in mosquito control it is extremely unlikely there would be any measurable effects on water hardness.

vi: **Electrical conductivity**: Materials used in mosquito control do not have high concentrations of chlorides or other ions. At the dosage rates used in mosquito control it is extremely unlikely there would be any measurable effects on conductivity.

vii: **Pesticide residues**: In general, materials used by MVCD are non-persistent, do not bioaccumulate, and are designed to biodegrade or break down after achieving the desired control of larval populations. Exceptions are slow-release formulations of methoprene, which are specifically designed for extended release of small amounts of active ingredient, and biological agents such as *Bacillus sphaericus, Lagenidium giganteum*, and mosquitofish, which may reproduce and recycle naturally under favorable conditions. In this case the "residue" actually has a beneficial effect by prolonging the period of larval control and reducing the need for repeated applications or use of more toxic materials. There are currently no EPA approved laboratories or protocols for detecting residues of larvicides used routinely by MVCD. Monitoring of mosquito larval populations, as already practiced routinely under our BMP, is the most sensitive method available for determining whether residual larvicide activity is present.

EVALUATION OF LESS-TOXIC CONTROL METHODS

Pesticide use by MVCD is only one aspect of an Integrated Pest Management (IPM) strategy. This strategy includes the use of physical and biological control techniques whenever possible and is based on a program of continuous monitoring of both adult and immature mosquito populations A complete description of the MVCD IPM strategy is given in the accompanying document "Statement of Best Management Practices". Nonchemical control methods, barriers to their use, and solutions to those barriers are listed below:

Physical control (see discussion in BMP document).
Cost: high, requires specialized equipment and expertise, may be labor intensive.
Barriers: high cost; lack of equipment in some districts; problems with disturbing habitats of endangered species; wetlands are sensitive habitats and highly regulated; requires extensive permit process .
Solutions to barriers: encourage landowners to do this work; some districts have personnel with expertise in wetlands restoration; work with restoration agencies.
Relative usefulness of this technique: used whenever possible; first choice because it is a permanent solution. If physical control is not feasible, or while working toward a physical control solution we will use biological or chemical control techniques.

Water management
Cost: cost of equipment and engineering can be very high initially; may be labor intensive; requiring someone on hand at all times to monitor water levels and operate gates.
Barriers: most land we treat is not under our control and it is difficult to force landowners to cooperate; most districts don't have adequate staff or budget to install and operate floodgates; conflict with other uses of wetlands such as waterfowl conservation, recreation (hunting).
Solutions to barriers: work with land owners as much as possible to encourage good water management; treat only when necessary.
Relative usefulness of this technique: used whenever possible; first choice because it is a permanent solution. When water management fails we use biological or chemical control

Biological control
Mosquito fish
Cost: low
Barriers: release of non native fish into natural sources is controversial; may compete with native fish; requires facilities and personnel to rear and maintain fish.
Solutions to barriers: use only in manmade sources; get fish from other districts and only keep a small supply on hand.
Relative usefulness of Mosquito fish: fish are considered when physical control is out of the question. Can be very useful but only under a very restricted set of conditions. If a source is suitable for fish and fish will not impact native species we will use this strategy; some districts treat only manmade sources or those lacking native fish

Bacterial pesticides: The primary pesticides used by MVCD may be considered a form of biological control

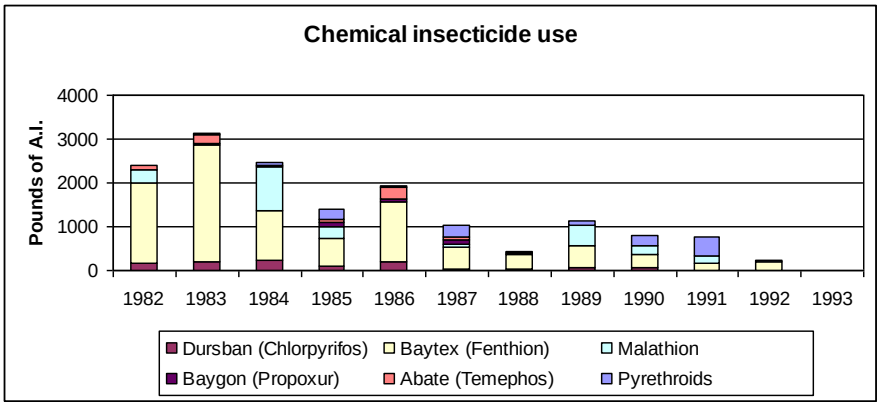
Bacillus sphaericus* and *B. thuringiensis* var. *israelensis
Cost: these materials are more expensive than organophosphate pesticides but cheaper than physical control.
Barriers: requires more careful monitoring of mosquito populations and more thorough knowledge of their ecology. Not effective against some species or some stages or in some types of sources. Very short duration of control; requires frequent retreating. Reliance on a single product may result in development of resistance.
Solutions to barriers: monitoring program for mosquitoes; training for district staff; rotate products.
Relative usefulness of this technique: these agents are considered when physical control is out of the question and fish cannot be stocked or maintained. Sometimes used in conjunction with stocking fish since these materials have been shown not to adversely affect fish. In this case, fish may be a long term solution but chemical are needed to initially bring down mosquito populations. Also need to consider possibility of development of resistance, therefore the need to rotate products used.

Chemical Control using methoprene and surface oils instead of organophosphates
Cost: these materials are more expensive than OPs but cheaper in the short term than physical control
Barriers: requires more careful monitoring of population and more thorough knowledge of ecology, resistance
Solutions to barriers: monitoring program for mosquitoes, training for techs, biologists on staff, rotate materials, investigate new materials
Relative usefulness of this technique: Like biological pesticides these materials are considered when physical control is out of the question and fish cannot be stocked or maintained. Sometimes used in conjunction with stocking fish since these materials have been shown not to adversely affect fish.. Decisions on whether to use these materials or bacterial pesticides are based on: stage and species of mosquitoes present, quality of water, access Also need to consider possibility of development of resistance, therefore the need to rotate products used.

EVALUATION OF THE EFFECTIVENESS OF BMP'S TO REDUCE DISCHARGES AND MINIMIZE AREA AND DURATION OF IMPACTS

Our Best Management Practices insure that all available less-toxic or least-toxic control methods are considered and that new methods are evaluated on an ongoing basis and, if effective, incorporated into our larval control programs. Implementation of BMP resulted in the complete elimination of the routine use of conventional chemical insecticides (organophosphates and carbamates) between 1982 and 1993 and a concomitant increase in use of less toxic methods including bacterial insecticides and insect growth regulators (Fig. 2, a and b).

A.



B.

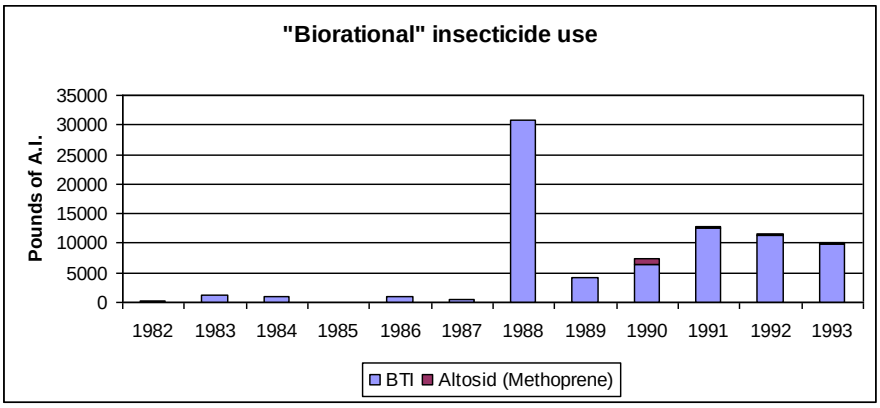


Fig. 2 a. Reduction in use of chemical larvicides by Coastal Region Districts, 1982-1993. b. Increase in use of bacterial insecticides and insect growth regulators.

PROPOSED MONITORING PLAN

We propose a monitoring plan consisting primarily of record-keeping and reporting elements. Records shall be kept by each district of all pesticide applications made to waters of the U.S. by its staff and/or contractors. These records shall include the site, material, concentration, quantity applied, habitat type, approximate water surface area, and the date and time for each application. In addition, each district shall report annually to the SFRWQCB on its aquatic pesticide applications, summarizing the recorded data to indicate the quantity of each pesticide active ingredient applied to each habitat type within the zone of each district that drains to each major final receiving body. If organo-phosphate or other non-standard larvicides, or herbicides with active ingredients other than glyphosate, are required, the SFRWQCB will be promptly notified so that an appropriate supplemental monitoring plan can be developed.

We will also conduct an annual review of our BMP to reflect any new practices and ensure that less-toxic methods and materials continue to be evaluated and incorporated as they become available. Any changes or revisions to our BMP will also be reported annually.

APPENDIX K3. Effects of Larvacides on Non-Target Organisms

Effects of Larvicides on Non-Target Organisms
USFWS 2003

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Introduction

The information contained within this document is a guide to mosquito larvicide effects on non-target organisms. Included is information on the four most commonly used larvicides: monomolecular surface films (Arosurf®), *Bacillus thuringiensis israelensis* (BTI), methoprene (Altosid®) and temephos (Abate®). Articles presented are representative entries whose information would lend itself to tabulation. This does not represent a comprehensive treatment of the subject.

The following information is provided for each larvicide: a short description of how the larvicide works, a generalized synopsis of non-target effects, label application rates of various formulations of the product, references cited within the effects table, and a tabulation of non-target effects on various organisms. The table is arranged by taxonomic categories (e.g., birds, insects), and alphabetical within category. Taxonomy may not be the most current. Label application rates are excerpted from the manufacturer's information sheets as follows:

Arosurf® now manufactured as Agnique® by the Henkel Corporation;
BTI (Vectobac® products) manufactured by Abbott Laboratories;
Methoprene (Altosid® products) manufactured by Sandoz Agro, Inc., and Zoecon;
Temephos (Abate® products) manufactured by Clarke Mosquito Control Products, Inc.

At the end of each section is an extensive bibliography of mosquito larvicide articles. Additional information is available on the Internet. Two web sites that are useful include:

http://ace.ace.orst.edu/info/extoxnet/pips/ghindex.html These Pesticide Information Profiles provide general information on many registered pesticides, such as mode of action, toxicity, ecological effects, and references.

http://www.famu.edu/jamsrl/peis/mosquito/mosqsearch.html The Non-target Search Form provides a searchable database for mosquito literature. A search can be conducted by author, organism, pesticide, or a key word search. The database provides abstracts for many of the articles.

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Arosurf® (ISA-20E)

now produced as **Agnique®**

Arosurf is a monomolecular surface film, which reduces the water surface tension. This interferes with larval orientation at the air-water interface and/or increases wetting tracheal structures, thus suffocating the organism. As the film spreads over the water surface, it tends to concentrate the larvae, which may increase mortality from crowding stress (Dale and Hulsman 1990).

According to the Henkel Corporation, Agnique's improvements over Arosurf center around removal of the byproducts that left the white residues in the drums and application equipment. Removing these byproducts lowered the freezing point of the product. The spreading ability was also improved, so that application of the product was made easier.

Synopsis of Non-target Effects

Arosurf had no adverse effect on any of the organisms tested. However, none of the studies listed investigated species such as water boatman or backswimmers.

Label Application Rates for Agnique

Example habitat: Salt-marsh, ponds, storm water retention basins, roadside ditches, grassy swales, potholes, fields, reservoirs, irrigated croplands, etc. Larvae: 0.2-0.5 gal/surface acre Pupae: 0.2-0.3 gal/surface acre

Example habitat: Pumping station bunkers, settings, polishing and evapo-percolation ponds of sewage treatment systems, drainage areas containing effluent from slaughter houses, etc.
Larvae: 0.4-0.5 gal/surface acre Pupae 0.2-0.3 gal/surface acre

References Cited:

Dale, P.E.R. and K. Hulsman. 1990. A critical review of salt marsh management methods for mosquito control. Review in Aquatic Sciences 3:281-311.

Hester, P.G., M.A. Olson, and J.C. Dukes. 1991. Effects of Arosurf[R] MSF on a variety of aquatic nontarget organisms in the laboratory. J. Amer. Mosq. Control Assn. 7:48-51.

Mulla, M.S., H.A. Darwazeh, and L.L. Luna. 1983. Monolayer films as mosquito control agents and their effects on non-target organisms. Mosq. News. 43:489-495.

Table 1. Non-target Effects of Arosurf® (now produced as Agnique®)

Classification	Organism	Reference	Formulation	Application Rate (study)	Adverse Effects	No Effects	Comments
Fish Atheriniformes	Longnose killifish *(Fundulus simulus)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Mollusks Basommatophora	Snail *(Physa sp.)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Crustaceans Amphipoda	Amphipod (*Grammarus* spp.& unknown)	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Anostraca	Fairy shrimp *(Streptocephalus seali)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Copepoda	Copepods	Mulla et al 1983	MSF	0.5-0.75 gal/acre		X	information from abstract
Decapoda	Fiddler crab *(Uca spp.)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test (3.3% mortality, not attributed to test)
Decapoda	Freshwater shrimp *(Palaemonetes paludosus)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test

Decapoda	Grass shrimp *(Palaemonetes pugio)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Decapoda	Crayfish *(Procambarius spp.)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Isopoda	Isopod *(Asellus spp.)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test
Ostracoda	Seed shrimp	Mulla et al 1983	MSF	0.5-0.75 gal/acre		X	information from abstract
Insects Coleoptera	Diving Beetle adults *(Berosus metalliceps)*	Mulla et al 1983	MSF	0.5-0.75 gal/acre		X	information from abstract
Ephemeroptera	Mayfly naiads (*Callibaetis pacificus*)	Mulla et al 1983	MSF	0.5-0.75 gal/acre		X	information from abstract
Annelids Polychaeta	Polychaete *(Laeonereis culveri)*	Hester et al.1991	MSF	47 ml/m^2 (50 gal/acre)		X	96-hour acute static toxicity lab test

Bacillus thuringiensis israelensis (BTI)

BTI is a bacterial pathogen which produces a parasporal body know as a "crystal." This toxin kills larvae rapidly by attacking the plasma membrane of the gut epithelia (Dale and Hulsman, 1990). BTI forms asexual reproductive spores that enable it to survive adverse conditions; during spore formation, BTI produces unique crystalline bodies as a companion product. These spores and crystals must be ingested before they act as poisons to target insects (referred to as a "stomach" poison). The crystals dissolve in response to intestinal conditions of susceptible insect larvae. The toxins released paralyze the gut, thus interfering with normal digestion which triggers the insect to stop feeding. Then the BTI spores can invade other tissues and multiply in the bloodstream until the insect dies. BTI is ineffective against adult insects. BTI is effective against mosquitoes, black flies, and certain midges. Other strains of *Bacillus thuringiensis* are effective against other insects, such as the wax moth, gypsy moth and cabbage looper, and a new strain has been found is effective against the boll weevil (Pesticide Information Profile, EXTOXNET).

Synopsis of Non-target Effects

The attached Table 2 presents detailed information regarding the effects of BTI on non-target organisms. A few generalizations can be drawn from this information. Target organisms for BTI applications are various species of mosquitoes (both freshwater and salt marsh) and black flies. Effectiveness of BTI on mosquito species is not included. Chironomids, also a Dipteran (like mosquitoes and black flies), were primarily the non-target group adversely affected by BTI, but this also varied by species. A 3-year study found the other Dipterans (crane flies and stone flies) were affected in the third year of the study, as were the Ephemeropterans (mayflies).

Label Application Rates

Vectobac G (200 International Toxic Units/mg = 0.091 billion ITU/lb)

Habitat: irrigation/roadside ditches, floodwater, standing ponds, woodland pools, catch basins, storm water retention ponds, tidal water, and salt marshes

Application Rate: 2.5 - 10 lbs/acre

Late 3rd instar or early 4th instar, high populations, or heavily polluted water (sewage lagoons, etc.) or abundant algae

Application Rate: 10 - 20 lbs/acre.

Allow 7 to 14 days between applications.

Vectobac 12AS (1200 ITU/mg = 4.84 billion ITU/gal or 1.279 billion ITU/liter)

Mosquito habitat: irrigation/roadside ditches, floodwater, standing ponds, woodland pools, catch basins, storm water retention ponds, tidal water, salt marshes, rice fields

Application rate: 0.25 - 1 pt/acre

Use higher rate in polluted water and when late 3rd and early 4th instar larvae predominate, when mosquito population is high, water is heavily polluted, or abundant algae

Application rate: 1- 2 pts/acre

Blackfly habitat – streams

stream water (=ppm) for 1 minute exposure time: 0.5 - 25mg/liter

stream water (=ppm) for 10 minute exposure time: 0.05 - 2.5 mg/liter

(use higher rate range when stream contains high concentration of organic materials, algae or dense aquatic vegetation)

Vectobac CG (200 ITU/mg = 0.091 billion ITU/lb)

Habitat: irrigation/roadside ditches, floodwater, standing ponds, woodland pools, catch basins, storm water retention ponds, tidal water, salt marshes, rice fields

Application rate: 2.5 - 10 lb/acre

Allow 7 to 14 days between applications.

Web Site:

Pesticide Information Profiles, EXTOXNET

http://ace.ace.orst.edu/info/extoxnet/pips/ghindex.html

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Table 2. Non-target Effects of BTI

Classification	Organism	Reference	Formulation	Application Rate (study)	Adverse Effects	No Effects	Comments
Fish Atheriniformes	Mummichog *(Fundulus heteroclitus)*	Lee & Scott 1989	Vectobac EC				96-hour LC_{50} = 980 mg/L (1,176,000 ITU/L); no effect conc. =22.36 mg/L
Cypriniformes	Golden Shiner (*Notemigonus crysoleucas)*	Mulligan & Schaefer 1981	B.t. H-14 (692±69 ITU/mg)	1.0 kg/ha & 2.0 kg/ha		X	hand applied to bait fish ponds
Crustaceans Cladocera	Water fleas	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Cladocera	Water fleas	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Conchostraca	Clam Shrimp	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Copepoda	Copepods	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$		X	experimental plots

				spores/ml)			
Copepoda	Eucopepoda	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Isopoda	*Asellus forbesi*	Knepper & Walker 1989	Bti			X	hardwood bottomland pools; isopods not negatively affected (information from abstract)
Ostracoda	Podocopa	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Ostracoda	Seed shrimp	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Insects Coleoptera	Beetles	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream
Coleoptera	Beetles	Mulligan & Schaefer 1981	B.t. H-14 (576±20 ITU/mg)	1.1 kg/ha		X	aerially applied to duck club pond
Coleoptera	Beetles	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Coleoptera	Beetles	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha			natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term

							effects study); significantly reduced in 1993 season only; not significantly reduced over the 3-yr period
Coleoptera	Dytiscid beetles	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Coleoptera	Elmids	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)		X	stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC
Coleoptera	Hydrophilid beetles	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Diptera	Biting midges Ceratopogonids	Hershey et al. 1998	Vectobac G	11.72 ± 0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); not affected until 3rd year, reduced by 67% in 1993; reduced by 29% over the 3-yr period
Diptera	Black flies	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)	X		stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC

Diptera	Black flies	Molloy 1992	Bactimos WP Teknar WDC Vectobac WP	ranged from 3.7ppm/15 min to 50ppm/1min	X		flowing streams; water temp. ranged from 3°C to 17°C; discharge rates ranged from 168 l/min to 20,740 l/min
Diptera	Black flies (Simuliidae)	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml	X		flowing stream
Diptera	Chironomid: *Procladius bellus & Tanypus neopunctipennis*	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	56 kg/ha		X	lake study; no effect
Diptera	Chironomid: *Chironomus decorus*	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	56 kg/ha	X		lake study; 42-67% control for 3 weeks
Diptera	Chironomid: *Procladius bellus & Tanypus neopunctipennis*	Rodcharoen et al. 1991	Vectobac ABG 6164 (technical powder)	1.4 kg/ha 2.8 kg/ha		X	lake study; no effect noted
Diptera	Chironomid: *Chironomus decorus*	Rodcharoen et al. 1991	Vectobac technical powder (5,000 ITU/mg)	2.2 kg/ha 4.5 kg/ha 6.7 kg/ha	X		lake study; lower rate yielded maximum control of 66% at 2 weeks; middle rate yielded higher level of control; higher rate yielded 95% control at 1 week, then 100% at 2-3 weeks; higher 2

							rates yielded over 70% control for 4 weeks
Diptera	Chironomid: *Chironomus decorus*	Rodcharoen et al. 1991	Vectobac 6264 (400 ITU/mg) corn grit granules	11.2 kg/ha 19.1 kg/ha			lake study: "mediocre" control (32 & 47% respectively) for about 2 weeks
Diptera	Chironomid: *Procladius bellus & Tanypus grodhausi*	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	13.5 kg/ha 28 kg/ha 56kg/ha		X	lake study; unaffected even at highest rate
Diptera	Chironomid: *Dicrotendipes* sp.	Rodcharoen et al. 1991	Vectobac 6264 (400 ITU/mg) corn grit granules	11.2 and 22.4 kg/ha	X		mesocosm studies; highly susceptible
Diptera	Chironomid: *Chironomus decorus*	Rodcharoen et al. 1991	Vectobac ABG 6164 (technical powder)	1.4 kg/ha 2.8 kg/ha	X		lake study; lower rate yielded maximum reduction of 73% 2 weeks post treatment and lasted about 4 weeks; high rate yielded max. control of 87% at 3 weeks post treatment
Diptera	Chironomid: *Chironomus* sp.	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	22.4 and 44.8 kg/ha	X		mesocosm studies; highly susceptible to higher rate
Diptera	Chironomid: *Chironomus* sp.	Rodcharoen et al. 1991	Vectobac 6 AS (aqueous	11.2 and 22.4 kg/ha	X		mesocosm studies; 11.2 kg/ha yielded 37% control at 1 week

			suspension)				post treatment; 22.4 kg/ha yielded 57% control at 2 weeks post treatment; conclusion that control not evident until 2 weeks post treatment
Diptera	Chironomid: *Procladius* sp.	Rodcharoen et al. 1991	Vectobac 6264 (400 ITU/mg) corn grit granules	11.2 and 22.4 kg/ha		X	mesocosm studies; lower rate yielded 24% control after 1 week; higher rate no effect; conclusion little to no control
Diptera	Chironomid: *Chironomus* sp.	Rodcharoen et al. 1991	Vectobac ABG-6164 (technical powder)	5.6 and 11.2 kg/ha	X		mesocosm studies; yielded 98% and 100% control (respectively) at 2 weeks post treatment
Diptera	Chironomid: *Paratanytarsus* sp.	Rodcharoen et al. 1991	Vectobac 6264 (400 ITU/mg) corn grit granules	11.2 and 22.4 kg/ha		X	mesocosm studies; conclusion little to no control
Diptera	Chironomid: *Paratanytarsus* sp.	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	22.4 and 44.8 kg/ha		X	mesocosm studies; conclusion little to no control
Diptera	Chironomid: *Chironomus decorus*	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	13.5 kg/ha 28 kg/ha 56kg/ha	X		lake study; lowest rate showed only 22% control at 2 weeks; higher rates showed 83% and 96% control (respectively); control of over 70% at 2 higher rates lasted over 4 weeks

Diptera	Chironomid: *Dicrotendipes* sp.	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	22.4 and 44.8 kg/ha	X		mesocosm studies; highly susceptible
Diptera	Chironomid: *Chironomus* sp.	Rodcharoen et al. 1991	Vectobac 6264 (400 ITU/mg) corn grit granules	11.2 and 22.4 kg/ha	X		mesocosm studies; highly susceptible
Diptera	Chironomid: *Procladius* sp.	Rodcharoen et al. 1991	Vectobac 6253 (200 ITU/mg) corn grit granules	22.4 and 44.8 kg/ha		X	mesocosm studies; lower rate no effect; higher rate yielded 17% control after 1 week conclusion little to no control
Diptera	Chironomidae	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); reduced by 66% in 1992 & 84% in 1993
Diptera	Chironomids	Cilek & Knapp 1992	Vectobac-6AS	50 ppm	X		field test in flowing creek, velocity 0.8 m/s & 0.5 m/s, water temp. 25°C, pH 7.5
Diptera	Chironomids	Cilek & Knapp 1992	Vectobac-G	22.4 kg/ha		X	field test in flowing creek, velocity 0.1 m/s, water temp. 25°C, pH 7.5

Diptera	Chironomids	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha			aerially applied to wetlands; peak numbers 1 day after treatment, with gradual decline thereafter
Diptera	Chironomids	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)		X	stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC
Diptera	Chironomids	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)	X		experimental plots; all larvae collected were killed w/i 2 days of treatment, but daily collections rapidly increased indicating short-term effects
Diptera	Chironomids (filter-feeders; *Rheotanytarsus spp.*)	Molloy 1992	Bactimos WP Teknar WDC Vectobac WP	ranged from 3.7ppm/15 min to 50ppm/1min	X		flowing streams; water temp. ranged from 3^oC to 17^oC; discharge rates ranged from 168 l/min to 20,740 l/min
Diptera	Chironomids – Other	Molloy 1992	Bactimos WP Teknar WDC Vectobac WP	ranged from 3.7ppm/15 min to 50ppm/1min		X	flowing streams; water temp. ranged from 3^oC to 17^oC; discharge rates ranged from 168 l/min to 20,740 l/min
Diptera	Chironomids	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream
Diptera	Chironomids	Charbonneau et at 1994	Vectobac-G	28.1 kg/ha		X	adversely affected in lab, but environmental factors (temperature, larval instar, water depth & water surface area coverage) reduced efficacy in the field

Diptera	Chironomids	Charbonneau et al 1994	Vectobac-G	5.6 kg/ha		X	adversely affected in lab, but environmental factors (temperature, larval instar, water depth & water surface area coverage) reduced efficacy in the field
Diptera	Chironomids – predatory	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); reduced 62% in 1992 & 83% in 1993
Diptera	Crane flies (Tipulidae)	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); reduced by 73% over the 3-yr treatment period
Diptera	Diptera	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); over 3-yr study total reduction = 63%
Diptera	Nematocera	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); over 3-yr treatment total reduction = 67%
Diptera	Soldier flies (Stratiomyidae)	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year

							for 3 years (1991-1993 long-term effects study); reduced in 1993 season only, reduction =74%; yielding 56% reduction over the 3-yr period
Ephemeroptera	May flies (Brachycera)	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); showed no effect until 1993 when reduced by 66%
Ephemeroptera	Mayflies	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Ephemeroptera	Mayflies	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Ephemeroptera	Mayflies	Molloy 1992	Bactimos WP Teknar WDC Vectobac WP	ranged from 3.7ppm/15 min to 50ppm/1min		X	flowing streams; water temp. ranged from 3^oC to 17^oC; discharge rates ranged from 168 l/min to 20,740 l/min
Ephemeroptera	Mayflies	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)		X	stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC
Ephemeroptera	Mayflies	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream

Hemiptera	Corixids	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Hemiptera	Notonectids	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Hemiptera	True bugs	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Hemiptera	True bugs	Mulligan & Schaefer 1981	B.t. H-14 (576±20 ITU/mg)	1.1 kg/ha		X	aerially applied to duck club pond
Odonata	Damselflies	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Odonata	Damselflies (Zygoptera)	Mulligan & Schaefer 1981	B.t. H-14 (552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Odonata	Dragonflies & Damselflies	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream
	Dragonflies	Mulligan &	B.t. H-14				

Odonata	(Anisoptera)	Schaefer 1981	(552±22 ITU/mg)	0.8 kg/ha		X	aerially applied to wetlands
Odonata	Dragonflies (Anisoptera)	Mulligan & Schaefer 1981	B.t. H-14 (576±20 ITU/mg)	1.1 kg/ha		X	aerially applied to duck club pond
Odonata	Dragonflies	Miura et al 1980	SAN 402 I WDC	0.25 kg/ha (~$1.3x10^3$ spores/ml) & 1 kg/ha (~$5.4x10^3$ spores/ml)		X	experimental plots
Plecoptera	Stoneflies	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream
Plecoptera	Stoneflies	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)		X	stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC
Trichoptera	Caddisflies	Colbo & Undeen 1980	B.t. H-14	$1x10^5$spores/ml		X	flowing stream
Trichoptera	Caddisflies	Molloy & Jamnback 1981	Primary powder (R153-78)	0.5ppm conc. ($1.4x10^8$ spores/mg)		X	stream study, flow rate 1770 l/min; water temp. range 8°- 17^oC
Trichoptera	Caddisflies	Molloy 1992	Bactimos WP Teknar WDC Vectobac WP	ranged from 3.7ppm/15 min to 50ppm/1min		X	flowing streams; water temp. ranged from 3^oC to 17^oC; discharge rates ranged from 168 l/min to 20,740 l/min.
Miscellaneous	Non-dipteran predators	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year

							for 3 years (1991-1993 long-term effects study); no significant seasonal effect in 1991 & 1992, but significant reduction in 1993
Miscellaneous	Total predatory insects	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study); no significant seasonal effect in 1991 & 1992, but 60% reduction in 1993
Miscellaneous	Non-insect macro-invertebrates	Hershey et al. 1998	Vectobac G	11.72±0.64 kg/ha		X	natural wetlands; aerial application, 6 treatments per year for 3 years (1991-1993 long-term effects study)

Methoprene

Methoprene is an insect growth regulator (IGR), which mimics juvenile hormones (Dale and Hulsman 1990). It interferes with the insect's maturation stages and makes it impossible for the insect to reach the adult stage, thus preventing it from reproducing. Methoprene is considered a biochemical pesticide because it interferes with the life cycle rather than direct toxicity. To be effective, it must be administered at the proper life stage of the mosquito (or target species). It is not toxic to pupal or adult stages. Treated larvae will pupate, but will not emerge as adults (Pesticide Information Profiles, EXTOXNET).

Synopsis of Non-target Effects

As seen in Table 3, methoprene had no effect on the vertebrate species tested. Mixed effects were seen for snails, and crustaceans such as grass shrimp and mud crabs. Insects most affected were dipterans, with some mixed effects reported for mayflies and some coleopterans.

Label Application Rates

Altosid® Liquid Larvicide (A.L.L.) effective on 2nd, 3rd, or 4th instar larvae of floodwater mosquitoes; has no effect on pupae or adult mosquitoes

Crop Areas: irrigated croplands after flooding, e.g. vineyards, rice fields, irrigated pastures, berry fields, orchards, bogs. Application Rate: 3 to 4 fluid ounces/acre (219 to 293 ml/hectare) in water.

Intermittently Flooded Areas: freshwater swamps and marshes, salt marshes, woodland pools and meadows, dredging spoil sites, drainage areas, waste treatment and settling ponds, ditches and other natural or man-made depressions. Application Rate: 3 to 4 fluid ounces/acre (219 to 293 ml/hectare) in water.

Dense Vegetation or Canopy Areas: Apply A.L.L. on sand granules at standard application rate (as stated above).

Altosid® Pellets is toxic to aquatic dipteran (mosquitoes) and Chironomid (midge) larvae. It has no effect on pupal or adult stage mosquitoes; pellets release effective levels for up to 30 days.

Floodwater Sites: pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, cattail marshes, woodland pools, floodplains, tires, and other artificial water-holding containers. Application Rate: 2.5 - 5.0 lb/acre.

Floodwater Sites: dredging spoil sites, waste treatment and settling ponds, ditches and other man-made depressions. Application Rate: 5.0 - 10.0 lb/acre.

Permanent Water Sites: ornamental ponds and fountains, fish ponds, cattail marshes, water hyacinth beds, flooded crypts, transformer vaults, swimming pools and other man-made depressions, etc. Application Rate: 2.5 - 5.0 lb/acre

Permanent Water Sites: storms drains, catch basins, roadside ditches, cesspools, septic tanks, waste settling ponds, vegetation-choked phosphate pits. Application Rate: 5.0 - 10.0 lb/acre.

Altosid® XR-G (extended residual granules) is toxic to aquatic dipteran; it has no effect on pupal or adult life stages; length of control up to 21 days, but actual length depends on duration and frequency of flooding.

Non-Crop Areas: snow pools, salt and tidal marshes, freshwater swamps and marshes, woodland pools and meadows, dredging spoil sites, drainage areas, ditches, water-holding receptacles and other natural or man-made depressions.

Aedes, Anopheles, and *Psorophora* spp. Application Rate: 5 - 10 lb/acre (5.6 - 11.2 kg/ha). *Culex, Culiseta, Coquillettidia,* and *Mansonia* spp. Application Rate: 10 - 20 lb/acre (11.2 - 22.4 kg/ha). Within these rates, use lower rate when water is shallow (≤2 ft. [60 cm]) and vegetation and/or pollution are minimal. Use higher rates when water is deep (≥2 feet) and vegetation and/or pollution are heavy.

Altosid® Briquets: toxic to aquatic dipterans; no effect on pupal or adult stage mosquitoes; under normal conditions, repeat treatment every 30 days; designed to control mosquitoes in small bodies of water.

Sites: storm drains, catch basins, roadside ditches, fish ponds, ornamental ponds and fountains, septic tanks, waste treatment and settling ponds, abandoned swimming pools, other man-made depressions, cattail marshes, water hyacinth beds, pastures, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, floodplains, dredging spoil sites.

Application Rates: non-(or low) flow, shallow depressions (up to 2 ft. deep), treat on basis of surface area placing one briquet per 100 sq. ft. Flowing water or deeper than 2 ft, treat on basis of volume, one briquet per 10 cu ft. (75 gal of water).

Altosid® XR (extended residual briquets): toxic to aquatic dipterans; no effect of pupal or adult stage mosquitoes; one application should last entire breeding season, or 150 days.

Sites: storm drains, catch basins, roadside ditches, fish ponds, waste treatment and settling ponds, cattail marshes, meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, floodplains and dredging spoil sites.

Application Rates: *Aedes* and *Psorophora* spp. in non-(or low) flow shallow depressions (≤2 ft. deep) treat on basis of surface area - 1 briquet per 200 ft^2. *Culex, Culiseta,* and *Anopheles* spp. - 1 briquet per 100 ft^2. *Coquillettidia* and *Mansonia* spp. for application to cattail marshes and water hyacinth beds, place 1 briquet per 100 $ft.^2$.

Web Site:

Pesticide Information Profiles, EXTOXNET
http://ace.ace.orst.edu/info/extoxnet/pips/ghindex.html

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Table 3. Non-target Effects of Methoprene

Classification	Organism	Reference	Formulation	Application Rate (study)	Adverse Effects	No Effects	Comments
Fish Atheriniformes	Killifish	McAlonan et at. 1976	Altosid 10-F	0.012 to 0.120 lbs AI/A		X	caused no mortality
Atheriniformes	Mosquitofish *(Gambusia affinis)*	Ellgaard et al 1979	methoprene	0.2 ppm		X	exposed for 12 days; methoprene was added at rate every 2 days such that total conc was increased by 0.1 ppm; no effect on motility
Atheriniformes	Mosquitofish *(Gambusia affinis)*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Atheriniformes	Mosquitofish *(Gambusia affinis)*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 1 ppm; 60% at 100 ppm; test duration 312 hours
Atheriniformes	Mummichog *(Fundulus heteroclitus)*	Lee & Scott 1989	methoprene EC				96-hour LC_{50} = 124.95 mg/L; no effect concentration = 24.68 mg/L
Cypriniformes	Goldfish	Ellgaard et al 1979	methoprene	0.2 ppm		X	exposed for 13 days; methoprene was added at rate every 2 days such that total conc was increased by 0.1 ppm; no effect on motility
Cypriniformes	*Heterandria formosa*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Perciformes	Bluegill	Quistad et al. 1976	methoprene	0.31 & 0.005 ppm			radioactive tag to study uptake; higher dose, fish exhibited stress (LC_{50} = 2.1 ppm); within 2 weeks after treatment, 93-95% residue

							had been eliminated
Amphibians Anura	Western toad tadpoles, *Bufo borcas helophilus*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 1 ppm; test duration 24 hours
Arachnids Acarina	Oribateid mites	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Mollusks Basommatophora	*Physa* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Basommatophora	Pond snail, *Physa* spp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations		X	laboratory toxicity tests: 0% mortality at 100 ppm; test duration 72 hours
Basommatophora	Snail, *Lymnaea* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations		X	laboratory toxicity tests: 0% mortality at 1 ppm; test duration 72 hours
Crustaceans Amphipoda	*Hyallela azteca* (Scud)	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months; greater reduction in open water habitats
Amphipoda	Sideswimmers, *Hyallela azteca*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.25 ppm; test duration 24-120 hours
Cladocera	Water fleas, *Daphnia magna*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 0.90 ppm; test duration 24 hours
Cladocera	Water fleas, *Daphnia magna*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study

Cladocera	Water fleas, *Daphnia magna*	Miura & Takahashi 1973	technical ZR-515	0.7 lb corncob granular/acre		X	outdoor cage study
Cladocera	Water fleas, *Daphnia magna*	Miura & Takahashi 1973	technical ZR-515, 10% flowable liquid (slow release)	0.1 ppm		X	outdoor test in artificial container; no detectable effects
Conchostraca	Clam shrimp, *Eulimnadia* sp.	Miura & Takahashi 1973	technical ZR-515	0.1 lb EC/acre		X	outdoor caged study
Conchostraca	Clam shrimp, *Eulimnadia* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.00 ppm; test duration 24 hours
Conchostraca	Clam shrimp, *Eulimnadia* sp.	Miura & Takahashi 1973	technical ZR-515	0.7 lb corncob granular/acre		X	outdoor caged study
Conchostraca	Clam shrimp, *Eulimnadia* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Copepoda	Copepods, *Cyclops* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Copepoda	Copepods, *Cyclops* sp.	Miura & Takahashi 1973	technical ZR-515	0.1 lb EC/acre		X	pond study
Copepoda	Copepods,	Miura & Takahashi	technical	5			laboratory acute toxicity tests: LC_{50} = 4.60 ppm; test duration 24

	Cyclops sp.	1973	ZR-515	concentrations			hours
Copepoda	Copepods, *Cyclops* sp.	Miura & Takahashi 1973	technical ZR-515, 10% flowable liquid (slow release)	0.1 ppm		X	outdoor test in artificial container; no detectable effects
Decapoda	Crayfish (*Procambarius clarki* and *Cambarellus* sp.)	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months; population increases attributed to reduced predator populations
Decapoda	Fiddler Crab	McAlonan et at. 1976	Altosid SR-10	0.024 to 0.384 lbs AI/A; 3 treatments at 2-week intervals		X	no significant mortality nor frequency of ecdysis affected
Decapoda	Fiddler Crab	McAlonan et at. 1976	Altosid 10-F	0.012 to 0.120 lbs AI/A		X	caused no mortality
Decapoda	Grass Shrimp (*Palaemonetes pugio*)	McKenney & Matthews 1990	methoprene, technical grade	1000 μg/l	X		lab study; all larvae died
Decapoda	Clam Shrimp (*Palaemonetes paludosus)*	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Decapoda	Grass Shrimp (*Palaemonetes pugio*)	McKenney & Matthews 1990	methoprene, technical grade	0.1 μg/l 10 μg/l 100 μg/l			lab study; 100 μg/l rate had significant effect; other rates had no effect
Decapoda	Grass Shrimp	McKenney	A.L.L.	1000 μg/l	X		lab study; all larvae died

	(*Palaemonetes pugio*)	& Matthews 1990					
Decapoda	Grass Shrimp	McAlonan et at. 1976	Altosid SR-10	0.024 to 0.384 lbs AI/A; one series of 4 treatments & second series of 3 treatments at 2-week intervals		X	no significant mortality nor frequency of ecdysis affected
Decapoda	Grass Shrimp (*Palaemonetes pugio*)	McKenney & Celestial 1993	A.L.L.	8, 16, 32, 62, 125, 250 μg/l	X		lab study; significant mortality was seen after 2 days exposure for 250, after 4 days for 62 & greater, and after 8 days for all conc. ; both dry weights & daily growth rates for 1- and 9-day old larvae significantly reduced by 8 μg/l and greater conc. exposures
Decapoda	Grass Shrimp (*Palaemonetes pugio*)	McKenney & Matthews 1990	A.L.L.	0.1 μg/l 10 μg/l 100 μg/l		X	lab study; no effect
Decapoda	Grass Shrimp	McAlonan et at. 1976	Altosid 10-F	0.048 to 0.120 lbs AI/A	X		produced greater than 60% mortality
Decapoda	Mud Crab (*Rhithropanopeus harrisii*)	Celestial & McKenney 1994	A.L.L.	varying conc.: 0.1, 1.0, 10.0 μg/l		X	lab study; no statistically significant reductions in survival rates; although zoeal stages I & II showed reduced survival rates; no significant differences in cumulative development duration at these conc.

Decapoda	Mud Crab (*Rhithropanopeus harrisii*)	Celestial & McKenney 1994	A.L.L.	100 μg/l	X		lab study; significant reductions in survival for all development stages except zoeal stage II; significant development duration, increased total development duration by 4 days
Decapoda	Mud Crab (*Rhithropanopeus harrisii*)	Celestial & McKenney 1994	A.L.L.	1000 μg/l	X		lab study; no larvae survived beyond zoeal stage I
Decapoda	*Mysidiopsis bahia*	McKenney & Celestial 1996	A.L.L.	varying: 2,4,8,16,32, 62 μg/l		X	lab study; no significant effects on mortality through life cycle
Decapoda	*Mysidiopsis bahia*	McKenney & Celestial 1996	A.L.L.	varying: 2,4,8,16,32, 62 μg/l	X		lab study; reproduction affected by sublethal concentrations greater than 2 μg/l; average time to first brood release significantly delayed for all conc. except 2 & 16 μg/l; brood size reduced in all conc. greater than 8 μg/l.
Decapoda	*Mysidiopsis bahia*	McKenney & Celestial 1996	A.L.L.	125 μg/l	X		lab study; 100% mortality by 4 days of exposure
Decapoda	*Mysidiopsis bahia*	McKenney & Celestial 1996	A.L.L.	varying: 2,4,8,16,32, 62 μg/l			lab study; 62 μg/l significantly affected dry weights after 15 days of exposure; other concentrations had no effect
Mysidacea	*Taphromysis louisiana* (opossum shrimp)	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months; greater numbers collected in open water habitats, but slightly higher mortality occurred in

							emergent plant habitat
Notostraca	Tadpole shrimp, *Triops longicaudatus*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 5.00 ppm; test duration 24-96 hours
Notostraca	Tadpole shrimp, *Triops longicaudatus*	Miura & Takahashi 1973	technical ZR-515	0.1 lb EC/acre		X	outdoor caged study
Notostraca	Tadpole shrimp, *Triops longicaudatus*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Ostracoda	Ostracod (*Cyprinotus* sp.)	Norland & Mulla 1975	Altosid EC	0.1 ppm		X	repeated treatments of experimental ponds; (information from abstract)
Ostracoda	Seed shrimp, *Cypricercus* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Ostracoda	Seed shrimp, *Cypricercus* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.50 ppm; test duration 24 hours
Ostracoda	Seed shrimp, *Cypricercus* sp.	Miura & Takahashi 1973	technical ZR-515	0.7 lb corncob granular/acre		X	outdoor caged study
Insects Coleoptera	*Berosus* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Coleoptera	*Berosus exiguus*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	*Berosus infuscatus*	Breaud et al.	methoprene	28 gm AI/ha	X		6 aerial applications over 18

		1977					months;
Coleoptera	Coleoptera	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); 46% reduction in 1992; 59% reduction in 1993; 48% reduction over 4-yr period
Coleoptera	*Copelatus* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Coleoptera	Dytiscid beetle (*Laccophilus* sp.)	Norland & Mulla 1975	Altosid EC	0.1 ppm	X		repeated treatments of experimental ponds; eliminated from treated ponds (information from abstract)
Coleoptera	*Enochrus blatchleyi*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	*Hydrocanthus* spp.	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Coleoptera	*Hydrovatus cuspidatus*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	*Laccophilus proximus*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	*Liodessus affinis*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months; population increases attributed to reduced predator populations
Coleoptera	*Lissorhoptrus* spp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;

Coleoptera	*Lixellus* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	Noteridae	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Coleoptera	Predaceous water beetle, *Laccophilus* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Coleoptera	Predaceous water beetle, *Laccophilus* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 2.00 ppm; test duration 48-72 hours
Coleoptera	Scavenger beetle (*Tropisternus lateralis)*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	*Suphisellus* spp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Coleoptera	Water scavenger beetle, *Tropisternus lateralis*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 1 ppm; test duration 120 hours
Coleoptera	Water scavenger beetle, *Helophorus* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 57% mortality at 0.8 ppm; 48% at 2.5 ppm; test duration 72-96 hours
Coleoptera	Water scavenger beetle, *Helophorus* sp.	Miura & Takahashi 1973	Miura & Takahashi 1973			X	irrigated pasture study
Coleoptera	Water scavenger beetle,	Miura & Takahashi	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 24 ppm; 100% at 100

	Hydrophilus triangularis	1973					ppm ; test duration 144-240 hours
Coleoptera	Water scavenger beetle, *Tropisternus lateralis*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Coleoptera	Water scavenger beetle, *Hydrophilus triangularis*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Coleoptera	Whirligig beetle, *Gyrinus punctellus*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 100% mortality at 6 ppm; test duration 48 hours
Diptera	*Anopheles* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Diptera	Biting Midges - Ceratopogonids	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); reduced in 1992 & 1993; 3-yr period showed reduction of 55%
Diptera	Chironomid	Norland & Mulla 1975	Altosid EC	0.1 ppm	X		repeated treatments of experimental ponds; twofold reduction by treatment (information from abstract)
Diptera	Chironomidae	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); seasonal significant

							reduction in 1992 & 1993, and for overall 3-yr treatment period
Diptera	Chironomids	Ali 1991	XR Briquets	0.82 kg AI/ha	X		experimental pond; 38-96% control for 7 weeks
Diptera	Chironomids	Ali 1991	Pellets	0.22 kg AI/ha	X		experimental pond; 64-98% control for 7 weeks
Diptera	Chironomids	Ali 1991	Granular (SAN 810 I 1.3 GR)	0.17 kg AI/ha	X		experimental pond; lost effectiveness in 3rd week post-treatment
Diptera	Chironomids	Ali 1991	A.L.L.	0.28 kg AI/ha	X		experimental pond; returned to pre-treatment levels in 3rd week after treatment
Diptera	Chironomids	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Diptera	Chironomids	Ali 1991	A.L.L.	0.015 kg AI/ha		X	experimental pond
Diptera	Crane flies -- Tipulidae	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); reduced in 1992 & 1993; 3-yr period showed reduction of 73%
Diptera	*Culex salinarius*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Diptera	Diptera	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); exhibited 3-yr reduction of 66%

Diptera	Flower fly, *Nylota* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 6 ppm; test duration 72 hours
Diptera	Flower fly, *Nylota* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Diptera	Green heads - Dolichopodidae	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Diptera	*Lispe* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Diptera	Midge, *Chironomus stigmaterus*	Miura & Takahashi 1973	technical ZR-515				irrigated pasture study; some dead pupae
Diptera	Midge, *Chironomus stigmaterus*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 50% mortality at 0.01 ppm; test duration 288 hours
Diptera	Mothfly, *Pericoma* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 50% mortality at 0.1 ppm; test duration 480 hours
Diptera	Nematocera	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); exhibited 3-yr reduction of 68%
Diptera	*Notophila* ap.	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Diptera	Predatory	Hershey et	Altosid 3-	5.82±0.44	X		natural wetlands; aerial

	chironomids	al. 1998	wk release granules	kg/ha			application, 6 treatments per year for 3 years (long-term effects study); seasonal significant reduction in 1992 & 1993, and for overall 3-yr treatment period
Diptera	Sandflies (*Psychoda* sp.)	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months; population increases attributed to reduced predator populations
Diptera	Shorefly, *Brachydeutera argentata*	Miura & Takahashi 1973	technical ZR-515				irrigated pasture study; some dead pupae
Diptera	Shorefly, *Brachydeutera argentata*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 70% mortality at 0.01 ppm; test duration 504 hours
Diptera	Soldier flies (*Eulalia* sp.)	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Diptera	Soldier flies -- Stratiomyidae	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); no effect seen until 1993, then showed 71%, with overall 3-yr reduction of 44%
Ephemeroptera	Mayflies -- Brachycera	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); no effect seen until 1993, then showed 69%, with overall 3-yr reduction of 36%

Ephemeroptera	Mayflies (*Callibaetis* sp.)	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Ephemeroptera	Mayfly nymphs, *Callibaetis* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% at 10 ppm; test duration 48 hours
Ephemeroptera	Mayfly (*Caenis* sp.)	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Ephemeroptera	Mayfly nymphs, *Callibaetis* sp.	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Ephemeroptera	Mayfly (*Callibaetis pacificus*)	Norland & Mulla 1975	Altosid EC	0.1 ppm	X		repeated treatments of experimental ponds; mortality in early and late instars during winter; effect lessened with rising water temperatures (information from abstract)
Hemiptera	Backswimmer, *Notonecta unifasciata*	Miura & Takahashi 1973	technical ZR-515, 10% flowable liquid (slow release)	technical ZR-515, 10% flowable liquid (slow release)		X	outdoor test in artificial container; no visible effects on populations
Hemiptera	Backswimmer, *Notonecta unifasciata*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.20 ppm; test duration 24 hours
Hemiptera	Backswimmer, *Notonecta unifasciata*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
		Breaud et al.					6 aerial applications over 18

Hemiptera	*Buenoa* spp.	1977	methoprene	28 gm AI/ha		X	months;
Hemiptera	Corixids (*Trichocorixa louisianae)*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months; population increases attributed to reduced predator populations
Hemiptera	Giant water bug (*Belostoma testaceum*)	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Hemiptera	Water treader (*Mesovelia mulsanti)*	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Hemiptera	Waterboatman, *Corisella decolor*	Miura & Takahashi 1973	technical ZR-515, 10% flowable liquid (slow release)	0.1 ppm		X	outdoor test in artificial containers; no visible effects on populations
Hemiptera	Waterboatman, *Corisella decolor*	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Hemiptera	Waterboatman, *Corisella decolor*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.65 ppm; test duration 24-96 hours
Odonata	Coenagrionidae	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Odonata	Damselfly nymphs, *Argia* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 1 ppm; test duration 48 hours

Odonata	Dragonflies (*Belonia & Anax)*	Breaud et al. 1977	methoprene	28 gm AI/ha	X		6 aerial applications over 18 months;
Odonata	Dragonfly nymphs, *Orthemis* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 24 ppm; 30 % at 100 ppm; test duration 72 hours
Odonata	Odonata naiads	Norland & Mulla 1975	Altosid EC	0.1 ppm		X	repeated treatments of experimental ponds; (information from abstract)
Odonata	*Pachydiplax* sp.	Breaud et al. 1977	methoprene	28 gm AI/ha		X	6 aerial applications over 18 months;
Miscellaneous	Non-dipteran predators	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); significant reduction in 1992 (46%) and 1993 (64%),
Miscellaneous	Total predatory insects	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha	X		natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study); significant reduction in 1992 (65%) and 1993 (77%), and over 3-yr period (62%)
Miscellaneous	Non-insect macro-invertebrates	Hershey et al. 1998	Altosid 3-wk release granules	5.82±0.44 kg/ha		X	natural wetlands; aerial application, 6 treatments per year for 3 years (long-term effects study);
Annelids Oligochaeta	Aquatic earthworms, *Aulophorus* sp. (3 species)	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 100 ppm; test duration 168 hours

Oligochaeta	Mud worm, *Tubifex tubifex*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 10 ppm; test duration 168 hours
Rhynochobdellida	Leeches, *Helobdella stagnalis*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 0% mortality at 1 ppm; test duration 72 hours
Aschelminths Nematoda	Nematodes	Miura & Takahashi 1973	technical ZR-515			X	irrigated pasture study
Rotifera	Rotifer, *Philodina* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 5% mortality at 100 ppm; test duration 48-72 hours
Flatworms Tricladida	Brown planarian, *Dugesia tigrina*	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory toxicity tests: 33% mortality at 10 ppm; test duration 168 hours
Protozoa Hymenostomatida	Paramecia, *Paramecium* sp.	Miura & Takahashi 1973	technical ZR-515	5 concentrations			laboratory acute toxicity tests: LC_{50} = 1.25 ppm; test duration 48 hours
Phytoplankton	Diatom, *Diatoma vulgare*	Miura & Takahashi 1973	technical ZR-515	0.1 ppm solution		X	lab study; no visible effects after 1 week
Phytoplankton	Green algae (3 species), *Pithaphora ocdogonia, Spirogyra* sp., *Hydrodictyon reticulatum*	Miura & Takahashi 1973	technical ZR-515	0.1 ppm solution		X	lab study; no visible effects after 1 week

Temephos

Temephos is an organophosphate pesticide, which functions by competing with acetylcholine for cholinesterase, the enzyme that transmits nerve impulses across synapses to other nerves and muscles (known as a "cholinesterase inhibitor"). While acetylcholine is present, the neurons continue to be stimulated; paralysis results from the failure of cholinesterase to destroy the acetylcholine (Dale and Hulsman 1990). Temephos is a general use pesticide; temephos-containing products are moderately toxic and are labeled with WARNING, due to the high toxicity of xylene, one of the carrier compounds found in many trade products. Toxicological effects include both acute and chronic toxicity (Pesticide Information Profiles, EXTOXNET).

Synopsis of Non-target Effects

Effects of temephos on some non-target organisms are presented in Table 4. Moderate toxicity to birds and fish; was shown to accumulate in tissues of fish and snails, but effect was reversible. Wide range of crustaceans, insects and mollusks were affected by temephos. Some crustacean and mollusks exhibited sub-lethal effects (slowed responses resulting in increased susceptibility to predation).

Label Application Rate

5% Skeeter Abate® (Abate® 5-BG) is used for the control of mosquito and midge larvae. It is toxic to birds and fish; fish and other aquatic organisms in water treated with this product may be killed. Consult state fish and game agency before applying this product to waters or wetlands. Do not use on crops used for food, forage or pasture.

Habitat: standing water, shallow ponds, lakes and woodland pools.
Application Rate: 2 lbs/acre

Habitat: tidal waters, marshes, swamps and waters high in organic content.
Application Rate: 4 lbs/acre

Habitat: highly-polluted water. Application Rate: 10 lbs/acre.

1% Skeeter Abate® (Abate® 1-BG) is used for the control of mosquito and midge larvae. It is toxic to birds and fish; fish and other aquatic organisms in water treated with this product may be killed. Consult state fish and game agency before applying this product to waters or wetlands. Do not use on crops used for food, forage or pasture.

Habitat: standing water, shallow ponds, lakes, woodland pools, catch basins.
Application Rate: 5 - 10 lbs/acre

Habitat: tidal waters, marshes, swamps and waters high in organic content.
Application Rate: 10 - 20 lbs/acre

Web Site:

Pesticide Information Profiles, EXTOXNET
http://ace.ace.orst.edu/info/extoxnet/pips/ghindex.html

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Table 4. Non-target Effects of Temephos

Classification	Organism	Reference	Formulation	Application Rate (study)	Adverse Effects	No Effects	Comments
Birds Aves	Blue Jays	Hill 1971	technical grade	5 conc. tested	X		30 ppm killed all birds in test; birds fed for 5 days on toxic diet
Aves	Bobwhites	Hill 1971	technical grade	5 conc. tested			LC_{50} = 1,540 ppm; birds fed for 5 days on toxic diet
Aves	Cardinals	Hill 1971	technical grade	5 conc. tested			LC_{50} = 76 ppm; birds fed for 5 days on toxic diet
Aves	House Sparrows	Hill 1971	technical grade	5 conc. tested			LC_{50} = 47 ppm; birds fed for 5 days on toxic diet
Aves	House Sparrows	Balcomb et al 1984	granules 4%AI	0.078 mg mean granule weight		X	no mortality in doses up to 40 granules
Aves	Mallard ducklings	Fleming, et al. 1985	Abate 4E	0.1ppm; 1 ppm; 10 ppm; 100ppm			treatments of 10 ppm or less did not enhance cold effects on ducklings nor depressed brain cholinesterase (ChE); 100pm did significantly affect cold tolerance and depressed brain ChE and degree of inhibition was less than previously used to document death from anticholinesterase insecticides
Aves	Mallard adults	Franson et al. 1983	Abate 4E	1 ppm & 10 ppm			females took longer to complete egg-laying with 10 ppm concentration diet
Aves	Mallard ducklings	Franson et al. 1983	Abate 4E	1 ppm & 10 ppm			ducklings in both treatment diets had 20% body weight (not statistically significant but noteworthy); survivability reduced 40% in both treatments

Aves	Red-winged Blackbirds	Balcomb et al 1984	granules 4%AI	0.078 mg mean granule weight		X	no mortality in doses up to 40 granules
Reptiles Squamata	*Natrix sipedon*	Fales et al. 1968	Abate 4E (EC	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; no dead found
Testudines	*Chrysemys picta*	Fales et al. 1968	Abate 4E (EC	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; no dead found
Amphibians Anura	*Rana clamitans*	Fales et al. 1968	Abate 4E (EC	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; no dead found
Caudata	*Triturus viridescens*	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; no dead found
Fish Atheriniformes	Guppies (*Sarotherodon galilaea*)	Kpekata 1983	temephos				acute effect lab study; 96-hour LC50 = 0.47 mg/l (information from abstract)
Atheriniformes	Guppies (*Lebistes reticulatus*)	Kpekata 1983	temephos				acute effect lab study; 96-hour LC50 = 1.9 mg/l (information from abstract)
Atheriniformes	Guppy (*Lebistes reticulatus*)	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in 10 ft. depth)		X	safe at 0.1 ppm; 24-hour LD_{50} = 200 ppm +
Atheriniformes	Juvenile snook (*Centropomis undecimalis*)	Pierce et al. 1989	temephos, aerially applied			X	no mortality observed (information from abstract)
Atheriniformes	Killifish	Wall and	Abate 1%	0.3 lb/acre			fish in 2 traps were dead, but those in 3rd

	(*Fundulus spp.)*	Marganian 1973	on sand granules				trap survived with no apparent effect for 7 days; unable to attribute mortality to pesticide
Atheriniformes	Killifish (*Fundulus spp.)*	Wall and Marganian 1971	Abate 1% on sand granules	0.4 lb/ac		X	
Atheriniformes	Mosquito fish (*Gambusia affinis*)	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in 10 ft. depth)		X	safe at 0.1 ppm; 24-hour LD_{50} = 200 ppm +
Atheriniformes	Mosquitofish	Tietze et al 1991	Abate 4-E	various		X	no affect at recommended application rate; 24-hour LC_{50} = 5.60 ppm
Atheriniformes	Mummichog *(Fundulus heteroclitus)*	Lee & Scott 1989	technical grade				96-hour LC_{50} = 0.04 mg/L; no effect concentration = 0.02 mg/L
Atheriniformes	Sheepshead minnow (*Cyprinodon variegatus*)	Pierce et al. 1989	temephos, aerially applied			X	no mortality observed (information from abstract)
Cypriniformes	Catfish	Chambers & Fabacher 1972	Abate R				LC_{50} determined to be 5-7ppm in laboratory
Perciformes	Blue gill (*Lepomis macrochirus*)	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water		X	safe at 0.1 ppm; 24-hour LD_{50} = 200 ppm +

				depth or 0.01 ppm in 10 ft. depth)			
Perciformes	Bluegills	Sanders et al 1981	Abate EC	18 g/ha		X	3 treatments in experimental ponds; initially more rapid growth and higher reproduction presumably from increased food (dead Dipterans), but declined after 3rd treatment attributed to decline in Dipterans
Perciformes	Bluegills	Sanders et al 1981	Abate EC	180 g/ha			3 treatments in experimental ponds; brain acetylcholinesterase activity depressed 40% when water temperature exceeded 20°C; lower growth and production rates attributed to greater losses of Dipterans from first treatment
Perciformes	Largemouth bass (*Micropterus salmoides)*	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in 10 ft. depth)		X	safe at 0.1 ppm; 24-hour LD_{50} = 200 ppm +
Arachnids Acarina	Water Mites -- Hydrachnidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; 1 species, no dead found
Mollusks Anisomyaria	Ribbed mussel (*Modiolus demissus*)	Wall and Marganian 1973	Abate 1% on sand granules	0.3 lb/acre		X	
Basommatophora	Snails -- Planorbidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 1 species, no live individuals in samples

Basommatophora	Snails -- Physidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 1 species, no live individuals in samples
Gastropoda	Snail (*Melampus bidentatus)*	Fitzpatrick and Sutherland 1976	Abate 2% granular	0.10 lb/acre; 10 applications at 2 week intervals	X		uptake detectable 1 day after 1st treatment; residues persisted for more than 5 weeks after last treatment;
Gastropoda	Snail (*Melampus bidentatus)*	Fitzpatrick and Sutherland 1976	Abate emulsion	0.032 lb/acre; 4 applications at 2 week intervals	X		uptake detectable 6 days after 2nd treatment; residues rose gradually as number of treatments increased, then decreased below detection limit 3-weeks after last treatment; data indicate significant but reversible decline in population density
Mesogastropoda	Mud snail (*Nassarius obsoletus*)	Wall and Marganian 1973	Abate 1% on sand granules	0.3 lb/acre		X	
Mesogastropoda	Mud snail (*Nassarius obsoletus*)	Wall and Marganian 1971	Abate 1% on sand granules	0.4 lb/ac			those confined in traps were alive but some appeared to have slowed responses
Mesogastropoda	Periwinkle (snail) *(Littorina littorea*)	Wall and Marganian 1973	Abate 1% on sand granules	0.3 lb/acre		X	
Crustaceans Amphipoda	Sideswimmer (*Hyallela azteca*)	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)		X	tolerant to temephos; higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)

Amphipoda	Sideswimmer (*Hyallela azteca)*	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in 10 ft. depth)			safe at 0.1 ppm; 24-hour LD_{50} = 0.65 ppm; LD_{90} = 2-2.5 ppm
Calanoida	Calanoid	Hanazato et al. 1989	Abate	500μg AI/l	X		shallow lake; eliminated; nauplii showed slight recovery by end of experiment
Calanoida	*Diaptomus spp.*	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)			higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)
Cladocera	*Bosmina longirostris*	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)	X		higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)
Cladocera	*Cyclops sp.*	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)	X		higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)

Cladocera	Water fleas -- Cladocerans	Hanazato et al. 1989	Abate	500μg AI/l	X		shallow lake; all eliminated; had not recovered by end of experiment
Cladocera	Water flea (*Daphnia pulex*)	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)	X		higher concentration used in lake fingers, lower concentration in main lake area; population reduced in fingers but recovered within 1-3 weeks (information from abstract)
Cladocera	Water flea (*Daphnia galeata*)	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)	X		higher concentration used in lake fingers, lower concentration in main lake area; population reduced in fingers but recovered within 1-3 weeks (information from abstract)
Crustacea	Crustacea	Frank and Sjogren 1978	temephos	0.025 lb AI/acre		X	copepods, ostracods, amphipods, & cladocerans; no effect on occurrence (numbers not studied)
Cyclopoida	Cyclopoids	Hanazato et al. 1989	Abate	500μg AI/l	X		shallow lake; eliminated; nauplii showed slight recovery by end of experiment
Cyclopoida	*Paracyclops fimbriatus*	Yasuno et al 1985	temephos	5 mg/l; 30 min exposure		X	model stream study
Decapoda	Brown shrimp (*Panaeus aztecus*)	Pierce et al. 1989	temephos, aerially applied			X	no mortality observed (information from abstract)
Decapoda	Fiddler Crab	Ward and Busch	Abate 99% pure	12 concentratio	X		24-hour lab experiments; number of crabs either dead or not responding to

		1976	crystalline powder	ns from 0.5 ppm to 15 ppm			stimulus (EC) increased with increasing temephos concentration; LC_{20} = 2.06 ppm; LC_{50} = 9.12 ppm; LC_{80} = 39.8 ppm; EC_{20} = 1.10 ppm; EC_{50} = 4.31 ppm; EC_{80} = 16.6 ppm
Decapoda	Fiddler Crab (*Uca sp.)*	Wall and Marganian 1973	Abate 1% on sand granules	0.3 lb/acre			few dead crabs found in treated area
Decapoda	Fiddler Crab (*Uca pugilator)*	Wall and Marganian 1971	Abate 1% on sand granules	0.4 lb/ac	X		numerous dead crabs found in treated areas; however, those confined in traps were not visibly affected at 7 days when released
Decapoda	Fiddler Crab	Ward et al. 1976	Abate 2% granular	0.1 lb AI/acre	X		field experiment; population reduced 14% after 2nd application and 30% after 4th application; conclusion that temephos has primarily sublethal effect on crabs that renders them more susceptible to predation
Decapoda	Fiddler Crab	Ward and Howes 1974	Abate 2% granular	0.1 lb AI/acre; 3 treatments 2 weeks apart; expected conc. 0.5 ppm	X		field test; populations declined over time in treated areas
Decapoda	Freshwater shrimp (*Palomonetes paludosus*)	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in	X		safe at 0.1 ppm; 24-hour LD_{50} = 1.0 ppm; LD_{90} = 2.0 ppm

				10 ft. depth)			
Decapoda	Grass shrimp (*Palaemonetes pugio*)	Pierce et al. 1989	temephos, aerially applied			X	no mortality observed (information from abstract)
Mysidacea	Mysids (*Mysidopsis bahia*)	Pierce et al. 1989	temephos, aerially applied		X		significant mortality at 1 site during 1 of 3 applications monitored (information from abstract)
Ostracoda	Seed shrimp (*Cyprinotus sp.*)	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)		X	tolerant to temephos; higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)
Insects Coleoptera	Burrowing Water Beetles -- Noteridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application;1 species, some mortality
Coleoptera	Crawling Water Beetles -- Halipidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 5 species found, all of which had some mortality
Coleoptera	Predaceous Diving Beetles -- Dytiscidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 13 species found, of which 6 had some mortality
Coleoptera	Water Scavenger Beetles -- Hydrophilidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 11 species found, all of which had some mortality
Coleoptera	Whirligig Beetles -- Gyrinidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 3 species found, of which 2 had some mortality

Collembola	Springtails -- Poduridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 1 species, no live individuals found at 24-hour sample
Diptera	Black flies	Dale et al. 1974	Abate 20% EC	50 ppb for 10 min.	X		complete kill 45-50 km downstream
Diptera	Blackfly (*Simulium argus*)	Mohsen and Mulla 1981	Abate 50% EC	various dilutions	X		24- hour LC_{50} = 0.020 ppm; LC_{90} = 0.038 ppm
Diptera	Blackfly (*Simulium virgatum*)	Mohsen and Mulla 1981	Abate 50% EC	various dilutions	X		24-hour LC_{50} = 0.0082 ppm; LC_{90} = 0.020 ppm
Diptera	Blackfly (*Simulium* spp.)	Muirhead-Thompson 1979	Abate 20% EC	various conc. ranging from 0.05 to 2.0 ppm	X		exposures ranged from 15 minutes to 1 hour; 24-h mortality ranged from 24% at 0.2 ppm to 98% at 1.0 ppm
Diptera	Chironomidae	Wallace et al 1973	Abate	initial conc. 0.1 ppm	X		stream study;
Diptera	Chironomids	Ali and Mulla 1977	temephos granules 1%	0.28 kg AI/surface ha	X		88-95% control of total midge larvae after 3 weeks of treatment; control lasted 5-6 weeks
Diptera	Chironomids (3 species)	Yasuno et al 1985	temephos	5 mg/l; 30 min exposure	X		model stream study
Diptera	Dipterans	Sanders et al 1981	Abate EC	18 g/ha	X		3 treatments in experimental ponds; biomass similar to control ponds, however biomass declined rapidly after 3rd treatment
Diptera	Dipterans	Sanders et al 1981	Abate EC	180 g/ha	X		3 treatments in experimental ponds; biomass declined rapidly after 1st

							application and remained low
Diptera	Midge (*Procladius sp.*)	Yasuno et al 1985	temephos	5 mg/l; 30 min exposure		X	model stream study
Diptera	Phantom Midges -- Chaoboridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 1 species, estimated millions dead
Diptera	True flies	Denno 1974	Abate 2% on celatom granules		X		densities reduced in *Spartina patens* community
Ephemeroptera	Mayflies	Wallace et al 1973	Abate	initial conc. 0.1 ppm	X		stream study;
Ephemeroptera	Mayfly (*Baetis parvus)*	Mohsen and Mulla 1981	Abate 50% EC	various dilutions	X		24-hour LC_{50} = 0.0097ppm; LC_{90} = 0.018 ppm
Hemiptera	*Laccotrephes griseus*	Mathavan and Jayakumar 1987	temephos	0.1 ppm	X		growth affected; fecundity severely reduced (information from abstract)
Heteroptera	Backswimmers --Notonectidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 3 species, heavy mortality; in lab experiments 0.02 ppm produced 100% mortality of backswimmers in 4 days
Heteroptera	Creeping Water Bugs -- Naucoridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 1 species, some mortality
Heteroptera	Giant Water Bugs – Belostomatidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 1 species, some mortality

Heteroptera	Marsh Treaders - -Hydrometridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application; 1 species
Heteroptera	Water Boatmen – Corixidae (*Trichocorixa verticalis)*	Campbell and Denno 1976	4E emulsifiable conc.	34.75 g AI/ha; 4 biweekly treatments		X	applications by helicopter
Heteroptera	Water Boatmen – Corixidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 4 species, only 1 of which had some live individuals
Heteroptera	Water Scorpions -- Nepidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre		X	lake application, sampled 24- & 48-hr. post-application;
Heteroptera	Water Treaders – Mesovliidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 1 species, no live individuals found post-treatment
Heteroptera	Water Striders – Gerridae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 3 species, 2 of which had some mortality
Homoptera	Cicadas/leaf hoppers	Denno 1974	Abate 2% on celatom granules		X		densities reduced in *Spartina patens* community
Hymenoptera	Ants/bees/wasp	Denno 1974	Abate 2% on celatom granules		X		densities reduced in both *Spartina alterniflora* and *Spartina patens* communities
Odonata	Damselfly -- Coenagrionidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre	X		lake application, sampled 24- & 48-hr. post-application; 2 species, only dead found in samples
Odonata	Dragonfly -- Aeschnidae	Fales et al. 1968	Abate 4E (EC)	0.39 lb/acre			lake application, sampled 24- & 48-hr. post-application; 1 species, some mortality
	Dragonfly --	Fales et al.	Abate 4E				lake application, sampled 24- & 48-hr.

Odonata	Libellulidae	1968	(EC)	0.39 lb/acre			post-application; 3 species, 1 only dead found, 1 no dead found, 1 some dead found
Plecoptera	Stone flies	Wallace et al 1973	Abate	initial conc. 0.1 ppm	X		stream study;
Trichoptera	Caddis flies	Wallace et al 1973	Abate	initial conc. 0.1 ppm	X		stream study;
Trichoptera	Caddisfly (*Hydropsyche pellucidula*)	Muirhead-Thompson 1979	Abate 20% EC	various conc. ranging from 0.05 to 1.0 ppm	X		exposed for 1 hour to Abate solution; 24-h mortality 29% at 0.2 ppm; 76% at 0.5 ppm; 74% at 1.0 ppm
Trichoptera	Caddisfly (*Rhyacophila dorsalis*)	Muirhead-Thompson 1979	Abate 20% EC	various conc. ranging from 0.2 ppm to 2.0 ppm			exposures ranged from 15 minutes to 30 minutes; 24-h mortalities reported were 12% at 0.5 ppm (15 min); 18% at 1.0 ppm (15 min); 8% at 2.0 ppm (15 min); 48% at 1.0 ppm (30 min); 33% at 2.0 ppm (30 min)
Trichoptera	Caddisfly (*Hydropsyche californica*)	Mohsen and Mulla 1981	Abate 50% EC	various dilutions			24-hour LC_{50} = 1.3 ppm; LC_{90} = 4.0 ppm
Annelids Oligochaeta	Oligochaetes	Ali and Mulla 1978	temephos	0.28 kg AI/ha (0.0092 ppm) & 0.17 kg AI/ha (0.0042 ppm)		X	higher concentration used in lake fingers, lower concentration in main lake area; (information from abstract)
Aschelminths Nematoda	Nematode (*Romanomermis culicivorax*)	Levy and Miller 1977	Abate	0.001 ppm		X	information from abstract

Rotifera	Rotifers	Hanazato et al. 1989	Abate	500μg AI/l	X		shallow lake; original species eliminated and replaced by other rotifer species
Flatworms Tricladida	Brown planaria (*Dugesia tigrina)*	Nelson et al. 1994	temephos	4E		X	only minimal effect under field conditions (information from abstract)
Plankton	Microscopic plankton (Rotifers, *Euglena, Coleps,* Ileonema, etc.)	Von Windeguth and Patterson 1966	Abate, technical material	0.20-0.25 lb/acre (conc. of 0.1 ppm in 1 ft water depth or 0.01 ppm in 10 ft. depth)			safe at 0.1 ppm; 48-hour LD_{100} =50 ppm

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APPENDIX K4. Environmental Effects of Mosquito Control

ENVIRONMENTAL EFFECTS OF MOSQUITO CONTROL
(USFWS, 2004)

This paper provides a summary of the potential impacts of mosquito control practices. This is not intended to discount the important role that mosquitoes play in the transmission of disease, nor is it intended to diminish the role that mosquito control can play in reducing the incidence of such vector-borne disease in humans. The first part discusses the ecological role of mosquitoes in the environment, aside from that as vectors of disease. The second part addresses the potential impacts of mosquito control pesticides to nontarget organisms and communities.

1. The Ecological Role of Mosquitoes

Mosquitoes are most often associated with their roles as vertebrate ectoparasites and vectors of disease-causing microorganisms. However, do mosquitoes provide any "beneficial" role in the environment, or are they, as Spielman and D'Antonio (2001) claim "self-serving" and of "no purpose other than to perpetuate her species"?

Mosquitoes As Prey

Larvae. Mosquitoes have evolved to use a wide variety of both permanent and temporary aquatic habitats for larval development. There are nearly as many habitats for mosquito larvae as there are types of lentic water bodies. For purposes of this discussion, mosquitoes will be divided into those that develop in ephemeral water bodies and those that develop in permanent to semi-permanent water.

The evolution of a drought- and sometimes freeze-resistant egg has allowed certain species of mosquitoes—the most common in the genera *Aedes*, *Ochlerotatus*, and *Psorophora*—to colonize a wide variety of ephemeral habitats large and small, from the tropics to sub-arctic zones. These mosquitoes lay eggs in dry or moist areas that will flood later. This strategy has at least two advantages: 1) the recently flooded detritus provides a nutrient-rich and abundant source of food for developing larvae; and 2) in many habitats there is a lag time before invertebrate predators colonize these temporary water bodies, allowing the larvae to develop in relatively predator-free environments. In most ephemeral habitats, mosquito eggs will hatch within hours of being flooded, often in very large numbers. In many of these habitats, such as summer flood pools and salt marshes, colonization by invertebrate predators occurs from highly mobile insects like dragonflies, beetles, and backswimmers that fly from more permanent bodies of water. Although some predators will arrive relatively quickly, it can take several days to weeks for an invertebrate predator community to become established. During the summer, a floodwater mosquito brood can develop from egg to adult in a week, and thereby mostly escape predation by these colonizing invertebrates.

In unpredictably flooded ephemeral habitats such as summer flood pools and storm-flooded salt marshes, there are few predators that have been identified to rely principally on mosquito larvae as a source of food. The unreliable nature of mosquito larvae as prey in these habitats prevents the development of any close predator-prey relationship unless the predator shares diapausing strategies similar to those of floodwater mosquitoes. The only predators in these habitats that rely on mosquito larvae for prey are other mosquitoes. A few species of *Psorophora* mosquitoes

have larvae that are predatory in late instar stages. These species are generally found in summer flood pools. Although there are few predators that specialize on mosquito larvae in these habitats, generalist predators such as beetles (larvae and adults), backswimmers, and some odonates (damselflies and dragonflies) will take advantage of the temporary abundance of mosquitoes if the timing of arrival into the habitats coincides with the presence of mosquito larvae.

Some ephemeral aquatic habitats, however, have flooding regimes that are more predictable. In at least two of these habitats, vernal pools and treeholes, we see the development of very close predator-prey relationships with mosquito larvae. In treeholes, species of another mosquito, *Toxorhynchites*, have evolved as predators of other treehole-dwelling mosquito larvae. Vernal pools in northern temperate regions predictably flood to their maximum extent in the early spring from rain and snowmelt, and this triggers a hatch of one or more species of *Ochlerotatus* mosquitoes. These are usually univoltine (single generation) species that laid eggs in the dry pool basin the previous summer. Hatching of mosquito larvae in vernal pools often occurs when water temperatures are still well below 10C C, with few predators active in such cold environments. The predators present at this time of the year are generally those that share similar overwintering strategies with mosquitoes, such as cyclopoid copepods (e.g., *Macrocyclops*) and a few species of beetles. Some species of predaceous diving beetles (family Dytiscidae) in the genus *Agabus* have evolved a diapausing strategy that closely resembles that of the *Ochlerotatus* mosquitoes. Unlike most dytiscid beetles, these species have drought- and freeze-resistant eggs that are laid in the dry basin the previous summer and hatch in the early spring concurrently with mosquitoes. The beetle larvae are active in the cold water and appear to feed primarily on mosquito larvae and pupae (Nilsson and Soederstroem 1988; Higgins and Merritt 1999). The predictable abundance of mosquitoes and general paucity of other potential prey species during the early spring in these pools has probably contributed to this specialization. Other predators in vernal pools will feed opportunistically on mosquito larvae. Some species of dragonflies and damselflies (Odonata, primarily *Sympetrum* and *Lestes*) have also evolved drought- and freeze-resistant eggs, but hatch later in the spring. Colonizing species of backswimmers (Notonectidae), water striders (Gerridae), and water beetles (Hydrophilidae and Dytiscidae) will feed on late-instar mosquito larvae and pupae, but are considered generalist predators (Higgins and Merritt 1999).

Mosquitoes that require water for oviposition include the common genera *Culex* and *Anopheles*. These mosquitoes colonize permanent to semi-permanent bodies of water, laying eggs on the surface. In many natural bodies of water, the larvae of these species must develop in the presence of an oftentimes-diverse invertebrate predator community. The co-occurrence of mosquito larvae and predatory invertebrates is more predictable in these habitats, but the diversity of other potential prey species may preclude the development of specialized predator-prey relationships. Potential invertebrate predators in these habitats include: backswimmers, water striders, giant water bugs (Belostomatidae), water measurers (Hydrometridae), adult and larval beetles (Dytiscidae, Hydrophilidae, Gyrinidae), many species of damselflies and dragonflies (Odonata), phantom midge larvae (Chaoboridae), and even copepods and flatworms. Although all of these predators can be considered generalists with regard to prey consumption, experimental evidence suggests that mosquito larvae, when available, are a preferred prey of some species (Helgen 1989; Urabe et al. 1990; Robert and Venkatesan 1997; Safurabi and Madani 1999).

Adults. Like other aquatic insects with terrestrial adult stages, mosquitoes provide a link between aquatic and terrestrial ecosystems as they convert detritus and aquatic microbial biomass into flying insect biomass. Most adult mosquitoes are relatively short lived. The probability of daily survival for adult mosquitoes, an important factor in disease transmission, varies among species and habitats. Daily survival probabilities usually range from 0.6-0.9, with much of the mortality coming from predation (Service 1993). Mosquitoes are fed upon by a variety of invertebrate predators, including spiders (Strickman et al. 1997; Fox 1998) and odonates (Sukhacheva 1996), although there are no known specialist predators that prey exclusively on mosquitoes. Vertebrate predators include insectivorous birds and bats (Zinn and Humphrey 1981), although mosquitoes often account for only a small percentage of the total biomass consumed. Consumption of mosquitoes by the Indiana bat, *Myotis sodalis*, for example, accounted for up to 6.6 percent of the total diet (Kurta and Whitaker 1998). The apparent absence of any specialized predator-prey relationships among adult mosquitoes and predators, however, does not necessarily discount the contribution of mosquitoes to the diet of a wide variety of generalized predators.

Other Ecological Roles of Mosquitoes

Mosquito larvae may feed by one or more of several different mechanisms. They may filter-feed, graze microbial biofilms, or even shred detritus (Merritt et al. 1992). In this sense, mosquitoes are a component of a functioning wetland ecosystem, processing detritus and aquatic microbes, and eventually providing a link between aquatic and terrestrial systems when they emerge.

Most adult mosquitoes require sugar meals during their lifetimes as a source of energy. The primary sources of sugars consumed by mosquitoes are nectar from flowers and honeydew excreted by aphids (Foster 1995). Both male and female mosquitoes frequently take nectar meals from flowers, but are they important as pollinators? Due to their small size and the limited probing abilities of the proboscis, mosquitoes are limited to feeding on nectar sources within flowers that have shallow or flat corollas. Unlike relatively large pollinators like bees and butterflies, mosquitoes can nectar feed efficiently without coming into contact with pollen-coated stamens. Thus, although they may transfer some pollen during the course of acquiring a meal of nectar, mosquitoes are probably not important pollinators in general (Foster 1995). A documented exception to this occurs in the subarctic where mosquitoes are significant pollinators of many plants (Kevan 1972).

The impact of reducing the density of mosquitoes in aquatic or terrestrial systems has not been studied. Generalist predators probably switch to alternate prey, which in turn may be impacted by the increased predation. The few specialist predators of mosquito larvae may be impacted the greatest due to the lack of alternate prey and/or the inability of such predators to uncouple from a closely evolved predator-prey relationship.

2. Nontarget Effects of Mosquito Control Pesticides

Mosquito control pesticides can be categorized into three groups: larvicides, adulticides, and water surface films (for controlling mosquito larvae and pupae). Compared with other forms of

pest control, there are relatively few pesticides available within each of these categories, and all differ with regard to efficacy and effects on nontarget organisms.

Larvicides

***Bacillus thuringiensis* var. *israelensis* (Bti).** Like other varieties of the natural soil bacterium, *Bacillus thuringiensis* (Bt), Bti is a stomach poison that must be ingested by the larval form of the insect in order to be effective. Bt contains crystalline structures containing protein endotoxins that are activated in the alkaline conditions of an insect's gut. These toxins attach to specific receptor sites on the gut wall and, when activated, destroy the lining of the gut and eventually kill the insect. The toxicity of Bt to an insect is directly related to the specificity of the toxin and the receptor sites. Without the proper receptor sites, the Bt will simply pass harmlessly through the insect's gut. Several varieties of Bt have been discovered and identified by the specificity of the endotoxins to certain insect orders. *Bacillus thuringiensis* var. *kurstaki*, for example, contains toxins that are specific to lepidopterans (butterflies and moths), while Bti is specific only to certain primitive dipterans (flies), particularly mosquitoes, black flies, and some chironomid midges. Bti is not known to be directly toxic to nondipteran insects.

Because Bti must be ingested to kill mosquitoes, it is much more effective on first-, second-, and early third-instar larvae than on late third and fourth instars since the earlier instars feed at a faster rate (fourth instar larvae feed very little). The pesticide is completely ineffective on pupae because they do not feed at all. Formulated products may be granular or liquid, and potency is expressed in International Toxicity Units (ITU), usually ranging from 200-1200 ITU. The concentrations of Bti in water necessary to kill mosquito larvae vary with environmental conditions, but are generally 0.05-0.10 ppm. Higher concentrations (0.1->0.5 ppm) of Bti are necessary when there is a high amount of organic material in the water, late-third and early fourth instar larvae predominate, larval mosquito density is high, or water temperature is low (Nayar et al. 1999). Operationally, Bti is applied within a range of volume or weight of formulated product per acre as recommended on the pesticide label, with the goal to achieve an effective concentration. The label recommended range of application rates under most conditions varies by a factor of 4 for most formulations (e.g., for granular formulations, 2.72-11.12 kg/ha (2.5-10 lb/acre)). For later instar larvae and water with a high organic content, higher application rates are recommended that may reach 8 times the lowest rate (e.g., for granular formulations, the higher rate is 11.1-22.5 kg/ha (10-20 lb/acre)). Mosquito control agencies use the recommended label rates, along with previous experience, to administer an effective dose. Typical application rates are often in the mid- to upper values of the normal ranges recommended on the labels (Abbott Laboratories 1999). Because water depths even within a single wetland can vary greatly, field concentrations of Bti can vary widely, especially when the pesticide is applied aerially. Efficacy is monitored by post-application reductions in mosquito larval density, but the actual concentration of Bti following an application is not measured. Thus, an insufficient concentration of Bti can be detected by low mortality of mosquito larvae, but an overdose (i.e., a concentration greater than necessary to kill mosquito larvae) of the pesticide is rarely monitored for.

The issue of Bti concentration is important with regard to impacts on nontarget organisms. Of particular concern is the potential for Bti to kill midge larvae (family Chironomidae). Chironomid (non-biting midge) larvae are often the most abundant aquatic insect in wetland

environments and form a significant portion of the food base for other wildlife (Batzer et al. 1993; Cooper and Anderson 1996; Cox et al. 1998). Negative impacts on chironomid density/biomass could have deleterious effects on wetland/wildlife food webs and could also lower biodiversity.

The potential for Bti to impact chironomid populations depends on the fate and availability of the pesticide, the ingestion of the pesticide, and the presence and number of specific receptor sites in the insect gut for the toxins (as discussed above). Fate and availability encompass both the initial dose/concentration and the fate of the pesticide in the aquatic environment. Chironomid larvae live primarily in the benthos of wetlands. Mosquito larvae ingest Bti primarily within the water column, but Bti readily adheres to suspended particulate matter and settles to the benthos (Yousten et al. 1992).

Ingestion of Bti by chironomid larvae depends primarily on the feeding mechanism. The family Chironomidae is a relatively large group, with nearly 1,000 species identified for North America (Merritt and Cummins 1996). This family encompasses a variety of feeding strategies: filter-feeders, collector-gatherers, scrapers, shredders, and even predators. Filter-feeding larvae are more likely to ingest Bti than larvae with other feeding strategies (Pont et al. 1999).

Chironomid larvae appear to possess mid-gut receptor sites for Bti endotoxins similar to those in mosquito larvae, and exhibit similar histopathological changes in the gut lining that lead to death of the insects when exposed to lethal concentrations of the pesticide (Yiallouros et al. 1999). There are, however, differences in the susceptibility of midge larvae to Bti at the subfamily level and among larval instars. In general, larvae in the subfamily Chironominae (Tribes Chironomini and Tanytarsini) are more susceptible to Bti than larvae of other subfamilies (Yiallouros et al. 1999) (Pont et al. 1999) (Ali 1981). Also, early-instar larvae are much more susceptible to Bti than later instars (Ali et al. 1981; Charbonneau et al. 1994).

There have been a number of laboratory and field studies examining the toxicity of Bti to chironomid larvae (Boisvert and Boisvert 2000). There have been many different formulations and potencies of Bti products used in these studies, and in many cases actual concentrations of Bti within the water were not measured. Also, differences in the species and instar of the chironomid larvae used (sometimes not specified), and in the environmental conditions of the field experiments make direct comparisons among the studies difficult. Most field studies examined the nontarget effects from a single application of Bti and did not address the potential long-term impacts from repeated applications over a season or over several seasons.

It is clear that in laboratory studies Bti is lethally toxic to some species of chironomid larvae at concentrations expected for mosquito control. Charbonneau et al. (1994) determined an EC_{50} (the concentration required to cause an effect in 50 percent of the test population) of 0.20 ppm for *Chironomus riparius* (fourth instar?), and the toxicity of Bti to earlier instars was over two orders of magnitude greater. Similarly, Ali et al. (1981) found the LC_{50} (the concentration required to kill 50 percent of the test population) for first-instar *Glyptotendipes paripes* (0.034 ppm) to be over two orders of magnitude lower than the LC_{50} for third instar larvae (8.31 ppm).

Charbonneau et al. (1994) studied the effects of Bti on chironomid larvae in the laboratory and the field. Laboratory toxicity tests on Chironominae larvae (the most susceptible subfamily)

demonstrated up to 100 percent mortality at label-recommended rates, but the toxicity of Bti to chironomids was influenced by several environmental factors. Factors that lowered toxicity to chironomids included higher water temperature, greater water depth, organic matter, and coverage by macrophytes. Field enclosure tests with Bti applied at 5.6 kg/ha (5 lb/acre) failed to demonstrate any pesticide effects on midge larvae within the enclosures, leading the authors to conclude that environmental factors reduce the toxicity of Bti to chironomids in the field. However, mortality of nontarget organisms within the enclosures was measured after 48 hours. Apparent effects of Bti on chironomids may not be detectable for 5-7 days post application (Ali 1981; Lacey and Mulla 1990; Pont et al. 1999). Also, because early instar larvae are much more susceptible to Bti, first and second instars would likely exhibit the greatest mortality. The 575 cm mesh used to sample benthic invertebrates in the field tests of the Charbonneau et al. (1994) study, however, was too large to effectively sample first- and some second-instars. Thus, the conclusions regarding the field component of this study must be viewed with caution.

There is some evidence from field studies in which negative impacts to chironomid larvae were observed that such impacts are relatively short-lived (e.g., Miura et al. 1980). In most of these studies, however, it is not clear if the rebounding densities of midge larvae represent the same species or even the same subfamily that was initially reduced by the pesticide. Furthermore, population-level impacts to species from repeated applications over a season were usually not addressed. Although many species of chironomids are capable of producing several generations per year and could re-colonize a treated wetland relatively quickly, other species have only one generation per year and therefore would not be able to re-colonize until the following year. The ability of Bti-susceptible species to re-colonize a wetland following pesticide treatment would also depend on 1) the frequency of Bti applications, 2) the extent of Bti treatments within the wetland, and 3) the extent of Bti applications in the surrounding landscape. Widespread larviciding with Bti would provide few refugia for re-colonizing source populations of susceptible species.

In a study that examined population-level impacts to chironomids from a single application of Bti at a mosquito control rate, investigators showed that, while there was no statistical difference in the number of emerging adult chironomids between control and treatment enclosures, the species composition was different (Pont et al. 1999). Species sensitive to Bti (*Tanytarsus horni, T. fimbriatus, and Microchironomus deribae*) were 24-54 percent less abundant in enclosures treated at mosquito control rates than in control enclosures, while a less sensitive species (*Polypedilium nubifer*) was over 200 percent more abundant in the treated enclosure versus control. Higher application rates resulted in greater reductions of the Bti-sensitive species. This suggests that as Bti-sensitive chironomid larvae are killed by the pesticide, less sensitive species may thrive as they are released from competition (Pont et al. 1999). Thus, although chironomid larval numbers often appear to rebound after a treatment with Bti, this may be indicative of a shift in the species composition of the community, with species less sensitive to Bti replacing the sensitive species. It is unknown how or if such a shift would affect food web dynamics, but biodiversity would be lowered.

There is only one published study that examined the long-term, nontarget effects of Bti (Hershey et al. 1998; Niemi et al. 1999). In this study conducted in Minnesota, 27 wetlands were sampled for macroinvertebrates over a 6-year period. All wetlands were sampled for 3 pre-treatment years and randomly assigned to 3 treatment groups: Bti, methoprene (see discussion below), and

an untreated control group. The wetlands were sampled for 3 treatment years. Bti was applied to wetlands in a granular formulation at the rate of approximately 11.1 kg/ha (10 lb/ac), which represents the high end of the normal label-recommended application range. Bti was applied to each treatment wetland 6 times per year at intervals of 3 weeks or after rainfall of >1.25 cm, whichever came first (Niemi et al. 1999). Although this frequency of application is high, it is within the range that could occur from operational mosquito control.

After the first year of treatment, no differences in macroinvertebrate density, biomass, or community composition (richness of genera) among the treatments were observed (Hershey et al. 1998). However, in the second and third years of treatment, highly significant differences were observed in the two treatment groups compared to control. Chironomid larvae were significantly impacted by Bti treatments, with reductions in density of 66 percent and 84 percent for the second and third years of the study, respectively, compared to densities in control wetlands (Hershey et al. 1998). Significant declines in other nematoceran (primitive) dipteran larvae were also observed during the last two years of the study. There were also declines in macroinvertebrate predator densities in the Bti treated wetlands that the authors interpret as indirect effects from the reduction in a prey base dominated by chironomid larvae (Hershey et al. 1998; Niemi et al. 1999).

In summary, there is clear evidence from both laboratory and field studies that Bti can kill some chironomid larvae. Species in the subfamily Chironominae are apparently the most susceptible to direct toxicity; other subfamilies exhibit little mortality at mosquito control rates. Even within the subfamily Chironominae there are apparent differences among in susceptibility to Bti, relating perhaps to feeding mode (Pont et al. 1999). Within susceptible species, toxicity is greatest to early instars. Lethal concentrations of Bti are orders of magnitude lower for early versus late instars, and well within the concentrations expected from operational mosquito control. There is evidence that environmental conditions such as temperature, organic content of the water, vegetation, and density of larvae can ameliorate some of the potential negative impacts to chironomid larvae (Charbonneau et al. 1994), although field experiments designed to test this may be suspect.

The only long-term study on the nontarget effects of Bti for mosquito control demonstrated significant adverse effects on the chironomid community of treated wetlands, and this translated into numerous significant negative effects within the food web (Hershey et al. 1998; Niemi et al. 1999). The intensity of Bti applications used in this study, both the application rate and the frequency of applications, would represent the high end of those that would normally occur for operational mosquito control. In addition, entire wetlands were treated, which may or may not occur with aerial applications of Bti. Thus, the Minnesota study may represent a “worst-case scenario” of potential mosquito control operations, but it has generated the only data available on the long-term nontarget effects from Bti. Studies that examine nontarget effects of Bti from a single application or even within a single season may not be adequate to detect potential long-term impacts from pesticide use (Hershey et al. 1995).

There is also evidence that application rate can have a profound effect on impacts to chironomids from Bti (Rodcharoen et al. 1991). Because application rates of Bti for mosquito control can vary by a factor of 8, field concentrations of the pesticide can reach levels that are toxic to chironomid larvae, yet are still within the pesticide label directions. In addition, there are no

label restrictions on the number of applications of Bti to any one area. Economic considerations may preclude regular applications at the highest label rate, yet even at lower rates, adverse impacts to chironomid midge larvae have been demonstrated (Miura et al. 1980; Ali 1981; Ali et al. 1981).

Bacillus sphaericus

Bacillus sphaericus (Bsph) is a naturally-occurring soil bacterium similar to Bti, and has been developed as a commercially-available mosquito larvicide since the early 1990s. Like Bti, it releases a protein endotoxin in the alkaline gut of larval mosquitoes that attaches to specific receptor sites of susceptible species. This endotoxin dissolves the lining of the gut wall and eventually kills the larva. Unlike Bti, Bsph has only one endotoxin (Bti has two or more). Also, unlike Bti, Bsph is very effective in water with a high organic content, and is therefore often used in such habitats for control of *Culex* mosquitoes. Bsph is also capable of "cycling" in the aquatic environment, meaning it can retain its larvicidal properties after passing through the gut of a mosquito and—unlike Bti—provide effective mosquito control for weeks after a single application. Bsph, however, is not effective on all species of mosquitoes.

Because Bsph is a more recently developed larvicide than Bti, there are fewer studies that have examined the nontarget effects of this pesticide. The data available, however, indicate a high degree of specificity of Bshp for mosquitoes, with no demonstrated toxicity to chironomid larvae at any mosquito control application rate (Mulla et al. 1984; Ali and Nayar 1986; Lacey and Mulla 1990; Rodcharoen et al. 1991). This high specificity to some mosquito species and low toxicity to chironomid larvae is probably the consequence of the one endotoxin contained with the Bsph spore. Unfortunately, this also makes the development of resistance to this pesticide more likely if this pesticide becomes widely and frequently used.

Methoprene

Methoprene is a synthetic mimic of a naturally produced insect hormone, juvenile hormone (JH). All insects produce JH in the larval stages, with the highest levels occurring in the insect's early developmental stages. As an insect reaches its final stage of larval development, the level of JH is very low. This low level of JH triggers the development of adult characteristics. When an insect is exposed to methoprene, a hormonal imbalance in the development of the insect results, and it fails to properly mature into an adult. The insect eventually dies in the pupal stage. The most susceptible stages of development to methoprene are the later instars (for mosquitoes, third and fourth instars). In mosquito control applications, methoprene is applied directly to the larval breeding habitat. Larvae will continue to feed and may reach the pupal stage, but they will not emerge as adults. Methoprene is completely ineffective on mosquito pupae and adults. It is available in several formulations: liquid, granular, pellet, and briquet. There are several micro-encapsulated and extended-release formulations that remain effective for up to 150 days.

The amount of methoprene necessary for mosquito control is < 1.0 part per billion (ppb). The initial concentrations of methoprene when applied to aquatic habitats may reach 4-10 ppb, but residual concentrations are approximately 0.2 ppb (Ross et al. 1994). Once released into the aquatic environment, it is non-persistent, with a half-life of about 30-40 hours. Micro-encapsulated and extended-release formulations will, of course, be present in the water longer as

the pesticide is slowly released over time, 7-150 days, depending on the formulation. In field applications, efficacy is determined only by an observed inhibition of emergence of adults, since larvae are not directly killed by the pesticide.

Because methoprene is a JH mimic and all insects produce JH, there is concern about potential adverse impacts to nontarget aquatic insects when this pesticide is used for mosquito control. As with Bti, there is particular concern regarding potential negative impacts to chironomid larvae due to their importance in food webs. As with any pesticide, toxicity is a factor of dose plus exposure. At mosquito control application rates, methoprene is present in the water at very small concentrations (4-10 ppb, initially). With regard to exposure, chironomid larvae occur primarily in the benthos, either within the sediments and/or within cases constructed of silk and detritus. Thus, there may be differences with regard to exposure to methoprene between chironomid and mosquito larvae, the latter occurring primarily in the water column.

The published literature on the impacts of methoprene to chironomids is not as extensive as that for Bti. However, there is evidence for potential toxicity to chironomid and other aquatic invertebrates from methoprene treatments. Some early experiments indicated approximately 50 percent mortality of *Chironomus stigmaterus* (Chironomidae) and 70 percent of *Brachydeutera argentata* (Diptera: Ephidridae) larvae when exposed to 0.01 ppm of technical grade methoprene (Miura and Takahashi 1973). Mulla et al. (Mulla et al. 1974) noted up to 100 percent inhibition of emergence for some midge species, although the lowest concentration tested was 0.1 ppm. Breaud et al. (1977) observed reductions in several aquatic invertebrate taxa, including chironomids, after six applications of methoprene over an 18-month period in a Louisiana marsh. The application rate in this latter study was 0.028 kg/ha of active ingredient, although the formulation was not specified (Breaud et al. 1977).

In testing different formulations of methoprene against chironomids in experimental ponds, Ali (1991a) found that sustained-released formulations inhibited emergence of midges by 38-98 percent, in some cases for up to 7 weeks. A liquid, microencapsulated formulation applied at mosquito control rates resulted in a 60 percent inhibition of emergence in the tribe Chironomini for 14 days post-treatment. A pelletized, sustained-release (30 days) formulation applied at mosquito control rates inhibited all chironomid emergence by 64-98 percent for 7 weeks. A briquet formulation (30 days sustained-release) produced 38-98 percent inhibition of all chironomids for 7 weeks. The granular formulation applied at the high end of mosquito control rates reduced chironomid emergence by 61-87 percent (Ali 1991a).

In the multi-year Minnesota study cited above, a 3-week sustained-release, granular formulation of methoprene was applied to treatment wetlands at a label-recommended rate of 5-10 kg/ha (Hershey et al. 1998; Niemi et al. 1999). The pesticide was applied six times per season at 3-week intervals. The impacts from methoprene in this study were very similar to those observed for Bti. Negative impacts were not observed until the second and third years of treatment. In those years, significant declines in aquatic insect density and biomass were detected in methoprene-treated wetlands compared to controls. Total insect biomass was 70 percent and 81 percent lower in the second and third years of treatment, respectively, than in control wetlands (Hershey et al. 1998). Reductions were observed across many insect taxa, including predators and non-predators, suggesting direct (pesticide) and indirect (food web) effects from methoprene treatments (Hershey et al. 1998).

Although the application rate of methoprene used in the Minnesota study was well within operational rates used in mosquito control, the frequency of application exceeded what would probably occur under most field situations. Using a 3-week sustained release formulation and applying that every 3 weeks ensured a nearly constant exposure of methoprene to aquatic invertebrates in the treated wetlands throughout the season. Under such a scenario, it is unlikely that most impacted invertebrate populations would be able to re-colonize the wetlands during the treatments. However, this does not discount the conclusion that nontarget aquatic invertebrates were indeed impacted by methoprene at rates and concentrations used for mosquito control. Whether or not the observed food web effects would have been lessened under a more realistic pesticide application regime is debatable.

Studies of adverse impacts from methoprene on insect taxa other than chironomids are less conclusive. Because methoprene affects insect development and does not directly kill larvae, traditional toxicity testing over a few days is often inadequate when looking for potential impacts. Methoprene toxicity can only be observed at the point in which the immature insects reach (or fail to reach) adulthood. Thus, many published laboratory and field studies looking at nontarget impacts from methoprene were of insufficient duration to detect actual negative impacts (e.g., Miura and Takahashi 1973).

Breaud et al. (1977) observed adverse effects from methoprene on 14 aquatic invertebrate taxa, including *Callibaetis* sp. mayflies, odonates (dragonflies and damselflies), predaceous diving beetles, and chironomids. Negative impacts to *Callibaetis* mayflies from methoprene treatments have been observed by others (Steelman et al. 1975; Norland and Mulla 1975). Miura and Takahashi (1973) did not observe any mortality on *Callibaetis* from methoprene in laboratory or field studies, but neither was of sufficient duration (48 hours and 1 week, respectively) to adequately detect developmental effects (Miura and Takahashi 1973). Pinkney et al. (2000) observed consistently lower numbers of mayflies emerging from methoprene-treated wetlands compared to controls, but these differences were not statistically significant (Pinkney et al. 2000).

There is evidence of methoprene impacts to non-insects as well. McKenney and Celestial (1996) noted significant reductions in number of young produced in mysid shrimp at 2 ppb (McKenney and Celestial 1996). Sub-lethal effects on the cladoceran, *Daphnia magna*, in the form of reduced fecundity, increased time to first brood, and reduced molt frequency have also been observed at concentrations < 0.1 ppb (Olmstead and LeBlanc 2001).

There has been speculation and some preliminary data to suggest that methoprene causes limb malformations in amphibians (La Clair et al. 1998). However, experiments with methoprene and its degradation products have failed to demonstrate developmental toxicity even at concentrations exceeding 100 times that expected for mosquito control (Ankley et al. 1998; Degitz et al. 2003). Therefore, current data do not support a role of methoprene in amphibian malformations.

In summary, there is evidence for significant adverse nontarget effects from methoprene even when applied at mosquito control rates. With regard to negative impacts to chironomid midges, there may be differences in susceptibility among species and differences depending on the formulation used. One study in particular suggested that methoprene formulations with short-term residual activity may have smaller impacts to chironomids (Ali 1991a). However, even the

"ineffective" liquid formulation used in this study reduced emergence of Chironomini midges by 60 percent for two weeks. Certainly, not all midges will be affected by a single application of methoprene for mosquito control. However, the apparent differences in pesticide formulations, the varied susceptibility of species, and perhaps even the influence of some as-yet-undetermined environmental factors, make predicting the degree of any impacts nearly impossible.

Because methoprene does not immediately kill susceptible chironomid larvae, they are still available for predators. However, repeated applications of methoprene over a mosquito breeding season would eventually hinder recruitment as adults repeatedly fail to emerge (Hershey et al. 1998). Longer-term studies conducted over the course of a season or over multiple seasons are especially necessary for examining nontarget impacts from methoprene in order to detect potential impacts on longer-lived larvae (e.g., odonates, mayflies, and aquatic beetles) and to detect potential impacts to long-term recruitment. As was the case with Bti, the ability for a population to re-colonize a wetland following a methoprene treatment would depend on the intensity and frequency of applications at different spatial scales.

Temephos

Temephos is the only remaining organophosphate pesticide used for larval mosquito control. Like all organophosphate pesticides, it functions on the nervous system by inhibiting the production of acetylcholinesterase. Without this enzyme, nerves continue to fire, eventually resulting in death of the insect. Temephos is available in liquid or granular formulations that are applied directly to aquatic breeding habitats of mosquitoes. Expected environmental concentrations of temephos in water are 20-35 ppb, but actual field concentrations can vary widely (Pierce et al. 1996). Temephos is not persistent, but can remain effective for 7-10 days (Fortin et al. 1987).

There have been many studies examining the adverse nontarget impacts of temephos. Many of these studies have documented significant negative impacts to a wide range of aquatic taxa, especially in freshwater wetlands. Temephos is very highly toxic to cladocerans (water fleas, e.g., *Daphnia*) at fractions of expected mosquito control concentrations (Fortin et al. 1987; Helgen et al. 1988). The U.S. Environmental Protection Agency (EPA) has determined an LC_{50} value of 0.01 ppb for *Daphnia magna* (EPA 1999), orders of magnitude lower than the expected environmental concentration of 20-35 ppb. The pesticide is highly toxic to chironomid larvae at or below mosquito control concentrations (Mulla and Khasawinah 1969; Iannacone and Alvarino 1998; Pinkney et al. 2000), although some researchers have documented only minimal effects on some species (Ali et al. 1978) (Ali 1991b). Temephos is especially toxic to larvae of the non-biting phantom midge, *Chaoborus* (Fales et al. 1968; Helgen et al. 1988; Pinkney et al. 2000). Temephos has also been found to be very toxic to potential mosquito predators such as odonates and backswimmers (Fales et al. 1968). Pinkney et al. (2000) reported significant reductions in insect diversity, richness, and density within temephos-treated experimental ponds, with significant declines in Ephemeroptera (mayflies), Odonata, Diptera, and Chironomidae compared to control ponds.

The effects of temephos on nontarget estuarine species are less studied. There are some data that suggest negative impacts from temephos are not as pronounced on estuarine species (Lawler et al. 1999b). However, there is evidence for toxicity to estuarine crustaceans from temephos at

concentrations below those expected from field applications for mosquito control (Mortimer and Chapman 1995; Brown et al. 1996). Studies have also shown sublethal and indirect impacts of temephos on fiddler crabs (Ward and Busch 1976; Pinkney et al. 1999). In addition, at least some chironomid species in salt marsh habitats are susceptible to temephos (Ali et al. 1992).

Temephos has also been shown to be lethal to tadpoles of green frogs at concentrations $\leq$ 10 ppb (Sparling et al. 1997).

It is clear that temephos is a much less specific larvicide compared to Bti and methoprene. Severe, negative impacts from temephos at mosquito control concentrations have been documented for a broad range of aquatic taxa in both freshwater and estuarine habitats, although some estuarine species are apparently more tolerant of the pesticide.

Surface Oils and Films

Surface oils and films are applied to mosquito breeding sites to kill mosquito larvae and pupae. The products create a barrier to the air-water interface and suffocate the insects, which require at least periodic contact with the water surface in order to obtain oxygen. The oils are mineral oil based and are effective for 3-5 days. Surface films are alcohol based and produce a monomolecular film over the water surface.

Both the oils and the films are potentially lethal to any aquatic insect that lives on the water surface or requires periodic contact with the air-water interface to obtain oxygen. Studies have demonstrated very significant negative impacts to water surface-dwelling insects from applications of oils (Mulla and Darwazeh 1981; Lawler et al. 1998).

Surface oils may also adversely impact wildlife by wetting the feathers of young waterfowl. This may be of particular concern at low temperatures when the oil could affect thermoregulation (Lawler et al. 1998).

Adulticides

All pesticides used to kill adult mosquitoes are broad-spectrum insecticides. The only selective aspect of these pesticides is in the manner in which they are applied. Most adulticides used currently are applied as ultra-low volume (ULV) sprays, meaning relatively small amounts are used (compared to some agricultural pesticides) and they are sprayed as very fine droplets (10-30 cm in diameter). This small droplet size allows the spray to drift for a relatively longer period of time compared to larger droplets, and the small size delivers an appropriate dose of the pesticide to kill an adult mosquito. Drift is a necessary component of adulticiding because these sprays are most effective on flying insects. For this reason, adulticide applications generally occur in the evening or early morning hours when the majority of mosquito species are most active. Adulticides may be applied by truck-mounted sprayers or applied aerially by helicopter or fixed-wing aircraft.

There are only two general classes of adulticides: organophosphates and pyrethroids. Both classes of pesticides work on the nervous system, although have different modes of action. Organophosphates are cholinesterase inhibitors while pyrethroids are sodium channel blockers.

There are currently three organophosphate adulticides: malathion, naled, and fenthion, although fenthion is used only in a few counties in Florida and will be removed from the market in 2004. The most common pyrethroids are the synthetic pyrethroids, permethrin, resmethrin, and sumithrin. The pyrethroids are usually combined with the synergist piperonyl butoxide, which interferes with an insect's detoxifying mechanisms. None of these pesticides is persistent, with half-lives ranging from hours (naled) to several days (malathion and some pyrethroids).

Nontarget toxicity from adulticides may occur in either terrestrial or aquatic habitats as a result of deposition, runoff, inhalation, or ingestion. In general, pyrethroids have lower toxicity to terrestrial vertebrates than the organophosphates. With the exception of fenthion, which is highly toxic to birds, the application rates of the organophosphate adulticides are not likely to cause any direct mortality of vertebrates. Pyrethroids, although less toxic to birds and mammals, are very toxic to fish and aquatic invertebrates (Anderson 1989; Siegfried 1993; Milam et al. 2000). The actual toxicity of pyrethroids in aquatic habitats, however, is less than may be anticipated because of the propensity of these pesticides to adsorb to organic particles in the water (Hill et al. 1994). There are also data that indicate synthetic pyrethroid degradates have endocrine disrupting properties (Tyler et al. 2000).

In general, there are very few studies that have examined the nontarget effects of mosquito control adulticides. As all of these chemicals are broad-spectrum insecticides, they are potentially lethal to most insects. Yet there is a paucity of data available on the nontarget impacts to either terrestrial or aquatic invertebrates. There are data indicating the high toxicity of adulticides to honey bees (Taylor et al. 1987; Hagler et al. 1989; Pankiw and Jay 1992a; Pankiw and Jay 1992b), although the timing of adulticide applications in the evening can be expected to minimize these impacts.

Salvato (2001) examined the toxicity of naled, malathion, and non-synergized permethrin to 5 species of butterflies, including larval and adult stages. Naled and permethrin were found to be the most toxic to all life stages. The LD_{50} data presented for some larvae and adults coincide with that delivered by a single ULV droplet of 5-23 cm, within the desired range for mosquito control (Salvato 2001). Mosquito control adulticiding has been identified as a likely contributing factor in the decline of several rare lepidopteran species in the Florida Keys (Calhoun et al. 2000; Salvato 2001).

All adulticides are very highly toxic to aquatic invertebrates in concentrations < 1 ppb (Milam et al. 2000). Because most adulticides can be applied over or near water when used for mosquito control, there are risks to aquatic invertebrates from direct deposition and runoff of the pesticides. However, very few field studies have been conducted that have examined the impacts to aquatic organisms from mosquito control adulticides. Jensen et al. (1999) failed to detect reductions in aquatic invertebrate abundance or biomass from truck-mounted applications of pyrethrin, permethrin, and malathion. However, the potentially most sensitive group of invertebrates, cladocerans (water fleas), were not sampled (Jensen et al. 1999). This could be important given that malathion residues of 6 ppb were recovered from water in the treatment areas during this study. This is several times the LC_{50} values of 0.69 ppb and 1.8 ppb of malathion for *Simocephalis serrulatus* and *Daphnia magna*, respectively (USEPA 2000), indicating that cladocerans would be at risk from applications of malathion for mosquito control.

Declines in flying insect abundance were also observed during this study following pesticide applications, but the numbers quickly rebounded (Jensen et al. 1999).

As was the case with studies of nontarget impacts from larvicides, the limited numbers of studies on adulticide impacts all involve examining short-term effects, usually from a single application of a pesticide. It is difficult to extrapolate the results of short-term experiments into predictions of long-term impacts, whether the short-term studies detected impacts or not. In addition, mosquito control is most often conducted at a landscape level. Studies of impacts at such larger temporal and spatial scales are non-existent, and would be a challenge both scientifically and economically.

Biological Control

The mosquitofish, *Gambusia affinis*, has been used for decades as a biological control of mosquito larvae. These fish are effective in removing mosquito larvae from relatively small, closed, and artificial aquatic systems, such as backyard ponds. In more complicated natural systems however, *Gambusia* are not selective predators, and can adversely impact native vertebrate and invertebrate communities (Rupp 1996). They can out-compete many native species of fish by feeding on eggs and fry, and they can actually reduce the density of natural invertebrate predators. There is also evidence that mosquitofish may cause direct and indirect impacts on tadpoles (Lawler et al. 1999a).

Summary/Conclusions

Mosquitoes are a natural component of many aquatic and terrestrial ecosystems. Like other aquatic insects with terrestrial adult stages, mosquitoes provide a link between aquatic and terrestrial habitats. Predation is probably the largest source of mortality for both larval and adult mosquitoes and, although there are relatively few predators that specialize on mosquitoes, these insects are fed upon by a wide variety of invertebrate and vertebrate predators. The impact of greatly reducing mosquito populations in aquatic and terrestrial ecosystems has not been studied.

Virtually every pesticide currently used to manage mosquito populations has the potential to adversely impact nontarget species. Widely used larvicides such as Bti and methoprene have been demonstrated to kill susceptible chironomid midge larvae, with experimental evidence suggesting that such population-level impacts may result in community-level food web effects. All adulticides are broad-spectrum insecticides that can potentially impact a wide variety of invertebrates and some vertebrates. The degree to which nontarget organisms or communities may be impacted by mosquito control pesticides is often difficult to predict because of differences in susceptibility among species, differences in toxicity of various formulated products, and basic knowledge gaps in toxicity data to certain species. An additional factor is the paucity of studies examining nontarget impacts of mosquito control at large spatial and temporal scales.

Organized mosquito control most often occurs at a landscape level such as a county or parish. When pesticides are applied to manage mosquito populations, it is often at multiple locations over relatively large spatial scales. Furthermore, pesticides may be applied to any given area multiple times in a season, year after year. The majority of nontarget mosquito control pesticide

studies have examined impacts at much smaller temporal and spatial scales, such as one application in a single wetland. While these studies provide useful data, it is difficult to extrapolate the results of these small-scale experiments into predictions of impacts from much larger scale treatments.

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APPENDIX K5. B.t.i.

The information in this profile may be out-of-date. It was last revised in 1996. EXTOXNET no longer updates this information, but it may be useful as a reference or resource.

Please visit the National Pesticide Information Center (NPIC) to find updated pesticide fact sheets. If you don't find a fact sheet related to your question, feel free to call 1-800-858-7378. NPIC is open seven days a week from 6:30am to 4:30pm Pacific Time.

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Pesticide Information Profiles

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EXTOXNET primary files maintained and archived at Oregon State University

Revised June 1996

Bacillus thuringiensis

Trade and Other Names: Trade names include Acrobe, Bactospeine, Berliner (variety kurstaki), Certan (variety aizawai), Dipel, Javelin, Leptox, Novabac, Teknar (variety israelensis), Thuricide, and Victory. Bacillus thuringiensis is also known at B.t.

Regulatory Status: This microbial insecticide was originally registered in 1961 as a General Use Pesticide (GUP). It is classified as toxicity class III - slightly toxic. Products containing B.t. bear the Signal Word CAUTION because of its potential to irritate eyes and skin.

Chemical Class: bacterium

Introduction: Bacillus thuringiensis (B.t.) is a naturally-occurring soil bacterium that produces poisons which cause disease in insects. B.t. is considered ideal for pest management because of its specificity to pests and because of its lack of toxicity to humans or the natural enemies of many crop pests. There are different strains of B.t., each with specific toxicity to particular types of insects: B.t. aizawai (B.t.a.) is used against wax moth larvae in honeycombs; B.t. israelensis (B.t.i.) is effective against mosquitoes, blackflies and some midges; B.t. kurstaki (B.t.k.) controls various types of lepidopterous insects, including the gypsy moth and cabbage looper. A newer strain, B.t. san diego, is effective against certain beetle species and the boll weevil. To be effective, B.t. must be eaten by insects during their feeding stage of development, when they are larvae. B.t. is ineffective against adult insects. More than 150 insects, mostly lepidopterous larvae, are known to be susceptible in some way to B.t.

B.t. forms asexual reproductive cells, called spores, which enable it to survive in adverse conditions. During the process of spore formation, B.t. also produces unique crystalline bodies. When eaten, the spores and crystals of B.t. act as poisons in the target insects. B.t. is therefore referred to as a stomach poison. B.t. crystals dissolve in the intestine of susceptible insect larvae. They paralyze the cells in the gut, interfering with normal digestion and triggering the insect to stop feeding on host plants. B.t. spores can then invade other insect tissue, multiplying in the insect's blood, until the insect dies. Death can occur within a few hours to a few weeks of B.t. application, depending on the insect species and the amount of B.t. ingested. Typical agricultural formulations include wettable powders, spray concentrates, liquid concentrates, dusts, baits, and time release rings.

Formulation: Typical agricultural formulations include wettable powders, spray concentrates, liquid concentrates, dusts, baits, and time release rings.

Toxicological Effects:

- **Acute toxicity:** B.t. is practically non-toxic to humans and animals. Humans exposed orally to 1000 mg/day of B.t. showed no effects [146]. A wide range of studies have been conducted on test animals, using several routes of exposure. The highest dose tested was 6.7 x 10^11 spores per animal. The results of these tests suggest that the use of B.t. products causes few, if any, negative effects. B.t. was not acutely toxic in tests conducted on birds, dogs, guinea pigs, mice, rats, and humans. No oral toxicity was found in rats, or mice fed protein crystals from B.t. var. israelensis [147]. The LD50 is greater than 5000 mg/kg for the B.t. product Javelin in rats and greater than 13,000 mg/kg in rats exposed to the product Thuricide [147,148]. Single oral dosages of up to 10,000 mg/kg did not produce toxicity in mice, rats, or dogs [148]. The dermal LD50 for a formulated B.t. product in rabbits is 6280 mg/kg. A single dermal application of 7200 mg/kg of B.t. was not toxic to rabbits [148]. B.t. is an eye irritant; 100 grams of formulated product applied in each eye of test rabbits caused continuous congestion of the iris as well as redness and swelling [149]. Very slight irritation from inhalation was observed in test animals. This may have been caused by the physical rather than the biological properties of the B.t. formulation tested [8]. Mice survived 1 or more 1-hour periods of breathing mist that contained as many as 6.0 x 10^10 spores B.t. per liter [143].
- **Chronic toxicity:** No complaints were made by 8 men after they were exposed for 7 months to fermentation broth, moist bacterial cakes, waste materials, and final powder created during the commercial production of B.t. [143]. Dietary administration of B.t. for 13 weeks to rats at dosages of 8400 mg/kg/day did not produce toxic effects [143]. Some reversible abnormal redness of the skin was observed when 1 mg/kg/day of formulated B.t. product was put on scratched skin for 21 days. No general, systemic poisoning was observed [8].

- **Reproductive effects:** There is no indication that B.t. causes reproductive effects [143].
- **Teratogenic effects:** There is no evidence indicating that formulated B.t. can cause birth defects in mammals [143,148].
- **Mutagenic effects:** B. thuringiensis appears to have mutagenic potential in plant tissue. Thus, extensive use of B.t. on food plants might be hazardous to these crops [143]. There is no evidence of mutagenicity in mammalian species.
- **Carcinogenic effects:** Tumor-producing effects were not seen in 2-year chronic studies during which rats were given dietary doses of 8400 mg/kg/day of B.t. formulation [148]. It is unlikely that B.t. is carcinogenic.
- **Organ toxicity:** There is no evidence of chronic B.t. toxicity in dogs, guinea pigs, rats, humans, or other test animals.

- **Fate in humans and animals:** B.t. does not persist in the digestive systems of mammals that ingest it [149].

Ecological Effects:

- **Effects on birds:** B.t. is not toxic to birds [8,150]. The LD50 in bobwhite quail is greater than 10,000 mg/kg. When autopsies were performed on these birds, no pathology was attributed to B.t. Field observations of 74 bird species did not reveal any population changes after aerial spraying of B.t. formulation [148].
- **Effects on aquatic organisms:** B.t. is practically nontoxic to fish [150]. Rainbow trout and bluegills exposed for 96 hours to B.t. at concentrations of 560 and 1000 mg/L did not show adverse effects. A small marine fish (Anguilla anguilla) was not negatively affected by exposure to 1000 to 2000 times the level of B.t. expected during spray programs. Field observations of populations of brook trout, common white suckers, and smallmouth bass did not reveal adverse effects 1 month after aerial application of B.t. formulation [148]. However, shrimp and mussels may be affected adversely [8].
- **Effects on other organisms:** Applications of formulated B.t. are not toxic to most beneficial or predator insects [148]. Treatment of honeycombs with B.t. var. aizawai does not have a detrimental effect upon bees, nor on the honey produced [151]. Very high concentrations (108 spores/ ml sucrose syrup) of B.t. var. tenebrionis, which is used against beetles such as the Colorado potato beetle, reduced longevity of honey bee adults but did not cause disease [151]. B.t. applied at rates used for mosquito control may cause the death of some non-target species [8]. Users of B.t. are encouraged to consult local officials or the nearest EPA regional office responsible for protecting endangered species before using B.t. products in counties where susceptible endangered species of Lepidoptera are known to be present [146]. It did not have negative effects on frogs and salamanders [150].

Environmental Fate:

- **Breakdown in soil and groundwater:** B.t. is a naturally-occurring pathogen that readily breaks down in the environment. Due to its short biological half-life and its specificity, B.t. is less likely than chemical pesticides to cause field resistance in target insects. B.t. is moderately persistent in soil. Its half-life in suitable conditions is about 4 months [152]. B.t. spores are released into the soil from decomposing dead insects after they have been killed by it. B.t. is rapidly inactivated in soils that have a pH below 5.1 [148]. Microbial pesticides such as B.t. are classified as immobile because they do not move, or leach, with groundwater. Because of their rapid biological breakdown and low toxicity, they pose no threat to groundwater.
- **Breakdown in water:** The EPA has not issued restrictions for the use of B.t. around bodies of

water. It can be effective for up to 48 hours in water. Afterwards, it gradually settles out or adheres to suspended organic matter [150].

- **Breakdown in vegetation:** B.t. is relatively short-lived on foliage because the ultraviolet (UV) light of the sun destroys it very rapidly. Its half-life under normal sunlight conditions is 3.8 hours [153]. It is not poisonous to plants and has not shown any adverse effect upon seed generation or plant vigor [150].

Physical Properties:

- **Appearance:** The insecticidal action of B.t. is attributed to protein crystals produced by the bacterium. The vegetative cells of B.t. are approximately 1 micron wide and 5 microns long, and are motile [146]. The commercial product contains about 2.5 x 10^11 viable spores per gram. B.t. products lose some of their effectiveness when stored for more than 6 months [8]. B.t. is incompatible with alkaline materials. Formulated products are not compatible with captafol, dinocap, or, under some conditions, leaf (or foliar) nutrients [8].
- **Chemical Name:** Bacillus thuringiensis [1]
- **CAS Number:** (B.t. variety kurstaki) 68038-71-1
- **Molecular Weight:**
- **Water Solubility:** Not Applicable
- **Solubility in Other Solvents:** Not Applicable
- **Melting Point:** Not Applicable
- **Vapor Pressure:** Not Applicable
- **Partition Coefficient:** Not Applicable
- **Adsorption Coefficient:** Not Applicable

Exposure Guidelines:

- **ADI:** Not Available
- **MCL**: Not Available
- **RfD:** Not Available
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: Not Available

Basic Manufacturer:

Sandoz Agro, Inc., and Abbott Laboratories
1300 E. Touhy Ave.
Des Plaines IL 60018

and

Chem. and Agric. Prod. Div.
1401 Sheridan Rd.
North Chicago, IL 60064

- **Phone:** 708-699-1616 ; 708-937-2739
- **Emergency:** 708-699-1616; Not Available

References:

References for the information in this PIP can be found in Reference List Number 10

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

APPENDIX K6. Methoprene

The information in this profile may be out-of-date. It was last revised in 1996. EXTOXNET no longer updates this information, but it may be useful as a reference or resource.

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EXTOXNET primary files maintained and archived at Oregon State University

Revised June 1996

Methoprene

Trade and Other Names: Trade names include Altosid, Apex, Diacan, Dianex, Kabat, Minex, Pharorid, Precor, and ZR-515.

Regulatory Status: Methoprene is a slightly to practically nontoxic compound in EPA toxicity class IV. It is a General Use Pesticide (GUP). Labels for containers of products containing methoprene must bear the Signal Word CAUTION.

Chemical Class: Not Available

Introduction: Methoprene is a compound which mimics the action of an insect growth regulation hormone. It is used as an insecticide because it interferes with the normal maturation process. In a normal life cycle, an insect goes from egg to larva, to pupa, and eventually to adult. Methoprene artifically stunts the insects' development, making it impossible for insects to mature to the adult stages, and thus preventing them from reproducing.

To be effective, it is essential that this growth inhibitor be administered at the proper stage of the target pest's life cycle. Methoprene is not toxic to the pupal or adult stages. Treated larvae will pupate but adults do not hatch from the pupal stage. Methoprene is also considered a larvicide since it is effective in controlling the larval stage of insects. Methoprene is used in the production of a number of foods including meat, milk, eggs, mushrooms, peanuts, rice, and cereals. It is also used in aquatic areas to control mosquitoes and several types of ants, flies, lice, moths, beetles, and fleas. It is available in suspension, emulsifiable and soluble concentrate formulations, as well as in briquette, aerosol, and bait form.

Formulation: It is available in suspension, emulsifiable and soluble concentrate formulations, as well as in briquette, aerosol and bait form.

Toxicological Effects:

- **Acute toxicity:** Methoprene is practically nontoxic when ingested or inhaled and slightly toxic by dermal absorption. The oral LD50 for methoprene in rats is greater than 34,600 mg/kg, and in dogs is greater than 5000 mg/kg [1]. It is slightly toxic by skin exposure, with reported dermal LD50 values of greater than 2000 to 3000 mg/kg in rabbits [1]. Methoprene is not an eye or skin irritant, and it is not a skin sensitizer [1]. The inhalation LC50 for methoprene in rats is greater than 210 mg/L [155]. No overt signs of poisoning have been reported in incidents involving accidental human exposure to methoprene [155].
- **Chronic toxicity:** No methoprene-related effects were observed in 2-year feeding trials with rats given doses of 250 mg/kg/day, nor in mice given 30 mg/kg/day [1]. Liver changes were observed in mice fed 50 to 250 mg/kg/day of methoprene during an 18-month study [155]. Increased liver weights occurred in rats fed 250 mg/kg/day for 90 days, but not during a 24-month feeding study in which rats were fed 125 mg/kg/day [155].
- **Reproductive effects:** Experimental data indicate that no reproductive hazards are associated with methoprene [155]. No methoprene-related effects were observed in three-generation reproduction studies in rats receiving dietary doses of 125 mg/kg/day [1].
- **Teratogenic effects:** There have been no teratogenic effects in animals dosed with methoprene; teratogenic effects were not seen in rats at doses of about 25 mg/kg/day, or in rabbits at doses of about 15 mg/kg/day [156,157]. Methoprene does not appear to be teratogenic.
- **Mutagenic effects:** Methoprene does not appear to be mutagenic. No methoprene-related mutagenic effects were observed in rats following a single dose of 2000 mg/kg [158].
- **Carcinogenic effects:** No tumors were seen in an 18-month feeding study with mice, or in a 24-month oncogenicity study with rats [156]. These data suggest that methoprene is not carcinogenic.
- **Organ toxicity:** The target organ primarily affected by methoprene after long-term exposure is the liver.
- **Fate in humans and animals:** In mammals, methoprene is rapidly and completely broken down and excreted, mostly in the urine and feces [157]. Some evidence suggests that methoprene metabolites are incorporated into natural body components [155]. Methoprene is excreted unchanged in cattle feces in amounts that are sufficient to kill some larvae that breed in dung

[131].

Ecological Effects:

- **Effects on birds:** Methoprene is slightly toxic to birds [1,158]. The reported 5- to 8-day LC50 values for Altosid, a methoprene formulation, are greater than 10,000 ppm in mallard ducks and bobwhite quail, and the acute oral LD50 for Altosid is greater than 4640 ppm in chickens [1,158]. In mallards an acute oral LD50 of greater than 2000 mg/kg was determined [158]. Nonlethal effects that may affect survival of the birds did appear at acute oral doses of 500 mg/kg. These effects appeared as soon as 2 hours after treatment and persisted for up to 2 days and included slowness, reluctance to move, sitting, withdrawal, and incoordination [63]. These effects may decrease bird survival by making them temporarily more susceptible to predation. No effects were observed in the reproduction of bobwhite quail and mallard ducks at 30 ppm constant feeding of Altosid [158].
- **Effects on aquatic organisms:** Methoprene is slightly to moderately toxic to fish [157]. The reported 96-hour LC50 values for the methoprene formulation Altosid were 4.6 mg/L in bluegill sunfish, 4.4 mg/L in trout, and greater than 100 mg/L in channel catfish and largemouth bass [1,8]. Methoprene residues may have a slight potential for bioconcentration in bluegill sunfish and crayfish [155]. Methoprene is very highly toxic to some species of freshwater, estuarine, and marine invertebrates, while the acute LC50 values are greater than 100 mg/L in freshwater shrimp, and it is greater than 0.1 mg/L in estuarine mud crabs [159]. Altosid had very little effect, if any, on exposed non-target aquatic organisms including waterfleas, damselflies, snails, tadpoles, and mosquito fish [159].
- **Effects on other organisms:** Tests with earthworms showed little if any toxic effects on contact [159]. It is nontoxic to bees [1].

Environmental Fate:

- **Breakdown in soil and groundwater:** Methoprene is of low persistence in the soil environment; reported field half-lives are up to 10 days [155]. In sandy loam, its half-life was calculated to be about 10 days [155]. When Altosid was applied at an extremely high application rate of 1 pound per acre, its half-life was less than 10 days [155]. In soil, microbial degradation is rapid and appears to be the major route of its disappearance from soil [155,157]. Methoprene also readily undergoes degradation by sunlight [157]. Methoprene is rapidly and tightly sorbed to most soils [155]. It is slightly soluble in water [1]. These properties, along with its low environmental persistence make it unlikely to be significantly mobile. In field leaching studies, it was observed only in the top few inches of the soil, even after repeated washings with water [155,159].
- **Breakdown in water:** Methoprene degrades rapidly in water [8]. Studies have demonstrated half-lives in pond water of about 30 and 40 hours at initial concentrations of 0.001 mg/L and 0.01 mg/L, respectively [49]. At normal temperatures and levels of sunlight, technical Altosid is rapidly degraded, mainly by aquatic microorganisms and sunlight [159,49].
- **Breakdown in vegetation:** Altosid is biodegradable and nonpersistent, even in plants treated at very high rates. It has a half-life of less than 2 days in alfalfa when applied at a rate of 1 pound per acre [159]. In rice, the half-life is less than 1 day [49]. In wheat, its half-life was estimated to be 3 to 7 weeks, depending on the level of moisture in the plant [155]. Plants grown in treated soil are not expected to contain methoprene residues.

Physical Properties:

- **Appearance:** Technical methoprene is a amber or pale yellow liquid with a faint fruity odor [1]

- **Chemical Name:** ispropyl(E,E)-(R,S)-11-methoxy-3,7,11-trimethyldodeca-2,4-dienoate [1]
- **CAS Number:** 40596-69-8
- **Molecular Weight:** 310.48
- **Water Solubility:** 1.4 mg/L @ 25 C [1]
- **Solubility in Other Solvents:** Miscible in organic solvents [1]
- **Melting Point:** Not Available
- **Vapor Pressure:** 3.15 mPa @ 25 C [1]
- **Partition Coefficient:** Not Available
- **Adsorption Coefficient:** Not Available

Exposure Guidelines:

- **ADI:** 0.1 mg/kg/day [12]
- **MCL**: Not Available
- **RfD:** Not Available
- **PEL:** Not Available
- **HA**: Not Available
- **TLV**: Not Available

Basic Manufacturer:

Zoecon Corp.
12005 Ford Rd., Suite 800
Dallas, TX 75234

- **Phone:** Not Available
- **Emergency:** 708-699-1616

References:

References for the information in this PIP can be found in Reference List Number 10

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product labeling or other regulatory requirements. Please refer to the pesticide product labeling.

APPENDIX K7. Pyrethrins and Pyrethroids

PYRETHRINS AND PYRETHROIDS
(http://extoxnet.orst.edu/pips/pyrethri.htm)

Produced By the Extension Toxicology Network

Pesticide Information Profiles

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EXTOXNET primary files maintained and archived at Oregon State University

Revised 3/94

PYRETHRINS AND PYRETHROIDS

TRADE OR OTHER NAMES: Several trade names associated with these compounds are Buhach, Chrysanthemum Cinerariaefolium, Ofirmotox, Insect Powder, Dalmation Insect Flowers, Firmotox, Parexan and NA 9184.

INTRODUCTION: Pyrethrins are natural insecticides produced by certain species of the chrysanthemum plant. The flowers of the plant are harvested shortly after blooming and are either dried and powdered or the oils within the flowers are extracted with solvents. The resulting pyrethrin containing dusts and extracts usually have an active ingredient content of about 30%. These active insecticidal components are collectively known as pyrethrins. Two pyrethrins are most prominent, pyrethrin-I and pyrethrin-II. The pyrethrins have another four different active ingredients, Cinerin I and II and Jasmolin I and II. The typical composition of pyrethrin is pyrethrin I (38.0%), cinerin I (7.3%), jasmolin I (4.0%), pyrethrin II (35.0%), cinerin II (11.7%) and jasmolin II (4.0%); the composition of piperonyl butoxide is 80% 5-[2-(2-butyloxyethoxy)ethoxymethyl]-6-propyl-1,3-benzodioxole and 20% related compounds. Pyrethrin compounds have been used primarily to control human lice, mosquitoes, cockroaches, beetles and flies. Some "pyrethrin dusts," used to control insects in horticultural crops, are only 0.3% to 0.5% pyrethrins, and are used at rates of up to 50 lb/A. Other pyrethrin compounds may be used in grain storage and in poultry pens and on dogs and cats to control lice and fleas. The natural pyrethrins are contact poisons which quickly penetrate the nerve system of the insect. A few minutes after application, the insect cannot move or

fly away. But, a "knockdown dose" does not mean a killing dose. The natural pyrethrins are swiftly detoxified by enzymes in the insect. Thus, some pests will recover. To delay the enzyme action so a lethal dose is assured, organophosphates, carbamates, or synergists may be added to the pyrethrins. Semisynthetic derivatives of the chrysanthemumic acids have been developed as insecticides. These are called pyrethroids and tend to be more effective than natural pyrethrins while they are less toxic to mammals. One common synthetic pyrethroid is allethrin. In this report, the term "pyrethrins" refers to the natural insecticides derived from chrysanthemum flowers; "pyrethroids" are the synthetic chemicals, and "pyrethrum" is a general name covering both compounds. The EPA classifies pyrethrin-I as a Restricted Use Pesticide (RUP). Restricted Use Pesticides may be purchased and used only by certified applicators.

TOXICOLOGICAL EFFECTS

Acute Toxicity: Synthetic pyrethroid compounds vary in their toxicity as do the natural pyrethrins. Pyrethrum carries the signal word CAUTION. Inhaling high levels of pyrethrum may bring about asthmatic breathing, sneezing, nasal stuffiness, headache, nausea, incoordination, tremors, convulsions, facial flushing and swelling, and burning and itching sensations (102). The most severe poisonings have been reported in infants, who are not able to efficiently break down pyrethrum. The lowest lethal oral dose of pyrethrum is 750 mg/kg for children and 1,000 mg/kg for adults (102). Oral LD50 values of pyrethrins in rats range from 200 mg/kg to greater than 2,600 mg/kg (96). Some of this variability is due to the variety of constituents in the formulation. Mice have a pyrethrum oral LD50 of 370 mg/kg (102). Animals exposed to toxic amounts may experience tongue and lip numbness, nausea, and diarrhea. Symptoms may also include incoordination, tremors, convulsions, paralysis, respiratory failure, and death. Pyrethroids can cause two quite different responses at near lethal doses in rats; aggressive sparring and a sensitivity to external stimuli progressing to tremors is the one response and pawing and burrowing behavior, and salivation leading to chronic seizures is the other (105). Human response to these two different types of pyrethroids has not yet been evaluated. Recovery from serious poisoning in mammals is fairly rapid. Rats and rabbits are not affected by large dermal applications (96, 102). On broken skin, pyrethrum produces irritation and sensitization, which is further aggravated by sun exposure.

Chronic Toxicity: Absorption of pyrethrum through the stomach and intestines and through the skin is slow. However, humans can absorb pyrethrum more quickly through the lungs during respiration. Response appears to depend on the pyrethrum compound used. Overall, pyrethrins and pyrethroids are of low chronic toxicity to humans and the most common problems in humans have resulted from the allergenic properties of pyrethrum (104). Patch tests for allergic reaction are an important tool in determining an individuals sensitivity to these compounds. Many of the natural and synthetic compounds can produce skin irritation, itching, pricking sensations and local burning sensations. These symptoms may last for about two days (105).

Reproductive Effects: Rabbits that received pyrethrins orally at high doses during the sensitive period of pregnancy had normal litters. A group of rats fed very high levels of pyrethrins daily for three weeks before first mating had litters with weanling weights much lower than normal (96). Overall, pyrethrins appear to have low reproductive toxicity.

Teratogenic Effects: The one rabbit reproduction study performed showed no effect of pyrethrins on development of the offspring (101). More information is needed.

Mutagenic Effects: No information was found.

Carcinogenic Effects: No carcinogenic status has been established for pyrethrins or pyrethroids.

Organ Toxicity: In mammals, tissue storage has not been recorded. At high doses, pyrethrum can be damaging to the central nervous system and the immune system. When the immune system is attacked by pyrethrum, allergies can be worsened. Animals fed large doses of pyrethrins may experience liver damage.

Rats fed pyrethrin at high levels for two years showed no significant effect on survival, but slight, definite damage to the livers was observed (96). Inhalation of high doses of pyrethrum for 30 minutes each day for 31 days caused slight lung irritation in rats and dogs (102). Fate in Humans and Animals: Pyrethrins, pyrethroids, and their metabolites are not known to be stored in the body nor excreted in the milk (100). The urine and feces of people given oral doses of pyrethrum contain chrysanthemumic acid and other metabolites (100, 96). These metabolites are less toxic to mammals than are the parent compounds (101). Pyrethrins I and II are excreted unchanged in the feces (100). Other pyrethrum components undergo rapid destruction and detoxification in the liver and gastrointestinal tract (96).

ECOLOGICAL EFFECTS

Pyrethrin is extremely toxic to aquatic life, such as bluegill and lake trout while it is slightly toxic to bird species, such as mallards. Toxicity increases with higher water temperatures and acidity. Natural pyrethrins are highly fat soluble, but are easily degraded and thus do not accumulate in the body. These compounds are toxic to bees also.Because pyrethrin-I, pyrethrin-II, and allethrin have multiple sites in their structures that can be readily attacked in biological systems, it is unlikely that they will concentrate in the food chain (100).

ENVIRONMENTAL FATE

Two pyrethroid synthetic insecticides, permethrin and cypermethrin, break down in plants to produce a variety of products (103). Pyrethrins have little residual effect. In stored grain, 50% or more of the applied pyrethrins disappear during the first three or four months of storage. At least 80% of what remains is removed by handling, processing, and cooking (101). Pyrethrins alone provide limited crop protection because they are not stable. As a result, they are often combined with small amounts of antioxidants to prolong their effectiveness. Pyrethrum compounds are broken down in water to nontoxic products. Pyrethrins are inactivated and decomposed by exposure to light and air. Pyrethrins are also rapidly decomposed by mild acids and alkalis. Stored pyrethrin powders lose about 20% of their potency in one year. As the pyrethrins are purified, their stability decreases; thus, pure pyrethrin-I and pyrethrin-II are the least stable of the pyrethrins (96). Purified pyrethrins are very expensive and are only available for laboratory uses.

PHYSICAL PROPERTIES AND GUIDELINES

Physical Properties:

Appearance: The pyrethrins are viscous brown resins, liquids, or solids which inactivate readily in air.

Chemical Name: n/a

CAS Number: 8003347
Molecular Weight: Due to differences in the types and amounts of esters in the pyrethrum mixture, its molecular weight ranges from 316 to 374.
Water Solubility: considered to be insoluble in water.
Solubility in Other Solvents: soluble in organic solvents like: alcohol, kerosene, nitromethane, petroleum ether, carbon tetrachloride, and ethylene dichloride.
Melting Point: n/a
Vapor Pressure: about 0 mm/Hg
Partition Coefficient: n/a
Adsorption Coefficient: n/a

Exposure Guidelines:
ADI: 0.04 mg/kg body weight (humans) (101)
MCL: Not Available
RfD: Not Available
PEL: 5 mg/m3
HA: Not Available
TLV: 5 mg/m3

BASIC MANUFACTURER
There are several manufacturers of products in this category.

REFERENCES
References for the information in this PIP can be found on the website, http://extoxnet.orst.edu/pips/pyrethri.htm) (Reference List Number 2)

DISCLAIMER: The information in this profile does not in any way replace or supersede the information on the pesticide product label/ing or other regulatory requirements. Please refer to the pesticide product label/ing.

APPENDIX K8. California Mosquito-Borne Virus Surveillance and Response Plan

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE & RESPONSE PLAN

Edmund G. Brown Jr., Governor

California Department of Public Health
Mosquito & Vector Control Association of California
University of California

For further information contact:
Vector-Borne Disease Section
California Department of Public Health
(916) 552-9730
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May 2012

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE AND RESPONSE PLAN

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Objectives

The California Mosquito-borne Virus Surveillance and Response Plan was developed to meet several objectives. Specifically, the Plan:

- Provides guidelines and information on the surveillance and control of mosquito-borne viruses in California, including West Nile, St. Louis encephalitis, and western equine encephalomyelitis viruses;
- Incorporates surveillance data into risk assessment models;
- Prompts surveillance and control activities associated with virus transmission risk level;
- Provides local and state agencies with a decision support system; and
- Outlines the roles and responsibilities of local and state agencies involved with mosquito-borne virus surveillance and response.

This document provides statewide guidelines, but can be modified to meet local or regional conditions.

Introduction

California has a comprehensive mosquito-borne disease surveillance program that has monitored mosquito abundance and mosquito-borne virus activity since 1969 (Reeves et al. 1990) and is an integral part of integrated mosquito management programs conducted by local mosquito and vector control agencies. Surveillance and interagency response guidelines have been published previously by the California Department of Public Health formerly known as the California Department of Health Services (Walsh 1987) and the Mosquito and Vector Control Association of California (Reisen 1995). The detection of West Nile virus (WNV) in New York, a virus not recognized in the Western Hemisphere prior to 1999, prompted the review and enhancement of existing guidelines to ensure that surveillance, prevention, and control activities were appropriate for WNV. From New York, WNV spread rapidly westward and by 2004 had been detected in all 48 states in the continental United States. In addition to WNV, California is vulnerable to introduction of other highly virulent mosquito-borne viruses of public and veterinary health concern, such as Japanese encephalitis, dengue, yellow fever, Rift Valley fever, chikungunya and Venezuelan encephalitis viruses. If an existing or introduced virus is detected, it is critical that local and state agencies are prepared to respond in a concerted effort to protect people and animals from infection and disease. The current document describes an enhanced surveillance and response program for mosquito-borne viruses in the State of California. Its contents represent the collective effort of the California Department of Public Health (CDPH), the Mosquito and Vector Control Association of California (MVCAC), and the University of California at Davis (UCD).

Background

Mosquito-borne viruses belong to a group of viruses commonly referred to as arboviruses (for **ar**thropod-**bo**rne). Although 12 mosquito-borne viruses are known to occur in California, only WNV, western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE) are significant causes of human disease. WNV is having a serious impact upon the health of humans, horses, and wild birds throughout the state. Since 2004, there have been 3,146 WNV human cases with 110 deaths and 1,167 horse cases. Consequently, the California Arbovirus Surveillance Program emphasizes forecasting and monitoring the temporal and spatial activity of

WNV, WEE, and SLE. These viruses are maintained in wild bird-mosquito cycles that do not depend upon infections of humans or domestic animals to persist. Surveillance and control activities focus on this maintenance cycle, which involves primarily *Culex* mosquitoes, such as the western encephalitis mosquito, *Culex tarsalis*, and birds such as house finches and house sparrows.

Immature stages (called larvae and pupae) of *Culex tarsalis* can be found throughout California in a wide variety of aquatic sources, ranging from clean to highly polluted waters. Most such water is associated with irrigation of agricultural crops or urban wastewater. Other mosquito species, such as *Culex pipiens, Culex quinquefasciatus*, and *Culex stigmatosoma*, play an important role in WNV, and possibly SLE, transmission cycles in urban and suburban areas. Historically, *Aedes melanimon*, a floodwater mosquito, played a role in a secondary transmission cycle of WEE involving rabbits. Additional mosquitoes such as *Aedes vexans* and *Culex erythrothorax* also could be important bridge (i.e. bird to mammal) vectors in transmission.

Mosquito control is the only practical method of protecting the human population from infection. There are no known specific treatments or cures for diseases caused by these viruses and vaccines are not available for public use. Infection by WEE virus tends to be most serious in very young children, whereas infections caused by WN and SLE viruses affect the elderly most seriously. WNV also kills a wide variety of native and non-native birds. There are WEE and WNV vaccines available to protect horses since both viruses can cause severe disease in horses. Mosquito-borne disease prevention strategies must be based on a well-planned integrated pest management (IPM) program that uses real-time surveillance to detect problem areas, focus control, and evaluate operational efficacy. The primary components of an IPM program include education, surveillance, and mosquito control.

Education

Residents, farmers, and duck club owners can play an important role in reducing the number of adult mosquitoes by eliminating standing water that may support the development of immature mosquitoes. For instance, residents can help by properly disposing of discarded tires, cans, or buckets; emptying plastic or unused swimming pools; and unclogging blocked rain gutters around homes or businesses. Farmers and ranchers can be instructed to use irrigation practices that do not allow water to stand for extended periods, and duck club owners can work with mosquito control agencies to determine optimal flooding schedules. Educating the general public to curtail outdoor activities during peak mosquito biting times, use insect repellents, and wear long-sleeved clothing will help reduce exposure to mosquitoes. Clinical surveillance is enhanced through education of the medical and veterinary communities to recognize the symptoms of WEE, SLE, and WNV and to request appropriate laboratory tests. Public health officials need to be alerted if a mosquito-borne viral disease is detected, especially if the public health risk is high.

Surveillance

Surveillance includes the monitoring, visualization, and analysis of data on climatic factors, immature and adult mosquito abundance, and virus activity measured by testing mosquitoes, sentinel chickens, wild birds (including dead birds for WNV), horses, and humans for evidence

of infection. Surveillance must focus not only on mosquito-borne viruses known to exist in California, but be sufficiently broad to also detect newly introduced viruses.

Climate Variation

The California Mediterranean climate provides ideal opportunities for forecasting mosquito abundance and arbovirus activity, because most precipitation falls during winter, as rain at lower elevations or as snow at higher elevations. Spring and summer temperatures then determine the rate of snow pack melt and runoff, mosquito population growth, the frequency of blood feeding, the rate of virus development in the mosquito, and therefore the frequency of virus transmission. In general, WEE virus outbreaks have occurred in the Central Valley when wet winters are followed by warm summers, whereas SLE and WN virus outbreaks seemed linked to warm dry conditions that lead to large populations of urban *Culex*. Although climate variation may forecast conditions conducive for virus amplification, a critical sequence of events is required for amplification to reach outbreak levels.

Mosquito Abundance

Mosquito abundance can be estimated through collection of immature or adult mosquitoes. The immature stages (larvae and pupae) can be collected from water sources where mosquitoes lay their eggs. A long-handled ladle ("dipper") is used to collect water samples and the number of immature mosquitoes per "dip" estimated. In most local mosquito control agencies, technicians search for new sources and inspect known habitats for mosquitoes on a 7 to 14-day cycle. These data are used to direct control operations. Maintaining careful records of immature mosquito occurrence, developmental stages treated, source size, and control effectiveness can provide an early warning to forecast the size of the adult population.

Adult mosquito abundance is a key factor contributing to the risk of virus transmission. Monitoring the abundance of adult mosquito populations provides important information on the size of the vector population as it responds to changing climatic factors and to larval control efforts. Four adult mosquito sampling methods are currently used in California: New Jersey light traps, carbon dioxide-baited traps, gravid (egg-laying) traps, and resting adult mosquito collections. The advantages and disadvantages of these sampling methods, and guidelines for the design, operation, and processing of the traps have been discussed in Guidelines for Integrated Mosquito Surveillance (Meyer et al. 2003) and are summarized in Appendix A.

Mosquito Infections

Virus activity can be monitored by testing adult mosquitoes for virus infection. Because *Culex tarsalis* is the primary rural vector of WNV, SLE, and WEE, and *Culex quinquefasciatus* and *Culex pipiens* are important urban vectors of WNV and SLE, surveillance efforts emphasize the testing of these species. Another species that should be tested is *Culex stigmatosoma*, which is a highly competent but less widely distributed vector of WNV and SLE that feeds on birds and is probably important in enzootic transmission where it is found in high abundance. Female mosquitoes are trapped, usually using carbon dioxide-baited or gravid traps, identified to species, and counted into groups (pools) of 50 females each for testing at the Center for Vectorborne Diseases (CVEC) at UC Davis. Procedures for submitting and processing mosquitoes for detecting virus infection are detailed in Appendix B. The current surveillance system is designed

to detect and measure levels of infection with WNV, SLE, and WEE. Although generally less sensitive than sentinel chickens, mosquito infections may be detected earlier in the season than chicken seroconversions and therefore provide an early warning of virus activity. Testing adult mosquitoes for infection is one of the best methods to detect newly introduced or emerging mosquito-borne viruses. Testing mosquito species other than *Culex* may be necessary to detect the introduction of viruses that do not have a primary avian-*Culex* transmission cycle.

Avian Infections

Detection of arboviral transmission within bird populations can be accomplished by 1) using caged chickens as sentinels and bleeding them routinely to detect viral antibodies (seroconversions), 2) collecting and bleeding wild birds to detect viral antibodies (seroprevalence), and 3) testing dead birds reported by the public for WNV.

In California, flocks of ten chickens are placed in locations where mosquito abundance is known to be high or where there is a history of virus activity. Each chicken is bled every two weeks by pricking the comb and collecting blood on a filter paper strip. The blood is tested at the CDPH Vector-Borne Disease Section for antibodies to SLE, WEE, and WNV. Some agencies conduct their own testing, but send positive samples to CDPH for confirmation and official reporting. Because SLE cross-reacts with WNV in antibody testing, SLE or WNV positive chickens are confirmed and the infecting virus is identified by western blot or cross-neutralization tests. Frequent testing of strategically placed flocks of sentinel chickens provides the most sensitive and cost-effective method to monitor encephalitis virus transmission in an area. Because chickens are continuously available to host-seeking mosquitoes, they are usually exposed to more mosquitoes than can be collected by trapping, especially when adult mosquito abundance or viral infection rates are low. Sentinel housing, bleeding instructions, and testing protocols are provided in Appendix C.

Virus activity in wild bird populations can be monitored by bleeding young (hatching year) birds to detect initial virus infection or by bleeding a cross-section of birds in an area and comparing seroprevalence among age strata to determine if the prevalence of the virus in the region has changed. Elevated seroprevalence levels ("herd immunity") among key species during spring may limit virus transmission and dampen amplification. New infections also can be detected by bleeding banded birds in a capture-recapture scheme. In contrast to the convenience of using sentinel chickens, the repeated collection and bleeding of wild birds generally is too labor intensive, technically difficult, and expensive for most local mosquito control agencies to perform routinely. In addition, the actual place where a wild bird became infected is rarely known, because birds may travel over relatively long distances and usually are collected during daylight foraging flights and not at nighttime roosting sites where they are bitten by mosquitoes.

Unlike WEE and SLE, WNV frequently causes death in North American birds, especially those in the family Corvidae (e.g. crows, ravens, magpies, jays). Dead bird surveillance was initiated by CDPH in 2000 to provide early detection of WNV. Dead bird surveillance has been shown to be one of the earliest indicators of WNV activity in a new area. Birds that meet certain criteria are necropsied at the California Animal Health and Food Safety Laboratory and kidney snips tested for WNV RNA by RT-PCR at CVEC or oral swabs of American crows tested by rapid antigen tests by local agencies. Dead birds are reported to CDPH's dead bird hotline (1-877-WNV-BIRD) or via the website, http://westnile.ca.gov. Beginning in 2010, results from RT-

PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on cycle threshold (Ct) values. In general, birds tested by RT-PCR with a Ct value of <30 and those positive by antigen tests are considered to be recently infected, whereas those with Ct values >30 are considered to have been chronically infected and the time since infection unknown. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. The communication and testing algorithm for the dead bird surveillance program is detailed in Appendix D.

Tree Squirrel Infections

In 2004, tree squirrels were included as a WNV surveillance tool, based upon evidence that they were susceptible to WNV and could provide information on localized WNV transmission (Padgett et al. 2007). In conjunction with dead birds, tree squirrels were reported to the California WNV hotline, necropsied at the California Animal Health and Food Safety Laboratory and kidney tissue was tested by RT-PCR at CVEC. Tree squirrels will continue to be tested for WNV in 2012 and are included in the submission protocol in Appendix D.

Equine Infections

Currently, equine disease due to WEE and WNV is no longer a sensitive indicator of epizootic activity (unusually high incidence of infections in animals other than humans) in California because of the widespread vaccination or natural immunization of equids (horses, donkeys, and mules). Nevertheless, confirmed cases in horses can indicate that WEE or WNV has amplified to levels where tangential transmission has occurred and risk to humans is elevated in that region of the State. Each year, CDPH and the California Department of Food and Agriculture (CDFA) alert veterinarians of the risk of WNV to horses, advocate for vaccination, and provide information on diagnostic services that are available for suspected cases of WEE or WNV encephalitis. Other mosquito-borne viruses may also cause encephalitis in horses and testing of equine specimens for these other viruses is available (see Appendix E).

Human Infections

Local mosquito control agencies rely on the rapid detection and reporting of confirmed human cases to plan and implement emergency control activities to prevent additional infections. However, human cases of arboviral infection are an insensitive surveillance indicator of virus activity because most persons who become infected develop no symptoms. For those individuals who do become ill, it may take up to two weeks for symptoms to appear, followed by additional time until the case is recognized and reported. No human cases of SLE or WEE have been reported in California in recent years. However, a total of 3,146 cases of WNV have been reported in California from 2003-2011.

To enhance human WNV testing and surveillance efforts throughout the state, a regional public health laboratory network was established in 2002. The laboratory network consists of the state Viral and Rickettsial Disease Laboratory (VRDL) as well as 26 county public health laboratories that are able to conduct WNV testing. Providers are encouraged to submit specimens for suspect WNV cases to their local public health laboratories. Specimens for patients with encephalitis may also be submitted directly to Neurologic Surveillance and Testing, which is based in the VRDL and offers diagnostic testing for many agents known to cause encephalitis, including

WNV and other arboviruses. In addition, VRDL collaborates with reference laboratories such as the regional laboratories of Kaiser Permanente to ascertain additional suspect WNV cases.

In accordance with Title 17 of the California Code of Regulations (Sections 2500 and 2505), physicians and laboratories are required to report cases of WNV infection or positive test results to their local health department. Positive WNV or other arbovirus test results are investigated by local health department officials to determine whether a patient meets the clinical and laboratory criteria for a WNV diagnosis. If so, the local health department collects demographic and clinical information on the patient using a standardized West Nile virus infection case report, and forwards the report to the state health department. The local health department also determines whether the infection was acquired locally, imported from a region outside the patient's residence, or acquired by a non-mosquito route of transmission such as blood transfusion or organ transplantation. Appendix F contains the protocol for submission of specimens to the regional public health laboratory network for WNV testing. Appendix G provides the national surveillance case definition for arboviral disease, including WNV infection.

Mosquito Control

Problems detected by surveillance are mitigated through larval and adult mosquito control. Mosquito control is the only practical method of protecting people from mosquito-borne diseases. Mosquito control in California is conducted by approximately 80 local agencies, including mosquito and vector control districts, county environmental and health departments, and county agriculture departments. Agencies applying pesticides directly to a water of the United States, or where deposition may enter a water of the United States, must obtain a National Pollutant Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States from Vector Control Applications (Vector Control Permit). Agencies must comply with provisions of the permit, including use of approved pesticides, pesticide use reporting, and visual, chemical, and toxicity monitoring requirements included in the permit. http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml

Compounds currently approved for larval and adult mosquito control in California are listed in Appendix H. Please refer to the Vector Control Permit, Attachments E and F, for a list of vector control pesticides that may be applied to waters of the United States, unless the receiving water has an existing impairment from a pesticide with the same active ingredient. Please review the California State Water Resources Control Board listing of impaired water bodies (303d list) prior to applying any pesticide.
http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/303d_list.shtml

Additional considerations regarding adult mosquito control in urban areas are described in Appendix I.

Larval Control

Mosquito larval and pupal control methods are target-specific and prevent the emergence of adult female mosquitoes which are capable of transmitting pathogens, causing discomfort, and ultimately producing another generation of mosquitoes. For these reasons, most mosquito control agencies in California target the immature stages rather than the adult stage of the

mosquito. Larval mosquito control has three key components: environmental management, biological control, and chemical control.

Environmental management decreases habitat availability or suitability for immature mosquitoes, and may include water management, such as increasing the water disposal rate through evaporation, percolation, recirculation, or drainage. Laser-leveling of fields minimizes pooling at low spots, allows even distribution of irrigation water, and precludes standing water for long periods. Controlled irrigation or the careful timing of wetland flooding for waterfowl can reduce mosquito production or limit emergence to times of the year when virus activity is unlikely. Environmental management may include vegetation management because emergent vegetation provides food and refuge for mosquito larvae. Management strategies include the periodic removal or thinning of vegetation, restricting growth of vegetation, and controlling algae.

Biological control uses natural predators, parasites, or pathogens to reduce immature mosquito numbers. Mosquitofish, *Gambusia affinis*, are the most widely used biological control agent in California. These fish are released annually in a variety of habitats, such as rice fields, small ponds, and canals.

There are several mosquito control products that are highly specific and thus have minimal impact on non-target organisms. These include microbial control agents, such as *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus*, and insect growth regulators, such as methoprene, that prevent immature mosquitoes from developing into adults. Surface films are very effective against both larvae and pupae, but also may suffocate other surface breathing aquatic insects. Organophosphate pesticides are used infrequently because of their impact on nontarget organisms and the environment.

Adult Control

When larval control is not possible or more immediate control measures are needed, adult mosquito control may be required to suppress populations of infected mosquitoes and interrupt epidemic virus transmission. Adult mosquito control products may be applied using ground-based equipment, fixed wing airplanes, or helicopters. Products applied in ultralow volume [ULV] formulations and dosages include organophosphates, such as malathion and naled, pyrethroids, such as resmethrin, sumithrin, and permethrin, and pyrethrins such as Pyrenone crop spray. Factors to consider when selecting an adulticide include: 1) efficacy against the target species or life cycle stage, 2) resistance status, 3) pesticide label requirements, 4) availability of pesticide and application equipment, 5) environmental conditions, 6) cost, and 7) toxicity to nontarget species, including humans.

For more information about mosquito control please see "Best Management Practices for Mosquito Control in California". http://www.westnile.ca.gov/resources.php

Response Levels

The California Mosquito-borne Virus Surveillance and Response Plan was developed to provide a semi-quantitative measure of virus transmission risk to humans that could be used by local mosquito control agencies to plan and modulate control activities. Independent models are presented for WEE, SLE and WNV to accommodate the different ecological dynamics of these

viruses (Barker et al. 2003). SLE and WN viruses are closely related, require similar environmental conditions, and employ the same *Culex* vectors. Seven surveillance factors are measured and analyzed to determine the level of risk for human involvement and thereby gauge the appropriate response level:

1. Environmental or climatic conditions (snowpack, rainfall, temperature, season)
2. Adult *Culex* vector abundance
3. Virus infection rate in *Culex* mosquito vectors
4. Sentinel chicken seroconversions
5. Fatal infections in birds (WNV only)
6. Infections in humans
7. Proximity of detected virus activity to urban or suburban regions (WEE only)

Each factor is scored on an ordinal scale from 1 (lowest risk) to 5 (highest risk). The mean score calculated from these factors corresponds to a response level as follows: normal season (1.0 to 2.5), emergency planning (2.6 to 4.0), and epidemic (4.1 to 5.0). Table 1 provides a worksheet to assist in determining the appropriate rating for each of the risk factors for each of the three viruses. Appendix J shows sources of data useful in the calculation of risk in Table 1.

For surveillance factor 2 (vector abundance), abundance is scaled as an anomaly and compared to the area average over 5 years for the same preceding two week period. The area typically encompasses the boundaries of a local mosquito and vector control district. The mosquito virus infection rate should be calculated using the most current data (prior two week period) and expressed as minimum infection rate (MIR) per 1,000 female mosquitoes tested. Calculations can also use maximum likelihood estimate (Biggerstaff 2003), which accounts for varying numbers of specimens in pools and the possibility that more than one mosquito could be infected in each positive pool when infection rates are high. For WNV and SLE, risk may be estimated separately for *Cx. tarsalis* and the *Cx. pipiens* complex, respectively, because these species generally have different habitat requirements and therefore spatial distributions (e.g., rural vs. urban).

Each of the three viruses differs in its response to ecological conditions. WEE activity typically is greatest during El Niño conditions of wet winters, excessive run-off and flooding, cool springs, and increased *Culex tarsalis* abundance. Historically, WEE virus spillover into a secondary *Aedes*-rabbit cycle was common in the Central Valley, but has not been detected for the past 25 years. In contrast, SLE and perhaps WNV activity appears to be greatest during La Niña conditions of drought and hot summer temperatures and both SLE and WNV transmission risk increases when temperatures are above normal. Abundance and infection of the *Culex pipiens* complex are included in both SLE and WNV estimates of risk because these mosquito species are important vectors, particularly in suburban/urban environments. The occurrence of dead bird infections is included as a risk factor in the WNV calculations. For surveillance factors 4-6 (chickens, birds, humans), specific region is defined as the area within the agency's boundary and the broad region includes the area within 150 miles (~241 km) of the agency's boundary.

Proximity of virus activity to human population centers is considered an important risk factor for all three viruses of public health concern. In the risk assessment model in Table 1 this was accommodated in two different ways. WEE virus transmitted by *Culex tarsalis* typically amplifies first in rural areas and may eventually spread into small and then larger communities. A risk score was included to account for where virus activity was detected. WNV and SLE virus

may be amplified concurrently or sequentially in rural and urban cycles. The rural cycle is similar to WEE virus and is transmitted primarily by *Cx. tarsalis*, whereas the urban cycle is transmitted primarily by members of the *Culex pipiens* complex. If the spatial distributions of key *Culex* species differ within an area (e.g., rural vs. urban), it may be advantageous to assess risk separately by species for abundance and infection rates in *Cx. tarsalis* and the *Cx. pipiens* complex. This would result in two estimates of overall risk for the areas dominated by each species.

Each of these surveillance factors can differ in impact and significance according to time of year and geographic region. Climatic factors provide the earliest indication of the potential for increased mosquito abundance and virus transmission and constitute the only risk factor actually measured from the start of the calendar year through mid-spring when enzootic surveillance commences in most areas. Climate is used prospectively to forecast risk during the coming season. Other factors that may inform control efforts as the season progresses are typically, in chronological order: mosquito abundance, infections in non-humans (e.g., dead birds for WNV, mosquitoes, sentinel chickens), and infections in humans. Enzootic indicators measure virus amplification within the *Culex*-bird cycle and provide nowcasts of risk, whereas human infections document tangential transmission and are the outcome measure of forecasts and nowcasts. Response to the calculated risk level should consider the time of year; e.g., epidemic conditions in October would warrant a less aggressive response compared to epidemic conditions in July because cooler weather in late fall will contribute to declining risk of arbovirus transmission.

The ratings listed in Table 1 are benchmarks only and may be modified as appropriate to the conditions in each specific region or biome of the state. Calculation and mapping of risk has been enabled by tools included in the CalSurv Gateway. Roles and responsibilities of key agencies involved in carrying out the surveillance and response plan are outlined in "Key Agency Responsibilities."

Table 1. Mosquito-borne Virus Risk Assessment.

WNV Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WNV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Dead bird infection** Number of birds that have tested positive (recent infections only) for WNV during the prior 3-month period. This longer time period reduces the impact of zip code closures during periods of increased WNV transmission.	1	No positive dead birds in broad region		
	2	One or more positive dead birds in broad region		
	3	One positive dead bird in specific region		
	4	Two to five positive dead birds in specific region		
	5	More than five positive dead birds in specific region		
6. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human infections in broad region		
	4	One human infection in specific region		
	5	More than one human infection in specific region		
			Cx tars	*Cx pip*
Response Level / Average Rating: Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

SLE Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to SLEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human cases in broad region		
	4	One human case in specific region		
	5	More than one human case in specific region		
			Cx tars	*Cx pip*
Response Level / Average Rating: Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

WEE Surveillance Factor	Assessment Value	Benchmark	Assigned Value
1. **Environmental Conditions** High-risk environmental conditions include above normal rainfall, snow pack, and runoff during the early season followed by a strong warming trend. Weather data link: http://ipm.ucdavis.edu	1	Cumulative rainfall and runoff well below average	
	2	Cumulative rainfall and runoff below average	
	3	Cumulative rainfall and runoff average	
	4	Cumulative rainfall and runoff above average	
	5	Cumulative rainfall and runoff well above average	
2**. Adult *Culex tarsalis* abundance** Determined by trapping adults, enumerating them by species, and comparing numbers to averages previously documented for an area for the prior 2-week period.	1	*Cx. tarsalis* abundance well below average (≤ 50%)	
	2	*Cx. tarsalis* abundance below average (51 - 90%)	
	3	*Cx. tarsalis* abundance average (91 - 150%)	
	4	*Cx. tarsalis* abundance above average (151 - 300%)	
	5	*Cx. tarsalis* abundance well above average (> 300%)	
3. **Virus infection rate in *Cx. tarsalis* mosquitoes** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	*Cx. tarsalis* MIR = 0	
	2	*Cx. tarsalis* MIR = 0.1 - 1.0	
	3	*Cx. tarsalis* MIR = 1.1 - 2.0	
	4	*Cx. tarsalis* MIR = 2.1 - 5.0	
	5	*Cx. tarsalis* MIR > 5.0	
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WEEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region	
	2	One or more seroconversions in broad region	
	3	One or two seroconversions in a single flock in specific region	
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region	
	5	More than two seroconversions per flock in multiple flocks in specific region	
5. **Proximity to urban or suburban regions** (score only if virus activity detected) Risk of outbreak is highest in urban areas because of high likelihood of contact between humans and vectors.	1	Virus detected in rural area	
	3	Virus detected in small town or suburban area	
	5	Virus detected in urban area	
6. **Human cases** Do not include this factor in calculations if no cases found in region or in agency.	3	One or more human cases in broad region	
	4	One human case in specific region	
	5	More than one human case in specific region	
Response Level / Average Rating: Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**	
		AVERAGE	

General suggestions for applying the risk assessment model locally

- Use a consistent time period for environmental conditions, adult mosquito abundance, mosquito infection rates, and human cases. If you use a period that differs from the prior two-week period defined in the risk assessment -- such as the prior month -- use the same period for all other relevant measures. Note that sentinel seroconversions and dead bird infections may need special treatment to accommodate bleeding schedules and zip code closures, respectively. For sentinel seroconversions, use the sentinel seroconversions from the most recent collection.
- If you have multiple trap types in your surveillance program, determine the vector abundance anomaly for each trap type and species and use the most sensitive trap type's value in the risk assessment.
- When determining the vector abundance anomaly, there should be at least two and preferably five years of prior data to provide a comparative baseline for the particular trap type. Ideally, the prior years should be contiguous and immediately precede the time period being evaluated.

Risk assessment as implemented by the CalSurv Gateway (http://gateway.calsurv.org)

- Assessment reports will be generated and delivered to the primary contacts of each agency by email every Monday.
- The time frame of each assessment report will be for the prior two-week period ending on the previous Saturday.
- Only those agencies with active Gateway accounts and active surveillance programs will receive the reports.
- All calculations are done at the agency level, thus the specific region is the area within the agency's boundary and the broad region includes the area within 150 miles (~241 km) of the agency's boundary.
- Due to privacy concerns and delays in detection and reporting, human cases are not part of the Gateway's risk assessment.
- All of the general suggestions from the prior section are used in the Gateway's implementation.
- Risk estimates based on mosquito abundance and infection rates will be calculated separately for the key mosquito species, *Cx. tarsalis* and the *Cx. pipiens* complex.
- For sentinel seroconversions, flavivirus positives are treated as WNV positives. If SLE is found, this will be adjusted accordingly.

Characterization of Conditions and Responses

Level 1: Normal Season

Risk rating: 1.0 to 2.5

CONDITIONS
• Average or below average snowpack and rainfall; below or average seasonal temperatures (<65F) • *Culex* mosquito abundance at or below five year average (key indicator = adults of vector species) • No virus infection detected in mosquitoes • No seroconversions in sentinel chickens • No recently infected WNV-positive dead birds • No human cases
RESPONSE
• Conduct routine public education (eliminate standing water around homes, use personal protection measures) • Conduct routine mosquito and virus surveillance activities • Comply with National Pollutant Discharge Eliminations System (NPDES) permit if applying pesticides to waters of the United States • Conduct routine mosquito control, with emphasis on larval control • Inventory pesticides and equipment • Evaluate pesticide resistance in vector species • Ensure adequate emergency funding • Release routine press notices • Send routine notifications to physicians and veterinarians • Establish and maintain routine communication with local office of emergency services personnel; obtain Standardized Emergency Management System (SEMS) training

Level 2: Emergency Planning

Risk rating: 2.6 to 4.0

CONDITIONS
• Snowpack and rainfall and/or temperature above average (66-79F) • Adult *Culex* mosquito abundance greater than 5-year average (150% to 300% above normal) • One or more virus infections detected in *Culex* mosquitoes (MIR / 1000 is <5) • One or more seroconversions in single flock or one to two seroconversions in multiple flocks in specific region • One to five recently infected WNV-positive dead birds in specific region • One human case in broad or specific region • WEE virus detected in small towns or suburban area
RESPONSE
• Review epidemic response plan • Enhance public education (include messages on the signs and symptoms of encephalitis; seek medical care if needed; inform public about pesticide applications if appropriate) • Enhance information to public health providers • Conduct epidemiological investigations of cases of equine or human disease • Increase surveillance and control of mosquito larvae • Increase adult mosquito surveillance • Increase number of mosquito pools tested for virus • Conduct or increase localized chemical control of adult mosquitoes as appropriate • Contact commercial applicators in anticipation of large scale adulticiding • Review candidate pesticides for availability and susceptibility of vector mosquito species • Ensure notification of key agencies of presence of viral activity, including the local office of emergency services

Level 3: Epidemic Conditions

Risk rating: 4.1 to 5.0

CONDITIONS
• Snowpack, rainfall, and water release rates from flood control dams and/or temperature well above average (>79F) • Adult vector population extremely high (>300%) • Virus infections detected in multiple pools of *Culex tarsalis* or *Cx. pipiens* mosquitoes (MIR / 1000 > 5.0) • More than two seroconversions per flock in multiple flocks in specific region • More than five recently infected WNV-positive dead birds and multiple reports of dead birds in specific region • More than one human case in specific region • WEE virus detection in urban or suburban areas
RESPONSE
• Conduct full scale media campaign • Alert physicians and veterinarians • Conduct active human case detection • Conduct epidemiological investigations of cases of equine or human disease • Continue enhanced larval surveillance and control of immature mosquitoes • Broaden geographic coverage of adult mosquito surveillance • Accelerate adult mosquito control as appropriate by ground and/or air • Coordinate the response with the local Office of Emergency Services or if activated, the Emergency Operation Center (EOC) • Initiate mosquito surveillance and control in geographic regions without an organized vector control program • Determine whether declaration of a local emergency should be considered by the County Board of Supervisors (or Local Health Officer) • Determine whether declaration of a "State of Emergency" should be considered by the Governor at the request of designated county or city officials • Ensure state funds and resources are available to assist local agencies at their request • Determine whether to activate a Standardized Emergency Management System (SEMS) plan at the local or state level • Continue mosquito education and control programs until mosquito abundance is substantially reduced and no additional human cases are detected

For more detailed information on responding to a mosquito-borne disease outbreak, please refer to:

Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks, California Department of Public Health (supplement to California Mosquito-Borne Virus Surveillance and Response Plan). http://www.westnile.ca.gov/resources.php

Key Agency Responsibilities

Local Mosquito and Vector Control Agencies

- Gather, collate, and interpret regional climate and weather data.
- Monitor abundance of immature and adult mosquitoes.
- Collect and submit mosquito pools to CVEC for virus detection.
- Maintain sentinel chicken flocks, obtain blood samples, and send samples to VBDS.
- Pick-up and ship dead birds for necropsy and WNV testing, or test oral swabs from American crows locally via rapid antigen screening assays.
- Update CDPH weekly of all birds that are independently reported and/or tested by VecTest, RAMP or immunohistochemistry.
- Update the surveillance gateway weekly with mosquito pool results that are independently tested by RAMP or PCR.
- Conduct routine control of immature mosquitoes.
- Comply with NPDES permit if applying pesticides to waters of the United States
- Conduct control of adult mosquitoes when needed.
- Educate public on mosquito avoidance and reduction of mosquito breeding sites.
- Coordinate with local Office of Emergency Services personnel.
- Communicate regularly with neighboring agencies

Mosquito and Vector Control Association of California

- Coordinate purchase of sentinel chickens.
- Receive, track, and disperse payment for surveillance expenses.
- Coordinate surveillance and response activities among member agencies.
- Serve as spokesperson for member agencies.
- Establish liaisons with press and government officials.

California Department of Public Health

- Collate adult mosquito abundance data submitted by local agencies; provide summary of data to local agencies.
- Maintain a WNV information and dead bird reporting hotline, 1-877-WNV-BIRD, and a WNV website: http://westnile.ca.gov.
- Coordinate submission of specimens for virus testing.
- Provide supplies for processing mosquito pool and sentinel chicken diagnostic specimens
- Test sentinel chicken sera for viral antibodies.
- Test human specimens for virus.
- Distribute a weekly bulletin summarizing surveillance test results.
- Send weekly surveillance results to the UC Davis interactive website.
- Immediately notify local vector control agency and public health officials when evidence of viral activity is found.
- Conduct epidemiological investigations of cases of human disease.
- Coordinate and participate in a regional emergency response in conjunction with California Emergency Management Agency.
- Conduct active surveillance for human cases.

- Provide oversight to local jurisdictions without defined vector-borne disease control program.
- Maintain inventory of antigens and antisera to detect exotic viruses.
- Provide confirmation of tests done by local agencies.

University of California at Davis

- Conduct research on arbovirus surveillance, transmission of mosquito-borne diseases, and mosquito ecology and control.
- Test mosquito pools and dead birds for endemic and introduced viruses.
- Provide a proficiency panel of tests for identification of viruses from human, equine, bird, or arthropod vectors to local agencies to ensure quality control.
- Maintain an interactive website (http://gateway.calsurv.org) for dissemination of mosquito-borne virus information and data.
- Maintain inventory of antigens, antisera, and viruses to detect the introduction of exotic viruses.
- Provide confirmation of tests done by local or state agencies.

California Department of Food and Agriculture

- Notify veterinarians and veterinary diagnostic laboratories about WEE and WNV and testing facilities available at UCD Center for Vectorborne Disease Research.
- Provide outreach to general public and livestock and poultry producers on the monitoring and reporting of equine and ratite encephalitides.
- Facilitate equine and ratite sample submission from the field.
- Conduct investigations of equine cases.

California Animal Health and Food Safety Laboratory

- Identify species of dead birds submitted for WNV testing.
- Conduct necropsies and testing on dead birds.
- Submit bird tissues to CVEC for testing.
- Test equine specimens for WNV.

Local Health Departments and Public Health Laboratories

- Test human specimens for WNV.
- Refer human specimens to CDPH for further testing.
- Notify local medical community, including hospitals and laboratories, if evidence of viral activity is present.
- Collect dead birds and ship carcasses to testing laboratories when needed.
- Test American crows via rapid assay or RT-PCR as resources allow.
- Participate in emergency response.
- Conduct epidemiological investigations of cases of human disease.
- Report WNV cases to CDPH.
- Conduct public education.

California Emergency Management Agency

- Coordinate the local, regional, or statewide emergency response under epidemic conditions in conjunction with CDPH via the Standardized Emergency Management System (SEMS).
- Serve as liaison with the Federal Emergency Management Agency (FEMA) in the event that a federal disaster has been declared.

Federal Centers for Disease Control and Prevention

- Provide consultation to state and local agencies in California if epidemic conditions exist.
- Provide national surveillance data to state health departments.

State Water Resources Control Board

- Review NPDES permit applications and respond in a timely manner.
- Review vector control pesticides registered by the California Department of Pesticide Regulation for inclusion on the Vector Control NPDES permit.

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Appendix A: Guidelines for Adult Mosquito Surveillance

The objective of Appendix A is to standardize mosquito sampling and reporting procedures to provide comparable and interpretable abundance measures among collaborating mosquito control agencies in California. This section summarizes information from Integrated Mosquito Surveillance Program Guidelines for California that has been adopted by the Mosquito and Vector Control Association (MVCAC) (Meyer et al. 2003). The MVCAC guidelines recommend stratifying the use of different sampling methods in rural, small town, and urban environments for each of the major biomes of California and provide a listing of target vector and nuisance mosquito species. The stratified sampling approach monitors vector populations and virus activity in rural enzootic foci, agricultural or suburban amplification sites, and densely populated urban centers to provide estimates of early, eminent, and current epidemic risk.

The four sampling methods currently used by mosquito control agencies are: 1) New Jersey (American) light trap, 2) CDC/ EVS style, or other CO_2-baited trap, 3) gravid trap, and 4) adult resting collections. Collection location sites should be geocoded and registered using the Surveillance Gateway [http://gateway.calsurv.org/]. Studies comparing trap design and efficiency for surveillance purposes have been published (Reisen et al. 2000; Reisen et al. 2002). These guidelines describe: 1) a comparison of the sampling methods, 2) equipment design, 3) operation, 4) specimen processing, 5) data recording and analysis, and 6) data usage.

Advantages and Disadvantages of Mosquito Sampling Methods:

New Jersey Light Trap	
Pros	**Cons**
• All female metabolic states and males collected • Minimal collection effort (can be run nightly without service) • Long history of use in California	• Selective for phototactic nocturnally active mosquitoes • Ineffective in the presence of competing light sources • Sorting time excessive because of other insects in traps • Specimens dead; less useful for virus detection • Collects comparatively few specimens
CDC/EVS CO_2 Trap	
Pros	**Cons**
• Samples biting population • Collects large numbers of virus vector species • Specimens alive; suitable for virus detection • Without light, collects mostly mosquitoes thus reducing sorting time • Battery operated, portable	• Collects >50% nullipars (females that have never blood fed or laid eggs) • Must be set and picked-up daily • Dry ice cost high; availability can be a problem • Does not collect males or bloodfed or gravid females
Gravid Trap	
Pros	**Cons**
• Collects females that have bloodfed and digested the blood meal; may have higher infection rate than CO_2 trap • Specimens alive; suitable for virus detection • Extremely sensitive for *Cx.quinquefasciatus* in urban habitat • Bait inexpensive • Battery operated, portable	• Collects only foul-water *Culex* [mostly *pipiens* complex] • Bait has objectionable odor • Must be set and picked-up daily

Resting Catches	
Pros	**Cons**
• All metabolic states collected • Minimal equipment needed • Specimens alive; suitable for virus detection • Blooded and gravid specimens can be tested to improve sensitivity of virus surveillance	• Standardization is difficult due to: 1. Variable shelter size and type 2. Variable collector efficiency • Labor intensive; difficult to concurrently sample a large number of sites

New Jersey (American) Light Trap (NJLT)

Operation

At a minimum, one trap should be located in each principal municipality of a district or have a distribution of one trap/township (36 sq. mi.). Correct placement of the NJLT is a critical factor in its performance as an effective surveillance mechanism for measuring the relative abundance of phototaxic mosquitoes. Place the traps at six-foot height. This can be done by using a metal standard, or by hanging the traps from tree limbs or roof eaves. These distances should maximize attractancy over a 360 degree radius. The trap should be placed on the leeward side of a structure or tree line to decrease the influence of wind on trap catch.

Traps should be kept away from smoke or chemical odors that may be repellent to the mosquitoes. Traps should be away from buildings in which animals are housed and not be in the immediate vicinity of sentinel flocks to diminish attractancy competition. Traps should be placed away from street and security lights that may diminish attractancy of the trap bulb. A trap should be placed approximately 100-200 feet from each sentinel chicken flock when possible.

Traps should be operated from week 14 to week 44 of the calendar year for districts north of the Tehachapi Mountains and all year long for districts south of the Tehachapi. Ideally, the traps should run for four to seven nights before the collection is retrieved (Loomis and Hanks 1959). The trap should be thoroughly cleaned with a brush to remove spider webs or any other debris that may hinder airflow through the trap. A regular cleaning schedule should be maintained during the trapping season to maintain trap efficiency.

Processing

Adult mosquitoes from the NJLT collection should be sorted from the other insects in an enamel pan before being identified and counted at 10x magnification under a dissecting microscope. Counting aliquots or subsamples of all specimen samples should be discouraged, because vector species may comprise only a small fraction of the total mosquito collection.

CDC style CO_2-baited trap

Operation

Carbon dioxide-baited traps can be used for abundance monitoring or capturing mosquitoes for virus testing. Traps should be hung from a 6-foot tall standard (approximately 4 feet above ground level) to standardize trap placement for population and virus infection rate monitoring. Knowledge of the host-seeking patterns of the target species is essential in determining CO_2-baited trap placement in the habitat to enhance catch size and therefore sampling sensitivity. *Culex tarsalis* primarily bloodfeed on birds and hunt along vegetative borders and tree canopies where birds roost and nest. *Culex erythrothorax* are best collected within wetland areas near

dense stands of tules and cattails. In large, open breeding sources such as rice fields, CO_2-baited traps could be hung on standards on the up-wind side of the source for *Culex tarsalis* and *Anopheles freeborni* collections. *Aedes melanimon* and *Aedes nigromaculis* are mammal feeders and typically seek hosts over open fields.

When used to supplement sentinel chickens for arbovirus surveillance, traps should be operated at different locations to enhance geographical coverage and thus surveillance sensitivity. Labor and time constraints determine the extent of sampling. When used to monitor population abundance, traps should be operated weekly or biweekly at the same fixed stations. Temperature, wind speed, wind direction, and rainfall should be recorded because these factors affect catch size. The mini-light may be removed, because it attracts other phototactic insects that may hinder sorting and/or damage female mosquitoes in the collection container and may repel members of the *Culex pipiens* complex. The CO_2-baited trap should not be placed in immediate proximity to the sentinel chicken flock because it will compete with, and therefore lessen, exposure of the sentinel birds, but may be placed within a 100-200 foot radius of the sentinel flock site, but no closer than 100 feet from the flock.

Processing

Mosquitoes collected for arbovirus surveillance should be processed according to the procedures outlined in Appendix B. If possible, ten pools of a species (*Culex tarsalis*, *Culex pipiens, Culex quinquefasciatus, Culex stigmatosoma, Aedes melanimon*, and *Aedes dorsalis*) should be submitted for virus testing from a given geographical location at a given time. Only live mosquitoes should be pooled for virus testing. Dead, dried specimens should be counted and discarded. Only whole specimens should be submitted; avoid including detached body parts (which may be from other mosquito species) or other Diptera (i.e., *Culicoides*, etc.) in the pool to prevent sample contamination. Avoid freezing specimens before sorting and counting. Mosquitoes collected for population monitoring should be anesthetized in a well-ventilated area or under a chemical hood using triethylamine, identified to species under a dissecting microscope, counted, pooled and immediately frozen at -80C or on dry ice for later virus testing.

<u>Reiter/Cummings gravid traps</u>

Trap design and components

The Reiter/Cummings gravid traps consist of a rectangular trap housing [plastic tool box] with an inlet tube on the bottom and an outlet tube on the side or top. The rectangular housing is provided with legs to stabilize the trap over the attractant basin containing the hay-infusion mixture. (Cummings 1992). The oviposition attractant consists of a fermented infusion made by mixing hay, Brewer's yeast and water. The mixture should sit at ambient temperature for a minimum of three to four days prior to allow fermentation and increase attractancy. New solutions should be made at least biweekly to maintain consistent attractancy.

Operation

The Reiter/Cummings gravid trap is primarily used in suburban and urban residential settings for surveillance of gravid females in the *Culex pipiens* complex. The trap is placed on the ground near dense vegetation that serves as resting sites for gravid females. Specimens may be retrieved on a one to three day basis.

Processing

Culex pipiens complex females collected with the gravid trap for arbovirus surveillance should be retrieved daily and the protocol for mosquito pool submission as outlined in Appendix B should be followed. For population monitoring of the *Culex pipiens* complex, collections may be retrieved every third day. The females are killed, identified and counted before being discarded. Autogenous females may also be attracted to the gravid trap.

Adult resting collections

Trap design and operation

A flashlight and mechanical aspirator can be used to collect adult mosquitoes resting in habitats such as shady alcoves, buildings, culverts, or spaces under bridges. Highest numbers usually are collected at humid sites protected from strong air currents. Adults resting in vegetation may be collected using a mechanical sweeper such as the AFS (Arbovirus Field Station) sweeper (Meyer et al. 1983). For quantification, time spent searching is recorded and abundance expressed as the number collected per person-hour.

Red boxes were developed to standardize collections spatially. Different researchers have used red boxes of varying dimensions. Largest catches are made in semi-permanent walk-in red boxes which measure 4' x 4' x 6' (Meyer 1985). Smaller 1' x 1' x 1' foot boxes typically collect fewer specimens, but are readily portable. The entrance of the walk-in red box should be left open, draped with canvas, or closed with a plywood door. The canvas or plywood door should have a 1 or 2 ft gap at the bottom to allow entry of mosquitoes, while affording some protection from the wind and decreasing the light intensity within the box. The box entrance should not face eastward into the morning sun or into the predominant wind direction.

Processing

Mosquitoes should be anesthetized with triethylamine, identified under a dissecting microscope, sorted by sex and female metabolic status (i.e., empty or unfed, blood fed or gravid), and counted. Females may be counted into ten pools of approximately 50 females per site per collection date for virus monitoring (see Appendix B). Only living females should be used for arbovirus surveillance. Data on metabolic status may indicate population reproductive age as well as diapause status.

Data recording and analysis

Counts from NJLTs, EVS, and gravid traps and information on pools submitted for testing or tested locally should be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/). Import from local or proprietary data systems is available. For comparisons of abundance over time, space, or collection methods, refer to Biddlingmeyer (1969).

Data usage

Mosquito collections from some or all of the four sampling methods collectively can be used to:

1. Assess control efforts.

2. Monitor arbovirus vector abundance and infection rates.
3. Compare mosquito abundance from collections with the number of service requests from the public to determine the tolerance of neighborhoods to mosquito abundance.
4. Determine proximity of breeding source(s) by the number of males present in collections from the NJLTs and red boxes.
5. Determine age structure of females collected by CO_2 traps and resting adult collections; such data are critical to evaluating the vector potential of the population.

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Appendix B: Procedures for Processing Mosquitoes for Arbovirus Detection

1. Collect mosquitoes alive and return them immediately to the laboratory. Collections should be kept humid during transport with moist toweling to prevent desiccation. Females should be offered 5-10 percent sucrose if held overnight or longer before processing.

2. Anesthetize mosquitoes by cold, carbon dioxide, or triethylamine (TEA). TEA is recommended because specimens are permanently immobilized with minimal mortality and with no loss of virus titer. TEA should be used either outdoors or under a chemical hood. Collections can be anesthetized outdoors using a few drops of TEA, the specimens transferred to Petri dishes, and then taken into the laboratory for processing. If refrigerated and kept humid, mosquitoes will remain alive in covered Petri dishes for one or two days without additional anesthesia. If mosquitoes are frozen before processing, sorting to species and enumeration must be done on a chill table to prevent virus loss.

3. Sort mosquito collections to species under a dissecting microscope at 10X to ensure correct identification and to make sure that extraneous mosquito parts (i.e., legs, wings) or other small insects such as chironomids or *Culicoides* are not inadvertently included in the pools. This is extremely important because diagnostics have transitioned from virus isolation to sensitive RT-PCR methods of viral detection. Count and discard dead and dried mosquitoes. Lots of 50 females per pool of each vector species from each collection site are then counted into individual polystyrene vials with snap caps containing two 5mm glass beads. Recommended sampling effort is ten pools of 50 females of each species from each site per week to detect minimum infection rates (MIRs) ranging from 0 to 20 per 1,000 females tested. Vials with pools should be labeled sequentially starting with #1 each year after the site code; e.g., KERN-1-12; where 12 refers to year 2012. Data on each pool can be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/). POOLS MUST BE ACCOMPANIED BY "MOSQUITO POOLS SUBMITTED FORM MBVS-3" AND CAN ONLY BE TESTED FROM REGISTERED SITES. Surveillance sites should be registered online at: **http://gateway.calsurv.org/.** Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access.

   List the site code for each pool that consists of a designated four-letter agency code followed by six digits identifying the site, i.e., KERN000001. Keep the pool numbers in sequence for the whole year regardless of the number of site codes: e.g., pool #1 may be from KERN000001, and pool #2 may be from KERN000004.

4. Freeze pools immediately at -70°C either on dry ice in an insulated container or in an ultra-low temperature freezer. Pools should be shipped frozen on dry ice to CVEC for testing by real time multiplex RT-PCR. Pools received by noon on Wednesday will be tested and reported by Friday or sooner using the Gateway website and automated email notification, in addition to the routine reporting within the weekly Arbovirus Surveillance Bulletin. Each pool is screened for WNV, SLE, and WEE viruses by a multiplex assay, with positives confirmed by a singleplex RT-PCR. Pools from selected areas also are screened for additional viruses using Vero cell culture with isolates identified following sequencing. Care must be taken

not to allow pools to defrost during storage or shipment, because each freeze-thaw cycle may result in a 10-fold decrease in viral titer, and all virus will be lost if the specimens sit at room temperature for extended periods. Address shipment to: Ying Fang, Center for Vectorborne Diseases, VM: // PMI, 3336 VetMed 3A, University of California, Davis, , Davis CA 95616. Pools received by Wednesday will be tested and reported through the Gateway the same week.

5. Local agencies that conduct their own testing by RT-PCR or RAMP® tests need to complete and pass a proficiency panel each year for the results to be reported by CDPH.

Appendix C: Procedures for Maintaining and Bleeding Sentinel Chickens

1. Procure hens in March or when they become available as notified by MVCAC when the chickens are 14-18 weeks of age to ensure minimal mortality during handling. Hens at this age have not yet begun to lay eggs, but they should have received all their vaccinations and been dewormed.
2. Ten sentinel chickens can be housed in a 3Wx6Lx3H ft coop framed with 2x2 and 2x4 inch construction lumber and screened with no smaller than 1x1 inch welded wire. It is critical that the wire mesh be large enough to allow the mosquitoes to easily enter the coop and the coops be placed in locations with a history of arbovirus transmission and/or high mosquito abundance. The site of and band numbers located at each coop must be registered online at: http://gateway.calsurv.org/. Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access. Coops should be at least two feet off the ground to reduce predator access, facilitate capture of the birds for bleeding, and allow the free passage of the feces through the wire floor to the ground. A single, hinged door should be placed in the middle of the coop, so that the entire coop is accessible during chicken capture. After construction, the lumber and roof should be protected with water seal. A self-filling watering device should be fitted to one end of the coop and a 25 lb. feeder suspended in the center for easy access. In exchange for the eggs, a local person (usually the home owner, farm manager, etc.) should check the birds (especially the watering device) and remove the eggs daily. If hung so the bottom is about four inches above the cage floor and adjusted properly, the feeder should only have to be refilled weekly (i.e., 100 lb. of feed per month per flock of ten birds). Therefore, if proper arrangements can be made and an empty 55-gallon drum provided to store extra feed, sentinel flocks need only be visited bi-weekly when blood samples are collected.
3. Band each bird in the web of the wing using metal hog ear tags and appropriate pliers. This band number, the date, and site registration number must accompany each blood sample sent to the laboratory for testing.
4. Bleed each hen from the distal portion of the comb using a standard lancet used for human finger "prick" blood samples. The bird can be immobilized by wedging the wings between the bleeder's forearm and thigh, thereby leaving the hand free to hold the head by grabbing the base of the comb with the thumb and forefinger. Use alcohol swabs on comb before bleeding. Blood samples are collected on half-inch wide filter paper strips, which should be labeled with the date bled and wing band number. The comb should be "pricked" with the lancet and blood allowed to flow from the "wound" to form a drop. Collect the blood by touching the opposite end of the pre-labeled filter paper strip to the wound. THE BLOOD MUST COMPLETELY SOAK THROUGH ON A ¾ INCH LONG PORTION OF THE STRIP. Place the labeled end of the strip into the slot of the holder (or "jaws" of the clothes pin) leaving the blood soaked end exposed to air dry.
5. Attach the completely dry filter paper strips to a 5x7 card in sequential order, from left to right by stapling the labeled end towards the top edge of the card, and leaving the blood soaked end free so that the laboratory staff can readily remove a standard punch sample. Write the County, Agency Code, Site, and Date Bled onto the card and place it into a zip lock plastic bag. Do not put more than one sample card per bag. It is important that blooded ends do not become dirty, wet, or touch each other. VERY IMPORTANT: CHICKEN SERA MUST BE ACCOMPANIED BY SENTINEL CHICKEN BLOOD

FORM (MBVS- 2) OUTSIDE THE ZIP-LOCK BAG. Do not staple the form to the bag. Samples from each bleeding date then can be placed into a mailing envelope and sent to:

Department of Public Health, Richmond Campus
Specimen Receiving Unit Room B106 **(ATTN: ARBO)**
850 Marina Bay Parkway
Richmond, CA 94804

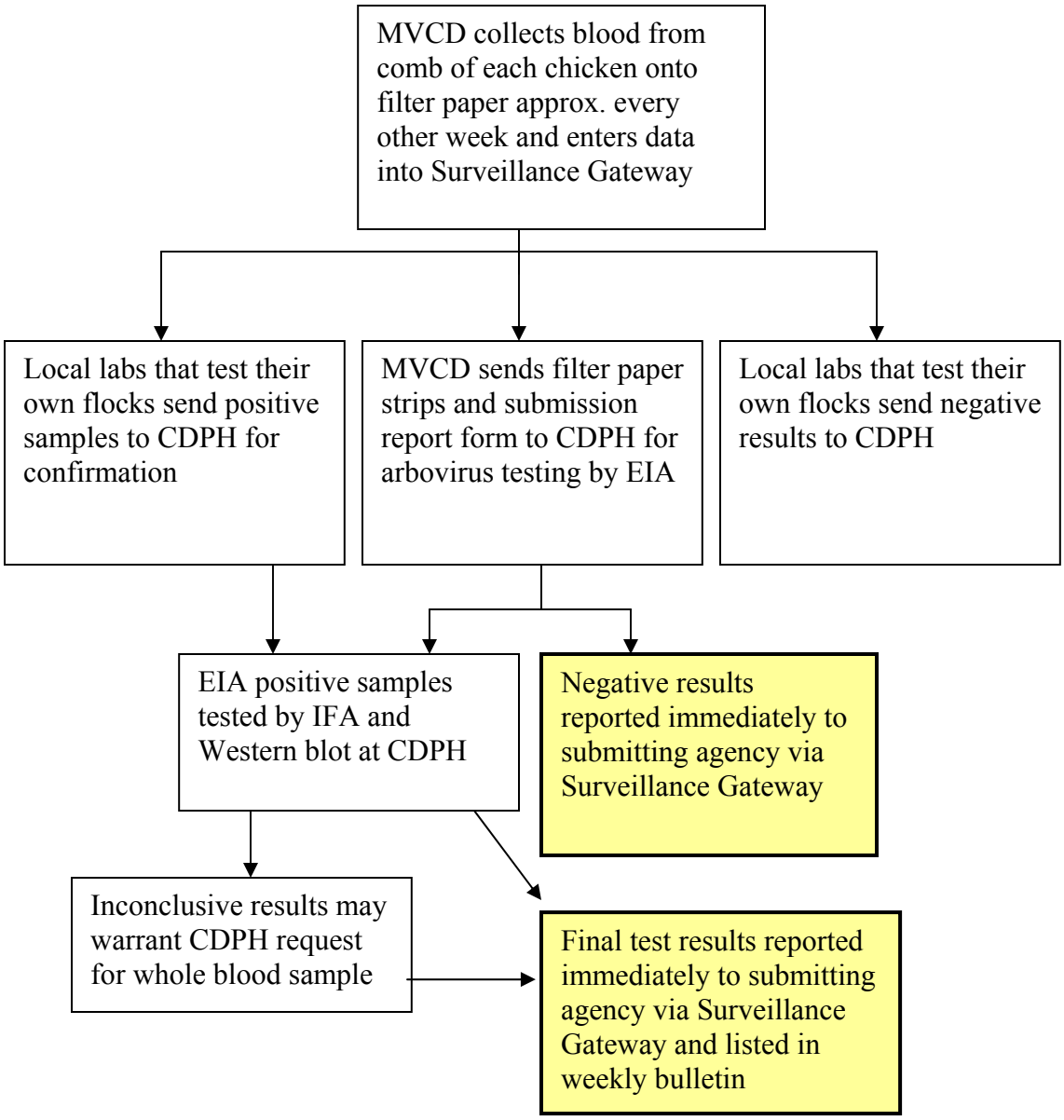
Specimens will be tested within 1-3 days upon receipt by the laboratory.

6. In the laboratory, a single punch is removed from the blooded end of the paper and placed into one well of a 96-well plate with 150 µl of diluent. Specimens are allowed to soak for 2 hours on a rotator and the eluate is tested for WEE, SLE, and WNV IgG antibody using ELISA. Positive specimens are tested further with an indirect fluorescent antibody test and confirmed with a Western blot. Inconclusive SLE or WNV positives are confirmed and identified by cross-neutralization tests. Test results are made available online at: http://gateway.calsurv.org/.

Reference

Reisen, W.K. 1995. Guidelines for Surveillance and Control of Arboviral Encephalitis in California, In: Interagency Guidelines for the Surveillance and Control of Selected Vector-borne Pathogens in California, Mosquito and Vector Control Association of California, Sacramento.

California Procedure for Testing Sentinel Chickens for the Presence of Antibodies to Flaviviruses (SLE and WNV) and WEE



Key:

EIA:	Enzyme immunoassay test
IFA:	Indirect fluorescent antibody test
MVCD:	Local Mosquito and Vector Control District/Health Dept.
SLE:	St. Louis encephalitis
CDPH:	CDPH Vector-Borne Disease Section, Richmond
WEE:	Western equine encephalitis
WNV:	West Nile virus encephalitis

Surveillance for Mosquito-borne Viruses
Registration of Agencies and Sites

1. Participation of agencies

Agencies interested in participating in the statewide surveillance program for mosquito-borne viruses should place orders for mosquito pool testing by UC Davis Center for Vectorborne Diseases (CVEC) through the Mosquito and Vector Control Association (MVCAC). Sentinel chicken testing should be ordered through the California Department of Public Health (CDPH). Agencies will be billed in advance for the number of samples to be tested.

Agencies are responsible for registering and maintaining updated information for their sites online at: http://gateway.calsurv.org/.

2. Registration of sentinel flock sites and wing band numbers

Agencies must use the unique band numbers assigned to their district by CDPH each year. Prior to submitting any sentinel chicken blood samples to CDPH, each agency must ensure that each flock site and accompanying band numbers are registered online at: http://gateway.calsurv.org/. CDPH will only test samples if they are accompanied by the form "SENTINEL CHICKEN BLOOD – 2012" (MBVS-2) for each flock site, which includes the registered agency code, the registered site code (assigned by local agency), the wing band numbers assigned to that site, and date bled. **Also, the form should indicate any changes made and match the sample card exactly.**

3. Registration of mosquito sampling sites

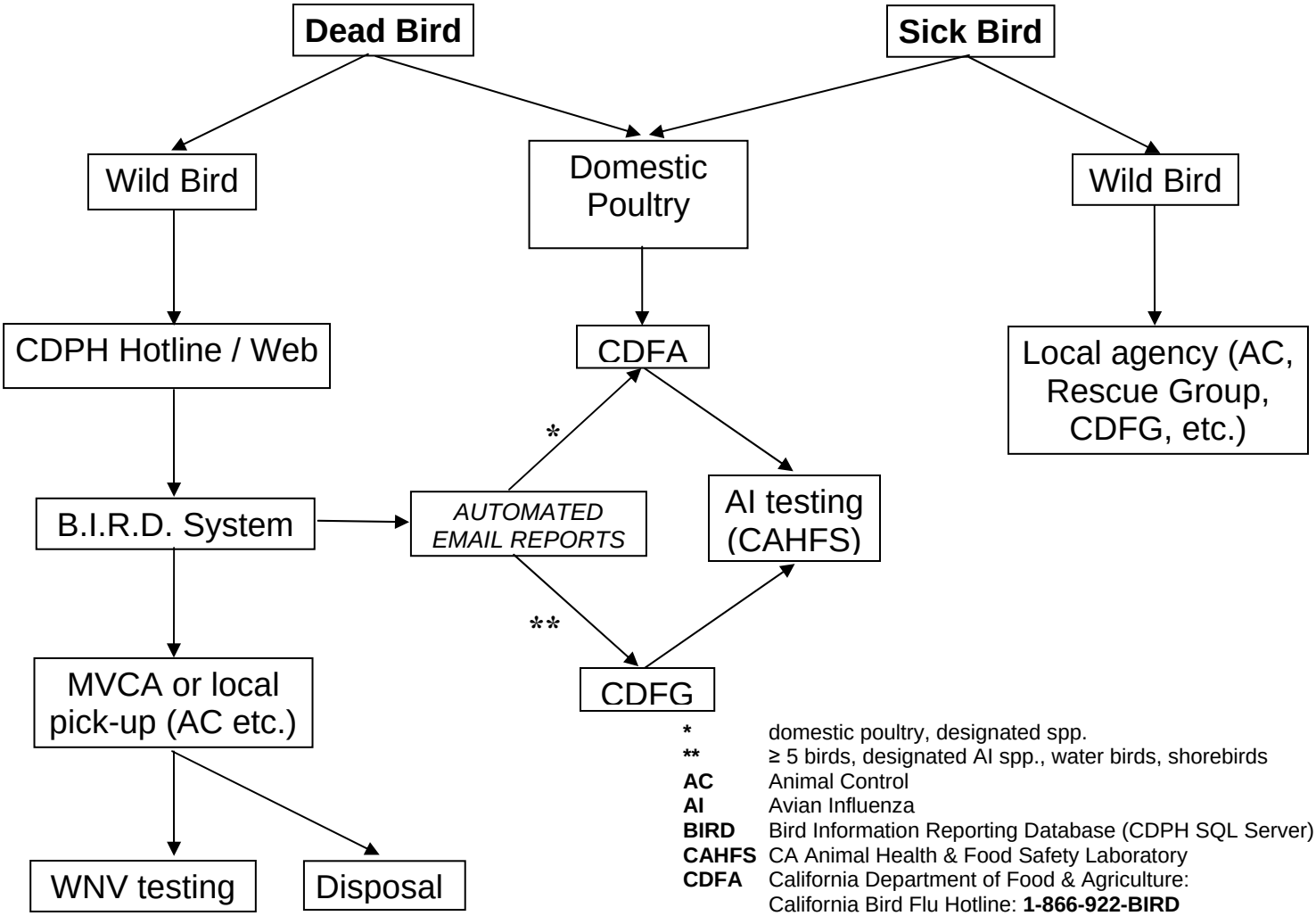
Registration of new sites used for collection of mosquitoes for virus testing may be accomplished by accessing the California Vectorborne Disease Surveillance Gateway http://gateway.calsurv.org/. Since 2010, the CalSurv Gateway has included enhanced spatial capabilities that allow users the option of directly entering geographic coordinates for sites or interactively selecting the location using a new Google Maps-based interface. The laboratory will test the pools provided that adequate information is provided on the "MOSQUITO POOL SUBMISSION" form (MBVS-3, revised 01/12/06), including your agency code, your site code for the site and geographic coordinates.

The geographic coordinates will be used to generate computer maps that show all registered sites and test results for each site. Also, as part of a collaborative effort, CVEC will host real-time maps in ArcGIS format at http://maps.calsurv.org. In addition to these maps, agencies can access maps using Google Earth through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org) that provide enhanced functionality and detail.

Appendix D: Procedures for Testing Dead Birds and Squirrels

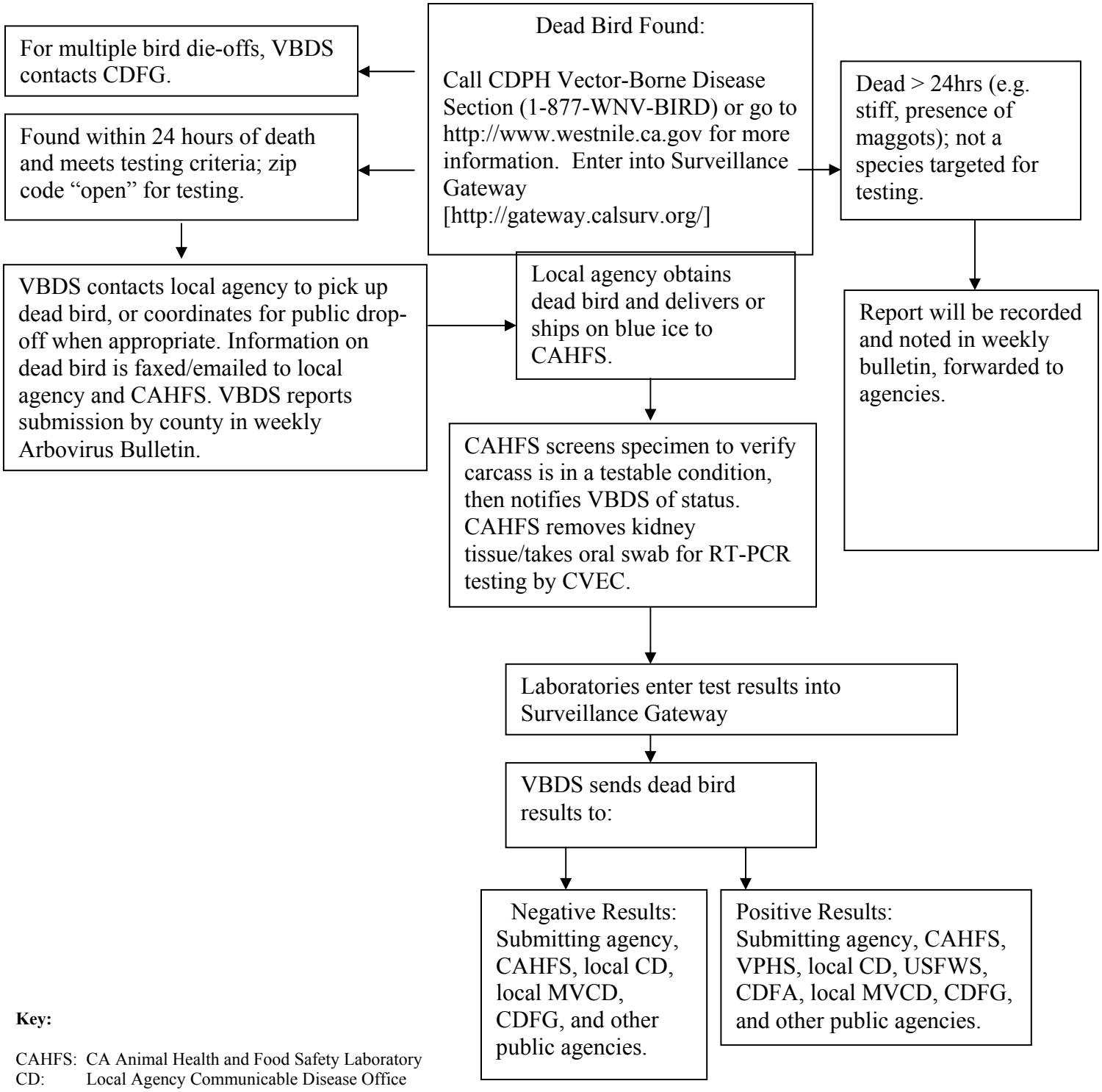
In 2000, CDHS initiated a dead bird surveillance program in collaboration with other public agencies. CDPH annually notifies about 600 agencies, organizations, and veterinarians involved with wildlife, including rehabilitation centers, about the program. The public is also notified about the program through the media and outreach materials. Dead birds and squirrels are reported to CDPH or data entered electronically through the Surveillance Gateway [http://gateway.calsurv.org/] and shipped to the California Animal Health & Food Safety (CAHFS) laboratory at UC Davis for screening and removal of kidney tissue (an oral swab is taken instead if the bird is an American Crow), which is then sent to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV RNA detection via RT-PCR. Beginning in 2010, results from RT-PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on cycle threshold (Ct) values. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. Overviews of the dead bird reporting and testing algorithms are provided below.

Sick / Dead Bird Reporting Protocol for Public and Local Agencies



*	domestic poultry, designated spp.
**	≥ 5 birds, designated AI spp., water birds, shorebirds
AC	Animal Control
AI	Avian Influenza
BIRD	Bird Information Reporting Database (CDPH SQL Server)
CAHFS	CA Animal Health & Food Safety Laboratory
CDFA	California Department of Food & Agriculture: California Bird Flu Hotline: **1-866-922-BIRD**
CDFG	California Department of Fish & Game http://www.dfg.ca.gov/regions/index.html
CDPH	California Department of Public Health West Nile virus & Dead Bird hotline: **1-877-968-BIRD** website: www.westnile.ca.gov
MVCA	Mosquito & Vector Control Agency

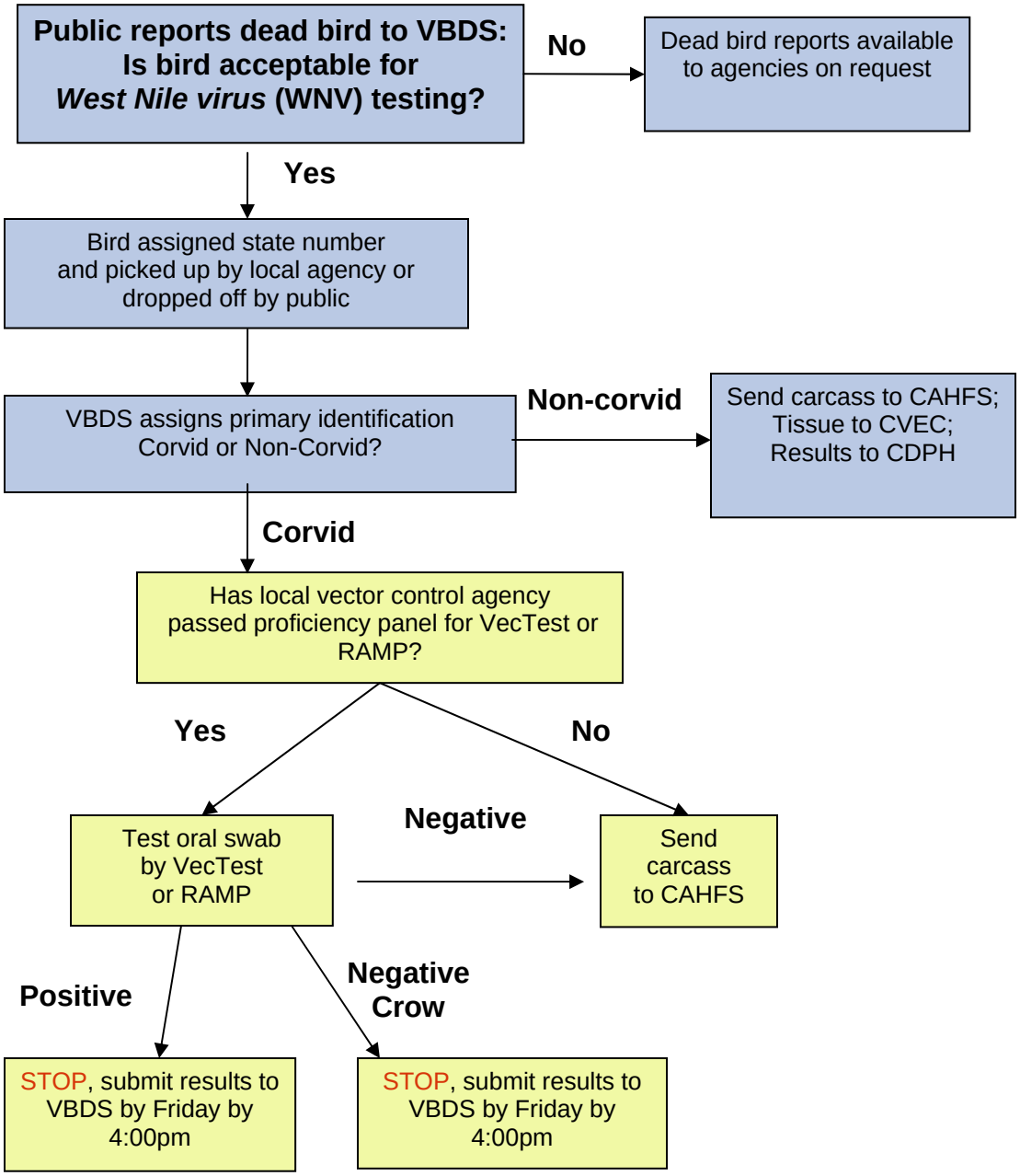
Procedures for Testing Dead Birds: RT-PCR



Key:

CAHFS: CA Animal Health and Food Safety Laboratory
CD: Local Agency Communicable Disease Office
CDFA: CA Dept. of Food and Agriculture
CDFG: CA Dept. of Fish and GameCVEC: UC Davis Center for Vectorborne Diseases
MVCD: Local Mosquito and Vector Control District
USFWS: US Fish and Wildlife Service
VBDS: CDHS Vector-Borne Disease Section, Richmond
VPHS: CDHS Veterinary Public Health Section, Sacramento
IHC: Immunohistochemistry

Procedures for Testing Dead Birds: Rapid Assays



CVEC = Center for Vectorborne Disease Research
VBDS = Vector-Borne Disease Section, California Department of Public Health
CAHFS = California Animal Health and Food Safety Laboratory

VBDS

Local Agencies

Dead Bird and Tree Squirrel Reporting and Submission Instructions for Local Agencies
California West Nile Virus (WNV) Dead Bird & Tree Squirrel Surveillance Program
California Department of Public Health (CDPH)
Division of Communicable Disease Control

When your agency receives a call from the public about a dead bird (especially recently dead crows, ravens, magpies, jays, or raptors) or dead tree squirrel, or one of your staff finds any dead bird, please immediately refer them to the **CDPH West Nile Virus and Dead Bird Hotline at 1-877-968-BIRD (2473)**.

The Dead Bird Hotline is monitored **8am - 5pm, 7 days a week.** CDPH will assess the suitability of the dead bird or tree squirrel for testing and contact your agency only if the carcass is approved for pickup. Any carcasses sent without prior notification will not be tested.

Only agencies listed under the permit issued to CDPH from the California Department of Fish & Game are authorized to pick up dead birds and tree squirrels. The agencies covered include local mosquito abatement districts, environmental health departments, and other designated agencies.

Members of the public may salvage dead birds found on their property or place of residence. **The public must first call the Dead Bird Hotline and obtain a Dead Bird Number**; a corresponding public salvage submission form will then be faxed to the appropriate agency. The public will be instructed by the hotline staff to double-bag the carcasses and drop them off at the designated agency within 24 hours, between 9 am - 3 pm, Monday – Friday, and **only in areas where local agencies are not picking up dead birds** (e.g., closed zip codes), unless otherwise requested by the local agency. **Note: only dead birds may be brought in by the public to local agencies for shipping. We discourage public salvage of all squirrels because ground squirrels, which could be infected with plague, may be misidentified as tree squirrels.**

***web links*:** bird and tree squirrel ID chart (pdf) tree squirrel surveillance Q&A (pdf)

Once the submission is approved, your agency can ship the carcass to the California Animal Health & Food Safety laboratory at UC Davis (CAHFS Central). CAHFS Central removes specific tissues and forwards the samples to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV testing. Shipping and testing expenses will be paid by CDPH. Carcasses are considered **Category B, Biological Substances.** This replaces the old designation, "Diagnostic Specimen".

To ensure the carcass arrives at CAHFS in a testable condition, to protect your safety, and to comply with shipping regulations, please follow these instructions:

- Only dead birds and tree squirrels can be picked up under our permit.

- Wear rubber or latex gloves when handling all carcasses. If gloves are not available, use a plastic bag -- turned inside out -- over your hand and invert the bag to surround the carcass. Do not touch a carcass with bare hands.

- **Collect fresh carcasses.** Badly decomposed or scavenged carcasses are of limited diagnostic value. Signs that a bird or squirrel has been dead for too long (over 24-48 hours) are the presence of maggots, an extremely lightweight carcass, missing eyes, skin discoloration, skin or feathers that rub off easily, strong odor, or a soft, mushy carcass.

- **If upon pick-up the carcass is found to be unacceptable (e.g. a species your agency or CDPH is not accepting or a badly decomposed specimen), please collect the carcass, double-bag it, and dispose of it in a secure garbage can or dumpster.** California Department of Fish & Game prefers that you burn or bury the carcass, but disposing of it in a dumpster is also acceptable. **Please call CDPH immediately and notify us that the animal will no longer be submitted.**

- Place each carcass into two sealed (zip-locked) plastic bags. **Double-bagging prevents cross-contamination and leakage**. **There should always be two bags separating the carcass from shipping documents.**

- Enclose the shipping documents into a SEPARATE ZIP-LOCK BAG. The primary shipping document is a copy of the dead bird submission form which contains the dead bird number and which is located on the Surveillance Gateway [http://gateway.calsurv.org/] or faxed by CDPH. CAHFS prefers that you put this separate zip-lock bag inside the <u>outer</u> bag containing the dead bird or squirrel.

- **Pack the carcass with blue ice packs.** Please limit the number of ice packs to the number required to keep the carcass fresh, as the weight of extra ice packs add to the shipping charges. In accordance to shipping regulations, an absorbent material such as newspaper must be included in the box to prevent any leakage.

- Ship the carcass in a hard-sided plastic cooler or a styrofoam cooler placed in a cardboard box. Unprotected styrofoam containers cannot be shipped without an outer box or container, as they may break into pieces during shipment. **Contact UPS/GSO directly to arrange for carrier pickup Monday through Thursday; this guarantees arrival at CAHFS before the weekend.**

- Contact **UPS** to pick up carcasses either by web (https://wwwapps.ups.com/pickup/schedule?loc=en_US) or by phone **1-800-PICK UPS** (1-800-742-5877)**. Select "UPS Next Day Air"** and **estimate the weight of the box** (generally 10 lbs for a single large bird packed with ice). Please DO NOT UNDER-ESTIMATE the weight of a package. For billing, the **UPS account number is: <u>23219W</u>.**

- Carcasses that need to be stored for an extended time period (over 2 days) should be put on dry ice or stored at -70ºC. If it is not possible to store carcass at -70ºC, a carcass may be stored at 0ºC (regular freezer) for a short period of time. **Refrigerating** the carcass is recommended for **overnight storage only** (this slows virus deterioration, but does not stop it).

- CDPH will provide prepared shipping boxes with appropriate labels. Any empty boxes shipped to your agency from CDPH will have its caution labels covered by a sheet of paper with "EMPTY BOX" printed on it. Please discard this sheet of paper before using the box to ship out a dead bird. If you need additional boxes, please contact VBDS at (510) 412-6251 or email arbovirus@cdph.ca.gov.

- Once West Nile virus is found in an area, agencies may test corvids via VecTest or RAMP assays. While results can be entered directly into the Surveillance Gateway, please **notify CDPH with results by 4:00pm Friday of each week to have results included in reports for the following week's State WNV updates.** Reporting forms can be found at (http://www.westnile.ca.gov/resources.php). **Note: any positive bird must be disposed of as biomedical waste (incineration).**

Dead Bird Shipping List

Please verify that your agency has the following items:

- CAHFS Address (see below)
- UPS preprinted labels
- WNV hotline number (877-968-BIRD; manned 8am - 5pm, 7 days a week)
- Crumpled newspapers or another absorbent material
- Rubber or Latex Gloves
- Packing tape
- Dead Bird Shipping Boxes
  - inner zip-lock bag
  - outer zip-lock bag
  - inner styrofoam box
  - outer cardboard box
  - blue ice packs

California Animal Health & Food Safety (CAHFS) laboratories:

CAHFS Central (530) 754-7372
ATTN: WNV
Jacquelyn Parker
University of California, Davis
West Health Science Drive
Davis, CA 95616

Appendix E: Procedures for Testing Equines and Ratites

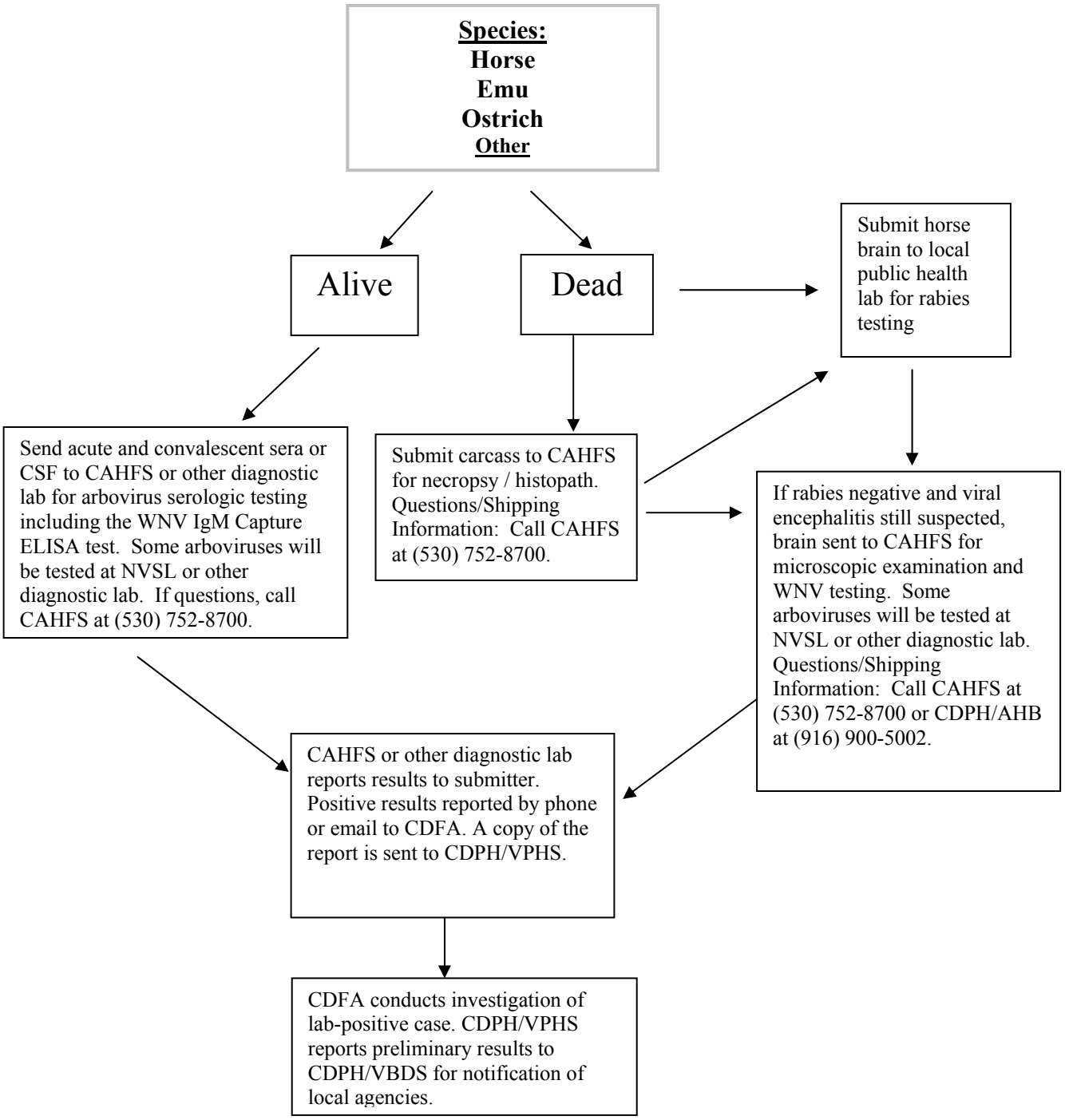
The California Departments of Public Health (CDPH) and Food and Agriculture (CDFA) developed a cooperative passive surveillance program for equine and ratite encephalomyelitis. Primary responsibility for equine and ratite West Nile virus (WNV) surveillance rests with CDFA. Equine encephalomyelitides are legally reportable to CDFA by veterinarians and diagnostic laboratories pursuant to Section 9101 of the Food and Agricultural Code. Venezuelan equine encephalomyelitis is an emergency animal disease that must be reported to CDFA by telephone within 24 hours.

This appendix contains information sent to veterinarians, public health lab directors, local health officers, public health veterinarians, animal health branch personnel, and interested parties every spring to inform them about the California Equine and Ratite Arbovirus Surveillance Program. The mailing includes a case definition for equine encephalomyelitides and instructions for specimen collection and submission for both equine and ratite samples. The information is distributed to approximately 1,200 practitioners, equine organizations, and other interested parties. Specimen submission is coordinated through the California Animal Health and Food Safety Laboratory System's (CAHFS) and other laboratories or individual veterinarians. Equine serum and cerebrospinal fluid are tested by CAHFS using the ELISA test to detect anti-WNV IgM. Equine neurologic tissue specimens are also sent to CAHFS for microscopic examination and, as indicated by clinical findings, forwarded to the USDA National Veterinary Services Laboratories (NVSL) for further arbovirus testing. All fatal cases of equine encephalitides are first evaluated for rabies at the local public health laboratory. An algorithm outlining the protocol for specimen submission and reporting is available for participants in the program and is included in this appendix.

Outreach is an important component of the program. CDPH and CDFA have developed and distributed educational materials concerning the diagnosis and reporting of arboviruses in equines and ratites.

Additional information on WNV for veterinarians, horse owners, and ratite owners, is available from CDFA, Animal Health Branch (916) 900-5002, and at the CDFA website: http://www.cdfa.ca.gov/AHFSS/Animal_Health/WNV_Info.html. Information on submission of laboratory samples is available from CAHFS (530) 752-8700 and at CAHFS website: http://cahfs.ucdavis.edu. A brochure containing facts about California WNV surveillance and general information about prevention and control is available from CDPH (916) 552-9730 and at CDPH's website: http://www.westnile.ca.gov; a special section for veterinarians and horse owners is available at: http://www.westnile.ca.gov/resources.php.

Algorithm for Submission of Specimens from Domestic Animals with Neurologic Symptoms



Key:

AHB:	Animal Health Branch
CAHFS:	California Animal Health and Food Safety Laboratory
NVSL:	National Veterinary Services Laboratory
VBDS:	CDPH Vector-Borne Disease Section
VPHS:	CDPH Veterinary Public Health Section
CDFA:	California Department of Food and Agriculture
CDPH:	California Department of Public Health

SURVEILLANCE CASE DEFINITIONS FOR WEST NILE VIRUS DISEASE IN EQUINES

NOTE: A HORSE WITH SIGNS OF ENCEPHALITIS MAY HAVE RABIES – TAKE PROPER PRECAUTIONS

CONFIRMED CLINICAL CASE:

A horse with compatible clinical signs including ataxia (stumbling, staggering, wobbly gait, or in-coordination) or at least two of the following: fever, circling, hind limb weakness, inability to stand, multiple limb paralysis, muscle fasciculation, proprioceptive deficits, blindness, lip droop/paralysis, teeth grinding, acute death.

Plus one or more of the following:

- Isolation of West Nile (WNV) virus from tissues[1]
- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF
- An associated 4-fold or greater change in plaque-reduction neutralization test (PRNT) antibody titer to WNV in appropriately timed[2], paired sera
- Positive polymerase chain reaction (PCR)[3] for WNV genomic sequences in tissues[1]
- Positive IHC for WNV antigen in tissue (Note: this test has low sensitivity in equids)

SUSPECT CLINICAL CASE[4]:

- Compatible clinical signs

EXPOSED EQUID:

- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF without any observable or noted clinical signs.

Assumptions on which case definition is based:

- Antibody in serum may be due to vaccination or a natural exposure; additional testing must be done to confirm WNV infection in a vaccinated horse.
- IgM antibody in equine serum is relatively short-lived; a positive IgM-capture ELISA means exposure to WNV or rarely a closely related flavivirus (SLE) has occurred, very likely within the last three months.

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[1] Preferred diagnostic tissue are equine brain or spinal cord; although tissues may include blood or CSF, the only known reports of WNV isolation or positive PCR from equine blood or CSF have been related to experimentally infected animals.
[2] The first serum should be drawn as soon as possible after onset of clinical signs and the second drawn at least seven days after the first.
[3] For horses it is recommended that RT-nested polymerase chain reaction assay be used to maximize sensitivity of the test (Emerg. Infect. Dis. 2001 Jul-Aug; 7(4):739-41)
[4] An equine case classified as a suspect case should, if possible, undergo further diagnostic testing to confirm or rule out WNV as the cause of the clinical illness.

Protocol for Submission of Laboratory Specimens for Equine Neurological Disease Diagnosis and Surveillance

Complete information on specimen collection and submission is available on the CDFA website at: http://www.cdfa.ca.gov/ahfss/Animal_Health/WNV_Lab_Submission.html

1. Specimen collection and submission:

A. Blood

- Acute sample (5-10 ml) / no later than 7 days after onset
- Convalescent sample (5-10 ml) / 14-21 days after onset
  Red top tubes of whole blood or serum (no preservatives or anticoagulants) should be submitted at ambient temperature to the California Animal Health and Food Safety (CAHFS) Laboratory* in your area. Do not freeze whole blood.
- **NOTE**: For WNV, an acute sample only is required since the assay used detects IgM (and vaccine does not interfere). For the other encephalitis viruses, the acute sample should be submitted immediately, and a convalescent sample may be requested later to assist with the interpretation and differentiation of vaccine titers from active infection.

B. Brain

- The local health department and CDFA/Animal Health District Office should be contacted if rabies is suspected.
- **The animal or intact head should be submitted to a CAHFS laboratory in your area as quickly as possible.** The intact head should be refrigerated, *not* frozen, immediately after removal using a leak-proof insulated transporting container with "cold packs" to keep the specimen at 4° C while in transit. *When it is impossible for the CAHFS Laboratory to receive the carcass or chilled intact head within 48 hours, the submission protocol should be coordinated with the CAHFS Laboratory.* Submission of the head intact is preferable to removal of the brain because: 1) the brain is better preserved (anatomically and virus titer) when left in the skull during transport, 2) specimens may be compromised if removal is not performed correctly, and 3) brain removal in field conditions may increase the risk of exposure to rabies.
- All equine specimens submitted first to the CAHFS Laboratory will be forwarded to: 1) a Public Health Laboratory to initially confirm or rule out rabies, then to 2) The National Veterinary Services Laboratories (NVSL) for arboviral testing, in addition to a complete diagnostic work-up at the CAHFS.
- All equine specimens submitted first to local public health laboratories for rabies testing and found to be negative should be forwarded to the local CAHFS Laboratory for arboviral testing.

C. Other specimens for differential neurological diagnoses

- Protocol for submission of these specimens may be coordinated through the CAHFS Laboratory, and may include sampling for equine herpes virus, EPM, or other agents associated with clinical neurological presentations.

2. Submission forms: Complete and include the transmittal forms supplied by the CAHFS Laboratory. See attached sample or download the form from their website: http://cahfs.ucdavis.edu/. The submittal form for each specimen should be placed in a leak-proof plastic bag and attached to the corresponding container.

3. Imperative information to include on the submission forms if West Nile virus is suspected: Precision case reporting by the veterinary practitioner is critical to mosquito control efforts that prevent WNV infection in both horses and humans. It is very important that each laboratory submission form is completed in its entirety. More specifically, it is imperative to include and communicate to us:

- The location(s) of the horse during the two weeks prior to the onset of clinical disease. (Please ensure that this information is included in addition to the "owner's address")
- Detailed clinical signs.
- The present condition of the horse (including dead and euthanized).
- An accurate vaccination history.

4. Shipment: For information on sample shipping including regulations governing the transportation of infectious materials contact CAHFS at 530-752-7578.

Appendix F: Protocol for Submission of Laboratory Specimens for Human West Nile Virus Testing

West Nile virus (WNV) testing within the regional public health laboratory network (i.e., the California Department of Public Health Viral and Rickettsial Disease Laboratory and participating local public health laboratories) is recommended for individuals with the following symptoms, particularly during West Nile virus "season," which typically occurs from July through October in California:

A. Encephalitis
B. Aseptic meningitis (Note: Consider enterovirus for individuals ≤ 18 years of age)
C. Acute flaccid paralysis; atypical Guillain-Barré Syndrome; transverse myelitis; or
D. Febrile illness*
   - Illness compatible with West Nile fever and lasting ≥ 7 days
   - Must be seen by a health care provider

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* The West Nile fever syndrome can be variable and often includes headache and fever (T ≥ 38°C). Other symptoms include rash, swollen lymph nodes, eye pain, nausea, or vomiting. After initial symptoms, the patient may experience several days of fatigue and lethargy.

Required specimens:

- Acute serum: ≥ 2cc serum

If a lumbar puncture is performed and residual CSF is available:

- Cerebral spinal fluid (CSF): 1-2cc CSF for further testing at CDC (N.B. these results may not be available for several weeks)

If West Nile virus is highly suspected and acute serum is negative or inconclusive, request:

- 2nd serum: ≥ 2cc serum collected 3-5 days after acute serum

Contact your local health department for instructions on where to send specimens.

Appendix G: Surveillance Case Definition for West Nile Virus Infection in Humans

West Nile virus infection is reportable to local health departments under Title 17 of the California Code of Regulations. Below is the case definition for West Nile virus disease as summarized by the Centers for Disease Control and Prevention (CDC) [available at http://www.cdc.gov/ncidod/dvbid/westnile/clinicians/surveillance.htm#casedef]. Blood donors that test positive for West Nile virus through blood bank screening should also be reported to CDPH, regardless of clinical presentation.

CASE DEFINITION: West Nile Virus

NOTE: This definition is for public health surveillance purposes only. It is not intended for use in clinical diagnosis.

Clinical Description

Arboviral infections may be asymptomatic or may result in illnesses of variable severity sometimes associated with central nervous system (CNS) involvement. When the CNS is affected, clinical syndromes ranging from febrile headache to aseptic meningitis to encephalitis may occur, and these are usually indistinguishable from similar syndromes caused by other viruses. Arboviral meningitis is characterized by fever, headache, stiff neck, and pleocytosis. Arboviral encephalitis is characterized by fever, headache, and altered mental status ranging from confusion to coma with or without additional signs of brain dysfunction (e.g., paresis or paralysis, cranial nerve palsies, sensory deficits, abnormal reflexes, generalized convulsions, and abnormal movements).

Laboratory Criteria for Diagnosis

- Fourfold or greater change in virus-specific serum antibody titer, or
- Isolation of virus from or demonstration of specific viral antigen or genomic sequences in tissue, blood, cerebrospinal fluid (CSF), or other body fluid, or
- Virus-specific immunoglobulin M (IgM) antibodies demonstrated in CSF by antibody-capture enzyme immunoassay (EIA), or
- Virus-specific IgM antibodies demonstrated in serum by antibody-capture EIA and confirmed by demonstration of virus-specific serum immunoglobulin G (IgG) antibodies in the same or a later specimen by another serologic assay (e.g., neutralization or hemagglutination inhibition).

Case Classification

- *Probable:* An encephalitis or meningitis case occurring during a period when arboviral transmission is likely and with the following supportive serology: 1) a single or stable (less than or equal to twofold change) but elevated titer of virus-specific serum antibodies; or 2) serum IgM antibodies detected by antibody-capture EIA but with no available results of a confirmatory test for virus-specific serum IgG antibodies in the same or a later specimen.
- *Confirmed:* An encephalitis or meningitis case that is laboratory confirmed.

Comment

- Because closely related arboviruses exhibit serologic cross-reactivity, positive results of serologic tests using antigens from a single arbovirus can be misleading. In some circumstances (e.g., in areas where two or more closely related arboviruses occur, or in imported arboviral disease cases), it may be epidemiologically important to attempt to pinpoint the infecting virus by conducting cross-neutralization tests using an appropriate battery of closely related viruses. This is essential, for example, in determining that antibodies detected against St. Louis encephalitis virus are not the result of an infection with West Nile (or dengue) virus, or vice versa, in areas where both of these viruses occur.
- The seasonality of arboviral transmission is variable and depends on the geographic location of exposure, the specific cycles of viral transmission, and local climatic conditions.

Asymptomatic West Nile Virus Infection: Asymptomatic infection with WNV, which is generally identified in blood donors, is also reportable. WNV-positive blood donors detected by blood banks are reported directly to local health departments. Blood donors who test positive for WNV may not necessarily be ill, nor will they initially have positive IgM or IgG antibody test results. Local health departments should report blood donors who meet the following criteria for being a presumptively viremic donor to CDPH:

A presumptively viremic donor (PVD) is a person with a blood donation that meets at least one of the following criteria:

a) One reactive nucleic acid-amplification (NAT) test with signal-to-cutoff (S/CO) $\geq$ 17
b) Two reactive NATs

Additional serological testing is not required. Local health departments should follow up with the donor after two weeks of the date of donation to assess if the patient subsequently became ill. If the donor did become ill as a result of WNV infection, an updated case report form should be sent to CDPH so that the blood donor may be reclassified as a clinical case.

Note: Due to the continued risk of unintentional or intentional introduction of exotic arboviruses into the United States (e.g., Venezuelan equine encephalitis virus), or the reemergence of indigenous epidemic arboviruses (e.g., St. Louis encephalitis and western equine encephalitis viruses), physicians and local public health officials should maintain a high index of clinical suspicion for cases of potential exotic or unusual arboviral etiology, and consider early consultation with arboviral disease experts at state health departments and CDC.

Appendix H: Compounds Approved for Mosquito Control in California

Label rates and usage vary from year to year and geographically; consult your County Agricultural Commissioner and the California Department of Fish and Game before application. Examples of products containing specific active ingredients are provided below, but this is not an inclusive list nor constitutes product endorsement. For more information on pesticides and mosquito control, please refer to the Environmental Protection Agency (EPA) Web site:
http://www.epa.gov/opp00001/factsheets/westnile.htm

Larvicides:

1. *Bacillus thuringiensis* subspecies *israelensis* (Bti: e.g. Aquabac 200G, VectoBac® 12AS, Teknar HP-D)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not persist well in the water column.

2. *Bacillus sphaericus* (Bs: e.g. VectoLex® CG)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not work well on all species. May persist and have residual activity in some sites.

3. Spinosad (e.g. Natular™ G30)
   Limitations: Effective against all larval stages and moderately effective against pupal stage. Toxic via ingestion and contact. Some formulations approved for use in OMRI certified organic crops.

4. IGRs (Insect Growth Regulators)
   a. (S)-Methoprene (e.g. Altosid® Pellets)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Works best on older instars. Some populations of mosquitoes may show some resistance.
   b. Diflurobenzamide (e.g. Dimilin®25W)
   Use: Impounded tail water, sewage effluent, urban drains and catch basins.
   Limitations: Cannot be applied to wetlands, crops, or near estuaries.

5. Larviciding oils (e.g.Bonide)
   Use: Ditches, dairy lagoons, floodwater. Effective against all stages, including pupae.
   Limitations: Consult with the California Department of Fish and Game for local restrictions.

6. Monomolecular films (e.g. Agnique® MMF)
   Use: Most standing water including certain crops.
   Limitations: Does not work well in areas with unidirectional winds in excess of ten mph.

7. Temephos (e.g. Abate® 2-BG)
   Use: Non-potable water; marshes; polluted water sites

Limitations: Cannot be applied to crops for food, forage, or pasture. This material is an organophosphate compound and may not be effective on some *Culex tarsalis* populations in the Central Valley. May require sampling and testing per General Vector Control NPDES permit requirements if applied to waters of the United States.

Adulticides:

1. Organophosphate compounds
   Note: Many *Culex tarsalis* populations in the Central Valley are resistant at label OP application rates.
   a. Malathion (e.g. Fyfanon® ULV)
      Use: May be applied by air or ground equipment over urban areas, some crops including rice, wetlands.
      Limitations: Paint damage to cars; toxic to fish, wildlife and bees; crop residue limitations restrict application before harvest.
   b. Naled (e.g. Dibrom® Concentrate, Trumpet® EC)
      Use: Air or ground application on fodder crops, swamps, floodwater, residential areas.
      Limitations: Similar to malathion.

2. Pyrethrins (natural pyrethrin products: e.g. Pyrenone® Crop Spray, Pyrenone® 25-5, Evergreen)
   Use: Wetlands, floodwater, residential areas, some crops.
   Limitations: Do not apply to drinking water, milking areas; may be toxic to bees, fish, and some wildlife. Some formulations with synergists have greater limitations.

3. Pyrethroids (synthetic pyrethrin products containing deltamethrin, cyfluthrin, permethrin, resmethrin, sumithrin or etofenprox: e.g. Suspend® SC, Tempo Ultra SC, Aqua-Reslin®, Scourge® Insecticide, Anvil® 10+10 ULV, Zenivex E20, and Duet – which also contains the mosquito exciter prallethrin)
   Use: All non-crop areas including wetlands and floodwater.
   Limitations: May be toxic to bees, fish, and some wildlife; avoid treating food crops, drinking water or milk production.

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Larvicides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Application	Pesticide classification
Bacillus sphaericus, (Bs)	VectoLex CG / WSP	73049-20	Valent BioSciences	Granule Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex WDG	73049-57	Valent BioSciences	Water dispersible granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac WDG	73049-56	Valent BioSciences	Water dispersible Granules	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac 12AS	73049-38	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac AS	275-52	Abbott Labs	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac G	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac GS	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac Tech. Pdr.	73049-13	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac 200G	62637-3	Becker Microbial	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Consume MP	62637-3	Spartan Chemical	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac XT	62637-1	Becker Microbial	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Bactimos PT	73049-452	Valent BioSciences	Granular flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar HP-D	73049-404	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Fourstar SBG	85685-1	Fourstar Microbials LLC	Granule	Larvae	Biorational
Bti / Bs combination	Vectomax G, CG, WSP	73049-429	Valent BioSciences	Granular and water soluble packet	Larvae	Biorational
Bti / Bs combination	Fourstar Briquettes	83362-3	Fourstar Microbials LLC	Briquette	Larvae	Biorational
Spinosad	Natular 2EC	8329-82	Clarke	Liquid concentrate	Larvae and pupae	Biorational
Spinosad	Natular G	8329-80	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natural G30	8329-83	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natular T30	8329-85	Clarke	Tablet	Larvae and pupae	Biorational
Spinosad	Natular XRT	8329-84	Clarke	Tablet	Larvae and pupae	Biorational
Monomolecular film	Agnique MMF	53263-28	Cognis Corp.	Liquid	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF G	53263-30	Cognis Corp.	Granular	Larvae and pupae	Surface film

Monomolecular film	Agnique MMF G Pak 35	53263-30	Cognis Corp.	Water soluble pack	Larvae and pupae	Surface film
Petroleum oil	Masterline Kontrol	73748-10	Univar	Liquid	Larvae and pupae	Surface film
Petroleum oil	BVA 2	70589-1	B-V Assoc.	Liquid	Larvae and pupae	Surface film
Petroleum oil	GB-1111	8329-72	Clarke	Liquid	Larvae and pupae	Surface film
Dimilin	Dimilin 25W	400-465	Uniroyal Chemical	Wettable powder	Larvae	IGR
S-Methoprene	Altosid ALLC	2724-446	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-Methoprene	Altosid ALL	2724-392	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-methoprene	Altosid Briquets	2724-375	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid Pellets / WSP	2724-448	Wellmark-Zoecon	Pellet-type granules / water soluble packet	Larvae	IGR
S-methoprene	Altosid SBG	2724-489	Wellmark-Zoecon	Granule	Larvae	IGR
S-methoprene	Altosid XR Briquets	2724-421	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid XR-G	2724-451	Wellmark-Zoecon	Granule	Larvae	IGR
Temephos	Abate 2-BG	8329-71	Clarke	Granule	Larvae	OP
Temephos	5% Skeeter Abate*	8329-70	Clarke	Granule	Larvae	OP
Temephos	Abate 4E	8329-69	Clarke	Liquid	Larvae	OP

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Adulticides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Stage	Pesticide classification
Malathion	Fyfanon® ULV	67760-34	Cheminova	Liquid	Adults	OP
Naled	Trumpet™ EC	5481-481	AMVAC	Liquid	Adults	OP
Prallethrin Sumithrin	AquaDuet Adulticide	1021-2562-8329	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	Duet Dual Action Adulticide	1021-1795	Clarke	Liquid	Adults	Pyrethroid
Deltamethrin	Suspend® SC	432-763	Aventis	Liquid	Adults	Pyrethroid
Cyfluthrin	Tempo SC Ultra	432-1363	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Kontrol	73748-1	Univar	Liquid	Adults	Pyrethroid
Permethrin	Aqualeur 20-20	769-985	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Reslin®	432-796	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+4	8329-35	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+12 ULV	8329-34	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 4-4 ULV	769-982	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 2-2	73748-3	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 4-4	73748-4	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 30-30	73748-5	Univar	Liquid	Adults	Pyrethroid
Permethrin	Permanone 31-66	432-1250	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Permanone® Ready-To-Use	432-1277	Bayer	Liquid	Adults	Pyrethroid

Permethrin	Perm-X UL 4-4	655-898	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Aquahalt	1021-1803	Clarke	Liquid	Adults	Pyrethroid
Pyrethrins	Evergreen 60-6	1021-1770	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® 25-5	432-1050	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® Crop Spray	432-1033	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7453	1021-1803	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7395	1021-1570	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7396	1021-1569	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Crop Spray	655-489	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 525	655-471	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 3610A	655-501	Prentiss	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (4%)	432-716	Bayer	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (18%)	432-667	Bayer	Liquid	Adults	Pyrethroid
Sumithrin	Anvil 2+2 ULV	1021-1687	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 10+10 ULV	1021-1688	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	AquaANVIL	1021-1807	Clarke	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E4 RTU	2724-807	Wellmark Intl.	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E20	2724-791	Wellmark, Intl.	Liquid	Adults	Pyrethroid
Lambda-cyhalothrin	Demand CS	100-1066	Syngenta	Liquid	Adults	Pryethroid

Appendix I: Adult Mosquito Control in Urban Areas

Adult mosquito control via ultra low volume (ULV) application is an integral part of an integrated mosquito management program. This response plan recommends the consideration of adult mosquito control to break local virus transmission cycles and reduce the risk of human infection. The following provides guidelines for local agencies considering ground or aerial ULV control of adult mosquitoes. Agencies should ensure they are complying with NPDES permit requirements.

Preparatory steps for aerial application contracts

- Send out request for proposals (RFP) to commercial applicators well in advance of any potential need for actual treatment. Specify required equipment and abilities in the RFP such as: 1) application equipment capable of producing desired droplet spectrum and application rate, 2) aircraft availability time frames, and 3) the demonstrated ability to apply the chosen product to the target area in accordance with label requirements.
- Outline the desired capabilities and equipment within the RFP such as: 1) onboard real time weather systems, and 2) advanced onboard drift optimization and guidance software.
- Determine in advance whether the vector control agency or contractor will secure and provide pesticides. If the contractor will supply the pesticide, verify their knowledge of and ability to comply with regulations regarding the transport, use, and disposal of all pesticide and containers.
- Enter into a contingency contract with the commercial applicator.
- Consider acquiring non-owned, multiple engine aircraft insurance with urban application endorsement for added protection.
- Determine product and application rate to be used, along with a contingency plan. The product choice may be subject to change depending on product availability, the determination of resistance, labeling restrictions, environmental conditions, or other unforeseen factors.

Preparatory steps for ground-based applications

- Ensure that application equipment has been properly calibrated and tested for droplet size and flow rate. The vector control agency should have enough equipment, operators, and product available to finish the desired application(s) between sunset and midnight, or within 2-3 hours pre-sunrise (or when mosquitoes are demonstrated to be most active) to maximize efficacy.
- Ensure that vehicles are equipped with safety lighting and appropriate identifying signs; use sufficient personnel.
- Contact local law enforcement and provide them with locations to be treated and approximate time frames.
- Consider using lead and trailing vehicles particularly if the area has not been treated before and personnel are available.

Implementing an aerial application contract

- Contact commercial applicator and determine availability.
- Review long-term weather forecasts. Ideally applications should be scheduled during periods of mild winds to avoid last minute cancellations.

Contractor should:

- Contact Local Flight Standards District Office (FSDO) for low flying waiver.
- Arrange for suitable airport facilities.
- Contact local air traffic control.
- Locate potential hazards prior to any application and implement a strategy to avoid those hazards during the application – often in darkness.
- Provide equipment and personnel for mixing and loading of material (if previously agreed upon in contract).
- Register with applicable County Agricultural Commissioners office.

Vector control agency should:

- Delineate treatment block in a GIS format and send to contractor.
- Identify areas that must be avoided during an application and include detailed maps of those areas to contract applicators (e.g. open water, registered organic farms, any area excluded by product label).
- Send authorization letter to FSDO authorizing contractor to fly on the agency's behalf; contractor should provide contact information and assistance.
- Send map of application area and flight times / dates to local air traffic control; contractor should provide contact information and assistance.
- Consult with County Agricultural Commissioners office. Commissioner's office can provide guidance on contacting registered bee keepers and help identify any registered organic farms that may need to be excluded from application.
- If vector control agency is providing material, ensure adequate quantity to complete mission and that the agency has means to transport material.

Efficacy evaluation for aerial or ground based application

- Choose appropriate method(s) for evaluating efficacy of application
  - Determine changes in adult mosquito population via routine surveillance.
  - Conduct three day pre and post-trapping in all treatment and control areas.
  - Set out bioassay cages with wild caught and laboratory reared (susceptible) mosquitoes during application.
- Ensure adequate planning so surveillance staff is available and trained, equipment is available, and trap / bioassay cage test locations are selected prior to application.
- Ensure efficacy evaluation activities are timed appropriately with applications.
- Enlist an outside agency such as CDPH and/or university personnel to help evaluate efficacy of application as appropriate.

Actions at time of application

- Confirm application rate with contractor.
- Confirm treatment block.
- Coordinate efficacy evaluations.

Public notification

Notification of the public prior to a mosquito control pesticide application by a vector control agency signatory to a Cooperative Agreement with CDPH, or under contract for such agency is not a legal requirement in California (California Code of Regulations – Title 3: Food and Agriculture: Division 6. Pesticides and Pest Control Operations: Section 6620a). However, public notification of pending adult mosquito control is recommended as early as possible prior to the treatment event.

Basic notification steps

- Provide notification of pending application as early as possible.
- Post clearly defined treatment block map online or through appropriate media outlet.
- Post product label and material safety data sheet (MSDS) online or through appropriate media outlet.
- Post and/or have available scientific publications regarding the efficacy of aerial or ground based applications (as appropriate), including effects on non-target organisms and risk-assessments.

Public relations considerations

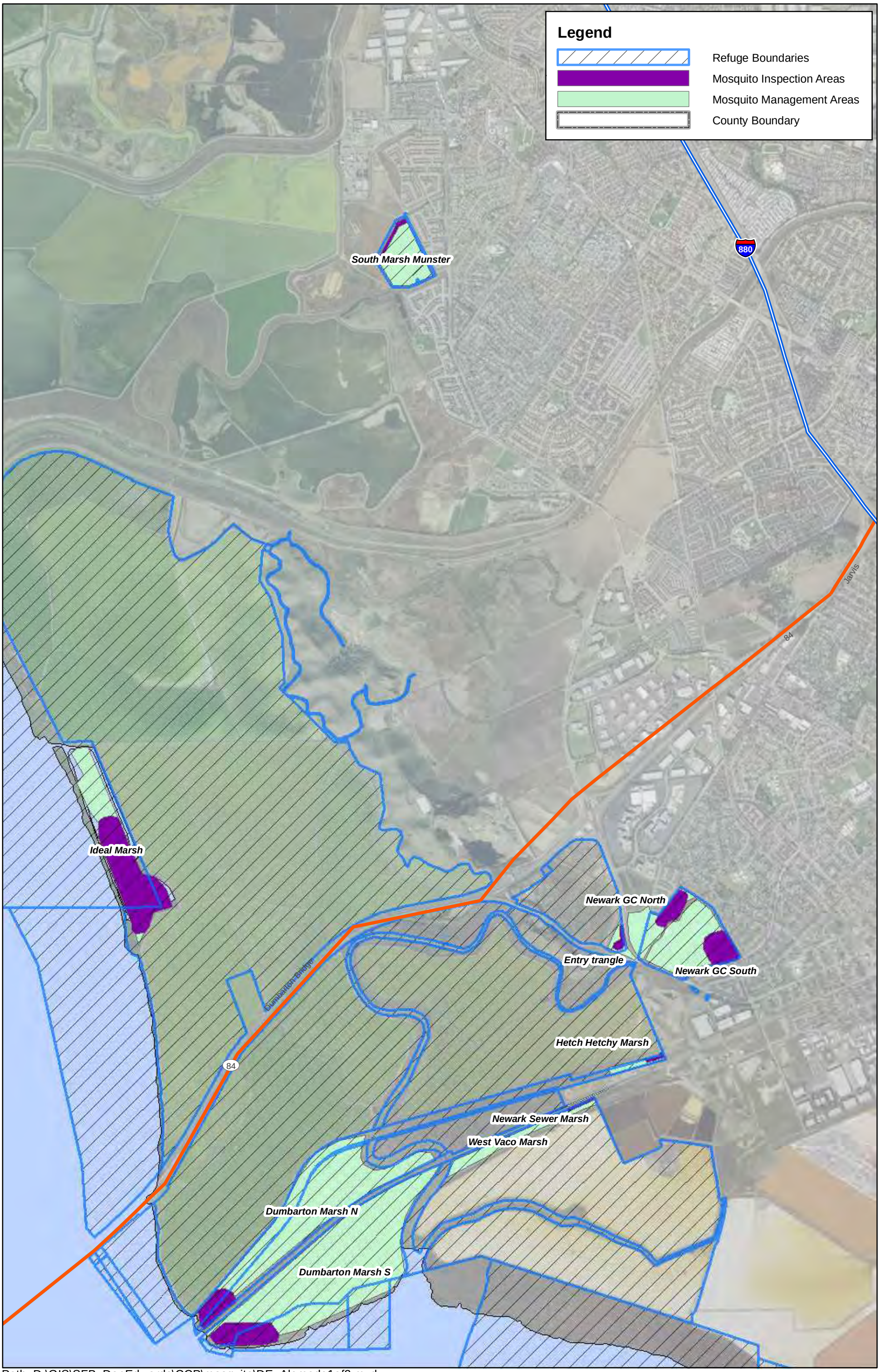
- Ensure staffing is adequate to handle a significant increase in phone calls.
- Ensure website capability is adequate to handle a rapid increase in visitors.
- Train personnel answering phones to address calls from citizens concerned about personal and environmental pesticide exposure.
- Ensure adequate follow-through for calls related to sporting events, concerts, weddings, and other outdoor events that may be scheduled during the application and within the treatment block

Appendix J: Websites Related to Arbovirus Surveillance, Mosquito Control, Weather Conditions and Forecasts, and Crop Acreage and Production in California

Website	URL	Available information
California West Nile Virus Website	http://westnile.ca.gov	Up to date information on the spread of West Nile virus throughout California, personal protection measures, online dead bird reporting, bird identification charts, mosquito control information and links, clinician information, local agency information, public education materials.
UC Davis Center for Vectorborne Diseases	http://cvec.ucdavis.edu/	Frequently updated reports and interactive maps on arbovirus surveillance and mosquito occurrence in California.
Mosquito and Vector Control Association of California	http://www.mvcac.org	News, membership information, event calendars, and other topics of interest to California's mosquito control agencies.
California Vectorborne Disease Surveillance Gateway	http://gateway.calsurv.org	Data management system for California's mosquito control agencies.
California Data Exchange Center	http://cdec.water.ca.gov	Water-related data from the California Department of Water Resources, including historical and current stream flow, snow pack, and precipitation information.
UC IPM Online	http://www.ipm.ucdavis.edu	Precipitation and temperature data for stations throughout California; also allows calculation of degree-days based on user-defined data and parameters.
National Weather Service – Climate Prediction Center	http://www.cpc.ncep.noaa.gov /products/predictions/	Short-range (daily) to long-range (seasonal) temperature and precipitation forecasts. Also provides El Niño-related forecasts.
California Agricultural Statistics Service	http://www.nass.usda.gov/Statistics_by_State/California	Crop acreage, yield, and production estimates for past years and the current year's projections. Reports for particular crops are published at specific times during the year – see the calendar on the website.
State Water Resources Control Board	http://www.swrcb.ca.gov/ water_issues/programs/npdes/ aquatic.shtml	National Pollutant Discharge Elimination System (NPDES) permit for vector control information.
US Environmental Protection Agency – Mosquito Control	http://www.epa.gov/pesticides /health/mosquitoes	Describes the role of mosquito control agencies and products used for mosquito control.
US Centers for Disease Control and Prevention – West Nile Virus	http://www.cdc.gov/ncidod/dvbid/westnile/index.htm	Information on the transmission of West Nile virus across the United States, viral ecology and background on WNV, and personal protection measures in various languages.

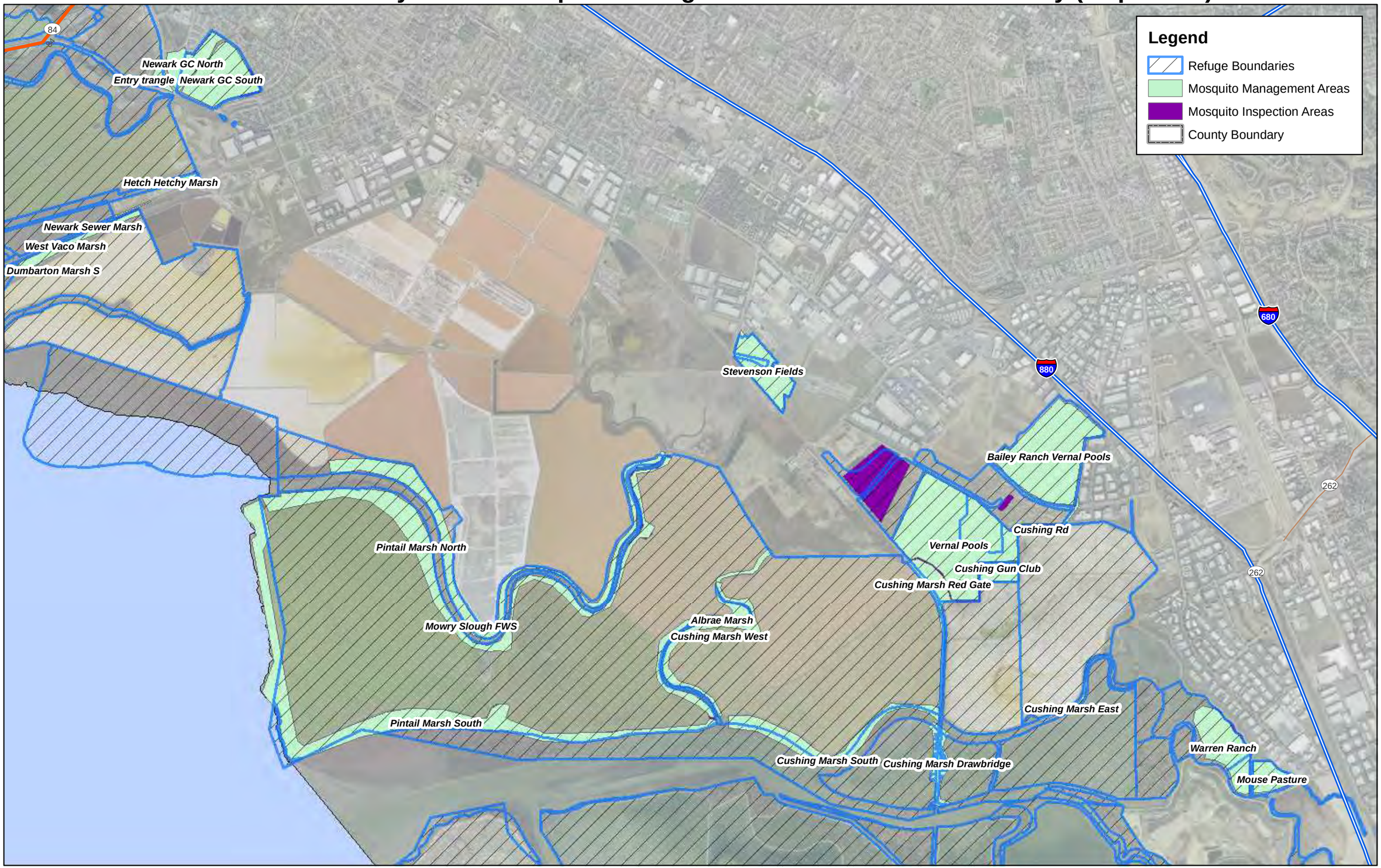
APPENDIX K9. Mosquito Management Maps

Don Edwards SF Bay NWR
Mosquito Management Sites in Alameda County (Map 1 of 2)



Path: D:\GIS\SFB_DonEdwards\CCP\mosquito\DE_Alameda1of2.mxd

Don Edwards SF Bay NWR - Mosquito Management Sites in Alameda County (Map 2 of 2)



Path: D:\GIS\SFB_DonEdwards\CCP\mosquito\DE_Alameda2of2.mxd

Don Edwards SF Bay NWR - Mosquito Management Sites in Santa Clara County

Path: D:\GIS\SFB_DonEdwards\CCP\mosquito\DE_Santa Clara.mxd

Don Edwards SF Bay NWR - Mosquito Management Sites in San Mateo County

Path: D:\GIS\SFB_DonEdwards\CCP\mosquito\mosquito-ES\DE_San Mateo.mxd

Appendix L. Wilderness Inventory

Wilderness Inventory for Don Edwards San Francisco Bay National Wildlife Refuge

Introduction

A wilderness inventory is the process used to determine whether to recommend lands or waters in the National Wildlife Refuge System to Congress for designation as wilderness under the National Wilderness Preservation System (NWPS). The Service is required by policy to conduct a wilderness review for each refuge as part of the CCP process outlined in 602 FW 1 and 3, and according to the National Environmental Policy Act compliance. Lands or waters that meet the minimum criteria for wilderness are identified in a CCP and further evaluated to determine whether they merit recommendation for inclusion in the NWPS.

There are three phases to the wilderness inventory process: (1) inventory, (2) study, and (3) recommendation. Land and waters that meet the minimum criteria for wilderness are identified in the inventory. These areas are called wilderness study areas (WSAs). In the study phase, a range of management alternatives are evaluated to determine if a WSA is suitable for wilderness designation or management under an alternate set of goals and objectives that do not involve wilderness designation.

The recommendation phase consists of forwarding or reporting the suitable recommendations from the Director through the Secretary and the President to Congress in a wilderness study report. The wilderness study report is prepared after the record of decision for the final CCP has been signed.

Areas recommended for designation are managed to maintain wilderness character in accordance with management goals.

Evaluation Criteria

According to Section 13 of the Service's Director's Order No. 125 (12 July 2000), in order for a refuge to be considered for wilderness designation, all or part of the refuge must:

- Be affected primarily by the forces of nature, with the human imprint substantially unnoticeable;
- Have outstanding opportunities for solitude or a primitive and unconfined type of recreation;
- Have at least 5,000 contiguous acres (2,000 ha) or be sufficient in size to make practicable its preservation and use in an unimpaired condition, or be capable of restoration to wilderness character through appropriate management, at the time of review; and
- Be a roadless island.

Evaluation of the Size Criteria

Roadless areas or roadless islands meet the size criteria if any one of the following standards applied:

- An area with over 5,000 contiguous acres. State and private lands are not included in making this acreage determination.
- A roadless island of any size. A roadless island is defined as an area surrounded by permanent waters or that is markedly distinguished from the surrounding lands by topographical or ecological features.
- An area of less that 5,000 contiguous Federal acres that is of sufficient size as to make practicable its preservation and use in an unimpaired condition, and of a size suitable for wilderness management.
- An area of less than 5,000 contiguous Federal acres that is contiguous with a designated wilderness, recommended wilderness, or area under wilderness review by another Federal wilderness managing agency such as the Forest Service, National Park Service, or Bureau of Land Management.

Evaluation of Naturalness Criteria

In addition to being roadless, a wilderness area must meet the naturalness criteria. The area must appear natural to the average visitor rather than "pristine"; it should "generally appear to have been affected primarily by the forces of nature with the imprint of man's work substantially unnoticeable." The presence of historic landscape conditions is not required. An area may include some human impacts provided they are substantially unnoticeable in the unit as a whole. Significant human-caused hazards, such as the presence of unexploded ordnance from military activity, and the physical impacts of refuge management facilities and activities are also considered in evaluation of the naturalness criteria. An area may not be considered unnatural in appearance solely on the basis of the "sights and sounds" of human impacts and activities outside the boundary of the unit.

Evaluation of Outstanding Opportunities for Solitude or Primitive and Unconfined Recreation

In addition to meeting the size and naturalness criteria, a wilderness area must provide outstanding opportunities for solitude or primitive recreation. The area does not have to possess outstanding opportunities for both solitude and primitive and unconfined recreation, and does not need to have outstanding opportunities on every acre. Further, an area does not have to be open to public use and access to qualify under this criteria; Congress has designated a number of wilderness areas in the Refuge System that are closed to public access to protect resource values.

Opportunities for solitude refer to the ability of a visitor to be alone and secluded from other visitors in the area. Primitive and unconfined recreation means non-motorized, dispersed outdoor recreation activities that are compatible and do not require developed facilities or mechanical transport. These primitive recreation activities may provide opportunities to experience challenge and risk; self-reliance; and adventure.

These two "opportunity elements" are not well defined by the Wilderness Act, but in most cases, can be expected to occur together. However, an outstanding opportunity for solitude may be present in an area offering only limited primitive recreation potential.

Conversely, an area may be so attractive for recreation use that experiencing solitude is not an option.

Evaluation of Supplemental Values
Supplemental values are defined by the Wilderness Act as "…ecological, geological, or other features of scientific, education, scenic, or historical value." These values are not required for wilderness.

INVENTORY FINDINGS

As documented below, none of the units of Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) meet the criteria to warrant wilderness consideration. Therefore, inclusion of this Refuge in the NWPS will not be sought.

Roadless Areas and Roadless Islands
Many roads and highways cross through the Refuge units, and therefore does not meet the roadless island criteria. Major roadways include Interstate Highway 880, U.S. Route 101, California State Route 237, and California State Route 84.

Size Criteria
While the Service owns more than 5,000 acres of this Refuge in fee title, the Refuge is located in a highly urbanized area. Much of the Refuge lands have been altered by human development and much of the lands are in the process being restored.

Naturalness Criteria
The Refuge units have been substantially changed from their origins as tidal wetlands. The Gold Rush era in the 1800s heavily changed the region where the Refuge is located. Mining operations contributed to large amounts of sedimentation in the area. Later, most of the Refuge was diked and actively managed for salt production, farming, and development. Today, salt production and both residential and commercial development surround the Refuge. The Refuge is also surrounded by several million people that make the San Francisco Bay Area their home. For these reasons, the Refuge does not meet the naturalness criteria for wilderness designation.

Opportunities for Solitude or Primitive and Unconfined Recreation
The major roadways described in the Roadless Areas and Roadless Islands section (described previously) can be heard or seen from many of the Refuge's units. These roadways are heavily traveled everyday as they provide major travel arteries around the south San Francisco Bay. Furthermore, there is substantial nearby residential and commercial development. This Refuge also receives roughly 800,000-900,000 visitors annually with its plethora of wildlife-oriented recreation, interpretation, and environmental education programs. Based on this assessment, the Refuge does not fully provide opportunities for solitude or primitive and unconfined types of recreation that are characteristic of a wilderness area.

Supplemental Values

The location of the Refuge relative to the saline waters of the Pacific Ocean results in a unique and rich tidal environment that directly transition to uplands. Large contiguous expanses of pickleweed-dominated tidal marsh support high densities of the endangered salt marsh harvest mouse as well as provide habitat for the endangered California clapper rail and other sensitive species. Hundreds of thousands of shorebirds and waterfowl use the Refuge as they migrate along the Pacific Flyway.

Appendix M. Applicable Laws and Executive Orders

This appendix contains an overview of laws, executive orders, polices, and plans created by federal, state and local agencies with jurisdiction in the vicinity of the Don Edwards San Francisco Bay National Wildlife Refuge. The following table contains a list of applicable laws and executive orders that may affect the Refuge's CCP or the Service's implementation of the CCP. A brief description of the law, executive order, policy, or plan is included as well as how it relates to the CCP.

Table 1. Applicable Laws and Executive Orders		
Law, Regulation, or Guideline	**Description**	**Relation to the CCP**
Agency Coordination		
Executive Order No. 12372, Intergovernmental Review of Federal Programs.	Requires that Federal agencies afford other agencies review of documents associated with Federal programs.	Copies of this environmental assessment were sent to the California State Clearinghouse, Federal and State agencies, and local governments.
Human Rights Regulations		
Executive Order 12898, Environmental Justice. February 11, 1994 Americans with Disabilities Act of 1990 (ADA)	Requires Federal agencies to consider the effects of projects and policies on minority and lower income population. Provides for access to Federal facilities for the disabled.	The proposed action will not have a disproportionately high and adverse human health or environmental effect on minority populations and low-income populations. The proposed action promotes reasonable and appropriate uses of the land that preserve the natural character and protect the natural resources of the area.
Cultural Resources Regulations		
Antiquities Act of 1906	This act authorizes the scientific investigation of antiquities on Federal land. It prohibits and provides penalties for unauthorized search for or collection of artifacts or other objects of scientific interest. The Act also authorizes the president to establish national monuments and cultural areas on Federal lands.	The Service will continue to comply with this Act under the CCP.
Executive Order No. 11593, Protection and Enhancement of the Cultural Environment	States that if the Service proposes any development activities that may affect archaeological or historical sites, the Service will consult with Federal and State Historic Preservation Officers to comply with Section 106 of the National Historic Preservation Act of 1966, as amended.	The Service will continue to comply with this Order under the CCP.

Table 1. Applicable Laws and Executive Orders		
Law, Regulation, or Guideline	**Description**	**Relation to the CCP**
Native American Graves Protection and Repatriation Act of 1990 (PL 101-601; 25 USC 3001 et seq.)(NAGPRA)	Regulations for the treatment of Native American graves, human remains, funeral objects, sacred objects, and other objects of cultural patrimony. Requires consultation with Native American Tribes during Federal project planning.	The Service will continue to comply with this Act under the CCP.
Archaeological Resources Protection Act of 1979 (PL 96-95; 93 STAT 722; 16 USC 470aa-47011), as amended (ARPA)	Protects archaeological resources on public lands.	The Service will continue to comply with this Act under the CCP.
Executive Order 13007, Indian Sacred Sites. 24 May, 1996	Provides for access to, and ceremonial use of, Indian sacred sites on Federal lands used by Indian religious practitioners and direction to avoid adversely affecting the physical integrity of such sites.	The Service will continue to comply with this Order under the CCP.
American Indian Religious Freedom Act 1978 (PL 95-341; 92 STAT 469; 42 USC 1996)	Provides for freedom of Native Americans to believe, express, and exercise their traditional religion, including access to important sites.	The Service will continue to comply with this Act under the CCP.
Archaeological and Historic Preservation Act of 1974 (PL 93-291; 88 STAT 174; 16 USC 469)	Provides for the preservation of historical buildings, sites, and objects of national significance.	The Service will continue to comply with this Act under the CCP.
Archaeological Resources Protection Act of 1979	Protects materials of archeological interest from unauthorized removal or destruction and requires Federal managers to develop plans to locate archeological resources.	The Service will continue to comply with this Act under the CCP.
National Historic Preservation Act of 1966 (PL 89-665; 50 STAT 915; 16 USC 470 et seq.; 36 CFR 800), as amended (NHPA)	Requires Federal agencies to consider the effects of any actions or programs on historical properties.	The Service will continue to comply with this Act under the CCP.
Biological Resources Regulations		
Endangered Species Act of 1973 (16 USC 1531 et seq.), as amended (ESA)	Provides for protection of plants, fish, and wildlife that have a designation as threatened or endangered.	An Intra-Service Section 7 has been completed with the Service for endangered and threatened species on the Refuge. Future consultation with NOAA-Fisheries for endangered and threatened species under their jurisdiction may be conducted when specific restoration projects have been identified.

Table 1. Applicable Laws and Executive Orders		
Law, Regulation, or Guideline	**Description**	**Relation to the CCP**
National Environmental Policy Act of 1969 (42 USC 4321 et seq) (NEPA)	Requires analysis, public comment, and reporting for environmental impacts of Federal actions.	The public has been notified of the availability of the draft Environmental Assessment and had a 30-day period to provide comments.
Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds. Jan. 10, 2001.	Instructs Federal agencies to conserve migratory birds by several means, including the incorporation of strategies and recommendations found in Partners in Flight Bird Conservation Plans, the North American Waterfowl Plan, the North American Waterbird Conservation Plan, and the United States Shorebird Conservation Plan, into agency management plans and guidance documents.	The Service has incorporated the strategies and recommendations of the listed management plans into the CCP to conserve migratory birds. The Service will continue to comply with this Order under the CCP.
Fish and Wildlife Conservation Act of 1980 (16 USC 661-667e), as amended	Requires the Service to monitor non-gamebird species, identify species of management concern, and implement conservation measures to preclude the need for listing under ESA.	The Service will continue to comply with this Act under the CCP.
Migratory Bird Treaty Act of 1918, as amended (MBTA)	Provides protection for bird species that migrate across state and international boundaries.	The Service will continue to comply with this Act under the CCP.
The Clean Water Act of 1972, Section 404 (33 USC 1344 et seq.), as amended	Provides for protection of water quality.	The Service will continue to comply with this Act under the CCP.
Fish and Wildlife Act of 1956 (16 USC 742a-743j)	Provides Secretary of Interior with authority to protect and manage fish and wildlife resources.	The Service will continue to comply with this Act under the CCP.
National Wildlife Refuge System Volunteer and Community Partnership Enhancement Act (1998)	Amends the Fish and Wildlife Act of 1956 to promote volunteer programs and community partnerships for the benefit of national wildlife refuges, and for other purposes	The Service will continue to promote volunteer programs and community partnerships under the CCP.
Fish and Wildlife Coordination Act of 1958	Requires equal consideration and coordination of wildlife conservation with other water resource development programs.	The Service will continue to comply with this Act under the CCP.
Emergency Wetlands Resources Act of 1986	Promotes the conservation of migratory waterfowl and offsets or prevent the serious loss of wetlands by the acquisition of wetlands and other essential habitats.	The Service will continue to comply with this Act under the CCP.
Federal Noxious Weed Act of 1990	Requires the use of integrated management systems to control or contain undesirable plant species, and an interdisciplinary approach with the cooperation of other Federal and State agencies.	The Service will continue to comply with this Act under the CCP.

Table 1. Applicable Laws and Executive Orders		
Law, Regulation, or Guideline	**Description**	**Relation to the CCP**
Executive Order 13112, Invasive Species, 1999	Directs federal agencies to prevent introduction and provide control of invasive species.	The Service will continue to comply with this Act under the CCP.
Rivers and Harbor Act of 1899	Requires authorization by the U.S. Army Corps of Engineers prior to any work in, on, over, and under a navigable water of the U.S.	The Service will continue to comply with this Act under the CCP.
Hazardous Materials Regulations		
Oil Pollution Act of 1990 (PL 101-380; 33 USC 2701, et seq.)	Provides oil pollution policies and protections.	The Service will continue to comply with this Act under the CCP.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (PL 96-510; 42 USC 9601, et seq.) (CERCLA)	Provides mechanism for hazardous waste clean up.	The Service will continue to comply with this Act under the CCP.
Land and Water Use Regulations		
The National Wildlife Refuge System Administration Act of 1966 (16 USC 668dd-668ee), National Wildlife Refuge System Improvement Act of 1997 (PL 105-57)	Administration, management, and planning for National Wildlife Refuges, Amends the National Wildlife Refuge System Administration Act of 1966. Requires development of CCPs for all refuges outside of Alaska.	The Service determined that research, haying, livestock grazing, wildlife observation and photography, environmental education and interpretation, hunting, fishing, recreational boating, and bicycling are compatible with the purposes for which the refuge was established. This document will satisfy this Act.
Executive Order No. 11988, Floodplain Management	Provides for the support, preservation, and enhancement of the natural and beneficial values of floodplains.	No structure that could either be damaged by or significantly influence the movement of floodwater in the project area is planned for construction by the Service, thus the proposed action is consistent with this Order.
Executive Order No. 11990, Protection of Wetlands	Provides for the conservation of the natural and beneficial values of wetlands and their associated habitats.	The Service plans no detrimental impacts to wetlands but plans to preserve, enhance, and restore wetlands in the project area, thus the proposed action is consistent with this Order.

Table 1. Applicable Laws and Executive Orders		
Law, Regulation, or Guideline	**Description**	**Relation to the CCP**
The Refuge Recreation Act of 1962, as amended	Provides for recreation use that is compatible with the primary purpose of a refuge.	The Service determined that recreation including hunting, fishing, wildlife observation, photography, environmental education, interpretation, bicycling, and recreational boating are compatible with the purposes for which the Refuge was established.
Fish and Wildlife Improvement Act of 1978	Improves administration of fish and wildlife programs and amends earlier laws including Refuge Recreation Act, NWRS Administration Act, and Fish and Wildlife Act of 1956. Authorizes the Secretary to accept gifts or real and personal property on behalf of the U.S. Also authorizes use of volunteers on Service projects and appropriations to carry out a volunteer program.	The Service will continue to comply with this Act under the CCP.
Land and Water Conservation Fund Act of 1948	This act provides funding through receipts from the sale of surplus federal land, appropriations from oil and gas receipts from the outer continental shelf, and other sources of for land acquisition under several authorities. Appropriations from the fund may be used for matching grants to states for outdoor recreation projects and for land acquisition by various federal agencies, including the Fish and Wildlife Service.	The Service will continue to comply with this Act under the CCP.
Migratory Bird Conservation Act of 1929 (16 U.S.C. 715-715d, 715e,715f-715r)	Established the Migratory Bird Conservation Commission. The Commission approves acquisition of land and water, or interests therein, and sets the priorities for acquisition of lands by the Secretary for sanctuaries or for other management purposes.	The Service will continue to comply with this Act under the CCP.
Wilderness Act of 1964 (16 U.S.C. 1131-1136; 78 Stat. 890)	Directs the Secretary of the Interior to review, within ten years, every roadless area of 5,000 acres or more and every roadless island regardless of size within the National Wildlife Refuge System and to recommend suitability of each such area.	The Refuges do not contain 5,000 acres of roadless land.

Appendix N. Appropriate Uses

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Don Edwards San Francisco Bay NWR

Use: Livestock Grazing

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: Eric C. May Date: 2/29/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: D. Zmeher Date: 3/19/2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Appropriate Use Justification: Livestock Grazing

The Warm Springs sub-unit of the Refuge supports vernal pools and upland grasslands. Currently a livestock grazing program is used to control non-native invasive grasses on the site. Grazing has had a positive impact on native vernal pool and upland vegetation by decreasing competition with non-native grasses. Without grazing the site would become overgrown with weeds. Grazing is an appropriate and easily controllable tool to manage wildlife habitats.

c. Service policy recognizes the importance of preventing the introduction and controlling populations of invasive species as noted in 601 FW 3 3.16(A), Biological Integrity, Diversity, and Environmental Health. Grazing is a tool consistent with that policy that will reduce competition from non-native species, allowing native vernal pool and grassland upland vegetation to thrive.

e. The grazing program will be directed and refined by a grazing plan for the Warms Springs sub-unit, that will be completed in the life of the Refuge's comprehensive conservation plan. The goal of the grazing plan will be to restore native grasslands and enhancing vernal pool habitat to some degree through this use.

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Don Edwards San Francisco Bay NWR

Use: Recreational Boating

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	YES	NO
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: Eric C. M[illegible] Date: 2/29/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: Dave Lin[illegible] Date: 3/20/2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Appropriate Use Justification: Recreational Boating

i/j. Boating facilitates wildlife observation, photography, fishing, and hunting, which are four of six priority public uses (the other uses are environmental education, and interpretation) promoted in the National Wildlife Refuge System Improvement Act of 1997. Boating is only permitted on navigable sloughs and the open water of the Refuge. Boating is an appropriate method of conveyance on some areas of the Refuge as it does not detract from the wildlife mission of the Refuge and facilitates access to and from the Refuge. This use encourages the public to access the Refuge and appreciate the wildlife values found there.

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Don Edwards San Francisco Bay NWR

Use: Research and Monitoring

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	**YES**	**NO**
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?	✓	
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), or (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: Eric C. [illegible] Date: 2/29/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: Dave Lineham Date: 3/20/12

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Appropriate Use Justification: Research and Monitoring

The Don Edwards San Francisco Bay NWR (Refuge) biological program encourages outside experts in a variety of natural and physical science disciplines to conduct research that contribute to management of species and habitats found on the Refuge. Research and monitoring by outside experts include: monitoring and control of non-native invasive weed species, monitoring and enhancement of habitat for migratory birds, monitoring and enhancement of habitat for endangered species (e.g., the western snowy plover, vernal pool tadpole shrimp, salt marsh harvest mouse, California clapper rail). Research and monitoring provided by others support our efforts to effectively manage the Refuge. Research and monitoring permitted on the Refuge are those that are geared toward improving management or monitoring capabilities. Research and monitoring are appropriate tools to gain additional knowledge for managing the Refuge.

FINDING OF APPROPRIATENESS OF A REFUGE USE

Refuge Name: Don Edwards San Francisco Bay NWR

Use: Mosquito Management

This form is not required for wildlife-dependent recreational uses, take regulated by the State, or uses already described in a refuge CCP or step-down management plan approved after October 9, 1997.

Decision Criteria:	**YES**	**NO**
(a) Do we have jurisdiction over the use?	✓	
(b) Does the use comply with applicable laws and regulations (Federal, State, tribal, and local)?	✓	
(c) Is the use consistent with applicable Executive orders and Department and Service policies?	✓	
(d) Is the use consistent with public safety?	✓	
(e) Is the use consistent with goals and objectives in an approved management plan or other document?	✓	
(f) Has an earlier documented analysis not denied the use or is this the first time the use has been proposed?	✓	
(g) Is the use manageable within available budget and staff?	✓	
(h) Will this be manageable in the future within existing resources?	✓	
(i) Does the use contribute to the public's understanding and appreciation of the refuge's natural or cultural resources, or is the use beneficial to the refuge's natural or cultural resources?		✓
(j) Can the use be accommodated without impairing existing wildlife-dependent recreational uses or reducing the potential to provide quality (see section 1.6D, 603 FW 1, for description), compatible, wildlife-dependent recreation into the future?	✓	

Where we do not have jurisdiction over the use ("no" to (a)), there is no need to evaluate it further as we cannot control the use. Uses that are illegal, inconsistent with existing policy, or unsafe ("no" to (b), (c), **or** (d)) may not be found appropriate. If the answer is "no" to any of the other questions above, we will **generally** not allow the use.

If indicated, the refuge manager has consulted with State fish and wildlife agencies. Yes ✓ No ___

When the refuge manager finds the use appropriate based on sound professional judgment, the refuge manager must justify the use in writing on an attached sheet and obtain the refuge supervisor's concurrence.

Based on an overall assessment of these factors, my summary conclusion is that the proposed use is:

Not Appropriate_____ **Appropriate** ✓

Refuge Manager: Eric C. [illegible] Date: 2/21/2012

If found to be **Not Appropriate**, the refuge supervisor does not need to sign concurrence if the use is a new use.

If an existing use is found **Not Appropriate** outside the CCP process, the refuge supervisor must sign concurrence.

If found to be **Appropriate**, the refuge supervisor must sign concurrence.

Refuge Supervisor: Dave Lanerian Date: 3/20/2012

A compatibility determination is required before the use may be allowed.

FWS Form 3-2319
02/06

Appropriate Use Justification: Mosquito Management

c. Service policy recognizes the importance of maintaining a balanced ecosystem landscape through wildlife population management as noted in 601 FW 3 3.14(B), Biological Integrity, Diversity, and Environmental Health. Controlling mosquito populations is consistent with that policy by reducing wildlife threats from mosquito-borne diseases, such as transmission of West Nile Virus to migratory birds.

d. With the spread of mosquito-borne diseases across the country, there is increasing pressure to manage mosquito populations that occur on lands of the National Wildlife Refuge System, especially in wetland areas such as the Refuge. There are six primary mosquito species that breed on the Refuge: *Aedes dorsalis, Aedes squamiger, Aedes washinoi, Culex erythrothorax, Culex tarsalis, and Culiseta inornata. Culex tarsalis* has the potential to be in the area and shows the greatest potential to amplify and maintain West Nile Virus in California. While mosquitoes are a natural component of wetlands, we recognize that they may pose a threat to human and wildlife health (e.g., West Nile Virus).

e. No current approved management plan exists. However, the use is consistent with the draft comprehensive conservation plan and the Service's Draft Mosquito and Mosquito-Borne Disease Management Policy (601 FW 7).

g/h. Use will be conducted by local mosquito abatement districts.

i. This use could have adverse impacts on the Refuge's natural resources. However, primary treatment of mosquitoes on the Refuge uses the least toxic pesticides (i.e., biological controls such as Bti (larvacides) and methoprene (pupacides) with minimal environmental impacts. If these areas were not treated when needed, larger mosquito populations could be produced resulting in the need to treat much larger areas with more toxic pesticides (such as adulticides) to minimize public health hazards.

j. Mosquito control is not expected to substantially impair wildlife-dependent recreational uses on the Refuge because control is not likely to take place on a daily or regular occurrence. Wildlife-dependent uses on the Refuge may be temporarily displaced, but are not expected to be excluded by mosquito control activities. Mosquito control will benefit wildlife-dependent recreational uses by providing a more pleasant visitor experience.

Appendix O. Persons Responsible for Preparing this Document, Core Team Members and Expanded Team Members

Persons Responsible for Preparing this Document, Core Team Members and Expanded Team Members

Core Team Members

Eric Mruz	Refuge Manager, Don Edwards San Francisco Bay NWR
Melisa Helton	Wildlife Refuge Specialist, Don Edwards San Francisco Bay NWR
Winnie Chan	Refuge Planner, San Francisco Bay NWR Complex
Jennifer Heroux	Visitor Services Chief, San Francisco Bay NWR Complex
Genie Moore	Environmental Education Center Director, Don Edwards Don Edwards San Francisco Bay NWR
Cheryl Strong	Wildlife Biologist, Don Edwards San Francisco Bay NWR
Rachel Tertes	Wildlife Biologist, Don Edwards San Francisco Bay NWR
Meg Marriott	Wildlife Refuge Specialist (former), Don Edwards San Francisco Bay NWR
Ivette Loredo	Wildlife Refuge Specialist, Don Edwards San Francisco Bay NWR
Tia Glagolev	Instructional Systems Specialist, Don Edwards San Francisco Bay NWR
Carmen Leong-Minch	Outdoor Recreation Planner, Don Edwards San Francisco Bay NWR
Kimby Wells	Environmental Education Specialist, Don Edwards San Francisco Bay NWR
Paul Mueller	Volunteer Coordinator, Don Edwards San Francisco Bay NWR
Eric McKee	Slow the Flow Program Coordinator, Don Edwards San Francisco Bay NWR, Environmental Education Center
Debra King	Interpretive Specialist/Watershed Watchers Program Coordinator, San Francisco Bay Wildlife Society, Don Edwards SF Bay NWR, Environmental Education Center
David Thomson	San Francisco Bay Bird Observatory

Expanded Team Members

Sallie Hejl	Regional Biologist, Pacific Southwest Region, USFWS
Brian Popper	USDA Wildlife Services
Chindi Peavey	San Mateo Mosquito and Vector Control District
James Counts	San Mateo Mosquito and Vector Control District
Noor Tietze	Santa Clara County Vector Control District
Nayer Zahiri	Santa Clara County Vector Control District
John Rusmisel	Alameda County Mosquito Abatement District
Erika Castillo	Alameda County Mosquito Abatement District

Appendix P. Response to Comments

1. INTRODUCTION

This appendix contains a summary of all comments that were received in response to the Draft Comprehensive Conservation Plan and Environmental Assessment (Draft CCP/EA) for Don Edwards San Francisco Bay National Wildlife Refuge (Refuge) during the official 30-day public comment period. Public comments on the Draft CCP/EA were accepted from May 16, 2012 to July 2, 2012. Some comments received shortly after this closing date were also accepted and analyzed.

All comments were reviewed and organized so that an objective analysis and presentation of the comments could be made (Section 2). Refuge responses are included in Section 3. The names and affiliations of all of the people who commented are listed in Section 4.

2. SUMMARY OF COMMENTS RECEIVED

The Refuge received a total of 18 comment letters (via fax, email, and letter) on the Don Edwards San Francisco Bay NWR CCP/EA during the comment period. Hardcopies and CDs of the Draft CCP/EA were mailed out to interested parties and available for the public to review at the San Francisco Bay NWR Refuge Complex, and the U.S. Fish and Wildlife Service, Pacific Southwest Region, Planning Office.

Affiliation Type	**Numbers of Comment Letters Received**
State Agencies	1
Local Agencies	5
Organizations	5
Public	5
Private Company	2
TOTAL	18

3. SUMMARY OF COMMENTS AND REFUGE RESPONSES

This section provides a summary of the individual comments received on the Draft CCP/EA, followed by the Refuges' responses to those comments. The comments were organized into topic areas:

A. Cultural Resources
B. Habitat Management and Restoration
C. Wildlife Management
D. Public Access
E. Environmental Education
F. Staffing
G. Jurisdiction and Acquisition
H. Mosquito Management
I. Other Projects
J. Climate Change

Every effort was made to present all substantive comments in this summary; the specific comments presented here are a representative sample of all the comments received. A comment that addressed several issues was sometimes placed in a single bullet, in the section to which it

was most closely related. Therefore, there is some overlap between topics. The Refuge response follows each group of comments. A copy of all of the original comments received on the Draft CCP/EA is maintained on file at San Francisco Bay National Wildlife Refuge Complex (Complex).

A. Cultural Resources

A.1. Comment: I would like to see the plan address or identify coordination and support of activities for appropriate archaeological investigation, recording, and (if appropriate) preservation of these resources, especially those that are not to be (or may not be) preserved (e.g., Drawbridge, salt ponds, Oliver Salt Works [Archimedes Screw Pumps]). (Bamford)

Refuge Response: Some Refuge sites have been investigated, recorded, and preserved (as needed). Cultural assessments on areas of the Refuge not yet surveyed will be conducted as funding and priority permits.

A.2. Comment: The draft CCP/EA should evaluate potential submerged cultural resources in the CCP tidelands. The California State Lands Commission (CSLC) maintains a shipwrecks database, available at http://shipwrecks.slc.ca.gov that can assist with this analysis. The database includes known and potential vessels located on the State's tide and submerged lands; however, the locations of many shipwrecks remain unknown. Please note that any submerged archaeological site or submerged historic resource that has remained in state waters for more than 50 years is presumed to be significant. (CSLC)

Refuge Response: A search of the shipwrecks database did not yield any shipwrecks in the Refuge. There was one shipwreck located near the Refuge, between Bair Island and Greco Island. We do not anticipate any tidal restoration or habitat enhancements in this area, and therefore do not expect there will be any impacts to this shipwreck site as a result of the CCP. We will update the shipwreck database and evaluate any submerged cultural resources within the Refuge as they become known.

A.3. Comment: The draft CCP/EA should also mention that the title to all abandoned shipwrecks, archaeological sites, and historic or cultural resources on or in the tide and submerged lands of California is vested in the State and under the jurisdiction of the CSLC. The recovery of objects from any submerged archaeological site or shipwreck may require a salvage permit under Public Resources Code section 6309. CSLC staff requests that the USFWS consult with Senior Staff Counsel Pam Griggs at the contact information noted at the end of this letter, should any cultural resources be discovered during implementation of the CCP. (CSLC)

Refuge Response: If any submerged cultural resources are found during our CCP implementation, we will consult with CSLC (Pam Griggs) or Senior Staff.

B. Habitat Management and Restoration

B.1. Comment: Alameda County Water District (ACWD) requests that the CCP/EA include the provision that field activities are coordinated with ACWD so that: a) ACWD can assist in identifying the location of abandoned wells, and b) any wells identified or discovered during construction activities are properly destroyed in accordance to ACWD

Well Ordinance 2010-01. In addition, ACWD requests that the CCP/EA include the provision that ACWD is notified of any future channel improvements and levee breaches, so that any abandoned wells in the area are located and properly destroyed before such improvements or breaches are implemented. (ACWD)

Refuge Response: The Refuge will coordinate with ACWD to identify and locate abandoned wells on the Refuge, as well as activities associated with any restoration work including levee breaches.

B.2. **Comment:** As required by ACWD's Well Ordinance No. 2010-01, drilling permits are required prior to the start of any subsurface drilling activities for wells, exploratory holes, and other excavations. (ACWD)

Refuge Response: The Refuge will comply with needed drilling permits under ACWD Well Ordinance No. 2010-01 for any drilling that may occur on the Refuge.

B.3. **Comment:** ACWD requests that the CCP/EA address maintaining access to ACWD's wells. (ACWD)

Refuge Response: The Refuge will continue to work with ACWD for access to existing monitoring wells.

B.4. **Comment:** When water system facilities were installed during the construction of the Complex in the late 1970s, the water main and appurtenances were installed by the Refuge. The General Services Administration (GSA), on behalf of the Refuge, entered into a 10-year agreement which provided for ACWD to use and maintain the water main as part of the public water distribution system. In the intervening decades, ACWD and the GSA have renewed the 10-year agreement. However, the most recent agreement has expired, and ACWD's roles and responsibilities, as well as those of the GSA and Refuge, for the water main and appurtenances to the Complex are unclear. (ACWD)

Refuge Response: The Refuge will coordinate with GSA and ACWD to find a solution for the expired 10-year agreement.

B.5. **Comment:** It is unclear as to whether the analysis is intended to be at a programmatic or project level. Upon review of the EA, (CSLC) staff finds that the level of detail and analysis in the EA is more consistent with a programmatic document. In addition, there are several references indicating that additional NEPA analysis would be conducted. For example, page B-51 of the EA states: "As site-specific designs are developed at these other marsh areas, further NEPA documentation will be completed." Therefore, CSLC staff assumes that more detail regarding proposed construction activities, and analysis of those activities, would be provided in subsequent NEPA documents prior to implementation of the CCP. (CSLC)

Refuge Response: The CCP is intended to be a programmatic document. Any future restoration projects prescribed in the CCP will likely require the Refuge to comply with laws and regulations such as National Environmental Policy Act, Endangered Species Act Section 7 consultation, and CEQA.

B.6. Comment: Page B-39 of the EA states that the EA and CCP identify measures that would avoid and minimize any environmental impacts that could occur during implementation of the CCP. However, the potential impacts have not been quantified and no formal mitigation measures are called out for impacts specific to the CCP. One example of how mitigation has been treated in the CCP/EA is provided on page B-41, under Water Quality and Contaminants, where it states that "Mitigation measures adopted in the Records of Decision for the Bair Island and SBSP projects incorporated best management practices that include the use of barriers to prevent sediment from flowing off the Refuge, thus minimizing impacts to water quality." As water quality impacts are anticipated outside of the Bair Island and SBSP project areas, this mitigation should be modified to reflect all potential impacts included under the CCP. In addition, per the Council on Environmental Quality (CEQ) NEPA Regulations, mitigation measures should be specific, tangible actions that will reduce a physical environmental effect. CSLC staff recommends that as details of the project components outlined in the draft CCP/EA are developed, specific, enforceable mitigation measures be included in subsequent environmental documents. (CSLC)

Refuge Response: Comment noted. More specific mitigation measures will be explored and prescribed as needed in future project-specific environmental documents.

B.7. Comment: CSLC staff recommends the inclusion of more detailed descriptions of the location and specifics of proposed activities in subsequent NEPA documents. (CSLC)

Refuge Response: See Refuge Response in B6. The Refuge will conduct NEPA analysis as needed on future construction activities that may occur.

B.8. Comment: The draft CCP/EA should detail and analyze the potential for construction activities to affect special-status plant or wildlife species that may occur in the Refuge area. In particular, the analysis should identify whether the proposed activities could adversely impact species such as Steelhead salmon that are likely to be present in associated marshes and small channels within the Refuge boundary where restoration or construction work would be conducted. The analysis should include a discussion of the potential turbidity, siltation, and other physical effects on all life stages of aquatic species. While CSLC staff recognizes that the Project is intended to conserve, enhance, and restore natural resources in the long-term, implementation of certain components of the CCP could nonetheless have effects that are adverse, either temporarily or permanently. If impacts to special-status species are found to be potentially significant, the EA should include feasible measures that could be implemented to avoid or substantially lessen the impact. (CSLC)

Refuge Response: Any construction or restoration activities which the Refuge conducts will need environmental permits and the assessment of biological impacts will be conducted and analyzed at that time.

B.9. Comment: Objective 1.1. Conduct standardized monitoring efforts and research projects in coordination with other regional efforts for salt marsh harvest mouse and California clapper rail within five years. Improve high tide refugia for these species.

Strategy 5 - "Expand high marsh and the ecotone/transition zone wherever possible to benefit these species." Does this pertain to acquisition of these habitats as well as expansion of existing habitat? The strategies for snowy plover expressly states, "Identify appropriate snowy plover habitat in approved acquisition boundary to prioritize for acquisition or protection." Acquisition of high marsh and ecotone/transition zone should be incorporated explicitly as a strategy for the salt marsh harvest mouse and California clapper rail. (CCCR)

Refuge Response: Comment noted. A strategy has been added regarding acquisition of habitat for the salt marsh harvest mouse and California clapper rail.

B.10. Comment: Suggested edits of CCP narrative:
p. 37 - We propose the following change to the text regarding salt ponds in Redwood City:

The remaining 1400 acres of ponds are located on the west side of San Francisco Bay in close proximity to the Refuge's Greco Island tidal marsh and Ravenswood complex. These ponds continue to function on a limited basis as salt-producing crystallizer and bittern ponds and multi-use areas under Cargill Salt ownership. Cargill Salt is in the process of determining the regulatory feasibility of developing some portion of this Redwood City salt pond site. Use of this site by thousands of migratory and wintering waterfowl for roosting and foraging is well-documented.

The rationale for making this change is that there are actually 1400 or 1436 acres of salt ponds at the Redwood City site and the description provided of the location of these ponds is confusing. The use of the site by waterbirds is well documented. (CCCR)

Refuge Response: The acreage for the salt ponds in Redwood City owned by Cargill Salt has been updated to 1400 acres. However, because these lands are not part of the West Bay Unit, the description of these lands has been moved to 3.6.1 Land Use, Existing Uses Surrounding the West Bay Unit. We have added a reference regarding known bird use on the site. We have revised the description of development plans for the site to, “Cargill Salt is in the process of preparing a development plan for these ponds”, per information from the Redwood City Planning web page.

B.11. Comment: p. 120 - The description of the Redwood City salt ponds should be revised as suggested above. 1,300 acres should be changed to either 1,400 or 1,436 acres - both figures have been cited. The current status should be revised to: "Cargill Salt is in the process of determining the regulatory feasibility of developing some portion of this Redwood City salt pond site." At this time we do not know whether restoration of the site will be proposed.

Refuge Response: See previous response to Comment B.10.

B.12. Comment: p. 98 - The statement "In the South Bay, several waterfowl breeding areas occurs near, or adjacent to the Refuge. These include..." The former Whistling Wings and Pintail Duck Clubs in Newark should be added to the list of sites. (CCCR)

Refuge Response: Comment added.

B.13. Comment: Preferred alternative:
The CCP describes three potential implementation alternatives. Alternative A, the no action alternative, represents the current level of management. Alternative B would provide moderate increases in wildlife and habitat management, visitor services and environmental education. Alternative C would provide substantial increases in the activities identified in Alternative B. The Refuge has identified Alternative B as the preferred alternative. In general we support the identification of Alternative B as the preferred alternative, however, we believe it is important that the following actions should be included in Alternative B:

- Monitor population density, presence/absence, abundance, and/or cover on focal plant and animal species every five years.
- Survey/monitor for Suisun thistle, salt marsh bird's beak, soft bird's beak, and California sea-blite distribution and abundance
- Further control of weeds; for example, reduce cover of invasive perennial pepperweed on the Refuge by 50 percent of 2010-2011 baseline inventory within threatened and endangered species habitat (high tide refugia, transition zone and tidal areas)
- Enhance and restore marsh-upland ecotone along all levees in the Ravenswood and Alviso pond systems through established dominance (>50%) of native plants. (CCCR)

Refuge Response: With regard to bullet one and four above, these actions require a very high level of funding and staffing that we do not believe possible with budget projections. We have added the second bullet to the CCP. We will consider the third bullet after the implementation of the Weed Management Plan.

C. Wildlife Management

C.1. Comment: With respect to the non-lethal methods of avian predator mitigation, I did not see provisions for monitoring mortality and injury/recovery against acceptable levels. Acceptable levels and periodic measurement would appear to be necessary for ensuring that the trapping/relocation activities are achieving a desired balance between the adverse effects on predators and on prey. (Bamford)

Refuge Response: Birds that are removed via non-lethal methods (i.e., live-trapped and relocated) are handled as minimally as possible and quickly relocated (generally less than 48 hours) in order to reduce any risk to mortality (per Migratory Bird Treaty Act (MBTA) requirements). Biologists observe the bird after capture and prior to release to insure the bird is healthy and uninjured. These individuals are also banded should they be sighted or recaptured; some individuals have even returned to capture sites. While we do not have long-term monitoring of relocated individuals, there is a long history of trapping raptors safely and releasing them for research and rehabilitation around the world. We only use traps that have been approved in a MBTA permit issued by the Migratory Bird Division of the U.S. Fish and Wildlife Service. Further, only a few individual predators would be removed and is not anticipated to have a population-level effect on the species.

There is currently no funding to track birds once they have been released. Monitoring these individuals requires considerable effort and resources. The Migratory Bird Treaty Act requires that migratory birds be relocated as the preferred method for removing a problem individual.

Although being caught in a trap can stress a raptor, trapped birds rarely are injured physically. The most frequent causes of trap-related injury or death are predation and weather. Raptors may succumb to temperature extremes or predation if allowed to struggle in traps for long periods. Used properly, the traps discussed in this chapter should rarely result in severe injury or death. (Source: Bird, David and Bildstein, Keith. 2007. Raptor Research and Management Techniques. Raptor Research Foundation. 464pp.)

C.2. Comment: We ask that the CCP 1) refer to the Burrowing Owl Conservation Strategy for updated information, 2) that management to enhance habitat for burrowing owls be included in the CCP, and 3) that Refuge expansion land acquisition strategy includes land for burrowing owls.

Specific recommendations:

- Please discuss burrowing owl habitat in the context of Grassland Habitat (CCP page 68).
- Please compare proposed methods for weed control in grassland and ruderal habitats for potential impacts to burrowing owls, and develop methods to avoid adverse impacts and to enhance the habitat for the owls (CCP page 151).
- Please add to the CCP an objective that aims to increase burrowing owl reproductive success at the Refuge (Alviso area, Warm Springs.)
- Please expand Objectives 2.1, 2.2 and 2.3 of the CCP to include surveys and habitat enhancement for burrowing owls.
- Nesting burrowing owls have been reported at Whistling Wings and Pintail duck clubs. This area is within the Refuge Expansion Boundary. Please consider it a high priority for acquisition.
- Dog walking in upland areas (EA page B-16) could conflict with the preservation of upland and grassland species, including ground-nesting birds. In Santa Clara County, burrowing owls have stopped nesting in remnant upland areas around the Bay where dogs are allowed (Palo Alto, Sunnyvale etc.). Only 2% of the refuge consists of grassland, and presence of dogs there can potentially be impactful. Please analyze potential impacts of dog walking activity on grassland species, including discussion of the potential to restore habitat and recover the burrowing owl population in the South Bay. (SCVAS)

Refuge Response: Burrowing owls are discussed in the "Landbirds" section of Wildlife (3.4.4) in the CCP. We will update the CCP with more current information on this species. Thank you for the reference of the Burrowing Owl Conservation Strategy in the Santa Clara County Habitat Conservation Plan.

With regard to weed control efforts in grassland and ruderal habitats, all proposed methods for weed control will be further evaluated in our forthcoming Weed

Management Plan. At that time, proposed methods for weed control will discuss impacts to Refuge resources (Objective 2.2).

With regard to a burrowing owl objective, surveying, habitat enhancement and predator control are some examples of how the Refuge can support burrowing owl reproductivity. Objective 2.1 does include burrowing owls in Strategy 4: *Participate in and support national and regional monitoring efforts* (i.e., San Francisco Bay shorebird surveys, mid-winter waterfowl surveys, burrowing owl, harbor seal, etc.). The Refuge would be pleased to be included in the local planning and conservation efforts and could participate in or facilitate surveys on Refuge lands. A strategy was added to Objective 2.3 to survey burrowing owls on Warm Springs.

With regard to Objective 2.3, the specific strategies for habitat enhancement for any particular species will be covered in the step-down weed management plan by habitat type. The following parts of the CCP discuss management to enhance or create burrowing owl habitat:

- Mayhew's Landing Restoration Planning (Section 4.2 Habitat Enhancement and Restoration).
- Enhancement and restoration of the marsh-upland ecotone, especially at Faber-Laumeister, La Riviere Marsh, EEC, A6, A8, and 75 miles of levee (Objective 2.5).

With regard to acquisition for burrowing owl habitat, Objective 2.10 includes identifying and acquiring areas with the potential to be restored to burrowing owl habitat.

We recognize the potential conflict between dogs and wildlife and for this reason the Refuge is closed to dog walkers, with the single exception of the hill around headquarters. If burrowing owl habitat enhancement is successful here, then dogs will have been an "existing condition." All dogs in this area are required to be leashed because of its proximity to the office this is relatively easy to enforce. No new areas are proposed for access to dog walking. Areas that currently have burrowing owls include Warm Springs and New Chicago Marsh, neither of which is open to dogs.

C.3. Comment: Objective 2.1. Within ten years of plan approval, conduct baseline surveys for population density, presence/absence, and abundance and/or cover of priority native plants, fish, and wildlife to determine species diversity that will inform habitat enhancement actions. [emphasis added] The rationale for this objective states, "Monitoring changes in biotic and abiotic resources will help management make informed decisions or develop, refine, and evaluate achievement of fish, wildlife, and habitat management objectives." We fully support actions to obtain baseline data for populations, but are concerned that a deadline that may extend up to ten years from plan approval is too far into the future. The life of the current CCP is only fifteen years, which could mean that data necessary to make informed wildlife and habitat management decisions would not be available until the final five years of the CCP. We recognize that in the end staffing, workloads, and prioritization will influence how soon this information can be obtained. (CCCR)

Refuge Response: Based on the best professional judgment of the Refuge staff and with a realistic increase in funds, the timeframe of ten years is most feasible given current survey abilities and efforts.

D. Public Uses

D.1. Comment: Continue to allow leashed dogs on the lower Tidelands Trail, but post new signage at the bridges re-stating the leash requirement and the penalty for non-compliance. If possible increase enforcement. (Breaud)

Refuge Response: Comment noted. In order to be consistent with the other lands we manage on the Refuge, we plan to prohibit dog-walking on most trails in close proximity to tidal marsh. Increased enforcement and additional signage will be necessary to ensure compliance with this change.

D.2. Comment: I would like to see the plan address or identify coordination and support of activities for appropriate archaeological investigation, recording, and (if appropriate) preservation of these resources, especially those that are not to be (or may not be) preserved (e.g., Drawbridge, salt ponds, Oliver Salt Works [Archimedes Screw Pumps]). I would also encourage limited access (e.g., guided tours, with appropriate fees as at Vasco Caves in East Bay). (Bamford)

Refuge Response: Interpretive tours that offer a cultural resource history of the area are offered from time to time at the Refuge, and new opportunities will be offered on a rotating basis. We will consider limited access to cultural resources when public safety and protection of cultural resources permits.

D.3. Comment: I didn't see any references to the effects of lead shot. Presumably it was investigated and determined to not affect this plan. If so, would it be appropriate to mentioned in that in the plan? (Bamford)

Refuge Response: Our hunting regulations state that steel shot is required to hunt waterfowl anywhere in California. You cannot possess lead shot while hunting waterfowl." We do not allow possession of lead shot on the Refuge.

D.4. Comment: Pond A6 should be opened to waterfowl hunting, as that would create additional hunter opportunity (only 7,500 acres out of a total of 30,000 acres are currently open to hunting), help to better disperse hunters throughout the Refuge and not conflict with other recreational uses (recognizing this particular pond is rarely used by the public). CWA also supports the creation of a new universally accessible blind to increase opportunity for disabled and other hunters, but advises the Service to solicit input from the local hunting community as to its specific location. (CWA)

Refuge Response: After some consideration, we determined that opening Pond A6 would not be a viable long-term opportunity. Alviso Pond A6 restoration was completed in 2010 as a Phase 1 action of the South Bay Salt Pond Restoration Project. The goal for this restoration project is to create approximately 330 acres of tidal salt marsh and tidal channel habitat that will evolve over time. The elevation of Pond A6 is currently below mean tide level (3.3 feet NAVD) and below the elevation at which marsh vegetation

colonizes emerging mudflats. However, over time, Pond A6 restoration will initially create large areas of emergent mudflat habitat. In addition, tidal channel and vegetated salt marsh habitats are expected to develop in Pond A6 as tidal channels reform and as sediment accumulates and vegetation establishes on the emerging mudflats. Therefore, Pond A6 will not persist as a salt pond in the future to support the Refuge's waterfowl hunting program. In addition, a number of applied research studies are being implemented as part of Phase 1 to answer questions regarding key SBSP Project uncertainties related to ecosystem restoration. These ongoing studies in Pond A6 also preclude the Refuge from opening Pond A6 to waterfowl hunting or any other public uses.

We are unaware of any significant conflicts between hunters and other recreational users at this time. Regarding your comment on the universally accessible blind, we plan to solicit input from the local hunting community on its design and location.

D.5. Comment: The Service should increase the number of hunt program meetings, data collection and hunter outreach in order to best adapt the hunt program to the needs of its users over time. In addition, developing brochures, signage and exhibits regarding hunting will appropriately help to educate the non-hunting public as to the historical importance and current contribution of waterfowl hunting to wildlife conservation. (CWA)

Refuge Response: Comment noted. We plan to increase outreach to the hunting and non-hunting community on the Refuge hunt program.

D.6. Comment: Conversion of salt ponds to tidal marsh should be focused on those ponds which provide only marginal wildlife habitat value. Salt ponds which receive high waterfowl or shorebird use should be maintained as such, or enhanced by reducing salinity levels, for example. (CWA)

Refuge Response: There is an ongoing process via SBSPRP to determine the best mix of ponds, tidal marsh, and upland for the benefit of wildlife and people. We understand that this will be an adaptive process given what we learn as we restore/modify habitat.

D.7. Comment: Navigable water areas within the Refuge's boundaries should continue to be open for boat access and waterfowl hunting 7 days per week during waterfowl season. Due to a current limited number of boat ramps available adjacent to SF Bay, the addition of new boat ramps should be considered. The Service should also permit hunters to launch scull boats and other small, nonmotorized craft off Refuge land (e.g. levees) and into navigable sloughs in appropriate areas. (CWA)

Refuge Response: We concur, navigable waters within the Refuge boundaries will continue to remain open to boat access and waterfowl hunting per state regulations. For the Alviso Ponds, waterfowl hunting is only allowed on Wednesdays, Saturdays, and Sundays per Refuge regulation. Boat access is currently allowed at different off-Refuge locations (e.g., Alviso Marina, outside the HQ entrance). We will research boat ramps on-Refuge when resources and funds allow.

D.8. Comment: Guided tours through the hunt zones, if not properly coordinated during hunt season, will likely cause conflicts between recreational users and decrease the quality of the hunting experience such as that which sometimes occurs at Bair Island and the A2E Pond (adjacent to the Bay Trail). (CWA)

Refuge Response: We are unaware of any significant conflicts between hunters and other recreational users at this time. With any future public access to hunt areas, we plan to coordinate tours as well as provide information and signage to self-guided tours so to avoid conflict with the hunt season and hunt areas.

D.9. Comment: A predator management plan should not just focus on protecting shorebirds or endangered species, but also any nesting waterfowl. Predators, including skunks and raccoons, may significantly reduce waterfowl nesting success, particularly in small or isolated habitat areas. Studies have shown that focused predator control programs can lessen this effect, in some cases substantially. (CWA)

Refuge Response: Both the Mammalian and Avian Predator Management Plans (appended to the CCP) benefit migratory birds, including waterfowl. However, because the majority of predator management is conducted during the breeding season, March-September, waterfowl are not a focal species. Waterfowl are most abundant and diverse on the refuge during the winter migration.

D.10. Comment: The creation of islands in managed ponds to benefit nesting and roosting waterfowl and shorebirds should be evaluated and implemented, where appropriate. (CWA)

Refuge Response: Comment noted.

D.11. Comment: The Compatibility Determination for Wildlife Observation and Photography permits walking, hiking, jogging, and bicycling on Refuge Trails, including the Bay Trail. This determination uses old, general research instead of using up-to-date, local research from the Don Edwards National Wildlife Refuge and its vicinity. We ask that the determination be re-evaluated. Instead of a blanket compatibility determination, the CCP should create an appropriate trail use / public management plan based on local existing and predicted trail use patterns and on relevant local studies.

According to the Bay Trail website, the Bay Trail would also provide "a commute alternative for cyclists" (see http://www.baytrail.org/overview.html). This is of concern since employers in the valley (Facebook, Google, Apple and others) are expecting thousands of their employees to commute daily on the Bay Trail, and even provide amenities and incentives to encourage this use of the trail.

Please adjust EA Table 3 (EA page 79) to reflect the expected increase in number of commuters through the refuge.

Recent, local studies by Dr. Lynne Trulio and Jana Sokale (see links below) show that trail walkers disrupted nesting snowy plovers, causing them to leave their nests. The plovers returned to their nest fairly quickly, but even a short disturbance can have

temperature impact on nest success and catch the attention of predators. Faster movement on the trail was more impactful than slow movement.

Local studies also indicate significant response to trail use from migratory waterfowl. Dr. Trulio and Ms. Sokale's research indicates that trail use reduces the foraging area available to migratory waterfowl. Since each type of waterfowl has specific foraging needs, and given that the research focused on areas that have historically had high waterfowl counts, it is premature to conclude that trail use by the public is compatible with the mandate of the Refuge to protect wildlife. (SCVAS)

Refuge Response: We have not conducted or participated in any studies looking at the impacts of bicycling on wildlife response; the work by Trulio and Sokale is focused on people walking on the trails. Most of the trails located on the Refuge are less compatible with commuter bicycling due to the remote nature and lack of connectivity of these trails. Though, a notable exception to this is the Moffett Trail opened adjacent to pond A2W. In addition, commuters tend to prefer paved trails for ease of riding and the Refuge does not have any paved trails.

There is currently a trail already located along the levee at pond A16 and this area does not have a high use by bicycles. Even if the Bay Trail did include a connection to the A16 trail, this would not be paved, nor would it be any more connected to an area where people really commute to or from. Another paved trail is located adjacent to Highway 237 that is more convenient and connected for commuters.

Despite the connectivity of Refuge trails and in light of potential future increases of commuter bicycling as indicated on the Bay Trail website, we agree that further management planning and monitoring may be needed for the different uses on trails, but believe it would be better suited to a step-down planning process. We will consider revising existing or creating additional visitor services compatibility determinations during that step-down planning process, and have added a strategy to the CCP regarding the need to assess trail uses. During that process, we will consider the management tools that you suggest for reducing disturbance from trail uses.

Table 3 in the EA represents a 30 percent increase in nature trail use/wildlife observation between Alternative A (current management) and Alternative B. We believe this sufficiently includes the anticipated increases in nature trail use by commuters. Should monitoring or future reports show an increase in trail use greater than our estimate, we will revise these estimates and consider any management tools to reduce impacts to Refuge properties and resources.

D.12. Comment: Page 131, Section 3.6.2. Public Uses – Mowry Unit – The document states that the ponds are open to hunting seven days per week. Cargill has not been notified that these ponds are available for hunting. This is a safety issue for our employees and we would request a review of this refuge use. Cargill requests that the Refuge not open the Newark or Mowry Units for hunting because we continue to operate in these ponds and have a concern for employee safety, equipment, and levee maintenance. (Cargill)

Refuge Response: We currently do not allow hunting within the Newark Ponds as the CCP states, "Newark Unit: All Refuge ponds are closed to hunting." Tidal marsh areas outside the ponds are open to hunting and under the jurisdiction of the California Department of Fish and Game hunting regulations.

Waterfowl hunting for the Refuge was opened on September 8, 2004 (69 FR 54375). We allow hunting in Mowry Ponds M1 – M6 as was published in the Code of Federal Regulations (50 CFR 32): http://cfr.regstoday.com/50CFR32.aspx#50_CFR_32p8. Since this comment letter, the Refuge, in coordination with Cargill, has placed tighter restrictions on hunting regulations in these ponds to address safety issues for hunters, Cargill staff, and Refuge staff. As a result, the Refuge made minor updates to our 2012-2013 Waterfowl Hunting Regulations posted at: http://www.fws.gov/desfbay/Hunt/Hunt_Information.htm

We will continue to work with Cargill to ensure that the Refuge hunt program does not interfere with Cargill's salt-making process or pose safety concerns for individuals.

D.13. Comment: Page 159, Figure 18. Public Uses by Management Unit – This figure shows the Mowry Unit as a Hunt Area. As noted above, Cargill requests that the Refuge not open the Newark or Mowry Units for hunting because we continue to operate these ponds and have a concern for employee safety, equipment, and levee maintenance. (Cargill)

Refuge Response: Please see response for "Comment: Page 131, Section 3.6.2. Public Uses – Mowry Unit".

D.14. Comment: Page 161, Figure 19. Refuge Hunt Map - This figure shows the Mowry Unit as a Hunt Area. As noted above, Cargill requests that the Refuge not open the Newark or Mowry Units for hunting because we continue to operate these ponds and have a concern for employee safety, equipment, and levee maintenance. Also, Cargill's lands are depicted in the color gray on this map. Although, these lands are not shown as part of the hunt area, the CCP falsely represents that they are part of the Refuge. Please color Cargill's land in white on the map. (Cargill)

Refuge Response: We have revised the hunt map so it doesn't show Cargill's fee property in gray. It only identifies the areas that are open to hunting. Regarding hunting in the Mowry Ponds, please see response for "Comment: Page 131, Section 3.6.2. Public Uses – Mowry Unit".

D.15. Comment: One of the planning tools missing from the documents is a comprehensive Trails compatibility determination. Currently, the document preparers have treated trail use and management as a subtopic in the Wildlife Observation and Photography CD (WO&P CD) while, in fact, trails are key elements for *all* land-based priority uses, provide access for Refuge management and easement partners and are used informally for non-priority purposes. Even if trails were considered uniquely for each type of public uses and of operations there would be a need for cumulative review to assess the combined impacts from all types of trail use. (CCCR)

Refuge Response: We agree that the Refuge needs to take a more proactive role in managing and monitoring its trails. The author of this comment has noted a number of issues that could be solved or better managed through a thoughtful planning process. These issues include involvement in regional trails systems, user conflicts, and rules and regulation enforcement. We will address these issues as part of the visitor services step-down planning process which follows the CCP.

D.16. Comment: It is unknown if any other Refuges have comprehensive Trails CDs. Possibly such a CD would be first and unique. That would not be a surprise as this Refuge was unique as the first urban Refuge and urbanity will always be a factor of significance. Refuge trails repeatedly link with trail systems of the surrounding communities and particularly with the San Francisco Bay Trail (Bay Trail). These linkages have introduced non-priority uses mentioned previously. These are users for whom wildlife is secondary to access, are not the public users described in the 1997 Improvement Act and who value the Refuge primarily as a source of new managed trails.

Unfortunately, this people-value of Refuge trails is an impression that is currently presented to the public on maps of the Bay Trail. On its maps, in addition to agreed-to segments of Bay Trail on the Refuge (Marshlands Road, Tidelands Trail, Moffet/Bay Trail), a reader will see many miles of Refuge Trails incorrectly color-coded as the "Bay Trail." [See South Bay-Bay Trail map attached.]

A Trails CD can establish use priorities for each segment of the Refuge's 30 miles of trails and establish a basis against which trail traffic density, use type, user type, hour(s)-of-use, incidents of illegal or unsafe activity and maintenance requirements can be monitored to inform management. With habitat disturbance data for same/like areas, trail data can inform trail management, continuously monitoring compatibility status. Additionally a completed Trails CD, can inform agencies like ABAG/Bay Trail or community groups like bicycle coalitions.

To this end, modifications are needed for the CCP and EA Alternatives to incorporate the establishment of a Trail monitoring and management plan (Alternative B), per the stipulations of a Trails CD. (CCCR)

Refuge Response: Compatibility Determinations (CDs) are a tool for refuge managers to determine the compatibility of a use of refuge lands, such as hunting or wildlife photography, with the refuge purpose. CDs are not usually used to determine the compatibility of a thing, such as a trail, but the uses of the trail. The compatibility of the trail itself is determined by whichever standards were available at the time it was established. All new trails are reviewed either during the CCP planning process or under individual project NEPA evaluations. We agree that a systematic review and evaluation of uses on trails is needed, but believe it would be better suited to a step-down planning process. We will consider revising existing or creating additional visitor services compatibility determinations during that step-down planning process, and have added a strategy to the CCP regarding future assessment of trail uses.

D.17. Comment: It is true that some people use bicycles to move about the Refuge to participate in any of the prioritized uses. Even these bicyclists have responsibilities i.e.

to defer to other trail users to avoid disrupting their activity, to avoid bike-produced injuries and to move at low speed to avoid wildlife disturbance. Of greater concern for Refuge impact are bicycle-commuters, long-distance bicycle exercisers and large-group recreational bicyclists.

Throughout the San Francisco Bay Area, including the cities and counties in which the Refuge resides, agencies, businesses and local governments have initiatives underway encouraging thousands of residents to replace automobiles with bicycles. All indications are that those initiatives are succeeding. The routes that serve those initiatives include both roads and trails. For the Refuge, a particular impact is the Bay Trail. Adjoining that trail and the Refuge, or nearby, large businesses like Facebook and Google are funding Bay Trail improvements, for their own employee-bicycle commuters and those of numerous smaller businesses.

The WO&P CD, in a footnote, states: "The Bay Trail is a planned *recreational* corridor that, when complete, will encircle San Francisco and San Pablo Bays with a continuous 500-mile network of bicycling and hiking trails."[NOTE: italics added] While the Bay Trail website still states that the trail has a recreational purpose, there is undisguised evidence that the agency is actively working with partners to provide a trail that serves bicycle-commuting as well.

It is not surprising then that the newest Refuge trail, the Moffett/ Bay Trail, near Google and large industrial parks, is the Refuge's busiest. On a recent day one visitor reported that she walked out on that trail with a small group to observe wildlife. To her great annoyance, the group cut short their visit to escape the unrelenting disruption of speeding bicyclists. That is just one example of a nonpriority use undermining a priority use. While this site is an official Bay Trail segment, its usage must be managed to *enhance the priority use* such that the public gets the values intended by Congress.

Commute hours often coincide with optimal wildlife watching hours i.e. dawn and dusk. Any Refuge trail that includes commuters will disrupt wildlife observation and photography at least five days a week. The Refuge needs a trails plan that ensures that all new trails are reserved for priority uses. (CCCR)

Refuge Response: The Refuge is committed to continuing its participation in the Bay Trail program. However, as a National Wildlife Refuge within that system, we will work with the Bay Trail to get our refuge trails and lands accurately represented on their map system. We feel that clearer designations on the maps will help to alert future uses to the special purpose of our trails. Also, as part of our step- down planning for visitor services, we will consider ways to encourage priority uses of the trails and to discourage or mitigate non-priority uses, whether they are from the Bay Trail or not.

D.18. Comment: For many years, the Visitor Center in Fremont has been a water and toilet stop for bike clubs out on large group rides, usually on weekends. Without notice, suddenly the facilities will become overcrowded by non-priority users. Members of these groups do not hang around to enjoy wildlife as the ride is the "thing" as they head off along Marshlands Road. As the Bay Trail expands, such large groups will follow its route wherever it goes or is said to go e.g. per the Bay Trail map. There is no doubt that

these large speeding groups would dramatically disturb wildlife. Just as all organized races are banned from the Refuge, these informally organized rides must be specifically banned as well. (CCCR)

Refuge Response: Marshlands Road is the property of Caltrans and any issues with through use of the road by bicyclists would fall under their jurisdiction. The issue of the use of Refuge trails by large groups, whether biking or hiking, will be considered as part of the step down planning process.

D.19. Comment: The WO&P CD cites Federal Highway Administration 2001 standards for sidewalks and trails as a guide to trail design for planning for trail-sharing. That reference may inform structural planning but is not sufficient for the determination of shared-use priorities on a Refuge trail.

In the WO&P CD it is suggested that trail sharing can be informed by signage that promotes trail etiquette e.g.: "…bicycles should give an audible warning before passing other trail users." IF all trail users are moving in the same direction, there is space such that safety isn't a concern, and there is no wildlife present that would be disturbed by the sound or bike speed, that "etiquette" would apply.

But the same etiquette cannot and should not apply if it would disrupt priority uses. If one birdwatcher is on a trail, moving along carefully in hopes of a good sighting, any audible warning from a bicyclist would disrupt the activity and very likely cause birds to flee or remain hidden from view. If a large group blocks the trail, gathered to hear an interpretative leader discuss adjoining habitat and wildlife, there should be no expectation that the group give way to a bicyclist. Refuge priority etiquette should require a bicyclist to quietly dismount and walk past as space allows.

This etiquette is particularly important for non-priority bicyclists or joggers to understand. While compatibility may or may not exclude their trail use, the individuals need to be aware that their use is secondary and that rapid movement and loud noises disturb wildlife. I recall watching a jogger on the Mallard Slough Trail as he threw rocks at nesting terns that arose to fly toward and above him. He clearly did not understand the birds' action nor realize that he'd caused it.

A Trails CD needs to stipulate that priority-use bicycle riders on the Refuge have the responsibility to disrupt neither wildlife nor other trail users. It also should stipulate signage or other actions that educate non-priority users (e.g. exercisers) about the limits to their use of the facility and that the Refuge can prohibit their use if those limits are ignored. (CCCR)

Refuge Response: The National Wildlife Refuge System recognizes six priority uses of its lands: hunting, fishing, interpretation, environmental education, wildlife observation and wildlife photography. Hiking, biking, car touring, among others, are all potential methods for conducting these priority uses. Given the diversity of uses and ways of conducting these uses, there is the strong potential for conflicts between different user groups. As part of our step down planning process for visitor services, we will consider

ways to encourage priority uses of the trails and to discourage or mitigate non-priority uses. In addition, we will seek ways to manage trail user conflicts.

D.20. Comment: The WO&P CD and other documents stipulate that trail use will be monitored by periodic law enforcement with scheduled biological surveys used to report habitat disturbance. While there is every reason to praise the effort and intentions of Refuge staff, facts fly in the face of the effectiveness of this level of monitoring. In the years that the writer has worked with the Refuge, it is seldom that Refuge Law Enforcement (LE) is fully staffed and/or present, allowing for too frequent turnover and time given to training. Even so, and even with an added LE position, these particular 30,000 acres are an overwhelming stretch to monitor. Additionally, biological surveys are generally annual and cover limited ground. Again, it is difficult to consider these surveys as effective trail monitoring resources. (CCCR)

Refuge Response: Comment noted.

D.21. Comment: The documents do propose training all members of staff to be able to be able to answer questions and otherwise inform members of the public they each encounter in their jobs. This action may develop a new "anywhere" resource that could also contribute to trail monitoring. (CCCR)

Refuge Response: Comment noted.

D.22. Comment: At some locations, remote cameras could be used, compiling data for periodic review. It is possible that one or more academic institutions or researchers might be interested in designing and implementing portions of a suitable monitoring program. Another method could be volunteer Trail Stewards, possibly people who walk the trails already and would respond to training to be able to answer questions while also gathering data about the trail uses encountered. [Please also see comments below regarding volunteers.] (CCCR)

Refuge Response: The issues raised about trail monitoring are noted. The use of cameras and volunteer Trail Stewards will be considered as part of our step down planning process.

D.23. Comment: It is something of a surprise then to see boating listed in the CCP as Non-Wildlife Dependent Recreation (4.12.9, p. 174). As the Recreational Boating CD (RB CD) has a finding of "Use is compatible with Stipulations" it seems the use should have been classified as wildlife-dependent. Similarly, the EA Alternatives public use entries include multiple boating actions. *It would be helpful if these conflicting references were clarified for the final documents.* (CCCR)

Refuge Response: The discussion on boating has been moved to the hunting, fishing, and wildlife observation sections under the Current Management, Public Uses section of the CCP (4.12) as boating is used to facilitate these priority uses.

D.24. Comment: It has been at least a year since the State Coastal Conservancy approved the final EIR for the Water Trail, a plan designed to support increased number of and

improved sites for small-craft access to the Bay. Its initial planning actions have already begun, very possibly leading to ever greater numbers of boating visits to the edges of the Refuge. On occasions of the highest tides I have seen such boaters navigating in the middle of Greco Island and the marshes along Newark Slough. The Water Trail can make such instances of disturbance more frequent and possibly involve more boats per disturbance instance. As these very sensitive habitats support endangered species and can have no fences, extensive signage and outreach will be needed to inform boaters that the marshes are closed at all times.

The Water Trail Plan is neither mentioned nor discussed in the RB CD discussion but it and Refuge actions to protect wildlife from more frequent disturbance must be discussed. (CCCR)

Refuge Response: As part of their EIR, the Water Trail identified impacts to natural resources due to disturbance from increased boating use of Bay waters, and they have proposed mitigations. As of the current plan, no new public launch sites are planned within the refuge or within non-motorized boating distance of the refuge. The increased boat traffic that the Water Trail may create will be mitigated by their proposed measures. It is expected that the Water Trail's Educational, Outreach and Stewardship plan will help educate new and existing boaters to boating ethics with a strong emphasis on resource protection messages. The refuge has one representative on the Water Trail's Advisory Team, and we are involved in crafting these messages, the educational materials and launch site signage. All new signage will occur at launch sites. The refuge will continue to post boundary signs where appropriate. In addition, the refuge has proposed to develop and implement its own outreach program to promote responsible, water-based recreation (Objective 3.4).

D.25. Comment: It was startling to find no mention of harbor seals in the RB CD discussion of anticipated impacts and also to find no reference citations to scientific sources about Bay-resident seals. The annual spring closure of Mowry Slough (to protect the pupping site) is mentioned but without species-specific explanation. Harbor seals respond quite differently to boaters than do other species discussed in the RB CD, making it more important to include a thorough review of the anticipated impacts of boaters.

Refuge Biology staff have or have access to extensive South Bay harbor seal data and studies that must be considered as part of the RB CD. (CCCR)

Refuge Response: Comment noted. We have included additional details on harbor seals in the recreational boating CD.

D.26. Comment: As boating can be a vehicle for all of the priority public uses, the RB CD should review each of those uses, separately and cumulatively, if there may be anticipated impacts. For instance, it should consider impacts from fishing debris (fishing lines) and disturbance by photographers who may enter closed areas to get a better shot. (CCCR)

Refuge Response: Comment noted. The CDs for recreational boating, wildlife observation and photography, fishing, and hunting have been reviewed to assess anticipated impacts through boating.

D.27. Comment: None of the documents mention the PA Dock but it should be included. Small craft leaving that site can easily paddle to the Faber-Laumeister unit or to the shoreline edging Pond A1. This site has been identified by the Water Trail as suitable for support to improve it as a boating launch site i.e., it could handle more boater traffic in the years ahead. (CCCR)

Refuge Response: Comment noted. The Palo Alto Baylands launch site is included.

D.28. Comment: Knowing how long it takes for Refuge airboats to navigate to/from the Jarvis ramp on Newark Slough for annual rail surveys, it was good to see the concept of a Dumbarton boat ramp included. That ramp idea is not mentioned in the Biological Alternatives but it should be. Survey time is money. For Alternative C, a possible new LE boat launch site is mentioned to provide faster Bay access. While the primary use of the proposed ramp is described as public use, it makes planning sense to use the CCP to describe how the ramp could provide greater efficiency for Refuge operations.

As this ramp is conceptual at this time, it would be expected that a more complete proposal would undergo its own environmental review. (CCCR)

Refuge Response: Comment noted.

D.29. Comment: For years it was curious to me that the bridges that cross Newark Slough near Headquarters did not have "No Wake Zone" signs. Each winter, hunters that stayed out until the tides were almost too low to return, drove full throttle past Headquarters to the Jarvis ramp, their wakes washing broadly through the marshes. I don't know if those No Wake signs ever got posted but do understand that jurisdictional issues complicate most waterway signage situations.

One possible action is that the Refuge work with other agencies to seek means to streamline sign placement on behalf of sensitive habitats and do so under Alternative B. Better public education through signage may be helpful to other agencies as well. (CCCR)

Refuge Response: We will investigate placement of no wake signs along Newark Slough. Also, as a member of the Water Trail Advisory Team, we will work with others on boating signage and education to reduce impacts to wildlife and habitat.

D.30. Comment: As two active fishing sites are informal and may disrupt some habitat, it would be better to provide a fishing pier at those locations. While Alternative B includes the objective of "…also design and install a small fishing platform at Coyote Creek and Faber-Laumeister.", the documents do not provide any project descriptions of the proposed installations. That means that this EA cannot adequately review these projects and environmental review may be needed when design details are available.

The documents also propose that a new boardwalk be built along the entire length of the interior levee at Faber-Laumeister. It raises the question of whether the boardwalk and fishing platform will be connected structures. The current access to the Faber-Laumeister fishing shoreline was not described. If the two structures will be connected, under NEPA, they should be considered a single project for review purposes. (CCCR)

Refuge Response: In the CCP, one of the fishing platforms was incorrectly named "Coyote Creek." The proposed action is to build a small fishing platform at Coyote Creek Lagoon in order to improve fishing access. Fishing is already permitted at the site. The fishing platform at Faber-Laumeister is to be part of the proposed boardwalk. Again, fishing is permitted activity at this location as well.

D.31. Comment: One of the Refuge "learnings" over these decades is that the design of the Alviso Environmental Education Center building, while aesthetically attractive, was highly inefficient for heating and cooling. The design also failed to recognize the need for the building to serve as a secondary visitor center. (CCCR)

Refuge Response: Under Objective 3.1, Strategy 14, we have acknowledged that the EEC needs to be improved in order to provide visitor information and contact facilities.

D.32. Comment: The documents omit discussion and CD justification of the basis for remodeling. It is not at all sufficient to use repeated statements like "…green/LEED features" without explaining what problem resolution/benefits those features or others would provide. What is the measurement basis that will demonstrate the value of remodeling? Utility usage? EE program requests vs. actual usage? Current extent of contact services vs. future service in this building? Other? Please improve each of the documents to present that information. (CCCR)

Refuge Response: Under Executive Order 13514 (Federal government's commitment to sustainability and reducing greenhouse gases) and the USFWS' climate change policy and its mitigation plan, the Service has committed to reducing the carbon footprint of its facilities, vehicles and workforce and to become carbon neutral by 2020. As a result, the Refuge will seek to attain the highest possible standard that is realistically achievable in its new construction and facility remodels. The rationale for Objective 3.2 and 4.5 have been augmented to reflect these goals. We have decided to use the LEED standard, which is a widely accepted standard system. There are many variables within the LEED model, and it is not practical at this time to determine which elements are possible and what the cost savings may or may not be.

D.33. Comment: The documents also omit discussion about how the final decisions of the on-going South Bay Shoreline Study regarding final alignment of the proposed Alviso levee which may impact the EEC. That action could influence the remodeling plan and even involve the need to move the building. Please add this discussion and incorporate appropriate contingencies plans to document discussion and findings. (CCCR)

Refuge Response: Any future remodels of the Environmental Education Center will be considered against the final proposed action of the Shoreline Study.

D.34. Comment: It was good to see proposals (Restoration Education, Slow the Flow programs) that expand programs suitable for college-level (adult) audiences. Other than the Slow the Flow program, for too long programs suited to adults have been largely in the interpretative program which lack the planned structure of the EE program. This is unfortunate because much of the curriculum of the EE programs is upgradable for use with adults. Adults like mud labs too!

Environmental Education for Refuge Volunteers: [Please also see comments below about the Volunteer Program.] While it is valuable to make EE curricula available to a broader public, the Refuge should not continue to overlook the adults with whom it will get the most "bang for the buck.'

For years, the best-informed Refuge volunteers, this writer among them, became well-qualified through self-driven education. Unfortunately such individuals represent only a small portion of the potential world of volunteers. As was learned during development of the original Salt Pond Docent program, very well qualified volunteers, often non-retirees, made the decision to volunteer *only after* they knew there would prepare through an in-depth, habitat-topical training program. Another tier of volunteers are willing to give their time but, especially if they will fill public-contact roles, need the same kind of topical training. For similar reasons, the Refuge has recognized in the CCP the importance of training all members of its staff for public contact.

The Refuge needs to modify its adult-level programs to enhance the capabilities of volunteers, current and new, and of all members of staff. (CCCR)

Refuge Response: The refuge will continue to seek a balance of programming for its diverse user groups. In Objective 4.1, Strategy 3, we will be seeking different ways to convey the main messages of the refuge, and as part of this process, we will consider the suggestion of education programs for adult audiences.

D.35. Comment: Often Interpretative programs are led by either volunteers or by partner organizations, actions that expand Refuge offerings. When these presenters are well-informed and qualified for the task, this is an exceptional way to build the program. As a former and sometime still leader of such programs, it is unfortunately clear that the Refuge does not (perhaps cannot) monitor these programs for quality or content. On occasion and in my observation, a presenter may misrepresent the Refuge, include inaccurate content or may not provide a program deserving of a visitor's time, representing the Refuge poorly. That outcome reduces the likelihood that a visitor will return. (CCCR)

Refuge Response: The refuge agrees and has identified the need for better and increased training for its volunteers. We have included a commitment to improve this in Objective 5.1, Strategy 4, "Establish a quality training program that will allow volunteers to conduct biological, environmental education, and interpretation activities…"

D.36. Comment: It is of great concern that the Alternatives propose green/LEED building programs with no explanation of how that curriculum is suited to the Refuge. In local

communities today, sustainability themes pervade all planning activities including the use of LEED standards. Universally, the missing component in the sustainability statements is wildlife and its habitats. Again and again, these descriptions fail to consider outdoor wildlife-impacting issues like pesticide use, pest-control, invasive plants, bird-safe windows, predator perching and other problems. At the Refuge, wildlife and their habitats need to be central to each and every program. Any building-green content included needs to stress the issues that developers consistently omit – wildlife.

The CCP/EA/CDs need to present its plans for EE and Interpretative programs to give voice to sustainable wildlife. The programs could be called "Sustainable Wildlife." As a Refuge advocate, I would take great pleasure in handing material about that program to any developer! (CCCR)

Refuge Response: The refuge's public programs are, and will continue to be, based on the USFWS mission, the refuge purpose, and current (and future) FWS initiatives. Any future programming based on our building remodels or green technologies and construction will be tied to the same goals. The commenter's specific suggestions are noted for future planning.

D.37. Comment: Because sufficient resources have never been given to volunteer labor, the Refuge perpetually struggles to sustain adequate numbers and quality of its volunteer workforce. The documents refer to this problem, in part, in the Alternative B proposal to "Separate visitor center roles from the volunteer coordinator roles." In effect, and for many years on a daily basis, the Volunteer Coordinator fulfills an interpretative, contact station management function, directly undercutting his/her ability to serve as volunteer-recruiter and employer-in-chief on behalf of ALL Refuge functions. In fact, the Volunteer Coordinator role may contribute more effectively to all Refuge activity if it was an administrative arm, not a unit of Visitor Services. Please keep this role-change in the Refuge Alternative B plan! (CCCR)

Refuge Response: Comment noted.

D.38. Comment: While the goals presented in Alternative B for this program are admirable (build a larger volunteer corps, expand docent program, establish stewardship programs at remote units), none can be achieved unless the program provides new benefits to the new recruits. Sadly, few consider recognition for total hours served as a significant benefit.

The most effective benefit will be a substantive training program. The current volunteer development mode today often requires almost one-on-one training of staff to volunteer, even to the basic topics of the Refuge's mission. That one-on-one emphasis burns staff time i.e. is inefficient. From a staff perspective, it would be more helpful if a volunteer came to a job with at least an introduction to the wildlife/habitat issues involved.

The science-run nature of Refuge management is particularly attractive to individuals who enjoy science even if only as an avocation. Science, by its nature, is about continuous learning. As such the most likely volunteer recruits are people who will be

attracted to a program that helps them expand their knowledge. That makes training the best reward the Refuge can provide.

Training does not have to be limited to classroom-style teaching but there should be a tracking mechanism by which training can be tracked by topic, date and time involved. That data can become a basis for matching volunteers to the jobs required.

Alternate training forms can include materials of EE programs, DVD recordings, online access to programs like those at USGS about the salt pond restoration, a lending library of recommended books and other training methods. There could be a Volunteer training workstation for individual, computer-based training. Training hours would count as volunteer hours and credit would be given credit for off-Refuge trainings such bird-watching classes or attendance at related public meetings or symposia. For some, walking-in-the-visitors shoes with a Family Discovery Pack or Refuge Geocaching can be a form of training as well.

Year-end rewards can recognize volunteers for personal investment in training. With each and every bit of training, a volunteer returns to family, friends and neighborhood as a better Refuge spokesperson and is more likely to continue as an active volunteer.

The CCP/EA/CDs need to include a major training program to attract and keep more volunteers and to improve the quality and contribution of the volunteer program overall. (CCCR)

Refuge Response: The refuge agrees and has identified the need for better and increased training for its volunteers. We have included a committed to improving this in Objective 5.1, Strategy 4, "Establish a quality training program that will allow volunteers to conduct biological, environmental education, and interpretation activities…" Commenter's specific suggestions are noted and will be considered during the training program planning.

D.39. Comment: Why is there no trail between Marsh and Seaport? I have never seen the area behind the buildings (commercial and trailer parks) except in Google maps satellite view and from Bayfront Park, but I would think that would be a potential location for a trail. Is it because Cargill wouldn't agree to it because they have dreams of development someday and don't want to provide trail access now? (Jones)

Refuge Response: There is no Refuge trail between Marsh Road and Seaport Boulevard because the Refuge does not own any properties between those two roads.

D.40. Comment: At Coyote Slough I observed several people in a motorized boat with rifles.. They threw bottles into the water and shot them. This was in front of the Harbor Seal haulout side on the north bank.

Several times at Coyote Slough the 2 shrimp boats from Alviso stopped in front of the seal haulout site and emptied their nets. Their motors were noisy.

There was no mention in the Plan about the impact of these shrimp boats. There are 2 boats from Alviso and sometimes one from Redwood City and a big one from San Francisco that I have seen going up and down the bay dragging nets.

Several times at Coyote Slough fishermen in motor boats anchored in front of the haulout site and fished for an hour or more. If I was able to get CF numbers from the boats I reported it to law enforcement but of course there was no action.

At Newark Slough where it enters the bay I have seen jet skiers come out of Newark slough and go out into the bay and make big circles and a great amount of noise near the Harbor Seal haulout side.

At Newark Slough where it enters the bay I have seen hunters hunting from the marsh with dogs running thru the marshes. This has occurred on the north bank near the haulout site and on the spit of land at the junction of Newark Slough and Plummer slough..

If I was able to get CF numbers from the boats I reported it to law enforcement but of course there was no action.

At Mowry slough near the mound which is the major Harbor Seal pupping site for the entire bay I have seen a hunter hunting from the marsh with a simulated duck with spinning wings on poles stuck in the marsh. He was shooting at ducks that landed in the slough. The hunter was very close to an open area where the seals usually haul out.

At Mowry slough near the mound I have seen a shrimp boat go up past the mound dragging a net. These boats usually stay in the deeper bay so this was very unusual. (Bell)

Refuge Response: Thank you for the information. It has been relayed to the refuge manager.

D.41. Comment: I have suggested several times in writing to Clyde and others that Mowry Slough be closed to boating all year and to hunting because Harbor Seals have been known to abandon haulout sites after disturbances. If this happens it may impact the number of Harbor Seals. As many as 300 seals and pups have been observed at Mowry Slough at the pupping season. See http://userwww.sfsu.edu/~halmark/seals.htm (Bell)

Refuge Response: Mowry Slough is closed to boats March 15-June 15 to protect the harbor seal haulout during their breeding season.

D.42. Comment: Here are a few comments about the Compatible Determination for Recreational Boating-

I served in the Coast Guard Auxiliary for several years. We patrolled the south bay on weekends aiding boaters in distress. This experience taught me much about hazard in the bay. The afternoon winds in the summer make it very hazardous for small kayakers and canoers. Immersion in cold water for more than a few minutes without a good thick

wet suit means death! The shallow bay makes it likely that kayaks and canoes will run aground and get stuck until the tide rises. I used to have a sea kayak and I would launch at Palo Alto and paddle to Newark Slough where my wife would pick me up with the car. Several times I got stuck in the mud while exiting from Palo Alto and trying to find the entrance to Newark Slough. When in the Coast Guard several times we had to call for a helicopter to rescue boaters that were stuck in the mud. Several times high winds in the afternoon prevented me in my kayak from returning to the Palo Alto launch site until the winds died down in the evening. Boating stores are now pushing the sales of inexpensive and light weight sit-on kayaks. These expose boaters to the cold water and are hard to manage in winds.

Kayaking and canoeing in the open bay can be very hazardous.
If launch sites and use of non-motorized boats are publicized there will be more incidents requiring USFWS and Coast Guard assistance. There will be people trying to walk thru the marsh after being stuck in the mud. These rescue attempts will have an impact on the marshes.

Corkscrew Slough at Bair Island is being used by kayaks and canoes to circle inner Bair Island. I have paddled it and observed Harbor Seals and pups there. If small boating is popularized this will impact the Harbor Seals there. (Bell)

Refuge Response: Any recreational boating promoted by the Refuge will include an outreach and education component to address wildlife disturbance and boater safety. Should new recreational boating opportunities promoted by the Refuge result in adverse impacts to wildlife, habitat, and human safety, we will reconsider these opportunities. We are also involved as an advisory member of the San Francisco Bay Area Water Trail. Through this Trail development, we will continue to encourage wildlife/habitat appropriate and safe non-motorized small boat recreation.

D.43. Comment: The map of launch sides omitted the floating ramps for launching of small boats at Redwood City and at Palo Alto. (Bell)

Refuge Response: Thank you for the information on the ramps at Redwood City and Palo Alto. They have been added to the map.

D.44. Comment: We support Alternative B, including expansion of opportunities for NMSB launch sites, as stated in Section 2.7 (Development of Alternatives). We would also like to see the expansion of opportunities for NMSB destination sites. Destination sites are sites at which non-motorized boats may land and re-launch, but are usually not accessible by car. They provide NMSB users with an opportunity to rest, picnic (with appropriate packing out of trash), or find refuge during emergencies. Providing specified destination locations for users to disembark can prevent potential problems with boaters landing in unauthorized sensitive areas and may also provide a location suitable for educational messages about boating and wildlife. Water Trail staff are available to assist Refuge staff with providing the boater perspective and input on the suitability of a site as a launch or destination. (SFBAWT)

Refuge Response: As a member of the Water Trail Advisory Team, we will consider wildlife-compatible destination sites in your planning process and have included this in the CCP Objective 3.3.

D.45. Comment: Thank you for specifically mentioning that the Refuge public use opportunities are expected to support the San Francisco Bay Trail and Water Trail Plan goals of providing access around the entire Bay (Goal 3, Objective 3.1, 3.3 and 3.4). The Water Trail supports the strategies identified under Objective 3.3 to promote water-based wildlife observation programs and under Objective 3.4 to implement a public outreach program to promote responsible, water-based recreation in order to decrease wildlife disturbance. The strategies under Objective 3.4 mention partnering with water-based recreation organizations to promote wildlife disturbance reduction messages and the distribution of prepared outreach materials. The Water Trail is currently developing education, outreach, and stewardship materials to increase boater awareness about wildlife disturbance and is working to disseminate this information regionally to ensure a consistent message. We would be interested in partnering with the Refuge to develop and disseminate boater education materials. (SFBAWT)

Refuge Response: Comment noted. We look forward to working with you on boater education through our participation in the Water Trail Advisory Team.

E. Environmental Education

E.1. Comment: Could Goal 4 be expanded beyond environmental education to incorporate historical interpretation? This could tie into the Partnerships in Paragraph 6.7 (e.g., universities and Ohlone for history). (Bamford)

Refuge Response: Comment noted. New interpretive programs will include historical interpretation. We will work with partners to facilitate these programs.

F. Staffing

F.1. Comment: Levels of staffing should be increased to meet the growing demands for monitoring/research, environmental education and enforcement. (CCCR)

Refuge Response: Comment noted. Increased staffing levels are necessary to keep up with existing activities as well as new actions prescribed in the CCP.

G. Jurisdiction and Acquisition

G.1. Comment: The Refuge site includes intertidal and subtidal lands subject to CSLC jurisdiction… Therefore, the CSLC should be named as both a trustee and a responsible agency for the Project see (see page 2 of this letter under CSLC Jurisdiction) (CSLC)

Refuge Response: We have updated the CCP to include CSLC jurisdiction in sections 1.5.3 and 3.2.

G.2. Comment: Page 9, Table 1. Don Edwards SF Bay NWR Timeline of Property Acquisition

a) Acreage - The document repeatedly mentions that the DESFBNWR is approximately 30,000 acres. Table 1, listing the acreage in the DESFBNWR,

cumulatively adds-up to 35,742.26 acres – a variance of nearly 20% from the 30,000 acre figure.

b) Donation - With regards to the 9,600 acres transferred by Cargill Salt to the DESFBNWR in 2003, the table incorrectly shows this transaction as a "Purchase" when in fact a majority of the land (more than 50% of the value) was donated by Cargill Salt (See Exhibit A – Statement of Just Compensation). Please include the word "donation" on this line.

c) Labeling - There is also an inconsistency in the labeling of properties in Table 1. Approximately 14,000 of the 15,437 acres acquired by the Refuge in 1979 were salt ponds. Pond A6 was also leased and used by the salt company as a salt pond along with Pond SF2. (Cargill)

Refuge Response: We have revised this table to accurately reflect our acreage according to our Realty Office records. We understand that Cargill lands acquired include a combination of purchase and donation. We have included this in the revised Table 1.

G.3. Comment: Page 9-10, Section 1.5.4. Land Protection – This discussion is misleading because it suggests that Congress approved the particular acquisition boundary depicted on the maps included throughout this document. In fact, that is not the case. This section needs to be expanded in order to clarify what in fact Congress approved in 1988. The 1988 legislation authorizing expansion of the Refuge boundaries beyond those originally approved by Congress in 1972, authorized the inclusion of "[u]p to 20,000 acres in the vicinity of the areas described [in the 1972 legislation] and similar to the areas described [in the 1972 legislation], which the Secretary determines are necessary to protect fish and wildlife resources." San Francisco Bay National Wildlife Refuge, Enlargement of the San Francisco Bay National Bay Refuge, Pub. L. No. 100-556, 102 Stat. 2780 (1988). However, no map depicting expanded boundaries was included as part of that legislative authorization. On Tuesday, July 12, 1988, at the U.S. House of Representatives, Subcommittee on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries, Dean of California Hon. Don Edwards testified in front of the subcommittee:

"H.R. 4272 will do only one thing: give these property owners the option, which they do not now have, to donate or sell wetlands and wildlife habitat to the wildlife refuge. Because the bill requires that land be purchased only from willing sellers, only those local landowners who have express an interest in selling or donating their land to the refuge will be affected by the scope of the legislation."

On Tuesday, July 12, 1988, at the U.S. House of Representatives, Subcommittee on Fisheries and Wildlife Conservation and the Environment, Committee on Merchant Marine and Fisheries, Paul Shepherd, Vice President and Land Manager, Leslie Salt Company <u>expressed concerns which ultimately led to the elimination of a map depicting the proposed expanded boundaries for the refuge</u>:

> "Our company strongly supports responsible expansion of the San Francisco Bay National Wildlife Refuge. But, for the reasons that I will outline for you, we must just as strongly oppose the approach used by the bill, H.R. 4272, which is the subject of this hearing.
>
> . . .
>
> Mr. Chairman, our specific problem with the bill is the incorporation of the map prepared by the U.S. Fish and Wildlife Service. As the boundaries are proposed, Leslie Salt Company has a major stake in this legislation.
>
> . . .
>
> The map was prepared by a single-purpose Federal agency, outside the procedures set forth in NEPA, the National Environmental Protection Act. It has been represented as a conceptual map only, but that is not the case. Specific parcels are included or excluded. The map's boundaries are anything but general or conceptual in nature.
>
> . . .
>
> The incorporation of the map, in other words, is tantamount to a Federal lien on the properties included within its boundaries.
>
> . . .
>
> We encourage the Federal Government to negotiate fairly with property owners for any parcels in which the government may be interested. However, we do not believe it is fundamentally fair for the Government to attempt to stack the deck in its favor by intimidating other potential buyers with legislated maps. This is the practical effect of the map and completely contradicts the legislation's concept of a willing seller."

Hearing on H.R. 4272 A Bill to Enlarge the San Francisco Bay National Wildlife Refuge Before the H. S. Comm. On Fisheries and Wildlife Conservation and the Environment, 100th Cong. 2d Sess 11-12, 16 (1988) (statement of Paul Shepherd, Vice President and Land Manager, Leslie Salt Company).

The congressional record from the Senate hearings on the bill reflects that the map originally proposed for inclusion was not adopted by Congress as part of the final legislation:

> "As introduced, the House and Senate bill to expand the refuge, H.R. 4272 and S. 2710, respectively, referred to a proposed map entitled "San Francisco Bay National Wildlife Refuge Additions – Proposed," dated March 1988, depicting lands and water for inclusion in San Francisco Bay Wildlife Refuge. This reference is **no longer** included in Section 201 of S. 1986."

Excerpt from October 14, 1988 Senate Hearing on S. 1986, S16373 (1988) (emphasis added).

This inaccurate depiction of Cargill's fee-owned lands as being within the "Approved Refuge Boundary" or "Approved Refuge Acquisition Boundary" and included within the Refuge's Planning Units pervades the Draft CCP including, without limitation, the following… (Cargill)

Refuge Response: We have revised section 1.5.4 Land Protection, to articulate what Congress approved in the 1988 legislation (Public Law 100-556) and what Congress gave

the Service the authority to do regarding additional land acquisition. Based on the 1988 legislation, the Service prepared a 1990 Environmental Assessment with a map titled, "San Francisco Bay National Wildlife Refuge Potential Additions." This map was developed for Refuge planning purposes and we have since referred to the map as the approved acquisition boundary, as defined by Service policy. Development of the map based on the 1990 EA does not need to be "approved" by Congress in order for the Refuge to use it as a planning tool. However, we have better articulated that we only wish to acquire land from willing sellers based on certain criteria (i.e., refuge goals & opportunities). In addition, we have revised Figure 3 of the CCP to reflect the 1990 Environmental Assessment.

G.4. Comment: Page 22, Section 2.4.1. Issues, Concerns, and Opportunities – Cargill's comment of "Do not include Cargill Salt's fee-owned lands in the CCP process" should be dually noted. This is a clear indication that currently Cargill is not a willing seller and does not want its lands included in the planning document. (Cargill)

Refuge Response: We understand that currently Cargill is not a willing seller.

G.5. Comment: Page 27, Figure 4. South Bay Salt Pond Restoration Project and Refuge Boundaries – This exhibit is grossly mislabeled showing most of Cargill's fee-owned lands as within an "Approved Refuge Acquisition Boundary". This was not authorized by Congress and therefore, not "approved". Please remove this reference from the map. (Cargill)

Refuge Response: This map was replaced with a Refuge Boundary Map that shows only Refuge lands that are either owned in fee title, leased, has an existing easement, or agreement. It also shows the footprint of the South Bay Salt Pond Restoration Project.

G.6. Comment: Page 28, Figure 5. Refuge Units and Vicinity Map – This exhibit is grossly mislabeled showing most of Cargill's fee-owned lands as part of the "Don Edwards S.F. Bay National Wildlife Refuge" and the Refuge planning units. Cargill's lands are not part of the Refuge nor should they be represented as part of the planning units. Please remove Cargill's properties and this reference from the map. (Cargill)

Refuge Response: This map was replaced with a Refuge Boundary Map that shows only Refuge lands that are either owned in fee title, leased, has an existing easement, or agreement.

G.7. Comment: Page 29, Figure 6. Refuge Map – This exhibit is grossly mislabeled showing most of Cargill's fee owned lands as within the "Approved Refuge Boundary". This was not authorized by Congress and therefore, not "approved". Please remove this reference from the map. (Cargill)

Refuge Response: This map was removed from this section as it was not necessary in the CCP. We refer to the Refuge Boundary Map, which only show Refuge lands that are either owned in fee title, leased, has an existing easement, or agreement.

G.8. **Comment: Page 30, Figure 7. Newark and West Bay Units** – This exhibit is grossly mislabeled showing most of Cargill's fee owned lands within the "Approved Acquisition Boundary". This was not authorized by Congress and therefore, not "approved". Please remove this reference from the map. Also, shown in white on the legend of the map under "Ownership Status" is the phrase "in holding". This falsely indicates that all properties on this map shown in white are "in holding" for the Refuge. Please remove this reference from the map. (Cargill)

Refuge Response: We have removed the references to "Approved Acquisition Boundary" and "in holding" from the map.

G.9. **Comment: Page 34, Figure 8. Alviso and Mowry Units** – This exhibit is grossly mislabeled showing most of Cargill's fee owned lands with the "Approved Acquisition Boundary". This was not authorized by Congress and therefore, not "approved". Please remove this reference from the map. Also, shown in white on the legend of the map under "Ownership Status", is the phrase "in holding". This falsely indicates that all properties on this map shown in white are "in holding" for the Refuge. Please remove this reference from the map. (Cargill)

Refuge Response: We have removed the references to "Approved Acquisition Boundary" and "in holding" from the map.

G.10. **Comment: Page 52, Figure 12. Predicted 100-year Floodplain for the South San Francisco Bay Region** - This exhibit is grossly mislabeled showing most of Cargill's fee-owned lands as part of the "Don Edwards S.F. Bay National Wildlife Refuge". Cargill's lands are not part of the Refuge. Please remove this reference from the map. (Cargill)

Refuge Response: Comment noted. This floodplain map was obtained by the Corps and it inaccurately identifies Cargill fee-owned lands as part of the Refuge. We have replaced the map with a correct version.

G.11. **Comment: Page 62, Figure 15. Distribution of Habitat Categories within the Approved Acquisition Boundary** – Since no "boundary" exists as part of the Congressional Record, Figure 15 has no basis for the breakdown it was given. Figure 15 should be removed from the plan. (Cargill)

Refuge Response: We use the term and associated map "approved acquisition boundary" because it has undergone NEPA review and has been approved by the Service and is the appropriate title per Service policy. This map does not need to be approved by Congress to be used by the Service as a planning tool. Public Law 100-556 did not specify a boundary for expansion, but gave the Service discretion to which lands it could acquire. The Service then conducted a formal planning and NEPA process to determine which lands to consider for additions to the Refuge. We have left this figure as is in the CCP to identify habitat types with the approved acquisition boundary.

G.12. **Comment: Page 66, Figure 16. Habitat Map** - This exhibit is grossly mislabeled showing most of Cargill's fee-owned lands as part of the "Don Edwards S.F. Bay

National Wildlife Refuge". Cargill's lands are not part of the Refuge. Please remove this reference from the map.

This map also incorrectly shows one of Cargill's parcels in the City of Fremont as Agricultural. This property is zoned and General Planned in the City of Fremont as "Tech Industrial" – please label it as such. This exhibit also incorrectly labels two hills owned by Cargill as Active Salt Ponds. Lastly, the small insert map depicting the Refuge units is incorrect. It is similar to Figure 5, which incorrectly includes Cargill's lands as part of the Refuge Units. Please make the appropriate corrections by removing references to Cargill's property. (Cargill)

Refuge Response: We have removed any references to Cargill lands as being part of the Refuge. However, some Cargill lands continue to be identified as within the approved acquisition boundary as described in the 1990 EA. We have re-labeled Cargill's parcel from "agricultural" to "developed." We do not have the ability to add the layer titled, "Tech Industrial. The parcel of two hills owned by Cargill is already designated as "Upland /Grassland." We have removed the small inset map from this figure.

G.13. Comment: In order to properly set the tone of the CCP document and eliminate misguided figures and text, it is important to inform the reader that; although Congress approved the expansion of the Refuge to 43,000 acres, it did not approve a map as an exhibit of the law. Therefore, there is no legal map showing an "Approved Refuge Acquisition Boundary" as part of the Congressional Record. This message has been previously conveyed to Refuge staff, but unfortunately they have failed to include it. With that said, all figures showing properties labeled as "Approved Refuge Acquisition Boundary" or "Approved Acquisition Boundary" need to be removed. (Cargill)

Refuge Response: We have revised section 1.5.4 Land Protection and Figure 3, to articulate what Congress approved in the 1988 legislation (Public Law 100-556) and what Congress gave the Service the authority to do regarding additional land acquisition. Based on the 1988 legislation, the Service prepared a 1990 Environmental Assessment with a map titled, "San Francisco Bay National Wildlife Refuge Potential Additions." This map was developed for Refuge planning purposes, as per Service policy, and we have since referred to the map as the approved acquisition boundary. Development of the map based on the 1990 EA does not need to be "approved" by Congress in order for the Refuge to use it as a planning tool. Public Law 100-556 did not specify a boundary for expansion, but gave the Service discretion to which lands it could acquire. The Service then conducted a formal planning and NEPA process to determine which lands to consider for additions to the Refuge. However, we have better articulated that we only wish to acquire land from willing sellers based on certain criteria (i.e., refuge goals & opportunities).

G.14. Comment: Page 63, Table 7. Habitat Types within the Approved Acquisition Boundary – How are these acreages derived when there is no congressionally approved map? The CCP should focus on the Refuge – land that is currently owned – in order to develop a useful table. Also, since no "boundary" exists as part of the Congressional

Record, Table 7 has no basis for the breakdown it was given. Table 7 should be removed from the plan. (Cargill)

Refuge Response: We use the term and associated map "approved acquisition boundary" because it has undergone NEPA review by the Service. This map does not need to be approved by Congress to be used by the Service as a planning tool. We have left this table in the CCP.

G.15. **Comment: Page 69, Developed Habitats and Pond Habitats** – Incorrectly refers to Approved Acquisition Boundary as if there were a map as part of the Congressional Record, which there is not. Please remove this reference from these sections. (Cargill)

Refuge Response: We use the term and associated map "approved acquisition boundary" because it has undergone NEPA review and has been approved by the Service and is the appropriate term defined in Service policy. This map does not need to be approved by Congress to be used by the Service as a planning tool. We have left these references in the CCP.

G.16. **Comment: Page 116, Section 3.6.1. Land Use** – Although the Refuge has the authorization to acquire up to 43,000 acres, there is no congressionally approved map depicting a boundary. What should be noted in this section is that although not all of the lands are under ownership of the Refuge, most of the lands listed as "Potential Additions to the San Francisco Bay National Wildlife Refuge" are already under public ownership and are managed to preserve and enhance significant wildlife habitat, protect migratory waterfowl and other wildlife, and provide an opportunity for wildlife-oriented recreation and nature study. (Cargill)

Refuge Response: The purpose of this section is to identify current land use (existing conditions) within the Refuge Units and land use in areas surrounding the Refuge. This provides context for CCP readers regarding habitats adjacent to the Refuge. Although some lands may be under public ownership and managed for conservation, the Refuge has no ability to ensure these lands will remain as such. No changes have been made to the section because our goal is to provide context, not planning goals.

G.17. **Comment: Page 117, Section 3.6.1. Land Use** – Mowry Unit – Incorrectly includes Cargill's lands within this planning unit. Please exclude Cargill's lands (acreage) from this section. (Cargill)

Refuge Response: Cargill lands (acreage) are not included in this section. We have included only the acreage that is fee-owned or managed by the Refuge. These lands include: Mowry Ponds M1-M6, M12, M13, and adjacent marshes, sloughs, and vernal pool areas. These areas total approximately 6,000 acres. We added a sentence to clarify Cargill's salt-making rights in perpetuity per the 1979 agreement.

G.18. **Comment: Page 120, Section 3.6.1. Land Use – West Bay Unit** - There is a misrepresentation of Cargill's Redwood City Plant Site operations where the document states it functions "on a limited basis". The Redwood City Plant Site is an operating salt plant. Please make this correction and remove all references of "on a limited basis".

This section also incorrectly includes Cargill's lands within this planning unit. Please exclude Cargill's lands (acreage) from this section. (Cargill)

Refuge Response: We have removed all references of "on a limited basis." We have not included Cargill lands (acreage) as part of the West Bay Unit.

G.19. Comment: Page 15, Table 2. Habitat Goals for the San Francisco Bay Joint Venture – This table is extremely confusing on how the acreages were derived. Since this document, the Draft Comprehensive Conservation Plan, is to be focused on Refuge lands, I recommend removing this table as it adds no value to the document. (Cargill)

Refuge Response: This table was created by SFBJV and we use it, in part, to guide our habitat management and restoration. The purpose for including it in the CCP is to identify that the Refuge's CCP goals contribute to overall regional habitat goals. We have kept the table in this section.

G.20. Comment: Page 37, Section 3.2. Regional and Historic Setting – West Bay Unit – There is a misrepresentation of Cargill's Redwood City Plant Site where the document states it functions "on a limited basis". The Redwood City Plant Site is an operating salt plant. Please make this correction and remove all references of "on a limited basis". Also, the Redwood City Plant Site is not part of the West Bay Unit as depicted on Figure 5 nor is the property "in holding" as depicted on Figure 7. Please remove the Redwood City Plant Site from the West Bay Unit. (Cargill)

Refuge Response: We have removed the phrase "on a limited basis" in the sentence of concern. We have removed the Redwood City Plant Site from the two maps as requested.

G.21. Comment: Page 115, Section 3.5.5. Historic Resources, 1st full paragraph – The statement, *"Given the social and economic significance of the salt industry in the South Bay, it is possible that the salt pond complexes would qualify as an historic district for the NRHP"* is completely speculative and outside the scope of the CCP process. Remove this sentence from the plan. (Cargill)

Refuge Response: We have removed the two sentences in that paragraph.

G.22. Comment: Page 31, Section 3.2. Regional and Historic Setting – It should be noted in both the Newark Unit and the Mowry Unit that Cargill Salt retains the salt making rights to these ponds in perpetuity, and that Cargill plans on continuing its rights in these ponds. Therefore, no planning will be conducted in these ponds that would interfere with Cargill's perpetual salt making rights as per the Declaration of Taking dated June 30, 1977. (Cargill)

Refuge Response: In the Newark and Mowry Unit paragraphs, we have added a sentence that reads, "Under a 1979 agreement between Cargill and the Service, Cargill Salt retains the salt making rights in the Newark Ponds in perpetuity. Cargill plans to continue salt making in these ponds."

G.23. Comment: Page 134, Section 3.6.4. Public Utilities/Easements – There are several rights/easements inadvertently left out of the Newark Unit and Mowry Unit – i.e.: Cargill's perpetual salt making rights need to be shown over both units, Cargill's drainage and utility easement through the Coyote Tract, Tracts 102 and 103, Caltrans drainage easement through the Coyote Tract, Tract 103, etc. (Cargill)

Refuge Response: We will review the lease agreements we have on file and include all rights/easements within the Newark and Mowry Units.

G.24. Comment: Page 188, Section 5.4. Refuge Goals, Objectives, and Strategies – Objective 2.4 – Please rephrase the statement "It is important to note that the Mowry and Newark Ponds are still active salt making ponds" to read "It is important to note that Cargill retains perpetual salt making rights on the Mowry and Newark Ponds; therefore, no change in use will be planned for these areas that would interfere with Cargill's rights as per the Declaration of Taking dated June 30, 1977." (Cargill)

Refuge Response: We have replaced the sentence to read, "It is important to note that Cargill retains perpetual salt making rights on the Mowry and Newark Ponds; therefore, no change in use will be planned for these areas that would interfere with Cargill's rights as per the Declaration of Taking dated June 30, 1977."

G.25. Comment: Page 14, Section 1.6. Related Project - It should be noted that North Creek was entirely donated by Cargill to CDFG. Cargill also supplied its dredge, *The Mallard*, at cost, to reconstruct the creek channel and banks. (Cargill)

Refuge Response: This is referring to the CDFG property near Eden Landing. Adding the recommended language regarding Cargill's donation of land and use of the Mallard is irrelevant to our CCP process. The purpose of this paragraph is to identify other restoration projects in the vicinity of the refuge that help accomplish our mission not to identify donors. Such language may already be included in CDFG documents.

G.26. Comment: Page 71, Section 3.4.2 – Summary of Habitat Categories within the Refuge – Developed Habitats – the reference to "two large parcels containing agricultural lands (876 acres total)…, offering potential restoration sites adjacent to freshwater marsh and tidal wetlands" includes Cargill's Fremont Coyote Tract. This tract of land is approximately 91 acres that is completely isolated from any hydrology, separated by Coyotes Hills to the west, Hwy 84 to the south, Paseo Padre Parkway to the east and a dirt access road to the north. The property is Zoned and General Planned within the City of Fremont as Tech Industrial. Please make the appropriate corrections. (Cargill)

Refuge Response: We have kept the reference to the "two large parcels…" in this section and it remains under Developed Habitats. We have removed the phrase "offering potential restoration sites to freshwater marsh and tidal wetlands" since that is speculative.

G.27. Comment: It should be noted that, except for Pond 3C in Baumberg, all salt evaporator ponds are under public ownership. All the parcels listed below are now in public

ownership and some of them are cooperatively managed to preserve and enhance significant wildlife habitat, protect migratory waterfowl and other wildlife, and provide an opportunity for wildlife-oriented recreation and nature study:

- Pond A4 – 321 acres
- Pond A18 – 856 acres
- Baumberg Tract – 850 acres
- Baumberg Ponds – 5450 acres
- Northern Channel – 16 acres
- A8 Peninsula Parcel – 16 acres

As mentioned above, the acreage total on Table 1 is 35,742.26 acres. With the addition of the properties listed immediately above, the total is 43,251 acres. Also to note is the approved Patterson Ranch Project which will transfer approximately 270 acres into perpetual open space, thereby bringing the total acreage for the DESFBNWR or its partners in cooperative management to 43,521 acres. The acreage in the DESFBNWR should be consistently and accurately referred to throughout the CCP document.

Although not all of the lands listed above are under ownership of the Refuge, it is understated throughout this document that most of the lands listed as "Potential Additions to the San Francisco Bay National Wildlife Refuge" are already under public ownership and are managed to preserve and enhance significant wildlife habitat, protect migratory waterfowl and other wildlife, and provide an opportunity for wildlife-oriented recreation and nature study. (Cargill)

Refuge Response: We have revised Table 1 to reflect accurate acreages. We cannot include the above properties in our total acquisition under purchase, lease, or agreement at this time since they are not owned or managed by the refuge. We can only manage the land we currently own in fee title, lease, or have an agreement. Therefore, we cannot include the above properties as part of the refuge in the CCP. We also cannot guarantee that the above listed properties will be managed to preserve and enhance significant wildlife habitat, protect migratory waterfowl and other wildlife, and provide an opportunity for wildlife-oriented recreation and nature study in perpetuity.

G.28. Comment: Additional Comment: Neither Congress Nor FWS Has Adopted Any Map designating "Approved Refuge Boundary Maps." Such Maps, as used in the Draft CCP, Must Therefore be Removed.

The San Francisco Bay National Wildlife Refuge was established in 1972 by Public Law 92-330. This law incorporated the first definition as to the boundary associated with the Refuge:

Sec. 2. There shall be included within the boundaries of the refuge those lands, marshes, tidal flats, salt ponds, submerged lands, and open waters in the south San Francisco Bay area generally depicted on the map entitled "Boundary Map, Proposed San Francisco Bay National Wildlife Refuge", dated July 1971, and which comprise approximately twenty-one thousand six hundred and sixty - two acres within four distinct units to be known as Fremont (five thousand five hundred and twenty acres), Mowry Slough (seven

thousand one hundred and seventy-five acres), Alviso (three thousand and eighty acres), and Greco Island (five thousand eight hundred and eighty-seven acres). Said boundary map shall be on file and available for public inspection in the offices of the Bureau of Sport Fisheries and Wildlife, Department of the Interior.

Sec. 3. (a) ... The Secretary may from time to time make corrections in the boundaries of the refuge, but the total area within the boundaries shall not exceed twenty-three thousand acres of land, marshes, tidal flats, salt ponds, submerged lands, and open waters.

Pub. L. No. 92-330 (1972) (emphasis added). Thus, the enabling legislation for the Refuge established its potential boundaries by reference to a map dated July 1971 showing a "general" depiction of the boundaries, a description of four units totaling approximately 21,662 acres, and a limit of23,000 acres on the total acreage of lands to be included within the Refuge.

On March 29, 1988, Congressman Don Edwards introduced H.R. 4272, which proposed an expansion to the boundary of the Refuge through incorporation of a map depicting certain properties as lying within the Refuge boundary.

Following introduction of H.R. 4272, Paul Shepherd, then Vice President and Land Manager for Leslie Salt Company, testified before at a House Subcommittee Hearing on July 12, 1988. Mr. Shepherd expressed the concerns of Leslie Salt Company, now Cargill, about the inappropriate designation of privately owned land as within an "approved" boundary for the Refuge:

[O]ur specific problem with this bill is the incorporation of a map prepared by the U.S. Fish and Wildlife Service. As the boundaries are proposed, Leslie Salt Company has a major stake in this legislation.

Leslie Salt owns well over 17,000 acres of the 20,850 acres that are the subject of the map. That comes to approximately 85 percent of the land authorized for acquisition under this bill. Moreover, the line drawn on the map takes in almost all of our developable lands.

[The map] has been represented as a conceptual map only, but that is not the case. Specific parcels are included or excluded. The map's boundaries are anything but general or conceptual in nature.

The targeting of so much of our land holdings for the expansion proposed by this legislation threatens our company with real economic harm. Regardless of the good intentions behind this bill, the practical effect of the inclusion of the map in H.R. 4272 has been to cast a cloud over the land parcels that are located within its boundaries. The mere existence of the map in an unreported bill already has reduced the value of these lands.

The incorporation of the map, in other words, is tantamount to a Federal lien on the properties included within its boundaries.

We encourage the Federal Government to negotiate fairly with property owners for any parcels in which the Government may be interested. However, we do not believe it is fundamentally fair for the Government to attempt to stack the deck in its favor by intimidating other potential buyers with legislated maps. This is the practical effect of the map and completely contradicts the legislation's concept of a willing seller.

Hearing on H.R. 4272 A Bill to Enlarge the San Francisco Bay National Wildlife Refuge Before the H. S. Comm. On Fisheries and Wildlife Conservation and the Environment, 1OOth Cong. 2d Sess 11-13 (1988) (statement of Paul Shepherd, Vice President and Land Manager, Leslie Salt Company).

The congressional record from the Senate hearings on Senate Bill 1986, the corollary to H.R. 4272, confirms that all references to the proposed 1988 map were intentionally excluded by Congress from the final bill that ultimately became law:

As introduced, the House and Senate bills to expand the refuge, H.R. 4272 and S. 2710, respectively, referred to a proposed map entitled "San Francisco Bay National Wildlife Refuge Additions-Proposed," dated March 1988, depicting lands and waters for inclusion in San Francisco Bay Wildlife Refuge. This reference is no longer included in section 201 of S.1986. However, the lack of any reference to the March 1988 map in this legislation should not be interpreted as an expression of opposition either to the acquisition of any of the lands and waters depicted on that map, or to the preparation by the U.S. Fish and Wildlife Service of a map depicting those or other proposed additions of lands and waters of the refuge.

Excerpt from October 14, 1988 Senate Hearing on S. 1986, S16373 (1988) (emphasis added).

The final text of Public Law 100-556, which in conjunction with the original 1972 legislation, governs FWS's authority regarding land that may be acquired for inclusion within the Refuge, reflects the fact that Congress rejected the proposed inclusion of the 1988 map originally proposed in connection with H.R. 4272. Rather than reference a map, Public Law 100-556 expanded the maximum acreage that can be included within the Refuge boundary by 20,000 acres (that is, from 23,000 acres up to 43,000 acres) without adoption of any map showing a specific geographic boundary for the expansion designated by Congress:

Sec. 2. There shall be included within the boundaries of the refuge the following:

(1) Those lands, marshes, tidal flats, salt ponds, submerged lands, and open waters in the south San Francisco Bay area generally depicted on the map entitled "Boundary Map, Proposed San Francisco Bay National Wildlife Refuge", dated July 1971, and which comprise approximately twenty-one thousand six hundred and sixty -two acres within four distinct units to be known as Fremont (five thousand five hundred and twenty acres), Mowry Slough (seven thousand one hundred and seventy-five acres), Alviso (three thousand and eighty acres), and Greco Island (five thousand eight hundred and eighty-seven acres). Said boundary map shall be on file and available for public

inspection in the offices of the Bureau of Sport Fisheries and Wildlife, Department of the Interior.

(2) Up to 20,000 acres in the vicinity of the areas described in paragraph (1), and similar to the areas described in paragraph (1), which the Secretary determines are necessary to protect fish and wildlife resources.

San Francisco Bay National Wildlife Refuge, Enlargement of the San Francisco Bay National Bay Refuge, Pub. L. No. 100-556, 102 Stat 2780 (1988) (emphasis added).

Congress, therefore, specifically rejected inclusion of the original 1988 map proposed with H.R. 4272 when it provided the Refuge with expansion authority of up to 20,000 additional acres in 1988. This is contrary to typical practice within the refuge system, wherein Congress has typically included an "approved refuge boundary" map when authorizing the expansion of any particular refuge. The decision by Congress not to do so when it passed expansion authority for the Don Edwards Refuge emphasizes that the acquisition authority in this particular Refuge is markedly different than it is for other FWS refuges.

A 1990 Environmental Assessment conducted for the Refuge confirms the significantly different treatment set by Congress in connection with any future establishment of an expanded Refuge boundary:

Because of the nature of the 1988 legislation, any interests acquired under the authorized expansion is flexible and dependent on many factors. The boundaries, and thus the lands now desired for acquisition for wildlife habitat, is not firmly established as is often the case in other acquisition projects. Hence, Congress has given the Service discretion as to which parcels it may acquire. Obviously, the acquisition of some parcels may be more desirable and thus, may be more actively pursued than others.

Until lands are acquired, they do not become part of the refuge. Lands identified herein as possible for acquisition may or may not be acquired depending on price, state of development or proposed development, character modification, opportunities to protect through other mechanisms, and other considerations. This environmental assessment is not intended to be used to influence general plan, zoning, or other land use determinations by State and local government.

"Final Environmental Assessment, Potential Additions to San Francisco Bay National Wildlife Refuge Alameda, San Mateo, and Santa Clara Counties, California" ("EA") at 2 (FWS 1990) (emphasis added).

Since passage of the 1988 legislation, the Secretary (including his/her designee, to the extent that such authority has been designated) has never promulgated approval of any map designated as an "Approved Refuge Boundary Map" for the Refuge.

Cargill is particularly concerned that the Draft CCP contains arbitrary maps and figures that are labeled as "approved refuge boundary" or "approved refuge acquisition boundary" and encompass lands owned in fee simple by Cargill. These maps were never

authorized by Congress or otherwise promulgated by the Secretary. In other portions of the Draft CCP, lands that are owned in fee simple by Cargill appear to be included directly within Refuge planning units- incorrectly indicating that private property is "within" the Refuge. These depictions erroneously suggest that FWS has either acquired private property for inclusion in the Refuge or that the designated property is effectively slated for acquisition, when neither inference is correct. These arbitrary designations will mislead the public and decision makers by suggesting that the properties may not be freely transferrable or, at minimum, the existence of significant restrictions on their use. As a result, the marketability of Cargill's property is significantly impacted by these unapproved and arbitrary designations.

As such, adoption of the current Draft CCP, incorrectly describing Cargill's private property as lying within an approved boundary and/or inferring ownership directly by the Refuge would be "arbitrary, capricious, an abuse of discretion, [and] otherwise not in accordance with law" in violation of the federal Administrative Procedures Act. 5 U.S.C. § 706(2)(A). We request that the relevant figures and maps be removed or redrafted prior to finalization of the CCP. (Barg, Coffin, Lewis and Trapp)

Refuge Response: In 1972, Public Law 92-330 authorized and directed the Secretary of Interior to establish a refuge and acquire up to 23,000 acres in South San Francisco Bay by June 30, 1977. Further, it authorized a refuge composed of four units (Mowry Slough, Fremont, Greco Island, and Alviso). Congress approved a refuge boundary map and authorized the Secretary, "…from time to time to make corrections in the boundaries of the refuge…" (PL 92-330)

In 1988, Public Law 100-556 increased the Service's acquisition authority from 23,000 acres to a total of 43,000 acres. Unlike the original legislation (PL 92-330), Congress did not specify a boundary for the 20,000 acre expansion. However, in PL 100-556, Congress did specify that the 20,000 acres be ". . . in the vicinity of . . . and similar to . . ." the existing refuge units, and that they be " . . .necessary to protect fish and wildlife resources." Hence, Congress gave the Service discretion as to which parcels it may acquire.

Following PL 100-556, the Service began a formal planning process to determine which lands would be considered for additions to the Refuge. This Service's planning process was conducted pursuant to NEPA and included opportunities for public comment. In 1990, the Service issued the Final Environmental Assessment, Potential Additions to the San Francisco Bay National Wildlife Refuge, Alameda, San Mateo, and Santa Clara Counties, California (Final EA). The preferred alternative in the Final EA included a map and a boundary in which the Refuge could expand to include the additional 20,000 acres authorized by PL 100-556. The map and boundary depicted in the 1990 Final EA identified 24,500 acres as "potential additions" because not all of the lands would be added to the Refuge for the following reasons: 1) no more than 20,000 acres out of the 24,500 acres identified would be added to the refuge under existing authorities; 2) Service plans for acquisitions do not preclude lawful, environmentally sound development, as determined by local government; 3)the acquisition cost of some of the lands may be prohibitive; 4) the amount of available funding for acquisition is unknown; and 5) some landowners indicated that they would not be willing sellers. On March 5,

1990, the Service selected the preferred alternative for implementation in a Finding of No Significant Impact (USFWS 1990).

This map boundary is now known as the approved acquisition boundary for the Refuge. According to our national policies, an approved acquisition boundary encloses "those lands that we have authority to acquire, in whole or in part. This boundary often encompasses both public and private land, but does not imply that all private parcels within the boundary are targeted for our acquisition. The approved acquisition boundary can originate from a variety of means (e.g., Executive Order, Congressional Order, Secretarial Order, Public Land Order, Service Director, Regional Director, and Migratory Bird Conservation Commission)" (343 FW 3). The Service has authority to acquire and/or manage lands within the approved acquisition boundary through various agreements, based upon planning and environmental compliance processes. Approval of an acquisition boundary does not grant the Service jurisdiction or control over lands within the approved acquisition boundary, and it does not make lands within the acquisition boundary part of the National Wildlife Refuge System. In fact, to date, many lands within the approved 1990 boundary have already been converted to urban developments.

We acknowledge that some maps in the Draft CCP erroneously included some of Cargill's fee title lands within the refuge boundary. These mistakes have been rectified.

G.29. Comment: The Scope of the Draft CCP Must Be Limited to Land Owned by the Refuge.

The Draft CCP, including its maps and figures, encompasses land owned by the Refuge and certain other private property owned by third-parties, including Cargill. This approach is overly broad and is not authorized under existing law; the CCP process must be limited to property owned by the Refuge and any discussion of adjacent, private property must be limited and specifically, and clearly identified.

The National Wildlife Refuge System Improvement Act of 1997 ("Act") requires that FWS "propose a comprehensive conservation plan for each refuge or related complex of refuges." 16 U.S.C. § 668dd(e)(l)(A)(i) (emphasis added). The term "refuge" is specifically defined as "a designated area of land, water, or an interest in land or water within the System, but does not include Coordination Areas." 16 U.S.C. § 668ee(11). The term "System""means the National Wildlife Refuge System ..." as defined in the Act and over which FWS has authority and control.

As such, the Act requires preparation of a plan applicable to the geographic scope of the property owned by the refuge actually being evaluated. In preparing a CCP, therefore, Congress did not intend for FWS to evaluate, or otherwise include, properties outside of property owned and maintained by the federal government as a refuge.

This conclusion is further evidenced by the directive from Congress that FWS, in preparing a CCP, shall "consult with adjoining ... private landowners ..." 16 U.S.C. § 668dd(e)(3)(A). The requirement indicates that Congress made a clear distinction between the scope of the CP -.which was limited to refuge property - and a need to

coordinate with adjoining private landowners during the planning process. Because of the overly broad reference to private properties - including erroneous maps that indicate private property is within the Refuge boundary - the Draft CCP is not in accord with the directive from Congress to limit evaluation to the actual Refuge.

If FWS adopts a final CCP containing these misrepresentations with respect to Cargill's property, it will have exceeded the scope of its authorization pursuant to the Act, because Congress did not provide for the comprehensive conservation planning process to extend to privately owned properties. For these reasons, finalization of the CCP in its current form would violate the Administrative Procedures Act because such an action would not be "in accordance with law." 5 U.S.C. § 706(2)(A). (Barg, Coffin, Lewis and Trapp)

Refuge Response: We acknowledge that some maps in the Draft CCP erroneously included some of Cargill's fee title lands within the refuge boundary. These mistakes have been rectified.

Public Laws 92-330 and 100-556 established the Refuge and gave discretion to the Secretary of the Interior to acquire up to 43,000 acres "for the conservation and management of wildlife and natural resource, the development of outdoor recreation opportunities, and interpretive education." To date the Refuge, has acquired (by fee title, easement, or lease) 30,000 of the 43,000 acres allowed under Public Law 100-556. The Refuge plans to continue acquiring lands within the approved acquisition boundary from willing sellers. We recognize that Cargill is not a willing seller at this time.

The Draft CCP identifies current land use (existing conditions) within the refuge units and land use in areas generally in the approved acquisition boundary. This provides context for CCP readers and refuge staff regarding habitats adjacent to the Refuge, particularly those habitats that would fit with the Refuge purposes. However, this discussion does not specify any planning actions on those lands generally within the approved acquisition boundary other than to express our interest in acquiring lands that meet the Refuge purposes from willing sellers.

For those lands which Cargill owns in fee simple as per the 1979 agreement between Cargill and the Service, we recognize that Cargill Salt retains the salt making rights in the Mowry and Newark Ponds in perpetuity. Therefore, no change in use will be planned for these areas that would interfere with Cargill's rights per the Declaration of Taking dated June 30, 1977.

G.30. Comment: Erroneous Designation of Cargill Owned Property as "Within the Refuge" May Cause Cargill Economic Harm Constituting an Unlawful Take Under the Fifth Amendment.

Moreover, FWS's designation of Cargill's properties as being within an "approved boundary" for the Refuge would constitute an unlawful take, in violation of the Fifth Amendment to the U.S. Constitution, for which Cargill must be compensated if the CCP is finalized without appropriate revision. FWS's improper inclusion of properties owned in fee simple by Cargill as lying within the Refuge boundaries imposes a cloud of

condemnation over Cargill's property. This is reflected in the comments made in 1988 by Mr. Shepherd, cited above and including the point that "[t]he targeting of so much of our land holdings for the expansion proposed by this legislation threatens our company with real economic harm."

As was raised by Mr. Shepherd in 1988, the continued and repeated reference to Cargill private property as being within some type of "approved refuge boundary" is erroneous and threatens Cargill with direct, and potentially serious, economic harm via diminution in value of its property and/or the inability to use its property freely. Failure to promptly correct this arbitrary and capricious representation of "approved" Refuge boundaries and the erroneous designation of Cargill property as "within" the Refuge may entitle Cargill to just compensation under the Fifth Amendment. (Barg, Coffin, Lewis and Trapp)

Refuge Response: We acknowledge that some maps in the Draft CCP erroneously included some of Cargill's fee title lands within the refuge boundary. These mistakes have been rectified. See response to the previous two comments.

G.31. Comment: Allowing Hunting on Property Owned by the Refuge, but on which Cargill Retains "Reserved Rights" for Salt Production, Violates the Final Judgment Associated with FWS's Acquisition of Certain Property

Leslie Salt, the predecessor to Cargill's salt manufacturing operations in the Bay Area, transferred thousands of acres to the Refuge in the 1970s. The Final Judgment related to FWS's acquisition of that property specifies that although the Refuge now owns the land Cargill retains specified "Reserved Rights." Exhibit CC to the Second Amendment to the Declaration of Taking, dated June 29, 1979. These "Reserved Rights" provide for the continuation of Cargill's unhindered and unobstructed salt production operations on certain parcels within the Refuge.

For example, the June 29, 1979 agreement includes the following key provisions delineating Cargill's Reserved Rights:

Leslie and the United States agree that Leslie's activities and operations on the Property shall conform to, and be governed by, the rules and regulations ... but only to the extent such rules, regulations, and restrictions are consistent with Leslie's exercise of its Reserved Rights. Should the United States, its agents, designees, and permittees take any action which interferes with or otherwise adversely affects Leslie's Reserved Rights then Leslie shall be entitled to compensation and other remedies as provided by law and this agreement, on account of impairment, interference with, or the taking of Leslie's Reserved Rights.

Agreement Between United States Fish and Wildlife Service and Leslie Salt Co. at 2 (June 29, 1979) ("FWS Agreement") (emphasis added).

The Draft CCP indicates that certain salt making ponds owned by the Refuge, but on which Cargill retains and exercises its Reserved Rights to manufacture salt, have been designated as open to the public for hunting seven days per week without Cargill's

approval. This is a major safety issue for Cargill's employees and may severely impede salt operations and necessary maintenance work in those ponds. The Refuge cannot designate locations, over which Cargill retains Reserved Rights, as approved for hunting without Cargill's explicit authorization. Doing otherwise, as the Draft CCP apparently does, is in direct violation of the FWS Agreement, could be enjoined by a court, and entitle Cargill to appropriate compensation for interference with its contractual rights.

Refuge Response: We currently do not allow hunting within the Newark Ponds as the CCP states, "Newark Unit: All Refuge ponds are closed to hunting." Tidal marsh areas outside the ponds are open to hunting and under the jurisdiction of the California Department of Fish and Game hunting regulations.

We do allow hunting in Mowry Ponds M1 – M6 as was published in the Code of Federal Regulations (50 CFR 32): http://cfr.regstoday.com/50CFR32.aspx#50_CFR_32p8. Since this comment letter, the Refuge, in coordination with Cargill, has placed tighter restrictions on hunting regulations in these ponds to address safety issues for hunters, Cargill staff, and Refuge staff. As a result, the Refuge updated our 2013-2013 Waterfowl Hunting Regulations posted at:
http://www.fws.gov/desfbay/Hunt/Hunt_Information.htm

We will continue to work with Cargill to ensure that the Refuge hunt program does not interfere with Cargill's salt-making process or pose safety concerns for individuals.

G.32. Comment: We take great exception to the text on page 191 under Objective 2.10 that suggests that the Refuge is only interested in acquiring **some** of the lands within the Refuge expansion boundary. Specifically, Objective 2.10 states, "*Rationale*: **Some** lands within the approved acquisition boundary have good potential to provide habitat or be restored for threatened and endangered species, and other Refuge purposes (bold emphasis ours.)"

It is quite clear from the 1988 Refuge expansion legislation as well as from the accompanying Congressional Record that all of the lands found within the approved refuge expansion boundary shall have, "good potential to provide habitat or be restored for threatened and endangered species…" Otherwise, they would not be in the boundary.

The 1988 legislation allowing for the expansion of the Refuge bill states:
Sect. 2. There shall be included within the boundaries of the refuge the following…
(2) Up to 20,000 acres…**which the Secretary determines are necessary to protect fish and wildlife resources."**

Furthermore, in the Congressional Record (Congressional Record-Senate, October 14, 1988, S16373) Senator Mitchell states that, "the development pressures in the vicinity of the refuge continue to increase, threatening valuable wildlife habitat, as well as areas that have served to buffer the human impacts on the wildlife resources within the refuge…**Under this legislation, the U.S. Fish and Wildlife Service should…determine which uplands, marshes, tidal flats, salt ponds, submerged lands, and open water should be added to the Refuge…[and] prepare a map**

depicting proposed refuge additions…" and Senator Pete Wilson added, "…Land acquisition of the sort that is called for in this bill is the only way to ensure that this sensitive habitat will be protected for tomorrow's wildlife and tomorrow's visitors…"

These are clear statements. From this, one must conclude that, as required by the statute, all the lands that are included within the Refuge's expansion boundaries, as depicted in the map and accompanying text found in the *Final Environmental Assessment, Potential Additions to San Francisco Bay National Wildlife Refuge, Alameda, San Mateo and Santa Clara Counties, California, May 4, 1990* (Assessment), are lands "necessary to protect fish and wildlife resources" and as such are lands appropriate and necessary for inclusion within the Refuge. If not, the Service failed to appropriately implement its legislative mandate.

For this reason, we believe that the CCP must emphasize in Objective 2.10 the need to acquire all of the lands identified in the Assessment that are still available for acquisition. (CCCR)

Refuge Response: Unlike the original legislation (PL 92-330), Congress did not specify a boundary for the 20,000 acre expansion. However, in PL 100-556, Congress did specify that the 20,000 acres be ". . . in the vicinity of . . . and similar to . . ." the existing refuge units, and that they be ". . . necessary to protect fish and wildlife resources." Hence, Congress gave the Service discretion as to which parcels it may acquire.

Following PL 100-556, the Service began a formal planning process to determine which lands would be considered for additions to the Refuge. The Service's planning process was conducted pursuant to NEPA and included opportunities for public comment. In 1990, the Service issued the Final Environmental Assessment, Potential Additions to the San Francisco Bay National Wildlife Refuge, Alameda, San Mateo, and Santa Clara Counties, California (Final EA). The preferred alternative in the Final EA included a map and a boundary in which the Refuge could expand to include the additional 20,000 acres as authorized by PL 100-556. However, the 1990 map identified more than 20,000 acres for potential additions to the Refuge (24,500 acres to be exact) because it was assumed that not all identified lands would be available for acquisition (e.g., some landowners may not be willing sellers). With the originally approved 23,000 acres, this additional acreage totals 47,500 acres and is more than the Service's statutory acquisition authority of 43,000 acres. Therefore we cannot acquire all lands within the approved acquisition boundary.

Furthermore, we recognize that Service plans for acquisitions do not preclude lawful, environmentally sound development, as determined by local government. Some lands within the approved acquisition boundary have already been developed and have lost their wildlife values. We also recognize that other lands within the approved acquisition boundary have already been acquired by other public agencies or conservation organizations with similar conservation goals similar to our own. According to our national policies, an approved acquisition boundary encloses those lands that we have authority to acquire, in whole or part. This boundary often encompasses both public and private land, but does not imply that all private parcels within the boundary are targeted for our acquisition.

G.33. **Comment: In the Assessment the Service, when developing the actual maps required by Congress, identified as priorities, (1) Non-tidal, (2) Abandoned salt ponds and (3) endangered species habitat.** This was further broken down into 7 categories and acreages:
1. Salt ponds – 58%; 14,260 acres
2. Freshwater wetlands – 22%; 5,270 acres
3. Salt marsh – 7 %; 1,710 acres
4. Uplands – 6%; 1,480 acres
5. Mud flats – 3%; 810 acres
6. Farmed wetlands –2 %; 590 acre
7. Estuarine open water- 2%; 380 acres.
(Final Environmental Assessment, Potential Additions to San Francisco Bay National Wildlife Refuge, Alameda, San Mateo and Santa Clara Counties, California, May 4, 1990).

All of these land types and habitats play a critical role in supporting the Refuge's fish and wildlife species.

We believe that the Refuge CCP should follow these priorities and identify possible acquisition lands. For example, the Redwood City abandoned salt ponds should be identified as a high acquisition priority as lands that currently support large numbers of shorebirds (the CCCR has video documentation of thousands of shorebirds using these ponds), as lands that traditionally supported the threatened Western snowy plover and as historic tidal marshes whose current elevation provides some of the best opportunities for tidal marsh restoration and for development of transition and upland ecotones.

Area 4 in Newark provides rare Salt Marsh Harvest Mouse (SMHM) habitat. Its acquisition would allow the Refuge to restore nearly the entire Mowry Slough headwaters. This is a rare opportunity (perhaps the only in the south Bay) to restore an entire slough and its adjacent transition and upland habitats in a slough that provides habitat for the California clapper rail and the Harbor seal as well as the previously mentioned SMHM.

Both of these sites also address the increasing need to acquire lands that will allow for wetland migration in the face of climate change and sea-level rise. (CCCR)

Refuge Response: We agree that the habitat types identified in the 1990 EA play a critical role in the Refuge's conservation of fish and wildlife species. As stated in Objective 2.10, we will begin a process of assessing remaining lands within the approved acquisition boundary with the potential to meet the Refuge's purposes. We will acquire these lands from willing sellers, as our resources allow.

G.34. **Comment:** We recognize the importance of preserving burrowing owl habitat and agree with the emphasis given that species in Section 2.10 but believe that other acquisition needs, such as lands needed to address climate change and that can provide rare habitats deserve equal recognition in the Rationale statement for this Objective. We also believe

it appropriate to identify specific lands that might be of special importance for acquisition. (CCCR)

Refuge Response: Through our assessment process in Objective 2.10, Strategy 1, we anticipate prioritizing and identifying specific habitats, including rare habitats important for acquisition. We have added a strategy regarding prioritizing lands based on climate change implications in Objective 2.10.

G.35. Comment: Finally, on this point, we were also disappointed to see acquisition listed as the last of the Section 2 goals. As clearly stated by Senator Pete Wilson in the Congressional Record, "…Land acquisition of the sort that is called for in this bill is the only way to ensure that this sensitive habitat will be protected for tomorrow's wildlife and tomorrow's visitors…" While the Refuge has acquired many of the lands identified in the Assessment, critical habitats remain unprotected and their acquisition should be among the Refuge's highest priorities. Once developed, these lands are lost forever and with climate change pushing habitats to the urban border all these unacquired lands take on an even greater importance. This latter point, the impact of climate change and the need to acquire adjacent upland areas, is recognized in Objective 2.9, Strategy 5. This need should also be identified or at least referenced in Section 2.10, the section that directly addresses acquisition policy. (CCCR)

Refuge Response: Comment noted. See previous response.

G.36. Comment: We appreciate finding in Appendix B, Table 1, under Alternative B, the Proposed Action, that acquisition is a priority in the CCP. This is found under the category "Land Management Priorities". However, in the actual text for Alternative B, as opposed to the Table, the discussion of acquisition is buried and nearly undetectable. It consists of only one sentence, and that is the last sentence in an extensive multi-paragraph Habitat Management section (as opposed to Land Management in the Table). As far as I could detect, acquisition is not discussed at all in the text of Alternative A (if it is to be found under the same Land Management heading as in Alternative B) although it is found in Alternative A in Table 1.

Even more disturbing, the description of Alternative B found on page 24 in the CCP text does not even mention acquisition. Thus, for those who don't read the Appendix, there is no indication that acquisition is a component of Alternative B, the Proposed Action.

All this suggests again that one of the most important functions of the Refuge, to acquire and protect important fish and wildlife habitats, has received very little attention and this sadly suggests a lack of interest. (CCCR)

Refuge Response: Regardless of the alternatives proposed during the CCP process, the Refuge has always been committed to acquisition of lands within the approved acquisition boundary from willing sellers as our resources allow. We discuss the importance of acquiring lands with fish and wildlife benefits in Sections 1.5.4 and 1.5.5., Land Conservation Methods. We agree that acquisition is important to protect fish and wildlife habitats. The importance of land acquisition has been further elaborated in the EA.

G.37. Comment: The CCP needs to better address the Congressional instruction to expand the Refuge by 20,000 acres. This should be represented as a high priority in the CCP. While acquisition is recognized as a Refuge Goal in Objective 2 (Objective 2.10) its location as the last objective in that section suggest a lack of interest. We suggest moving it up in the list of goals under Objective 2. (CCCR)

Refuge Response: Comment noted. See response previously in G.29.

G.38. Comment: The failure to identify acquisition as a component of Refuge Management in the summary of Alternative B found in the main text of the CCP should be corrected. Thus, acquisition as a management activity should be added to the summary of Alternative B as found on CCP, pg. 24. It should also be added to the text of Alternative A in Appendix B. (CCCR)

Refuge Response: The importance of acquisition has been further elaborated in the CCP and EA.

G.39. Comment: Climate change should be included in the Rationale for acquisition in Objective 2.10. (CCCR)

Refuge Response: Comment noted. Climate change has been included in the rationale.

G.40. Comment: One of the *Strategies* in Objective 2.10 should be to identify lands within the Refuge expansion boundary that would help the Refuge address the impacts of sea level rise and climate change, investigate the feasibility of acquiring those lands and acquire them when feasible. (CCCR)

Refuge Response: Comment noted. A strategy has been added to Objective 2.10 to reflect this.

G.41. Comment: While we whole-heartedly support Objective 2.10. "Actively work with partners and willing sellers to acquire remaining lands within the approved acquisition boundary of the Refuge," we are puzzled by the language of the rationale, "*Some* of the lands within the approved acquisition boundary have good potential to provide habitat or be restored for threatened and endangered species, and other Refuge purposes." [emphasis added] If the word "some" was used because lands within the approved acquisition boundary have been developed and can no longer provide wildlife or habitat values, it would be more appropriate to provide a separate statement to that effect, rather than utilizing language that calls into question of the value of all of the lands within the approved acquisition boundary.

There should be no question that the lands identified in the approved acquisition boundary would be valuable additions to the Refuge. The Final Environmental Assessment (FEA) Potential Additions to San Francisco Bay National Wildlife Refuge Alameda, San Mateo, and Santa Clara Counties, California issued March 5, 1990 states:

Through its planning process, including and incorporating other studies done by the Service and other entities, the Service identified tracts of land which are suitable for inclusion in the San Francisco Bay National Wildlife Refuge.

Under the description of the "Purpose and Need for Action" the FEA states:

The reason for proposing to expand the refuge by approximately 20,000 acres is to enhance the purposes for which the refuge was originally established. These purposes as stated in Public Law 92-330 are:

1. *For the preservation and enhancement of highly significant wildlife habitat.*
2. *For the protection of migratory waterfowl and other wildlife, including species known to be threatened with extinction.*
3. *To provide an opportunity for wildlife-oriented recreation and nature study within the open space so preserved.*

The *proposed action is needed to preserve, enhance, or restore essential environments (or habitats) for wildlife* and to provide for the enjoyment of wildlands and wildlife by the public. [emphasis added]

The language is quite explicit that the lands identified in the acquisition boundary were determined to be "highly significant wildlife habitat" and either possess or have the potential to possess "essential" environments (or habitats) for wildlife. The use of the word "some" in the rationale of Objective 2.10 disregards the painstaking, thoughtful, and thorough process by which the acquisition boundary was identified. **This language must be revised to: "*All* of the lands within the approved acquisition boundary have good potential...**" (CCCR)

Refuge Response: We concur that only some of the lands within the approved acquisition boundary have been developed and can no longer feasibly provide wildlife or habitat values. This has been clarified in the rationale for Objective 2.10. With discretion from Congress in Public Laws 92-330 and 100-556, the Service developed a map, "Potential Additions to the San Francisco Bay National Wildlife Refuge, Alameda, San Mateo, and Santa Clara Counties, California" pursuant to the National Environmental Policy Act and included opportunities for public comment. This map was developed for Refuge planning purposes and we have since referred to the map as the approved acquisition boundary, as defined by Service policy. However, the 1990 map identified more than 20,000 acres for potential additions to the Refuge (24,500 acres to be exact) because it was assumed that not all identified lands would be available for acquisition (e.g., some landowners may not be willing sellers). With the originally approved 23,000 acres, this additional acreage totals 47,500 acres and is more than the Service's statutory acquisition authority of 43,000 acres. Therefore we cannot acquire all lands within the approved acquisition boundary. According to our national policies, an approved acquisition boundary encloses those lands that we have authority to acquire, in whole or part. This boundary often encompasses both public and private land, but does not imply that all private parcels within the boundary are targeted for our acquisition.

G.42. Comment: Continuing with the rationale for Objective 2.10:

The Refuge is *particularly interested in acquiring property that will benefit burrowing owls, migratory birds that are a Refuge trust species*. The Refuge is *committed* to acquiring these lands from willing sellers as identified in the 1990 Final Environmental Assessment of Potential Additions to the San Francisco Bay National Wildlife Refuge. [emphasis added]

Is it the intent of this description to include lands that were described in Strategy 4, or only property that benefits burrowing owls and migratory birds? Strategy 4 states, "*If feasible*, acquire or protect currently unprotected high marsh, ecotonal, and uplands habitats by working with adjacent landowners, NGOs, and other Federal and State agencies." [emphasis added]

Why would the CCP make the distinction of being "committed" to acquiring burrowing owl habitat, but not "committed" to acquiring or protecting unprotected high marsh, ecotonal and upland habitats? Furthermore, Strategy 5 states the Refuge will, "*Identify and acquire* areas with the potential to be restored to burrowing owl habitat." [emphasis added]

Again, there is a distinction between "if feasible" and the more affirmative "identifying and acquire" areas. We do not disagree that burrowing owl habitat is under continued and serious threat by development and is worthy of protection, however, high marsh, ecotonal and uplands habitat has also been acknowledged by the CCP to be extremely rare and under serious and continued threat of being developed. The rationale of this objective should be reworded to clarify the Refuge is "committed" to acquiring unprotected high marsh, ecotonal and uplands habitats, and the strategy rewritten to indicate the Refuge will "identify" and "acquire" such areas. (CCCR)

Refuge Response: Regarding Objective 2.10, Strategy 4, “if feasible” was removed. The intent of this objective is to acquire unprotected high marsh, ecotonal, and upland habitats within the approved acquisition boundary. We have little burrowing owl habitat, a species of concern, and have added a strategy particular to that species.

G.43. Comment: Strategy 1 - "Investigate remaining lands within the approved acquisition boundary with the potential to meet the Refuge's purposes." We are strongly opposed to the language of this strategy - it should be removed from the objective. Please refer to the discussions provided above and below regarding the values of the lands within the approved acquisition boundary.

Finally, the Refuge needs to actively and routinely express its interest in acquiring lands within the approved acquisition boundary to all owners willing, or unwilling. We are aware of at least three instances of lands located within the approved acquisition boundary, where the landowners have claimed the Refuge has not indicated an interest in acquiring the lands, and have used this perceived lack of interest on the Refuge's part to conclude the lands must have only limited habitat and wildlife values.

Interest in acquiring or protecting all lands within the approved acquisition boundary (that have not been developed) should regularly be expressed by Refuge staff. This action is consistent with the vision statement developed for the Refuge. There should be

no question in any landowner's mind (who owns lands within the approved acquisition boundary) that their lands would be considered a valuable addition to the Refuge.

The CCP narrative provides four examples in which there are ongoing acquisition discussions. What is unclear from the description is whether these discussions were actually initiated by the Refuge, or by the landowner/project proponent. The CCP narrative describes acquisitions as a "method of increasing habitat for Refuge wildlife and habitat resources." The narrative goes on to state, "In addition, global warming and impending sea level rise may require that the Refuge seek lands adjacent to its current holdings to provide wildlife and habitat resources into the future." We concur and urge the Refuge to more actively pursue acquisition/protection of lands within the approved acquisition boundary. (CCCR)

Refuge Response: Regarding the comment on the remaining lands within the approved acquisition boundary, please refer to the response to G.38. Regarding the Refuge's initiative to express interest in acquiring lands, we have expressed interest when our work priorities allow. Further, we are hindered by the availability of funds for acquiring such properties. We hope that additional staffing as prescribed in the CCP will allow us to take more of an active role on acquisition priorities.

G.44. Comment: Inadequate discussion of the values of the lands within the approved acquisition boundary:
The actual narrative of the CCP should be amended to describe the attributes of lands within the approved acquisition boundary. There is little to no discussion explaining the value of these lands - such information should be included within the narrative of the CCP to help inform future Refuge actions and to help the public and decision-makers understand why these lands must be acquired or protected. Examples of the types of information that would be useful to the public and decision-makers might include:

- the habitats that are supported by lands included in the approved acquisition boundary,
- the suite of species would benefit from acquisition of the lands,
- whether the lands in question mitigate the impacts of sea level rise or offset impacts of salt pond conversion to tidal marsh, etc. (CCCR)

Refuge Response: We disagree with the comment. The primary purpose of the affected environment section of the CCP is directed at describing the lands and resources within the refuge boundary that the Refuge manages or owns. Secondarily, we have described the general habitat types within the approved acquisition boundary and the general wildlife resources that are found there. We do not have complete information on lands within the approved acquisition boundary because we do not actively conduct surveys on lands that we do not manage or own. We have a general understanding of the habitats within the approved acquisition boundary through a habitat map in the CCP (Figure 16). This information, combined with our understanding of the habitat needs of our trust species, informs us of priority lands for acquisition.

G.45. Comment: There is a need to explicitly state throughout the CCP the value of lands within the acquisition boundary. This is important not only for internal planning purposes, it also serves to inform landowners that there is continued interest in their

lands, and to inform decision-makers and the public who may in turn provide support for acquisition efforts. (CCCR)

Refuge Response: We disagree. The CCP is intended primarily to guide management of lands that the Refuge owns and manages. The Refuge may also identify and prioritize habitat types that maybe beneficial in acquiring to meet the Refuge's purposes.

G.46. Comment: p. 117 - The Description of the Patterson Ranch project is inaccurate and inconsistent with the description provided on p. 121. The description provided on p. 121 accurately reflects the current status of the project. The Patterson Ranch project does not include any impacts to the Cargill owned Fremont-Coyote Tract. (CCCR)

Refuge Response: The description of the Patterson Ranch project has been deleted from p. 117 as this section only relates to properties owned or managed by the Refuge in the Newark Unit. The description on p. 121 is unchanged.

H. Mosquito Management

H.1. Comment: Pg. 4 (K-8) Last paragraph. "There were no humans cases of WNV reported in San Mateo County from available state reports (2007-2011)."

State reports are actually available for WNV data in California back to 2005. In 2005, San Mateo County did in fact have one human case of WNV. Since "historical health threat" is to be used as a factor in determining Threat Level, as defined in the Mosquito Management Plan's (MMP) Table 2, it is imperative to document San Mateo County's human case in this report.

The recently completed Final Mosquito Management Plan for the San Pablo Bay National Wildlife Refuge specifically cites a human disease case from Santa Clara County in 2004 (pg. G-31). We feel strongly that the proposed MMP should be at least as inclusive of local historical disease data.

State WNV activity summaries for all counties going back to 2005 have been included for your reference (Attachment 1). These documents were all retrieved on 6/27/12 as reports available on http://westnile.ca.gov. (SMCMVC)

Refuge Response: Comment noted. This information has been added to the MMP.

H.2. Comment: Pg. 5 (K-9) Table 1. Cases of West Nile Virus by County, 2007-2011.

Table 1 does not currently include cases of WNV in tree squirrels. As seen in Attachment 1, San Mateo County has had several squirrels test positive for WNV. The California state health department considers WNV cases in squirrels to be significant indications of local disease activity, stating that "tree squirrels, because they do not fly, provide evidence of highly localized WNV transmission to mammals." (Attachment 2) On page 15 (K-19) of the MMP, birds and squirrels together are recognized as the "most sensitive method of detecting the presence of WNV."

Although we recognize that squirrel data was not recorded before 2006, all three MADs in this MMP have had squirrels test positive for WNV and these cases should be added to Table 1. (SMCMVC)

Refuge Response: Comment noted. Table 1 of the MMP has been updated with the information you have provided.

H.3. Comment: Pg. 5 (K-9) Mosquito Biology section, first paragraph. "Depending on seasonal and environmental conditions and the particular mosquito species involved, it generally takes from three to up to three months for a mosquito to complete its life from developed egg to early adult stage."

Word missing; we believe the intended text was "…generally takes from three days to up to three months…"

Because no references are given for this sentence, the author's intended statement is unclear. The MMP for the San Pablo Bay NWR includes the following statement in its analogous section on mosquito biology (pg. G-28): "In Northern California, it takes a mosquito from three to 12 days to complete a life cycle, depending on seasonal and environmental factors and the species of mosquito." We find the upper limit of this estimate (12 days) to be low, in our experience. While is not apparent where the "three months" time frame appearing in the current draft MMP originates from, we do not object to this estimate. (SMCMVC)

Refuge Response: "Days" added. Reference included.

H.4. Comment: Pg. 11 (K-15) Threat Level 2 section. "Human health threats include the presence of a vector species and historical incidence of disease in the local area."

This statement seems to limit the term "human health threats" to only situations directly involving "historical incidence of disease." We contend that a severe biting nuisance or an emergent disease with no "historical incidence" in the local area may also be declared a health threat, if so designated by the "appropriate public health authority" (as designated in Table 2 of the MMR). We propose the sentence to be amended to read the following:

"Human health threats typically include the presence of a vector species and historical incidence of disease in the local area." (SMCMVC)

Refuge Response: Comment noted, "typically" was added to this sentence in the Mosquito Management Plan.

H.5. Comment: Pg. 11 (K-15) Threat Level 2 section. "Some areas may already be operating under Phase 2 if they have had recent and recurring presence of mosquito-borne disease."

"Phase 2" should be replaced with "Threat Level 2" for consistency. (SMCMVC)

Refuge Response: Comment noted. Change made.

H.6. Comment: Pg. 11 (K-15) Threat Level 3 section. "The preferred larvicide treatments are biorationals (biological agents) B.t.i., B.s., and methoprene because of limited non-target effects (Appendix K3, K4). Chemical larvicides treatments (e.g. methoprene) would be the second preferred method for larvicides control."

Methoprene seems to be indicated here as both the primary and secondary preferred material for control. We suggest rewording these sentences to clarify meaning. (SMCMVC)

Refuge Response: Comment noted. Section was reworded to prescribe methoprene as a secondary preferred material for control.

H.7. Comment: Pg. 12 (K-16) Threat Level 5 section. "In this phase, mosquito-borne disease activity has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge."

For consistency, "phase" should be replaced with "threat level." (SMCMVC)

Refuge Response: Comment noted. Change made.

H.8. Comment: Pg. 15 (K-19) Dead wildlife section. "Submission of dead birds by the public is also solicited by the MADs. Residents are directed to call the California Department of Health Services if they find a dead bird ((877) WNV-BIRD). This information is conveyed to the MADs, which collects the bird and submits it for testing."

The paragraph correctly identifies both birds and squirrels as important testing specimens. Sentences cited above should also include references to squirrels. The California Department of Public Health has replaced the CDHS. We suggest the following wording of these statements:

"Submission of dead birds and tree squirrels by the public is also solicited by the MADs. Residents are directed to call the California Department of Public Health's West Nile virus hotline if they find a dead bird or squirrel ((877) WNV-BIRD). This information is conveyed to the MADs, which collects the bird or squirrel and submits it for testing." (SMCMVC)

Refuge Response: Comment noted. Change made.

H.9. Comment: Pg. 15 (K-19) Mosquito pools section. "This method is not as efficient at detecting the presence of virus, but is used to supplement information gained by testing wild birds."

Is there a reference the author can cite for this statement? While it is true that this method is not generally employed for county-wide monitoring for WNV in the same way as bird or squirrel testing, it is be misleading to state that the method is not efficient at detecting the presence of virus. Positive mosquito pools have indicated WNV presence

around the same time or earlier as the first positive birds of the season in many counties over the past several years. Mosquito testing is a valuable monitoring tool in its own right, as this method does not rely on the opportunistic and sporadic nature of public dead bird and squirrel reporting.

We would suggest omitting the statement altogether. Alternately, if the sentence is to be maintained, it should include a reference citation. (SMCMVC)

Refuge Response: This statement has been deleted.

H.10. Comment: Pg. 17 (K-21) Product name section. "VectoLex CG, VectoLex G Granules, VectoLex WDG, VectoLex WSP"

The authors should consider adding "Spheratax SPH" to this list, as Spheratax formulations of B.s. products have recently been brought to market by Advanced Microbiologics, LLC. The Spheratax products have comparable formulations to VectoLex products (Attachment 3). This may be addressed in future meetings between NWR and MAD staff. (SMCMVC)

Refuge Response: Approvals for use of pesticides on the Refuge are updated only at the end of the calendar year for use in the following year. Please request use of this product through the Pesticide Use Proposal (December 2012) for calendar year 2013.

H.11. Comment: Pg. 18 (K-22) Product name section. "Vectobac 12AS, Vectobac G"

Teknar HP-D should be added to this list, as it is already included in Table 5 and Table 6 on pg. 20 (K-24). Summit B.t.i. Briquettes are also included in Table 6 and should be added to this list. (SMCMVC)

Refuge Response: Comment noted. Products added.

H.12. Comment: Pg. 20 (K-24) Table 5. Pesticides permitted for use on the Refuge in 2011 for San Mateo County

Will this table be updated for 2012 in the final permit? If so, we would like to substitute "BVA 2 Oil" for "Mosquito Larvicide GB-1111 (Clarke)" in this document. BVA 2 Oil is listed as an alternate Product Name for Golden Bear -1111 on pg. 22 (K-26), and is the only pupacide currently used by the San Mateo County MVCD. (SMCMVC)

Refuge Response: The tables have been updated with the Pesticide Use Proposals for 2012 that were submitted in December 2011/January 2012. BVA 2 Oil was not included in the Proposal. Please request use of this product through the Pesticide Use Proposal (December 2012) for calendar year 2013.

H.13. Comment: Pg. 22 (K-26) Pupacide section.

The larvicide section is grouped by active ingredient, while the pupacide section is grouped by brand name. We suggest the header for the pupacide section be changed to

at least include the active ingredient, as the mineral oil larvicides are actually represented by two separate brand names, "Golden Bear Oil (GB1111)," and "BVA 2 Oil." Agnique is the only brand name under which the alcohol-based surfactant larvicide is sold, but the active ingredient name is Poly (oxy-1,2-ethanediyl), α-Isooctadecyl-ω-hydroxyl. (SMCMVC)

Refuge Response: Comment noted. The Pupacide section has been categorized by active ingredient instead of brand name, for consistency with the other sections.

H.14. Comment: Pg. 25 (K-29) Reptiles and Amphibians section. "Because mosquito control is applied directly to vernal pools, VPTS and CTS may be directly affected…. The effects of pesticides on VPTS and CTS are unknown at this time. However, refuge surveys over the last several years indicate that there is continued, long-term presence of VPTS and CTS in these pools."

VPTS is not defined as an abbreviation until pg. 27 (K-31). Additionally, VPTS are not reptiles or amphibians and should not be included in this section. (SMCMVC)

Refuge Response: Comment noted and VPTS moved to the Endangered Species section.

H.15. Comment: Pg. 29 (K-33) Stipulations and Best Management Practices… section, second bullet point. "This information will be made available at or before the time of the annual meeting."

No other reference is made to an annual meeting before this statement in the MMP. The MMP for the San Pablo Bay NWR includes a section on Annual Meeting/Training on pg. G-21, and this bullet point may be referring to a similar meeting not currently defined in the proposed Don Edwards NWR MMP. (SMCMVC)

Refuge Response: Chapter 2 of the MMP discusses annual coordination with the mosquito and vector control districts.

H.16. Comment: Pg. 30 (K-34) Motor Vehicle Operation section, fifth bullet point. "Aerial pesticide (larvicide or pupacide) application is required in lieu of ground-based application methods in areas with endangered species." (Bullet point is repeated in Endangered Species Habitat section.)

This restriction will significantly hamper effective and efficient mosquito control operations. There may be instances where a small or pocketed treatment area can be effectively treated on foot with sensitivity to environmental concerns for a fraction of the material and cost of an aerial treatment. For instance, the San Mateo County MVCD has worked cooperatively in the field with biologists from the California State Coastal Conservancy for the past several years to treat specific tufts of invasive cordgrass while ensuring no harm or disturbance would come to California clapper rails or their habitat. We respect the need to protect endangered species, but making one-size-fits-all recommendations for control operations leads to imprecise and inefficient control activities.

We suggest the following statement: "In areas with endangered species, special care will be taken to select application methods for larvicides or pupacides which minimize impact on the species of concern and their habitat. In these instances, pesticide application methods will be chosen in consultation with the Refuge manager before the application occurs." (SMCMVC)

Refuge Response: We prefer the use of aerial mosquito control application as it is less physically impacting than ground application, particularly where we have endangered species. We have revised the language to add flexibility: "aerial mosquito control application in encouraged over ground-based application methods" in both the "Motor Vehicle Operation" and "Endangered Species Habitat" sections.

H.17. Comment: Pg. 30 (K-34) Endangered Species Habitat section, second bullet point. "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed access February 1 to July 15 in areas that are inhabited by California clapper rails and along slough and channel edges (100 meter buffer)."

This restriction as written will prevent needed access to many known larval mosquito breeding sites in Bair Island. We share the desire to protect clapper rails and their nesting sites. However, exempting a 100-meter buffer of ALL slough and channel edges from mosquito management activities (including surveillance, a crucial part of IPM) will lead to massive unregulated mosquito breeding in these areas. The potential for mosquito fly-offs to neighboring communities from these areas will be greatly increased. This in turn raises the probability of increased Threat Levels, which may trigger otherwise preventable pupaciding and adulticiding events. Moreover, many of our potentially affected treatment areas have no recent history of clapper rail presence and consist of vegetative communities not associated with California clapper rails.

We suggest the following edited statement: "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed from February 1 to July 15 in areas that are inhabited by California clapper rails."

Alternately, if Refuge management would like to keep the 100-meter buffer as a default, we propose the following addition: "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed from February 1 to July 15 in areas that are inhabited by California clapper rails and along slough and channel edges (100 meter buffer) without authorization of the Refuge manager."

We believe the proper balance of environmental and public health stewardship can best be achieved by working cooperatively and actively with Refuge management to craft appropriate solutions to these complicated and site-specific issues. This change in wording gives the Refuge manager latitude to allow reasonable access for necessary mosquito surveillance activity. (SMCMVC)

Refuge Response: This bullet has been changed to: "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would be not be allowed access February 1 to July 15 in areas that are inhabited by California clapper rails without authorization of the refuge manager".

H.18. Comment: Pg. 32 (K-35) First bullet point on the page. "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed access February 1 to July 15 in areas used by nesting snowy plovers."

While this restriction does not currently prevent access to surveillance of known larval mosquito breeding sites in San Mateo County, it is impossible to anticipate how this will change as the salt pond areas are restored and evolve over time. We would like to keep some measure of flexibility in these guidelines, with an emphasis on working together with Refuge management to implement responsible, science-based solutions specific to individual and changing situations.

We suggest the following edited statement: "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed from February 1 to July 15 in areas used by nesting snowy plovers without authorization of the Refuge manager."

We also note that this mosquito management plan does not include a mandated Annual Meeting among Don Edwards NWR and MAD representatives. As regulations, available materials, restoration issues, and public health concerns change, it is important to provide a forum for open communication, updates, and proposed adjustments to mosquito management practices. Inclusion of an annual meeting will allow all parties to openly discuss and debate reasonable mosquito surveillance and treatment options rather than relying on rigid guidelines for overly broad categories of mosquito control situations. Modern MADs and Refuge managers both preferentially use science-based approaches to solve specific problems, and ongoing collaboration is crucial to communicate and enact these solutions. We suggest inclusion of a mandated Annual Meeting to discuss mosquito issues in the refuge and refer the authors to the meeting outlined in the recent San Pablo Bay NWR MMP (pg. G-21). (SMCMVC)

Refuge Response: Edit made to the bullet statement. Chapter 2 includes annual meetings between the Refuge and the mosquito and vector control districts.

H.19. Comment: More studies are warranted for food chain effects or how an ecosystem responds to lack of mosquitoes, before deciding on supporting the underlying premise. (SCCVCD)

Refuge Response: We agree that more research is needed on food chain effects or ecosystem effects to lack of mosquitoes. We hope to work with you and other partners to analyze these questions. Until then, we must take a precautionary approach and conservatively limit mosquito control activities under the assumption that mosquitoes are part of the ecosystem.

H.20. Comment: How is it that on the refuge, language protecting "non-arboviral" mosquitoes on refuge property is in direct conflict with California State Health and Safety Code regarding creating a public nuisance (2060)? According to this state code, "(b) The person or agency claiming ownership, title, or right to property or who controls the diversion, delivery, conveyance, or flow of water shall be responsible for the abatement of a public nuisance that is caused by, or as a result of, that property or the diversion, delivery, conveyance, or control of that water." (SCCVCD)

Refuge Response: There is no waiver of sovereign immunity requiring the Refuge to comply with the California Health and Safety Code provisions relating to mosquito abatement. The Refuge recognizes that they have a responsibility to manage health threats from mosquitoes as set forth in Service policy and the 2005 Interim Guidance for Mosquito Management on National Wildlife Refuges. Based on these policies and guidance, as well as overarching Refuge goals, the Refuge has developed to the mosquito management plan to respond to pests that threaten human and wildlife health.

H.21. Comment: By far the greatest issue with this document was the apparent elimination of our capacity to control "nuisance mosquitoes". (SCCVCD)

Refuge Response: The Service does not recognize nuisance mosquitoes because it is an arbitrary term with no quantifiable distinction between it and non-nuisance mosquitoes. There is no set, measurable criteria for nuisance mosquitoes making it arbitrary as to when each district can conduct control. Instead, a phased approach is used as a structure to provide a systematic method using disease history, disease presence, and mosquito population numbers to control mosquitoes to reduce the threat of mosquito-borne disease.

H.22. Comment: It is confusing as to how there could be no documented health threat or mosquito management issues in phase 1 without the execution of mosquito surveillance. Mosquito surveillance needs to be included in phase 1. Mosquito and vector surveillance should be ongoing to identify potential and existing mosquito management issues. Mosquito and vector surveillance should also be performed as a component of a proactive, as opposed to a reactive, mosquito control program. The Districts cannot contact the refuge regarding a health threat in phase 2 without having performed mosquito surveillance on the refuge in phase 1. (SCCVCD)

Refuge Response: Given the history of mosquito-borne disease in the surrounding vicinity of the Refuge, we recognize that all the districts are in Phase 2 of the Mosquito Management Plan and should be conducting surveillance per stipulations in the Plan.

H.23. Comment: In the response section the plan states "increase the intensity and frequency of larvicides." The language *if appropriate* should be added to the statement mentioned in phase 4. It may not always be appropriate to automatically increase the intensity and frequency of larvicides. (SCCVCD)

Refuge Response: Comment noted. Language in the MMP revised.

H.24. Comment: As indicated in comments submitted by CDPH VBDS, a declaration of a public health emergency is not appropriate relative to mosquito-borne health issues. Conceptually, to have high risk of public health issues as criteria to initiate adult mosquito control constitutes a reactive approach and is problematic in several aspects (e.g., minimizing public health risk, efficacy, possible increased adulticide use and departure from sound IPM practices, etc.). This is a subject that warrants further discussion; perhaps phase 5 should be separated to address the issues of exceeding adult mosquito thresholds on the refuge in general, and then actually reaching a high risk public health situation. (SCCVCD)

Refuge Response: Initiating adult mosquito control is (Threat Level 5) is not triggered by the declaration of a public health emergency. Adult mosquito control would be permitted with documented mosquito-borne disease activity near or on the Refuge. Appropriate documentation of a high risk to public health and safety would include species-specific adult mosquito monitoring data from the Refuge, or areas near the Refuge, that show an increase in the rate of disease-infected mosquitoes, as well as a risk assessment as defined in the California Mosquito Surveillance and Response Plan.

H.25. Comment: As with the proposed phased approach, using a "public health emergency" as criterion to initiate larval and adult mosquito control operations is inappropriate and again constitutes reaction approach to vector control. The District recommends referring to the California Mosquito-borne Virus Surveillance and Response Plan and also considering and integrating established thresholds for "nuisance mosquito species". (SCCVCD)

Refuge Response: The mosquito management plan does not require a public health emergency in order to conduct larval and adult mosquito control operations. Historical presence of mosquito-borne disease in the area permits the use of larvicides for control of mosquito populations. Some larvicides have also been determined safe for aquatic environments that represent the Refuge. The use of adulticides in Refuge environments could have potential impacts to Refuge resources and the food sources they may depend upon. Therefore, we view that the use of adulticide should require a higher threshold for use, such as species-specific adult mosquito monitoring data from the Refuge, or areas near the Refuge, that show an increase in the rate of disease-infected mosquitoes, as well as a risk assessment as defined in the California Mosquito Surveillance and Response Plan.

We recognize that nuisance mosquito species are an ongoing management concern of the local mosquito abatement districts. We believe that the actions outlined in the phased approach will be effective in preventing disease outbreaks and will also provide some ancillary benefits in controlling nuisance mosquitoes. However, we cannot allow the application of mosquito pesticides simply to control nuisance mosquitoes.

H.26. Comment: The draft plan acknowledges the significance of nuisance mosquito and mosquito populations in general, however it does not include provisions for controlling larval or adult populations of "nuisance" species. Requiring a "public health emergency" and the presence of a pathogen or arboviral disease to control adult mosquito populations severely limits the ability of the Districts to control mosquito vectors and

minimize the potential for discomfort and injury to local residents. The California Health and Safety Code establishes that mosquito species capable of producing human discomfort and injury are indeed "vectors" (Section 2002). FIFRA section 2100 defines the term "vector" as "…any organism capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including mosquitoes…" Restricting the application of adulticide to a one-time event is inappropriate in term of proper IPM practices, and can dramatically reduce the efficacy of adult mosquito control. Controlling large adult mosquito populations and breaking a disease transmission cycle commonly requires more than one ultra-low volume (ULV) adulticide application. (SCCVCD)

Refuge Response: With regard to nuisance mosquitos, please see response to the previous comment. We will consider additional adulticide applications in the event that a single treatment is not effective. Such applications must be coordinated with the Refuge.

H.27. Comment: The draft plan should allow for Refuge Managers and District staff to fully practice proper IPM, make adaptive management decisions and practice prudent mosquito control. For example, language within the plan could state: *Refuge Managers and District staff shall work collaboratively utilizing an IPM strategy including mosquito surveillance, source reduction and larval control (if necessary) to achieve mosquito management and minimize the need for adult mosquito control operations on the refuge* (this would include all vector species and nuisance and disease/arbovirus carrying species alike). (SCCVCD)

Refuge Response: We believe that the mosquito management plan does present a comprehensive IPM process for conducting mosquito control, based on historical and present data on mosquito-borne disease in the area. We view the plan as a living document that will require working and meeting collaboratively on an annual basis to allow all parties involved in mosquito control to manage lands adaptively.

H.28. Comment: Pg. 4, (K-8)

Third paragraph. "By the mid-1980s most districts in the Bay area had replaced the majority of chemical controls materials that are relatively non-toxic with few ecological side-effects - with biorational methods." The sentence is awkward and possibly missing a word making the meaning unclear. A possible revision would be to move the phrase "with biorational methods" after the word materials and make controls singular (By the mid-1980s most districts in the Bay area had replaced the majority of chemical control materials **with biorational methods** that are relatively non-toxic **and have fewer** ecological side-effects).

Last paragraph. The MMP West Nile Virus (WNV) case counts only go back to 2007. Since WNV was first introduced into California in 2003, a relatively short period of time, all local activity since then should be counted and reflected in Table 1 to accurately portray the WNV historical health threat. This would add two more human cases to Alameda County bringing the total number of WNV human cases to four. A WNV positive osprey was also found near refuge property in 2004.

In addition, squirrels have been used as a WNV surveillance tool since 2004 and are considered an indicator of "highly localized WNV transmission to mammals" (Tree Squirrels: A New Surveillance Tool for West Nile Virus) because they do not fly. Currently all squirrel data has been omitted from Table 1 when it should be included. Since 2004, Alameda County has had 15 WNV positive squirrels. WNV summaries dating back to 2003 for Alameda County are attached for reference. (ACMAD)

Refuge Response: The language on biorational methods has been revised accordingly. WNV summaries for all three districts have been updated with data since 2005 (www.westnile.gov) and squirrels have been included in the summaries.

H.29. Comment: Pg. 9, (K-13)

Bullet point #5. "At the beginning of the mosquito breeding season, the districts will provide a firm schedule of seasonal activities to the Refuge Manager. If activities are proposed that differ from the schedule, the districts will notify the Refuge Manager at least two business days prior to accessing the Refuge."

The Alameda County mosquito Abatement District operates under an Integrated Vector Management Program and adjusts its response to mosquito production according to environmental conditions and the presence of immature mosquitoes themselves. Therefore, it is impossible to provide a firm schedule for control activities in advance. Mosquitoes breed year round on Refuge lands and larval abundance and development is determined by several factors, including but not limited to: rainfall, high tides, ambient temperatures and intentional flooding. Natural factors such as rainfall and temperatures cannot be determined in advance, and a **firm schedule** of inspections and treatments for *Aedes squamiger*, *Aedes washinoi*, *Culex erythrothorax*, *Culex tarsalis*, and *Culiseta inornata* is impossible. The refuge managers do not have a set schedule for intentional flooding of the Mouse Pasture and ACMAD staff are usually given only a day's notice before this occurs. A **two business day advance notice prior to accessing the Refuge** can be the difference between treating mosquitoes with a biorational product in their early larval stages versus pupaciding or adulticiding. The result of such a requirement will inevitably lead to daily calls to the Refuge Manager and the need to use more toxic materials to control mosquitoes. (ACMAD)

Refuge Response: We have revised this language to request a general schedule of activities and their locations. For any significant changes to the schedule, particularly in endangered species habitat, we continue to request that you contact us prior entering the Refuge.

H.30. Comment: Pg. 10, (K-14)

Table 2, Footnote 1. Definition of human health threat is "based on the presence of endemic or enzootic mosquito-borne diseases." Page 3 (K-7) correctly identifies "public health risks from mosquito-borne diseases and significant nuisance." The definition of human health threat should take into account the "historic documents concerning mosquitoes and mosquito-borne diseases in California focus on the presence of malaria and **large nuisance populations of mosquitoes** affecting the first immigrants and settlers" (pg. 3). **<u>In order to meet the "social obligation to protect the health and</u>**

well-being of the human communities surrounding refuges," (pg.1) nuisance mosquitoes must be considered a human health threat. (ACMAD)

Refuge Response: While we recognize that nuisance mosquito species are an ongoing management concern of the districts, the Service does not recognize nuisance mosquitoes because it is an arbitrary term with no quantifiable distinction between it and non-nuisance mosquitoes. There is no set, measurable criteria for nuisance mosquitoes making it arbitrary as to when each district can conduct control. We believe that the actions outlined in Threat Levels 1 through 5 of the Mosquito Management Plan will be effective in responding to mosquito-borne disease risks and will also provide some ancillary benefits in controlling nuisance mosquitoes. The phased approach is used as a structure to provide a systematic method using disease history, disease presence, and mosquito population numbers to control mosquitoes to reduce the threat of mosquito-borne disease.

H.31. Comment: Pg. 11, (K-15)

Threat Level 2. "Some areas may already be operating under Phase 2 if they have had **recent and recurring** presence of mosquito-borne disease." The wording in this section has changed from "historical" (used earlier in the document) to "recent and recurring". To remain consistent and not impose further restrictions we suggest the wording be changed to "historical incidence of mosquito-borne disease."

Threat Level 3. "The preferred larvicide treatments are biorationals (biological agents) B.t.i., B.s., and methoprene because of limited non-target effects (Appendix K3, K4). Chemical larvicides treatments (e.g., methoprene) would be the second preferred method for larvicides control."

Methoprene is listed as a primary, biorational, and a secondary, chemical, preferred material for larval control. For clarity, methoprene should be removed from the first sentence and only referenced as a chemical larvicide. (ACMAD)

Refuge Response: The term "historical" has been readded to Threat Level 2. However, we believe it is important to show that there is not only historical evidence, but recurring presence of mosquito-borne disease in an area in order to justify mosquito control activities.

H.32. Comment: Pg. 18, (K-22)

Product names (B.t.i section). The paragraph above this section lists six products, but only two appear in the product names section. VectoBac G, VectoBac 12AS, Teknar HP-D, VectoBac WDG, Bactimos pellets, and Summit B.t.i. Briquettes should all be listed under product names in this table. (ACMAD)

Refuge Response: Comment noted. Product names added.

H.33. Comment: Pg. 19, (K-23)

Table 4. BVA 2 should be added to the table. This is the pupacidal oil currently used by ACMAD. (ACMAD)

Refuge Response: Please discontinue use of this product until 2013. The tables have been updated with the Pesticide Use Proposals for 2012 that were submitted in December 2011/January 2012. BVA 2 Oil was not included in the Proposal. Please request use of this product through the Pesticide Use Proposal (December 2012) for calendar year 2013.

H.34. Comment: Pg. 22, (K-26)
Section 8.4.2 Pupacide. BVA 2 is should also be listed in this section.
Golden Bear-1111. This section covers both Golden Bear-1111 and BVA 2 so the heading should reflect that. We suggest changing the heading to "Surface Films." In addition, a description of BVA 2 should also be included. (ACMAD)

Refuge Response: Please see previous comment regarding BVA 2. Heading has been changed to "Surface Oils and Films.

H.35. Comment: Pg. 29, (K-33)
Contra Costa goldfield. "**Motor vehicles would not be permitted to operate** during the Contra Costa goldfields blooming season…Contra Costa goldfields may also be indirectly affected by MAD staff spreading non-native plant species by foot (**no motor vehicles will be permitted in these areas**) within the listed plant's habitat."
These sentences are in conflict with the stipulations mentioned under endangered species habitat bullet points 4 and 5 (pg. 31, K-35), with which we agree. We would like the bolded phrases deleted or modified. (ACMAD)

Refuge Response: Comment noted. The language has been changed to reflect the bullet points 4 and 5 (K-35).

H.36. Comment: Section 10, General Stipulations
Bullet point #1. The phrase "minimize the use of pesticides" is too vague. For example, smaller quantities of more toxic pesticides might be used (e.g., adulticides) vs. using greater quantities of less toxic materials (biorationals). Does "minimize the use" mean fewer total applications or less amount of total material applied? Preferred wording would be "The MADS will be required to utilize an Integrated Management strategy and continually investigate…" (ACMAD)

Refuge Response: "Minimize the use of pesticides" can include the factors mentioned, including less toxic materials and fewer applications. We request that the districts use their best professional judgment to effectively control mosquitoes while reducing the use of pesticides in order to reduce impacts to the environment.

H.37. Comment: Bullet point #9. States that "pesticide application should not occur within 100 feet of natural sloughs and channels" is unacceptable for effective mosquito control. Many sloughs bifurcate into smaller branches and pockets that breed mosquitoes. Many/most of these smaller branches, as well as some isolated pools of water are within 100 feet of a main channel or slough. Larvicides typically are not applied directly to a major channel or slough. But they are frequently used in smaller channels and pools next to these areas. (ACMAD)

Refuge Response: This bullet point is intended to limit pesticide impacts to navigable waterways and open water where they can impact aquatic species. We request that pesticide application should not occur within 100 feet of major natural sloughs and channels that have the potential to disperse into major navigable waterways and open water. This bullet has been revised to reflect this point.

H.38. Comment: Bullet point #12. This sentence appears to be missing something. The sentence reads " To reduce the spread of nonnative invasive plants all construction equipment, clean vehicles and personnel gear of any possible seeds, soil or plant material before arriving on site". Suggest it be changed to "To reduce the spread of nonnative invasive plants, all construction equipment, vehicles and personnel gear will be cleaned of seeds, soil or plant material before arriving on site. (ACMAD)

Refuge Response: Changes made.

H.39. Comment: Pg. 30, (K-34)
Section 10, Motorized Vehicle Operation
Bullet point #5. "Aerial pesticide (larvicide or pupacide) application is required in lieu of ground-based application methods in areas with endangered species."
Based on the maps showing the presence of endangered species, most parts of Refuge land would require aerial treatments. Aerial application of larvicides/pupacides has rarely been performed on refuge land in Alameda County because of the small size of most individual sources of mosquito development there. This type of application would only be performed under extreme circumstances, such as the presence of immature mosquitoes over a large area (greater than 50 acres), significant presence of mosquito-borne disease, or where access by other means is impossible, such as sources surrounded by sloughs which can only be accessed by air or boat. Treatment by aerial application is not part of the District's treatment regimen because it is cost prohibitive, helicopter services must be contracted for at a cost of at least $1,200 per hour, plus transportation costs of $200 to $500 per application. In addition, liquid formulations of the biorational materials used on the refuge have no residual effect, so aerial applications would need to be performed every three weeks for during the summer season. We would prefer this statement to read, "In areas with known endangered species, extreme care shall be taken to avoid adverse impacts on species habitat and well-being. When possible, inspections and treatments shall be performed on foot. When not practical, mechanized equipment such as ATVs or ARGOs will be considered for use only with approval of the Refuge manager". (ACMAD)

Refuge Response: This bullet was replaced with: "Aerial pesticide (larvicide or pupacide) application is encouraged over ground-based application methods in areas with endangered species." Also, a bullet was added regarding endangered species habitat: "Inspections and treatments will be primarily performed on foot, when possible."

Section 10, Endangered Species Habitat
H.40. Comment: Bullet point #1. "Aerial pesticide (larvicide or pupacide) application is required in lieu of ground-based application methods in areas with endangered species."

See above comments under Section 10, Motorized Vehicle Operation, Bullet point #5. (ACMAD)

Refuge Response: See previous response.

H.41. Comment: Bullet point #2. "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would be not be allowed access February 1 to July 15 in areas that are inhabited by California clapper rails and along slough and channel edges (100-meter buffer)." Based on the map, "Don Edwards SF Bay NWR Mosquito Management and Endangered Species Sites in Alameda County," Alameda County has several marsh areas considered Clapper rail territory, including Mowry Sough and Pintail Marsh. These large areas can be significant producers of the salt marsh mosquito, *Aedes dorsalis* and Ae. Squamiger. Aedes dorsalis larvae develop year round, Ae squamiger larvae between November to March. Completely denying ACMAD staff access to these marshes from February to mid-July would result in large fly offs of adult mosquitoes. The only treatment option left would be adulticiding, which would have a much greater impact on non-mosquito species. Specific clapper rail habitat needs to be distinguished from those areas that breed mosquitoes, as typically these areas have minimal, if any overlap. In addition, the phrase "…and along slough and channel edges (100-meter buffer)" was addressed in Section 10, General Stipulations Bullet point #9, which mentioned a less restrictive buffer of 100 feet. (ACMAD)

Refuge Response: This bullet has been modified to, "Access (via foot or mechanized vehicle) to tidal marsh and muted tidal marsh for the purpose of mosquito management would not be allowed access from February 1 to July 15 in areas that are inhabited by California clapper rails without authorization of the Refuge Manager.

H.42. Comment: Pg. 31(K-35)
Section 10, Use of Pyrethrins
Bullet point #1. "Use of adulticides must meet the following criteria: (1) when mosquito-borne disease incidence has been documented on the Refuge or within flight range of vector mosquito species present on the Refuge and (2) when there are no practical and effective alternatives to reduce a mosquito-borne, disease-based health threat."

ACMAD would like to reserve the right to use adulticides in the event of a large fly off of *Aedes* species. In some cases these mosquitoes have been shown to transmit disease causing viruses. In addition the aggressive nature of these mosquitoes can result in large numbers of complaints from the public, and in some individuals, cause severe allergic reaction. To our knowledge, ACMAD has never performed an adulticiding operation on Refuge property. Regular access to Refuge land for larval surveillance and subsequent larviciding should obviate the need for adulticiding. (ACMAD)

Refuge Response: The use of adulticide on the Refuge would require conditions and procedures as indicated in Threat Level 5 of the Mosquito Management Plan, the risk assessment in the most recent Mosquito-borne Virus Risk Assessment in the California

Mosquito-borne Virus Surveillance and Response Plan, and approval from the Refuge Manager.

H.43. Comment: Letter appended to comment from ACMAD written by Bartkiewicz, Kronick, and Shanahan.

Refuge Response:
California State Law
We wish to address a point made in the letter asserting that California law applies to the Service's management of mosquitoes (California Health and Safety Code section 2060(b), 2002(j)). There is no waiver of sovereign immunity requiring the Service to comply with the California Health and Safety Code provisions relating to mosquito abatement. Decisions regarding whether and how to manage mosquito populations on national wildlife refuges are guided by Service policy, which is discussed below. We believe the Refuge has made a good faith effort to develop a comprehensive integrated pest management plan in the form of the Mosquito Management Plan that meets both the Service's policies for pest management and the overall State goals of mosquito management.

There are several sources of Service policy that provide guidance on the management of mosquito populations on refuge lands. The Fish and Wildlife Service Manual, at 569 FW 1.6, directs the Service to manage pests if the "pest causes a threat to human or wildlife health or private property … or Federal, State, or local governments designate the pest as noxious; the pest is detrimental to refuge management goals and objectives; *and* the planned pest management actions will not interfere with achieving [Refuge] management goals and objectives." Service policy further provides that pest management methods are chosen based on ranked factors, with human safety being the most important factor. Environmental integrity, effectiveness and cost are also considered, in that order. (569 FW 1.7)

In addition, the Service has issued interim guidance on the management of mosquito populations on Refuge lands. See, *2005 Interim Guidance for Mosquito Management on National Wildlife Refuges.* The 2005 Interim Guidance provides that the Service "will allow populations of native mosquito species to function unimpeded unless they cause a wildlife and/or human health threat." If the Service agrees that there is a "documented" health threat and the threat is "above action levels," the 2005 Interim Guidance directs the Service to take appropriate action in coordination with federal, state and/or local agencies such as vector control districts. (See 2005 Interim Guidance, Table 1.)

The determination of whether to undertake response actions on Refuge lands in response to human health threats is guided by Service policy, which is informed by the qualified opinions of federal, state and/or local public health agencies. According to the 2005 Interim Guidance, "the first step in addressing mosquito management on a refuge is notification by the appropriate Federal, State, or local public health authority of a potential mosquito-associated health threat."[1] If a human health threat is documented

[1] The 2005 Interim Guidance provides that a "mosquito-associated health threat is defined as an adverse impact to the health of human, wildlife, or domestic animal populations from mosquitoes. A health threat determination will be made by the

by these agencies, the 2005 Interim Guidance encourages cooperation and consultation between the Service and public health agencies to determine whether on-Refuge interventions should occur. Before authorizing mosquito monitoring or abatement actions on refuge lands, the Service must ensure that there is sufficient documentation of the existence of a public health threat. Once a threat is established, the Service has an important role in deciding whether on-Refuge interventions should occur. A decision to take abatement action on Refuge lands is not solely in the province of local vector control agencies. The 2005 Interim Guidance sets forth a number of criteria for the Service to consider in deciding whether on-Refuge abatement actions should occur. (See, the Action Thresholds and Treatment Options sections of the 2005 Interim Guidance for a full explanation of when and how treatment options are considered.)

Nuisance and the Phased Response Plan
The comment letter suggests that mosquito populations are currently causing a nuisance and must be addressed. In the absence of documentation of a health threat, the Service cannot determine whether to authorize control or abatement measures on refuge lands. We believe that the actions outlined in Threat Levels 1 through 5 of the Mosquito Management Plan will be effective in responding to mosquito-borne disease risks and will also provide some ancillary benefits in controlling nuisance mosquitoes. The phased approach is used as a structure to provide a systematic method using disease history, disease presence, and mosquito population numbers to manage mosquitoes to reduce the threat of mosquito-borne disease.

Mosquito Control as a Use
The term "use" refers to any activity on a National Wildlife Refuge that is not a management activity conducted by refuge personnel for the purpose of conservation of fish and wildlife resources. It does not imply an extractive activity. Because we do not conduct mosquito management operations ourselves, but allow it when necessary through agreements with mosquito control agencies, mosquito management must be considered a use.

I. Other Projects

I.1. Comment: Regarding the San Francisquito Creek Restoration Project (SFCP), preserve the channels and levee section being planned for removal. Please preserve these channels free of vegetation and from becoming dry as the City of East Palo Alto and the community does not have the monies needed to upgrade this system. These are the Purdue Street outlet and channel, Stevens Street outlet and channel, and the Illinois Street outlet and channel. (Huerta)

Refuge Response: The SFCP which is being planned by the Joint Powers Authority (JPA) to improve flood control along the San Francisquito Creek corridor is noted in the CCP as Related Projects. The Refuge is not part of the planning and design work needed for this project, but we have commented during public scoping meetings offered by the JPA. As you may know, the Faber Tract is owned by the City of Palo Alto, but

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appropriate Federal, State, or local public health authority that has the expertise and the official capacity to identify human, wildlife, or domestic animal health threats. Documentation of a specific health threat on a refuge by a Federal, State, or local public health agency must be based on local and current mosquito population and/or mosquito-borne disease monitoring data."

through a Memorandum of Understanding with the City, the property is managed as part of the Refuge. The Refuge is concerned with impacts related to the lowering of the levee on the Faber Tract adjacent to SFCP. The Faber Tract has one of the highest populations of breeding California clapper rails in the Bay area, and if this levee were to be lowered, we have concerns that increased sediment rates, changing hydrology dynamics, high tide refugia, changes in vegetation, and invasive could cause negative impacts to endangered species. The Refuge will continue to work with JPA as needed to insure that impacts to endangered species and their habitats are protected.

The Faber Tract, which has the Bay Trail on the west side, and a public trail to the North, is already providing public use for hikers and wildlife observation. The levee adjacent to the SFCP will remain closed to the public in order to reduce impacts to endangered species from these activities. Cooley Landing is in the process of opening to the public and will provide additional trails for the public to enjoy.

The storm drains channels located within the Faber/Laumeister Tracts will remain as is and the Refuge has no plans to change or discontinue the use of these drains.

J. Climate Change

J.1. Comment: The draft CCP/EA briefly notes the potential effects of sea level rise on the Refuge and the CCP's contribution to greenhouse gas (GHG) emissions; however, the effects associated with implementing the CCP are not quantified. Please note that when reviewing lease applications CSLC staff is directed to (1) request information concerning the potential effects of sea level rise on proposed projects, and (2) if applicable, require applicants to indicate how they plan to address sea level rise and what adaptation strategies are planned during the projected life of each project. (CSLC)

Refuge Response: Comment noted.

J.2. Comment: Please provide a comprehensive analysis of the impacts of expected Sea Level Rise on Transitional Upland Habitat and discuss the ways in which the CCP would contribute to the protection of these habitats. (SCVAS)

Refuge Response: The Refuge will be working with others to assess sea-level rise impacts on refuge properties and resources (Objective 2.9).

The protection and creation/enhancement of transitional upland habitat is discussed in the following objectives and restoration plans:

> Objective 1.1. Conduct standardized monitoring efforts and research projects in coordination with other regional efforts for salt marsh harvest mouse and California clapper rail within five years. Improve high tide refugia for these species.
>
> Objective 2.2. Within two years of Plan approval, complete and implement a Weed Management and Re-vegetation plan on the Refuge.

Objective 2.5. Within the life of the Plan, enhance and restore marsh-upland ecotone, especially at Faber-Laumeister, La Riviere Marsh, EEC, A6, A8, and 75 miles of levee by establishing a dominance (>50 percent) of native plants along the levees or transitional uplands of the Refuge.

J.3. Comment: Lack of time frame and clarity regarding Climate Change Objectives and Strategies:
The CCP is correct in identifying the threat posed by invasive species and devotes an appropriate and thoughtful discussion to this issue, i.e. invasions of non-native and nuisance species pose a significant threat to the long-term viability of the Refuge. Unchecked invasive species could substantially alter community structure, lead to significant declines in species biodiversity, and adversely affect listed and rare species. The consequences of inaction are clearly explained and the time frames developed for the Objectives and Strategies appropriately convey a sense of urgency and hence priority - "Objective 2.2. Within two years of Plan approval, complete and implement a Weed Management and Re-vegetation plan on the Refuge." This is also true for the issue of mammalian and avian predator management. Even the development of a visitor services plan, which does not deal with direct threats to the resources of the Refuge, has a specified time frame of five years.

In contrast, the discussion regarding climate change fails to impart any sense of urgency/prioritization and does not adequately disclose the ramifications of inaction. (CCCR)

Refuge Response: Comment noted. We have added a timeframe of five years to Objective 2.9. We do not have internal expertise of climate change assessments. We will need funding and external expertise to help us with this analysis.

J.4. Comment: "Collecting data on physical and biological changes" can help to inform how to proceed with the conversion of salt ponds to tidal marsh, but we remain extremely concerned the objectives and strategies pertaining to climate change fail to convey the urgent need to acquire and/or protect lands that can ameliorate the expected impacts of sea level rise.

There should be no need to investigate the dire need to provide for the upslope migration of tidal marsh species as sea level rises. (CCCR)

Refuge Response: Comment noted. We agree that areas higher than the tidal marsh plain provide migration benefits, but we still believe it is important to understand the physical and biological changes that are taking place in order to make informed management decisions and potentially mitigate for such changes (e.g., introduced species, hybridized species, conflicts between species in different habitat types).

4. LIST OF PEOPLE AND ENTITIES THAT PROVIDED COMMENTS

State Agency
California State Lands Commission (CSLC)

Local Agency
Alameda County Mosquito Abatement District (ACMAD)
San Mateo County Mosquito and Vector Control District (SMCMVC)
Santa Clara Vector Control District (SCCVCD)
Alameda County Water District (ACWD)
San Francisco Bay Area Water Trail (SFBAWT)

Organizations
Citizens Committee to Complete the Refuge (CCCR)
California Waterfowl Association (CWA)
Santa Clara Valley Audubon Society (SCVAS)

Private Companies
Barg, Coffin, Lewis and Trapp, LLP
Cargill

Individuals
R. Bamford
N. Bell
B. and D. Breaud
B. Huerta
D. Jones