GLENN COUNTY MOSQUITO & VECTOR CONTROL DISTRICT
165 Co. Road G – Willows Airport
Willows, CA 95988

Phone: 530-934-4025 **Fax: 530-934-5971**

E-Mail –gcmvcd@now2000.com

Phil Isorena, Chief
NPDES Wastewater Unit
State Water Resources Control Board
Division of Water Quality
P.O. Box 100
Sacramento, CA 95965-9250

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DIVISION OF WATER QUALITY

Dear Phil Isorena,

Enclosed is Glenn County Mosquito and Vector Control District's (District) addendum to the Pesticide Application Plan (PAP) for the NPDES Vector Control Permit Application for the District. Enclosed, is the District's service area and hydrology maps, and the District's BMPs. Should you have any questions or further inquires, please don't hesitate to contact me.

Respectfully,

Jack F. Cavier Jr.
District Manager

Addendum to Glenn County Mosquito and Vector Control District's Notice of Intent (NOI)
November 8, 2011

1. **Historic applications to/over/near waters of the U.S. (high water mark of various creeks, streams and named water bodies, etc.)**
   In prior years, the District has applied larvacides and/or adulticides directly to or in the vicinity of the following water bodies and their unnamed tributaries:

Angel Slough	Little Butte Creek
Baker Slough	Logan Creek
Butte Creek	Sacramento River
Campbell Slough	Sheep Corral Creek
French Creek	Stony Creek
Gay Creek	Walker Creek
Hambright Creek	White Cabin Creek
Howard Slough	Willow Creek
Hunter Creek	Wilson Creek

   In prior years the District has also applied larvacides and/or adulticides directly to or in the vicinity of canals, ditches, or other constructed conveyance facilities owned and controlled by:

City of Orland
City of Willows (California Water Service)
East Corning Basin Private Pumpers
Glenn-Colusa Irrigation District
Glide Water District
Kanawa Water District
Orland-Artois Water District
Orland Unit Water Users Association
Princeton-Codora-Glenn Irrigation District
Provident Irrigation District
Reclamation Districts # 1004, 2140, 2047, 2106
Sacramento Wildlife Refuge Complex Properties within Glenn County
Tehama-Colusa Irrigation District
Western Canal Water District
Willow Creek Mutual Water District

2. **Limitations of each agency in utilizing BMPs in their District. (funding feasibility, equipment, negotiations with landowners, etc.)**

   BMPs are not always followed or implemented due to several factors or limitations. Usually the factors and/or limitations are the cots and/or regulations.

   Financial constraints on other cooperative public agencies is a significant limitation. Proper maintenance of storm water systems (e.g. pumping/vacuuming clogged storm drains/drain inlets, removal of emergent vegetation from retention/detention ponds, proper maintenance and design of waste water treatment facilities, etc.) is consistently overlooked or under funded.

   The cost of equipment, employee time, treatment materials is a significant limitation. Mitigating large mosquito sources requires a significant investment in equipment and trained personnel for moving soil and vegetation, which is beyond the means of most property owners and this District. Most landowners are relatively cooperative, but they lack the resources for long-term source reduction (e.g. installation of new water conveyances, emergent vegetation control, and re-grading irrigated agricultural land to reduce mosquito habitat). The District is sometimes unable to access known or suspected mosquito sources due to impenetrable vegetation (which the District lacks the resources to remove) or uncooperatively residents/property owners (which interfere with the timely inspection/treatment of larval sources). Compliance with permits, monitoring requirements, and paperwork is requiring more employee time, which reduces the number of man-hours available for our employees to inspect mosquito sources and implement non-pesticide alternatives.

   Legal restrictions and/or regulations to manipulate land, vegetation, or redesign is a significant limitation. Regulations and State and Federal laws prohibiting the necessary land improvements do to the presence of threatened or endangered species is a large limitation that does not allow for proper BMPs to be implemented. Additionally, cooperative working agreements between State, Federal, and private managed wetlands/rice land is a limitation (e.g. providing incentive programs to increase migratory waterfowl habitat).

   Last of all, biological control such as mosquito fish may not be suitable in all mosquito breeding sources due to poor water quality, mosquito larvae densities, emergent vegetation, temporary source (dries up), source may have sensitive species, and/or source may drain into natural waterways.

8. **Specific BMPs that the agency uses and give examples of where they have been implemented in the past instead of directly referencing the State BMP manual.**

The Glenn County Mosquito and Vector Control District (District) is aware that adjusting land management practices and installing proper Best Management Practices (BMPs) can reduce mosquito populations thereby reducing mosquito control costs, reducing the amount of pesticides used in mosquito control applications, helping to protect the public's health, and contributing to the District's Integrated Vector Management (IVM) approach to mosquito and vector control.

IVM is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. The District's IVM program uses current, comprehensive information on the life cycles of pests and their interaction with the environment. This information is used to manage pest nuisance and public health threats by the most economical means, and with the least possible hazard to people, property, and the environment. The District's IVM includes vector surveillance, source reduction and/or elimination, best management practices, Public education, biological control, chemical control and monitoring.

The District has used many BMPs throughout its 49 year existence and are a critical component of the District's IVM program. BMPs for mosquito harboring sites (breeding sources) come in all shapes and sizes. Mosquito breeding sources may be as small as a bucket or as large as several hundred acres of agricultural used land or managed wetlands.

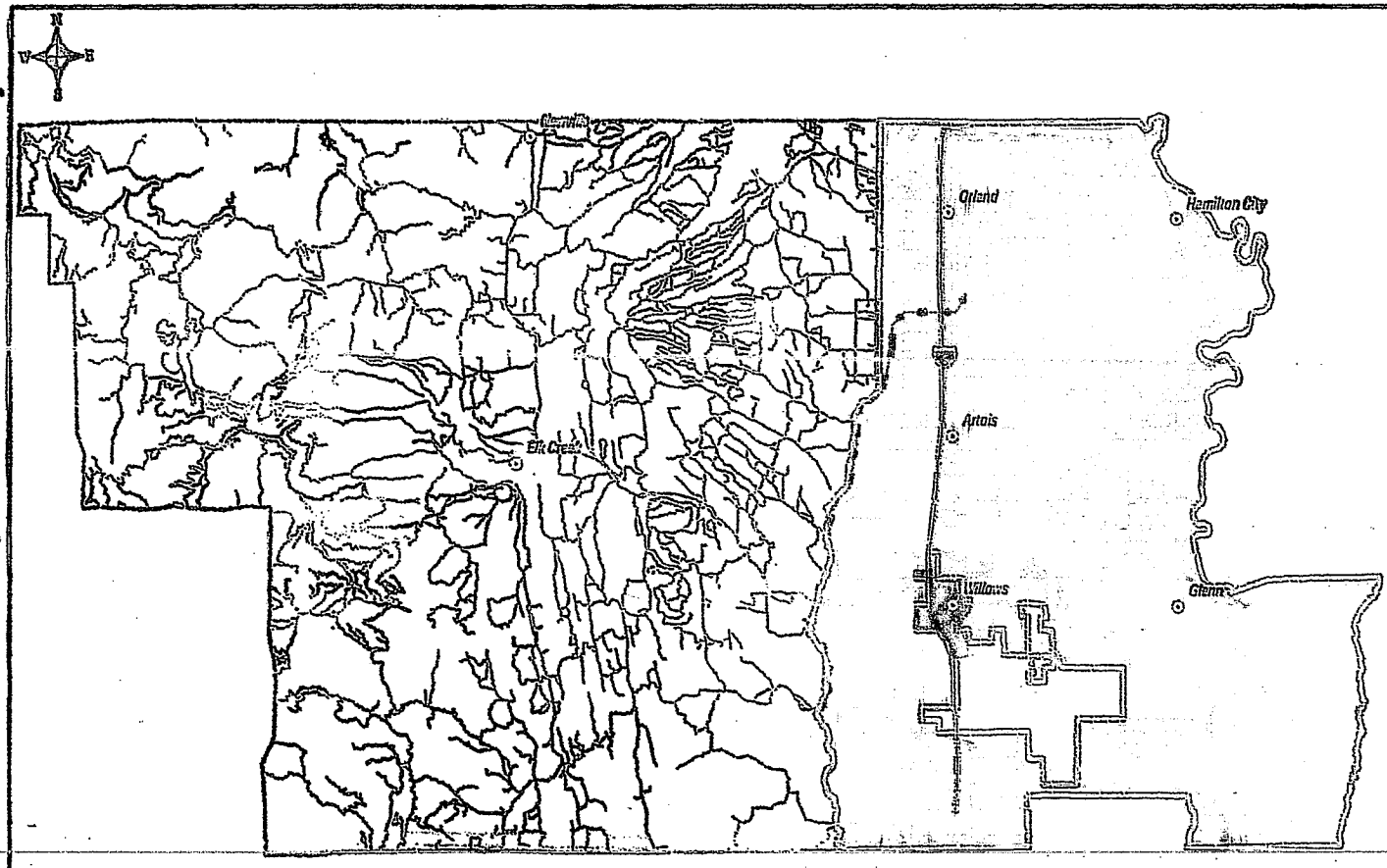
Examples of BMPs used to manage small mosquito breeding sources is to physically control or eliminate the source (e.g. turning over water buckets, washing out bird baths, unclogging boat drains, turning over flower pots, unclogging rain gutters, using pumps to pump water out of unused /abandoned items such as broken fountains and/or discarded chest freezers, etc.). For sources that are permanent or cannot be physically controlled, the District will access if biological control measures will work such as planting mosquito fish (Gambusia affinis).

For larger mosquito breeding sources, the District works cooperatively with property owners and/or land managers to effect short and long term management strategies. Examples of BMPs used to manage medium to large mosquito breeding areas the District has used: changed irrigation practices of agricultural lands and managed wetlands, water conveyance system improvements, water conveyance system design, managed wetland design and maintenance, agricultural design and maintenance, repairs of water leaks, maintenance of un-maintained swimming pools, maintenance of storm water systems/structures, storm water design, aerators, etc..

Additionally, the District works cooperatively and meets at least annually with the United States Fish and Wildlife Services to review BMPs that may need to be implemented on state an/or federal lands. The District works with all county and city local governments to assess the best ways to reduce mosquito breeding habitat.

For a more detailed and extensive list of BMPs the District may use and/or suggest to property owners/land managers within Glenn County, please see the District's Best Management Practices & Monitoring Plan for Application of Biological & Residual Pesticides to Surface Waters of the U.S. manual.

Map of Glenn County MVCD and the Valley-wide Mosquito Control District in Glenn County



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GLENN, CALIFORNIA, THIS _____ DAY
_____, 2007.

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COUNTY OF GLENN, CALIFORNIA
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AT THE REQUEST OF THE BOARD OF
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MOSQUITO ABATEMENT PROGRAM.

COUNTY AUDITOR, COUNTY OF GLEI

Legend

- Program Service Area
- County of Glenn
- Streets and Roads
- Tehama-Colusa Canal

Note:
REFERENCE IS HEREBY MADE TO THE MAPS AND DEEDS OF RECORD IN THE OFFICE OF THE ASSESSOR OF THE COUNTY OF GLENN FOR A DETAILED DESCRIPTION OF THE LINES AND DIMENSIONS OF ANY PARCELS SHOWN HEREIN. THOSE MAPS SHALL GOVERN FOR ALL DETAILS CONCERNING THE LINES AND DIMENSIONS OF SUCH PARCELS. EACH PARCEL IS IDENTIFIED IN SAID MAPS BY ITS DISTINCTIVE ASSESSOR'S PARCEL NUMBER.

GLENN COUNTY
VALLEY-WIDE MOSQUITO ABATEMENT DI
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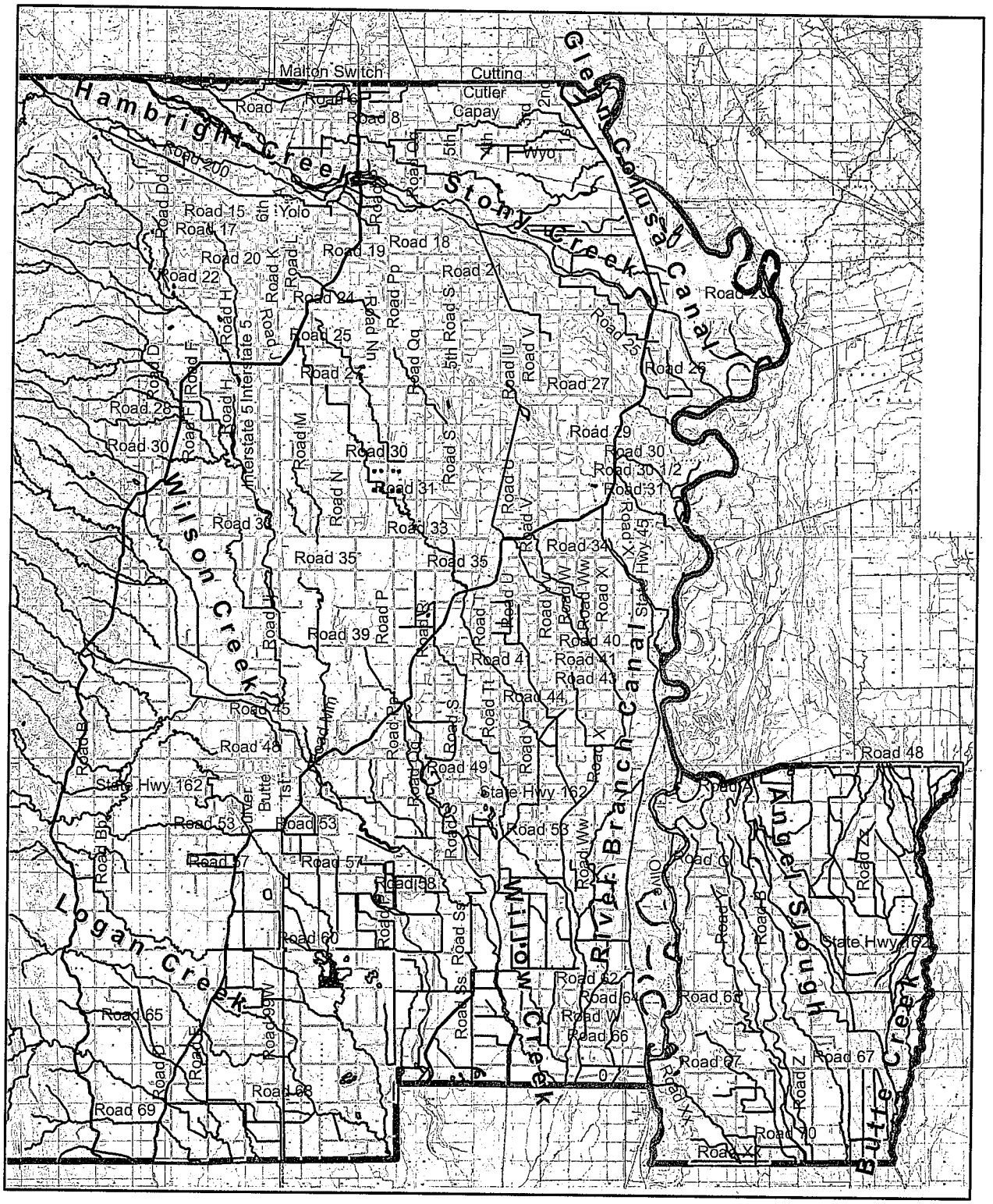


Hydrology of Glenn County

The Statement of Best Management Practices and

Monitoring Plan

For Application of Biological and Residual Pesticides to

Surface Waters of the US

By the Glenn County Mosquito and Vector Control District

Table of Contents

Statement of Best Management Practices
and
Monitoring Plan
For
the Glenn County Mosquito and Vector Control District

FOR WATER QUALITY ORDER NO 2011-xxxx-DWQ STATEWIDE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR RESIDUAL PESTICIDES TO WATERS OF THE UNTIED STATES FOR VECTOR CONTROL APPLICATIONS

BACKGROUND

The Glenn County Mosquito and Vector Control District (GCMVCD), within the jurisdiction of the Region *(5)* Water Quality Control Board, is seeking coverage under the General Permit as "a public entity' that applies ***residual*** pesticides for vector and weed control in ***or near*** 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, GCMVCD is allowed categorical exemptions from meeting priority pollutant/objectives for public health pest management. The underlying health and safety statutory mandates and requirements for GCMVCD are found in the California Health and Safety Code.

While various mosquito larvicides used by the GCMVCD (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 isroelensis, B. sphaericus* and m*ethoprene)* 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).

This document presents and discusses the GCMVCD BMPs and a monitoring plan as a requisite to the General Permit. GCMVCD is 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, This Monitoring Plan provides ***some*** exemptions to General Permit requirements that are presented and justified below.

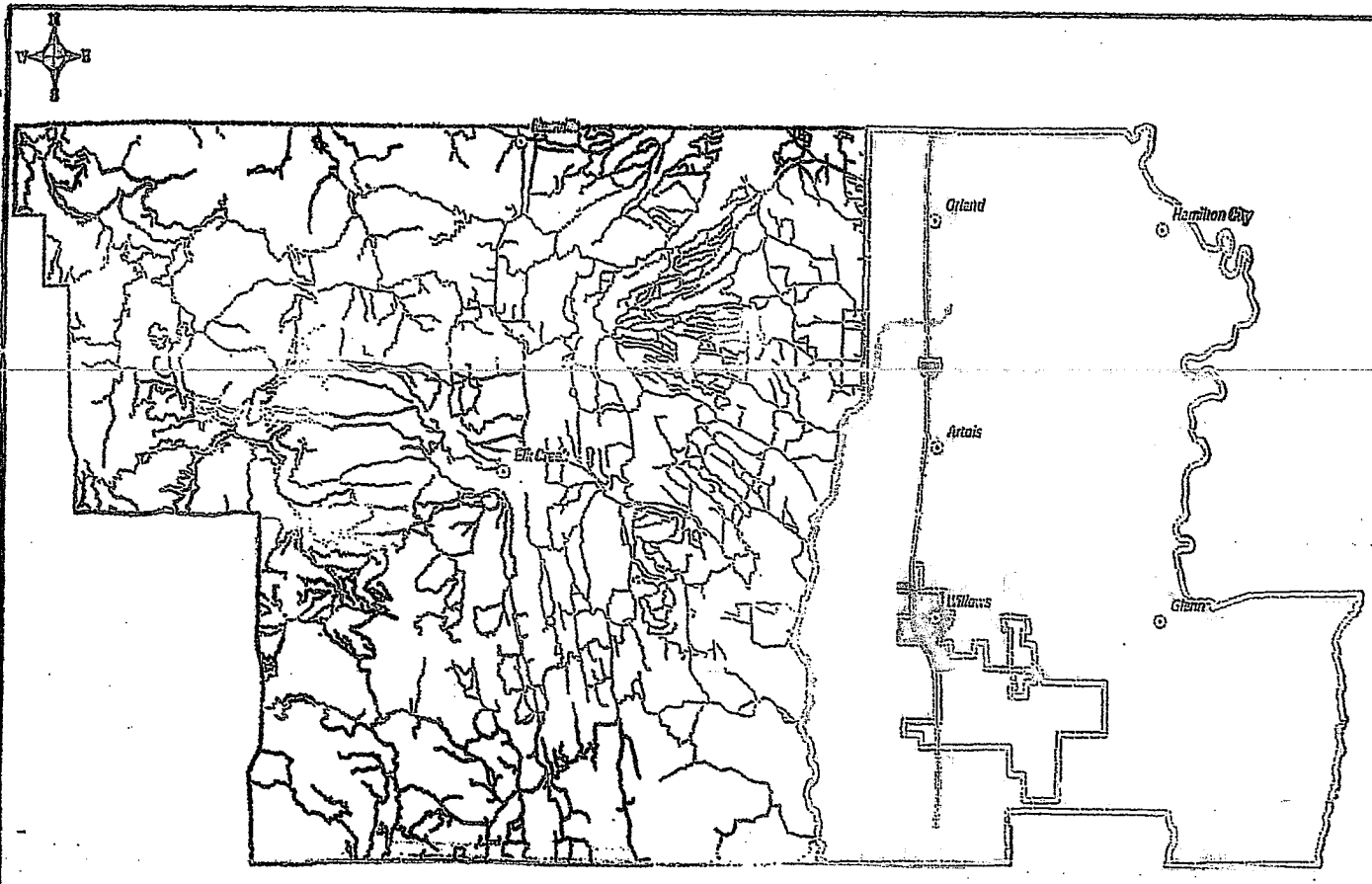
Statement of Best Management Practices

INTRODUCTION

The GCMVCD was formed in 1962 by a vote of the residents of Willows Area in Glenn County. The District currently serves 6.5 square miles with a population of approximately 6,500 people. The district was formed (pursuant to California Health and Safety Code Sections 2200-2280) as a result of concerns by local citizens and governments to reduce the risk of vector-borne disease or discomfort to the residents of Glenn County. This includes vector-borne diseases such as mosquito-borne encephalitis and malaria. GCMVCD is indirectly regulated by the Department of Pesticide Regulation (DPR). District Personnel and applicators are licensed by the California Department of Public Health (CDPH). Pesticide use by GCMVCD is reported to the County Agricultural Commission (CAC) in accordance with an annual Memoranda of Understanding among DPR, CDPH, and the CAC 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.

In 2007, the County of Glenn formed a Valley-wide Mosquito Control District, which covers the Valley floor of Glenn County. The GCMVCD does mosquito control work under a yearly MOU agreement between GCMVCD and County of Glenn.

Map of Glenn County MVCD and the Valley-wide Mosquito Control District in Glenn County



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CLERK OF THE BOARD OF SUPERVISORS

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CLERK OF THE BOARD OF SUPERVISORS

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COUNTY AUDITOR, COUNTY OF GLENN

GLENN COUNTY
VALLEY-WIDE MOSQUITO ABATEMENT DI
ASSESSMENT DIAGRAM

The GCMVCD has implemented Best Management Practices (BMP) based on integrated vector management (IVM). 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 GCMVCD staff ("technicians") assigned to zones within the district. 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. GCMVCD conducts public outreach programs and encourages local residents to contact the district 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 GCMVCD IVM 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. Similar projects have been undertaken in Sutter and Yuba Counties.

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

Maintenance activities are conducted within seasonal wetlands, ditches, canals, 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.

New projects, such as wetland restoration, excavation of new ditches, construction of new water control structures, all require review and assessment under CEQA. Since this can be a time-consuming and expensive proposition, GCMVCD tries to work with landowners and resource groups to manage their lands in a manner that does not promote mosquito development. GCMVCD staff review proposals for wetlands construction to assess their impact on mosquito production. The district then submits 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 GCMVCD. 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),* and Guppies *(Poecilia reticulata)*

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.

GCMVCD continues to investigate other biological agents, and guppies *(Poecilia reticulata),* will prey on mosquito larvae.

Advantages: The use of predatory fish as a component of an IVM 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 predatory fish in certain habitats. Guppies will not survive when temperatures dip below *52°* F. All of the fish may be preyed upon by other predators. They are opportunistic feeders and may prefer alternative prey when available. Introduction of predatory fish 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: Mosquito fish populations are unlikely to impact water quality.

Solutions to Barriers: Strict stocking guidelines adopted by GCMVCD restrict the use of predatory fish 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 organisms.

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 vector management program may reduce the need for use of conventional insecticides. *Lagenidium* may recycle naturally in certain habitats, providing long-term larval control 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 the GCMVCD mosquito control program 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 (eg. black flies 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 therefore not effective against nonfeeding stages such as late 4th instar larvae or pupae. BS is also ineffective against certain mosquito species. 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 its 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 IVM 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 inert, charcoal-based carriers such as pellets and briquettes to meter out a consistent amount that ranges 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. GCMVCD does not use methoprene in vernal pools due to potential impacts 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: 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, may be similarly affected. Agnique MMF 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 has been developed and adopted by the GCMVCD Board of Trustees. These criteria are shared with 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 and may be considered cultural control techniques:

* Drainage way construction and maintenance practices
* Dredge material disposal sites
* Irrigated pastures
* Permanent ponds used as waterfowl habitat
* Permanent Water impoundments
* Marsh
* Sedimentation ponds and retention basins
* Utility construction practices

GCMVCD also provides 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. GCMVCD has 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.

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 GCMVCD 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 GCMVCD. 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.

I. 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 Sacramento Valley Air Quality Management District. This strategy is limited to manmade impoundments and fallow farmlands. Factors limiting the use of this technique include weather, the limited number of approved bum days, and proximity of human habitation. As a general rule, burning is a last resort and has not been used by GCMVCD.

II. 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 GCMVCD staff utilize small hand tools or motorized equipment (backhoe). 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 factors include cost, the presence of sensitive species or habitats and the limited time period that GCMVCD is allowed to perform the activity for many types of mosquito developmental sites.

III. Chemical

Chemical control of vegetation could occur in man-made habitats such as impoundments, channels and ditches. Both pre- and post-emergent herbicides could be 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. The District does not currently use this method to control vegetation. If the district were to consider this option, the herbicides would be glyphosate based (Roundup and Rodeo).

Chemical name: Glyphosate

Product names: Roundup, Rodeo

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. GCMVCD in recent years have only used the Roundup, Rodeo. Glyphosate acts in plants by inhibiting amino acid synthesis. Roundup (41% of the isopropylamine salt of glyphosate with 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).

H. ORGANOPHOSPHATES (OP)

While GCMVCD has used organophosphates in the past, OP use in recent years has been limited due to mosquito resistance and other factors. 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

GCMVCD applicators must be certified to apply public health pesticides. The CDPH Vector-Bone Disease Section administers certification training and testing. All mosquito control personnel applying pesticides or overseeing the application of pesticides must obtain and maintain a Vector Control Technician certificate. The Mosquito and Vector Control Association of California provides training materials and exams are conducted by the CDPH. 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.

GCMVCD conducts 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 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 Public Health 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 Public Health 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 CDPH, 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 CDPH 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/ Outreach Pogram

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 provides 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.

Monitoring Plan for GCMVCD

INTRODUCTION

The GCMVCD within the Central Valley Region *(5)* is seeking coverage under the General Permit for ***residual pesticides discharge to or near waters*** of the U.S. The monitoring plan is presented in this document to the Regional Water Quality Control Board and shall be implemented by the District. 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.

MONITORING PLAN

The GCMVCD monitoring plan will consist of ongoing implementation of District Best Management Practices and Integrated pest management, record-keeping and reporting elements. Records shall be kept of all pesticide applications made to waters of the U.S. by District 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. The District shall report ***monthly*** to the Central Valley Region WQCB on its ***Residual*** 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 organophosphate, other non-standard larvicides or herbicides are required, the Central Valley RWQCB will be promptly notified so that an appropriate supplemental monitoring plan can be developed.

The SWRCB General Permit provides that monitoring exemptions may be appropriate for vector control projects involving microbial larvicides, thin film larvicides and methoprene. For the reasons explained in the District's Monitoring Plan and BMPs, District monitoring requirement may include water sampling and water ***chemistry analysis and toxicity done by a coalition of MVCD's.***

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.

Characterization of Pesticide Application Projects by GCMVCD

Types of sources treated

Activities of the GCMVCD 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. However, this approach requires the use of more potent pesticides applied over a greater area and is therefore avoided whenever possible.

There are 22 species of mosquitoes in the district (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 Sacramento Valley has a varied climate, with the preponderance of rain deposited during winter months (November through May), and summer temperatures often exceeding 100°F. 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 mosquito species and type of source targeted varies seasonally. For example, creeks and waterways that have substantial flow during winter months may only be 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 wetlands may require treatment from fall through spring or when artificially irrigated. Tables 2 and 3 include information on the seasonality of mosquito species and their development sites.

RESIDUAL PESTICIDES USED AND ASSESSMENT OF IMPACTS ON BENEFICIAL USE

Residual Pesticides used by GCMVCD fall into the 3 categories: bacterial larvicides, methoprene, and surfactants (surface-acting agents). Table 1 summarizes the amount of these products applied annually by the district. 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 (eg. black flies 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). BIT 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 GCMVCD as a liquid or sometimes bonded to an inert substrate (ie: 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. Mosquito mortality usually occurs within 48 hours of toxin ingestion.

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 the 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 on BTI granules recommend using 2.5 to 10 lb. /acre in "cleaner" water and 10 to 20 lb. /acre in "organic" or polluted waters.

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 salt marshes, 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 breeding 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 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.

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, 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 & 0' 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 formulations are sold under the trade name of Altosid. These

[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.

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.) & ALL. 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.

ALTOSD XR BRIQUETS. This formulation consists of 2.1% (wt./wt.) s-methoprene (.00145 lb. AT/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 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.

C. 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. Agnique MMF 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: Agnique MNF

Formulations and dosages

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 GCMVCD 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 LD5O 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. 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 5 gallons (surfactants) of active ingredient per acre. 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 content. 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 GCMVCD 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* which may 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 pesticide activity is present.

EVALUATION OF LESS-TOXIC CONTROL METHODS

Pesticide use by GCMVCD is only one aspect of its Integrated Vector Management (IVM) 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 IVM 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 and Water Management (see discussion in BMP document).

Cost: high, requires specialized equipment and expertise, may be labor intensive.
Barriers: high cost; potential problems with disturbing habitats of endangered species; wetlands are sensitive habitats and highly regulated; may require extensive permit process.
Solutions to barriers: encourage landowners to do work; train personnel 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.

Biological control

Mosquito fish (Gambusia affinnis)

Cost: low
Barriers: release of non-native fish into natural sources is controversial; may compete with native fish.
Solutions to barriers: use only in aquatic sites where impacts on native species will be will be minimal
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.
Bacterial pesticides: The primary pesticides used by GCMVCD 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 chemicals 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 unacceptable 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.

TABLE 1.A

Larvicides Used by Glenn County Mosquito and Vector Control District

Name of Product	Active Ingredients
Vectobac (all formulations)	*Bacillus thuringiensis var. israelensis*
Vectolex (all formulations)	*Bacillus sphaericus*
Altosid (All formulations)	(S)-Methoprene
Agnique MMF	Poly (oxy-l,2-ethanediyl); a isooctadecyl-w-hydroxyl
Agnique MMF G	Poly(oxy-1,2-ethanediyl, a(C_{16-20}branched and linear alkyl)-w-hydroxy
VectoMax WSP	*Bacillus thuringiensis* and *Bacillus sphaericus*

TABLE 1.B

Public Health Pesticides for ULV Adult Mosquito Control Used by Glenn County MVCD

Name of Product	EPA #	Active Ingredients
(Bayer Pyrenone 25-5)	#432-1050	Natural Pyrethrin & PBO
(MGK Pyrocide 5-25)	#1021-1569	Natural Pyrethrin & PBO
Clarke Anvil 10-10	#1021-1688-8329	Manufactured Pyrethroids & PBO
Clarke Bio-Mist 4+12	#8329-34	Manufactured Pyrethroids & PBO

Adverse effects from Ultra Low Volume (ULV) applications are rare: however, people with Health Problems should be aware when and where the applications are being conducted. This information can be obtained by contacting the local mosquito and vector control agency. All ULV adulticides are registered with US EPA. Chemicals currently registered for ULV applications against mosquitoes in California (as of December 2007) include organophosphates (e.g., malathion and naled), pyrethrins, and pyrethriods (e.g., sumithrin and permethrin). Formulations of both pyrethrins and pyrethroids include the synergist piperonyl butoxide (PBO), which increases their activity against mosquitoes.

Adult mosquitoes are controlled when mosquito borne disease activity is documented and/or thresholds are reach or exceeded. Thresholds are base on local sampling of the adult mosquito population snd/or when the risk of mosquito-borne disease increase above levels established by the state WNV surveillance and response plan.

Organophosphates:

Malathion and Naled are neurotoxins. Malathion is used typically early and late in the season.

Pyrethrins

Pyrethrins are natural insecticides derived from the Chrysanthemum flowers. Adult mosquitoes are rapidly paralyzed and killed on contact.

Pyrethroids

Pyrethroids are manufactured pyrethrins. They have very low toxicity to birds ans mammals, but are toxic to fish if misspplied.

Disadvantaged: Adult mosquito control is non-selective on other insects.

Basic resistance management techniques can include:

1. Do not use the same class of chemical against both immature and adult mosquitoes.
2. Apply pesticides at rate recommended on the label, Do not under dose.
3. When possible, utilize a different chemical class at the beginning and end of treatment season.
4. If possible, assess susceptibility at the beginning and sometime during the mosquito season.
5. Resistance management can also involve utilizing surveillance methods following larvicide and adulticide applications to continually check for control efficacy.

TABLE 2

Species of mosquitoes found within Glenn County Mosquito and Vector Control District

Culex apicaltis
Culex boharti
Culex erythrothorax
Culex pipiens
Culex stigmatosoma
Culex tarsalis
Culex thriambus

Aedes vexans

Ochlerotatus dorsalis
Ochlerotatus melanimon
Ochlerotatus nigromaculis
Ochlerotatus sierrensis
Ochlerotatus sticticus
Ochlerotatus washinoi

Culiseta incidens
Culiseta inornata
Culiseta particeps

Anopheles franciscanus
Anopheles freeborni
Anopheles punctipennis

TABLE 3

Typical Larval Mosquito Development Sites (Source Types)

Irrigated Farm Land
Riparian Areas
Wetlands
Roadside Ditches
Abandoned Swimming pools
Ornamental Ponds
Pastures
Dairy Sumps and Drains
Catch Basins
Detention Basins/Retention Basins

Potentially any aquatic site that has standing water for longer than three consecutive days.

Quality Assurance Plan
for Application of Aquatic Pesticides to Waters of the US
by the Glenn County Mosquito and Vector
Control District

This Quality Assurance Plan uses the Cooperative Agreement between the California Department of Public Health (CDPH) and the Glenn County Mosquito and Vector Control District (GCMVCD) as its sole point of reference. Pursuant to Section 116180 of the California Health and Safety Code, the CDPH "may enter into a cooperative agreement with any local district or other public agency engaged in the work of controlling mosquitoes, gnats, flies, other insects, rodents, or other vectors and pests of public health importance, in areas and under terms, conditions and specifications as the director may prescribe".

The GCMVCD has signed a cooperative agreement with CDPH for calendar year 2010 (enclosed).

The District, through the terms of the agreement, agrees to

1.) Calibrate all application equipment using acceptable techniques before using, and to maintain calibration records for review by the County Agricultural Commissioner. All equipment used by the District is calibrated at least once a year. Copies of calibration records are kept on file at the District Office.

2.) Maintain for at least two years for review by the County Agricultural Commissioner a record of each pesticide application showing the target vector, the specific location treated, the size of the source, the formulations and amount of pesticide used, the method and equipment used, the type of habitat treated, the date of the application, and the name of the applicator(s). Pesticide application records are kept on file for at least two years. The district maintains a database covering the last five years of pesticide applications; previous years (dating back to 1985) are stored on hard copy.

3.) Submit to the County Agricultural Commissioner each month a Pesticide Use Report, on Department of Pesticide Regulation form PR-ENF-010. The report shall include the manufacturer and product name, the registration number from the label, the amount of each pesticide, the number of applications of each pesticide, and the total number of applications, per county, per month. The district has been performing this activity and will continue to do so.

4.) Report to the County Agricultural Commissioner and the Department of Public Health, 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 the California Department of Health Services 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. All District personnel that apply pesticides are certified through the California Department of Public Health to apply pesticides. All pesticide applications are performed pursuant to label instructions and in accordance with state and federal laws. All certified employees applying pesticides receive, at a minimum, 20 hours of continuing education

hours per two-year cycle. Most GCMVCD district employees receive over 20 hours in a single year.

6.) Be inspected by the County Agricultural Commissioner on a regular basis to ensure that local agency activities are in compliance with state laws and regulations relating to pesticide use. The District has worked cooperatively with both County Agricultural Commissioners to ensure agencies compliance with state or local laws.

Integrated Mosquito Management

Immature Stages Management Guidelines

Source Sampling and Assessment

Vernal pool?	Yes →	Do not walk in habitat, return water to habitat Do not apply biologicals – consider ecological criteria.
No ↓		
Fairy shrimp present?	Yes →	Do not walk in habitat, return water to habitat Do not apply biologicals – consider ecological criteria.
No ↓		
Are endangered species present?	Yes →	Has supervisor been consulted about habitat? Avoid disturbing endangered species. If collected, return endangered species to habitat. Sample source.
No ↓		
Environmentally sensitive habitat[i]	Yes →	Has supervisor been consulted about habitat? Sample source
No ↓		
Will mosquitoes develop in the habitat?	No →	Has supervisor been consulted about habitat? Sample source
Yes ↓		

Sample Source and consider preventive physical measures.

Preventive Physical Measures

Can I remove the source? Or Can I turn over the source? Or Can I remove the water? Or Can I drain the source?	Yes →	Take necessary preventive physical measures
No ↓		
Can habitat be modified to reduce mosquito development?	Yes →	Consult with General Foreman, then take necessary preventative physical measures.
No ↓		

Consider preventive biological Measures

Preventive Biological Measures

Will habitat support immature mosquitoes?	No →	Do not apply biologicals. Set a return inspection date.
Yes ↓		
Time water will remain in source?	Intermittent→	Consider ecological criteria.
Permanent ↓		
Environmentally sensitive habitat[1]?	Yes →	Consult with supervisor before release. Can stock if available: backswimmers, flatworms, R. culicivorax, or L. giganteum.
No ↓		
Water Quality?	Highly Organic→	Stock with guppies or consider ecological criteria
Fresh ↓		
Swimming pool or backyard pond?	Yes →	Can stock guppies or mosquitofish.
No ↓		

Can apply if available: Mosquitofish, guppies, Backswimmers, flatworms, R. culicivorax, or L. giganteum Or consider ecological criteria.

Ecological Criteria

Mosquito stages present?	eggs →	Do not treat. Set a return inspection date.
1st to pupa ↓		
Number of immature mosquitoes?	Less than 0.05→ Immature/dip	Do not treat. Set a return inspection date.
Greater than 0.05 immature/dip ↓		
Number of immature mosquitoes with beneficials present?	Less than 0.1→	Do not treat. Set a return inspection date.
Greater than 0.1 immature/dip ↓		

Consider target population modification

Target Population Modification[1]

Source size?	More than 5 acres→	Consult with supervisor before treatment.
Less than 5 acres ↓		

Water quality?	Moderate to highly organic *Culex* sp →	Apply appropriate public health pesticide [ii] and consider treatment methods.
Fresh ↓		
Majority of immature stages present?	Late 4th to pupae→	Apply appropriate public health pesticide [iii] and consider treatment methods.
1st to early 4th ↓		
Vernal pool?	Yes →	Apply only Bti and consider treatment methods.
No ↓		
Fairy shrimp present?	Yes →	Apply only Bti and consider treatment methods.
	No ↓	
Apply appropriate public health pesticde[2] And consider treatment methods.		

Treatment Method

Distribution of immature?	Isolated location →	Treat selectively
Throughout source ↓		
Treat entire source		

[i] Examples of environmental sensitive habitats: wetlands, riparian areas, organic farms, State, Federal, local wildlife areas or other areas posted as such.

[ii] Public health pesticide (PHP) use and resistance management. A. Consult PHP's label before treatment. B. Apply PHP's within the same class or mode of activity on a rotational basis by the following guidelines unless no other alternatives are available: slow release PHP formulations rotate to a new class after three consecutive applications to the same site and short-lived PHP's formulations rotate to a new class after en consecutive applications to the same site (note: applications can be over more than one year).

Factors or conditions that may modify immature mosquito management guidelines:

1. Availability or suitable larvicides
2. Susceptibility of immature mosquito populations to larvicides.
3. Environmental conditions not listed in the program.
4. Sentinel chicken seroconversion
5. Human malaria, West Nile virus or encephalitis occurrence.
6. Unforeseen biological or environmental conditions.