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).

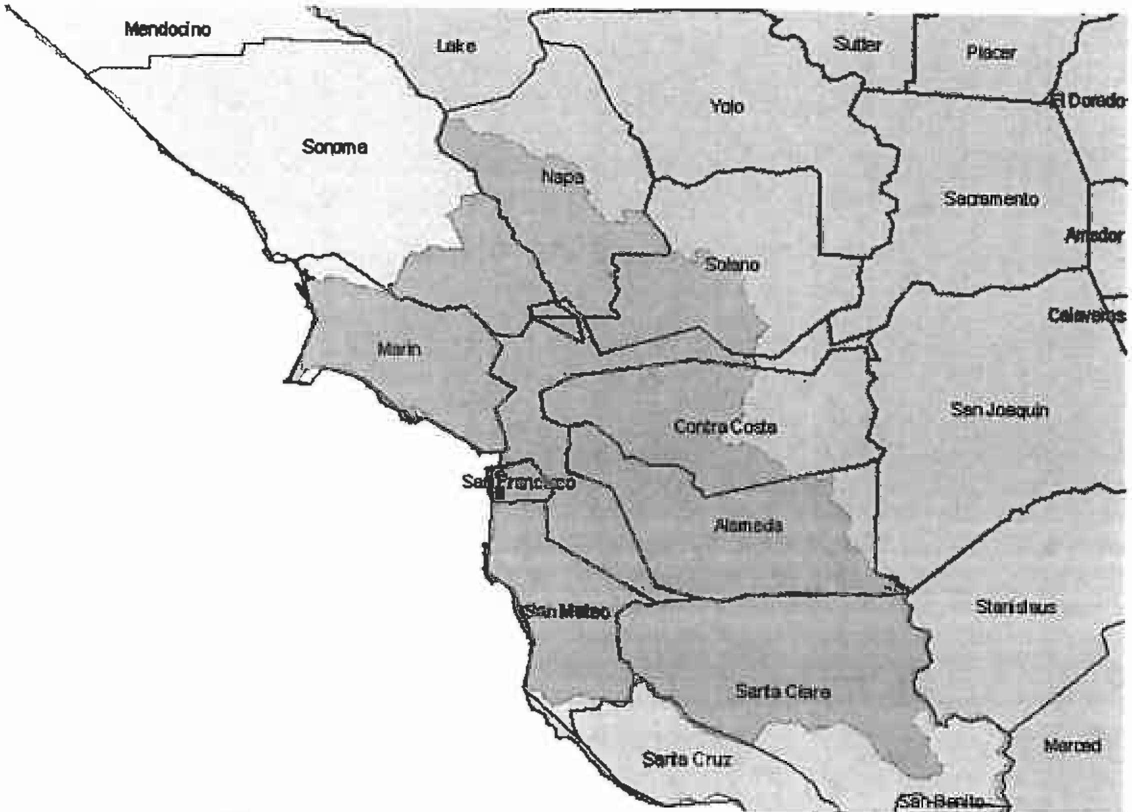
Similarly, a limited use by MVCD of herbicides, glyphosate and sulfometuron methyl (Table 1) is largely restricted to Napa County. These compounds are probably not reaching Waters of the U.S. since they are used on the berms of wastewater channels and ponds and are not applied directly to water.

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).

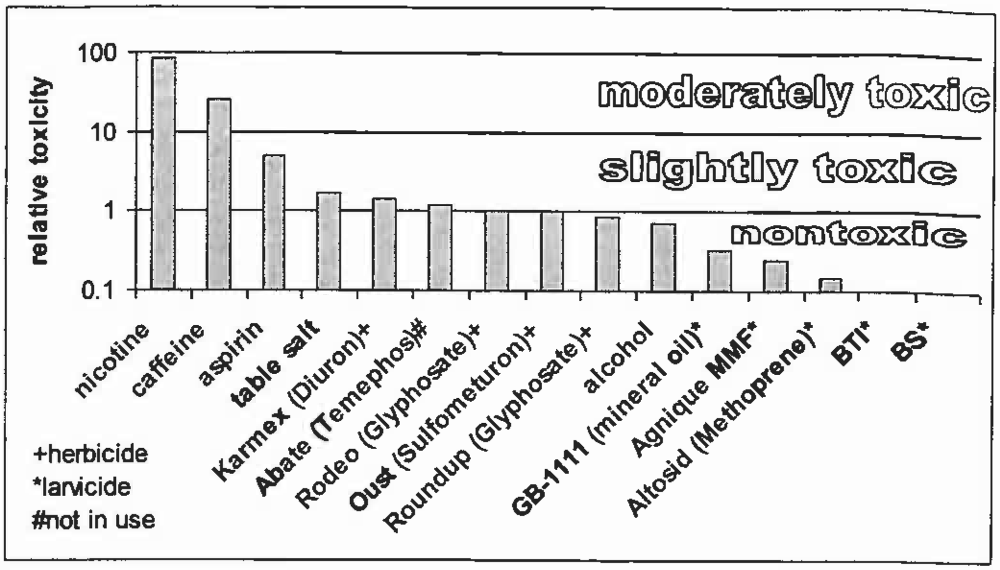


Fig. 1. Relative toxicities of pesticides used by mosquito and vector control programs, based on rat LD50 data from product labels, in comparison with some common household chemicals.

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

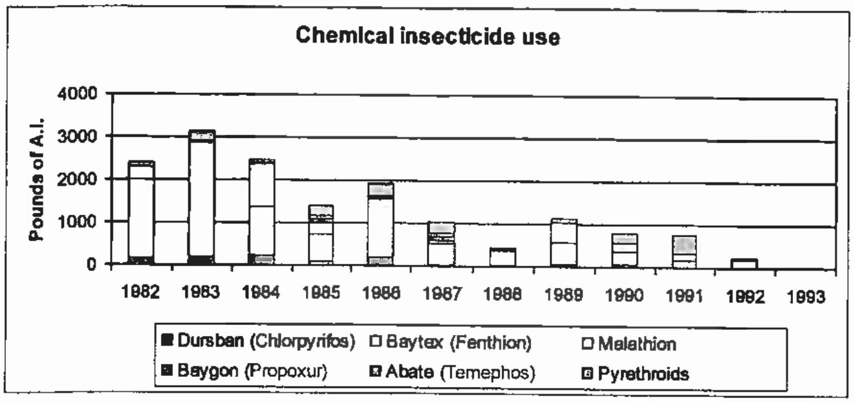
Bacillus sphaericus* and *B. thuringiensis* var. *israelensis
Cost: these materials are more expensive than organophosphate pesticides but cheaper than physical control.
Barriers: requires more careful monitoring of mosquito populations and more thorough knowledge of their ecology. Not effective against 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.

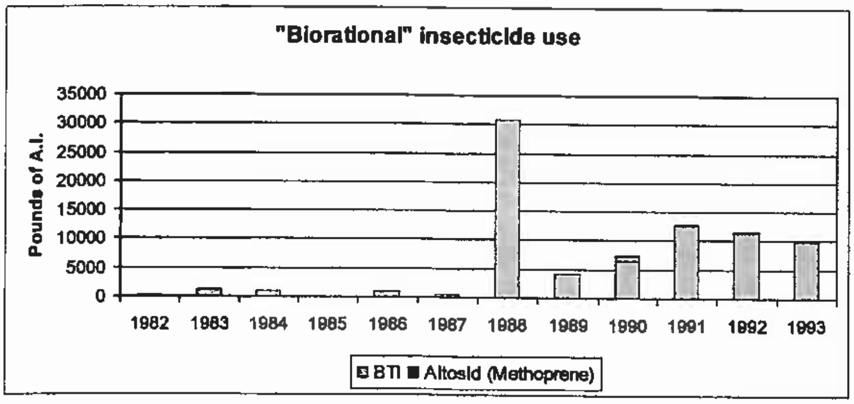


Fig. 2 a. Reduction in use of chemical larvicides by Coastal Region Districts, 1982-1993. b. Increase in use of bacterial insecticides and insect growth regulators.

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.