ATTACHMENT G – NOTICE OF INTENT

WATER QUALITY ORDER NO. 2011-0002-DWQ
GENERAL PERMIT NO. CAG 990004

STATEWIDE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT FOR BIOLOGICAL AND RESIDUAL PESTICIDE DISCHARGES TO WATERS OF THE UNITED STATES FROM VECTOR CONTROL APPLICATIONS

I. NOTICE OF INTENT STATUS (see Instructions)

Mark only one item ☒ A. New Applicator ☐ B. Change of Information: WDID# ____________

☐ C. Change of ownership or responsibility: WDID# ____________

II. DISCHARGER INFORMATION

A. Name NAPA COUNTY MOSQUITO ABATEMENT DISTRICT			
B. Mailing Address P.O. BOX 10053			
C. City AMERICAN CANYON	D. County NAPA	E. State CA	F. Zip Code 94503
G. Contact Person WESLEY MAFFEI	H. Email address bugsydoc1@yahoo.com	I. Title MANAGER	J. Phone 707-553-9610

III. BILLING ADDRESS (Enter Information *only* if different from Section II above)

A. Name			
B. Mailing Address			
C. City	D. County	E. State	F. Zip Code
G. Email address	H. Title	I. Phone	

IV. RECEIVING WATER INFORMATION

A. Biological and residual pesticides discharge to (check all that apply)*:

1. ☐ Canals, ditches, or other constructed conveyance facilities owned and controlled by Discharger.
   Name of the conveyance system: ______

2. ☒ Canals, ditches, or other constructed conveyance facilities owned and controlled by an entity other than the Discharger.
   Owner's name: COUNTY OF NAPA
   Name of the conveyance system: ______

3. ☒ Directly to river, lake, creek, stream, bay, ocean, etc.
   Name of water body: SAN PABLO BAY AND SUISUN MARSH

* A map showing the affected areas for items 1 to 3 above may be included. (see attached)

B. Regional Water Quality Control Board(s) where application areas are located (REGION 1, 2, 3, 4, 5, 6, 7, 8, or 9): Region 2 AND 5
(List all regions where pesticide application is proposed.)

A map showing the locations of A1-A3 in each Regional Water Board shall be included.

V. PESTICIDE APPLICATION INFORMATION

A. Target Organisms: X Vector Larvae   X Adult Vector

B. Pesticides Used: List name, active ingredients and, if known, degradation by-products

SEE ATTACHED PESTICIDES USED LIST

C. Period of Application: Start Date JAN 1, 2011   End Date DEC. 31, 2016

D. Types of Adjuvants Added by the Discharger:
NONE

VI. PESTICIDES APPLICATION PLAN

A. Has a Pesticides Application Plan been prepared?*
☒ Yes ☐ No

If not, when will it be prepared? ______

* A copy of the PAP shall be included with the NOI. (see attached)

B. Is the applicator familiar with its contents?

☒ Yes ☐ No

VII. NOTIFICATION

Have potentially affected governmental agencies been notified?

☒ Yes ☐ No

* If yes, a copy of the notifications shall be attached to the NOI. (see attached)

VIII. FEE

Have you included payment of the filing fee (for first-time enrollees only) with this submittal?

☒ Yes ☐ NO ☐ NA

IX. CERTIFICATION

"I certify under penalty of law that this document and all attachments were prepared under my direction and supervision in accordance with a system designed to ensure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine or imprisonment. Additionally, I certify that the provisions of the General Permit, including developing and implementing a monitoring program, will be complied with."

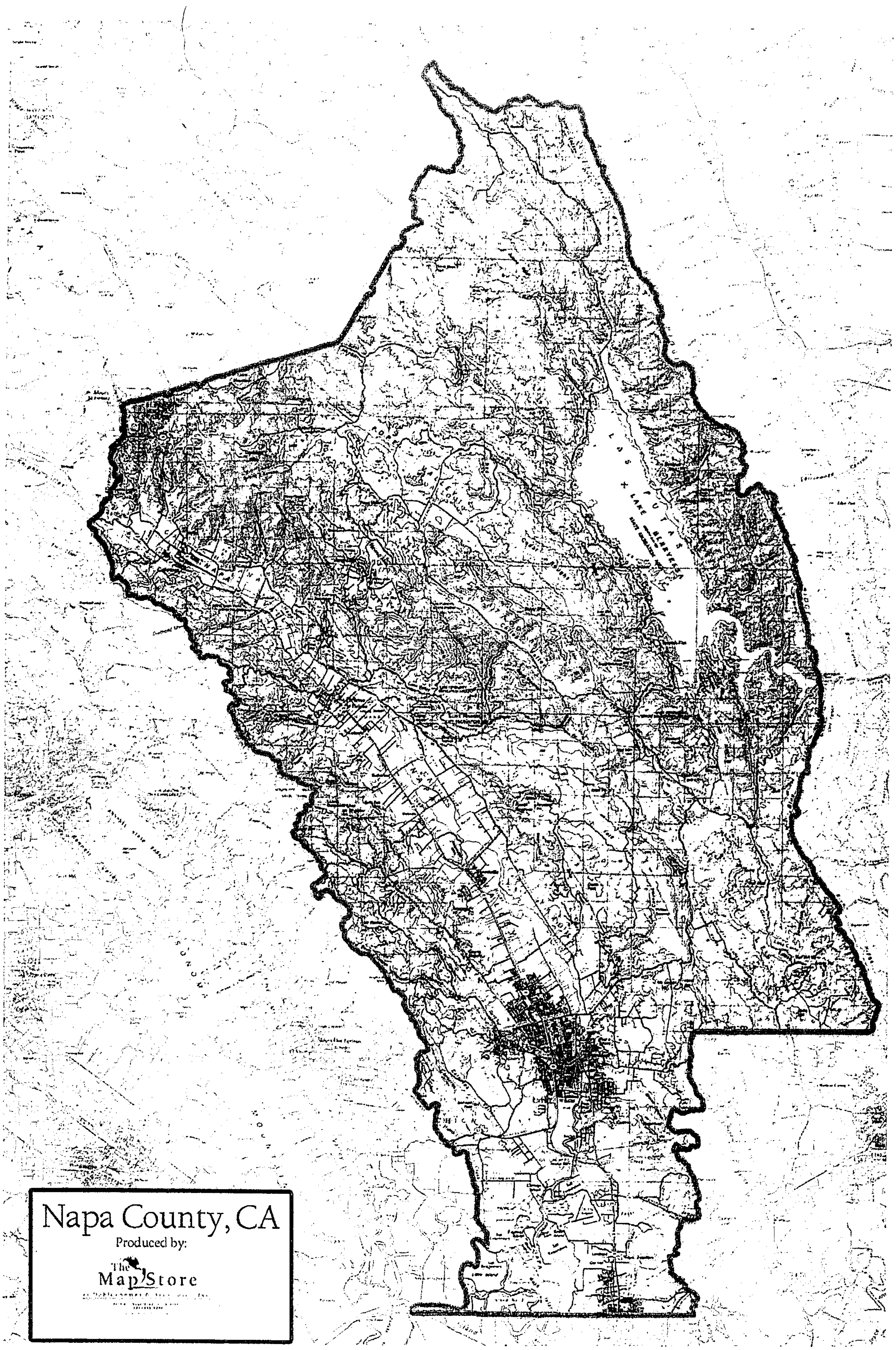
A. Printed Name: WESLEY A MAFFEI

B. Signature: Wesley A Maffei **Date:** 23, MAY 2011

C. Title:

X. FOR STATE WATER BOARD USE ONLY

WDID:	**Date NOI Received:**	**Date NOI Processed:**
Case Handler's Initial:	**Fee Amount Received:** $	**Check #:**


Napa County, CA
Produced by:
The Map Store

Pesticides Used, Napa County Mosquito Abatement District

Pesticide Name	Common Name	EPA #
Vectolex CG Biologic	Bacillus sphaericus 7.5% granule	275-77
Vectobac 12AS	Bacillus thuringiensis israelensis 1.2% Liquid	275-66
Vectobac G	Bacillus thuringiensis israelensis 0.2% granule	275-50
Vectobac TP	Bacillus thuringiensis israelensis powder 100%	73049-13
Teknar HPD	Bacillus thuringiensis israelensis 1.6%	73049-404
Vectolex WSP	Bacillus sphaericus 7.5% granule in water soluble packets	73049-20
VectoMAX CG	Bacillus sphaericus 2.7% and Bacillus thuringiensis israelensis 4.5% granules	73049-429
Vectolex WDG	Bacillus sphaericus 51.2% water dispersable granule	73049-57
FourStar 150 Bti	Bacillus thuringiensis israelensis 7% 150 day briquet	69504-2
FourStar 45 Bti	Bacillus thuringiensis israelensis 7% 45 day briquet	69504-2
FourStar 180 Bs	Bacillus sphaericus 6% Bti 1% 180 day briquet	83362-3
Agnique MMF	water soluable surface film	2302-14
Altosid Briquets	methoprene 7.9% 30 day	2724-375-64833
Altosid XR Briquets	methoprene 2.1% 150 day	2724-421-64833
Altosid Liquid conc	methoprene 20% liquid conc	2724-446-64833
Altosid Pellets	methoprene 4% pellet 30 days	2724-448-50809
Altosid XR-G	methoprene 1.5% granule 21 days	2724-451
Altosid WSP	methoprene 4.25% granule in water soluble packs 30 days	2724-448
Altosid SBG	methoprene 0.2% granule 5-10 days	2724-489
Skeeter Abate	temephos 5%	8329-70
Natular XRT	Spinosad 6.25% tablets 180 days	8329-82
Natular G30	Spinosad 2.5% granules 30 days	8329-83
Golden Bear Oil	Aliphatic Petroleum Hydrocarbons	8898-16
Bva 2	Refined Petroleum distillate	70589-1
Scourge 4%	4.14% Resmethrin 12.42% Piperonyl Butoxide	432-716
Scourge 18%	18% Resmethrin 54% Piperonyl Butoxide	432-667
Pyrenone 25-5	5% Pyrethrins 25% Piperonyl Butoxide	432-1050
MGK Pyrocide	5% Pyrethrins 25% Piperonyl Butoxide	1021-1569
Pyronyl Oil Conc. 525	5% Pyrethrins 25% Piperonyl Butoxide	655-471
Permanone	3.98% Permethrin 8.48% Piperonyl Butoxide	432-1277

Napa County Mosquito Abatement District Pesticide Application Plan

The Discharger shall develop a Pesticides Application Plan (PAP) that contains the following elements:

1. **Description of ALL target areas, if different from the water body of the target area, in to which larvicides and adulticides are being planned to be applied or may be applied to control vectors. The description shall include adjacent areas, if different from the water body of the target areas;**

   The District is responsible for all potential mosquito breeding sources within the boundaries of Napa County.
   Please see attached map.

2. **Discussion of the factors influencing the decision to select pesticide applications for mosquito control;**

   Please see the following attached documents:

   a) Statement of Best Management Practices for Napa County MAD
   b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
   c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
   d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
   e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
   f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

   All of these documents are a key part of the Districts frequent program reviews and overall decision making process.

3. **Pesticide products or types expected to be used and if known, their degradation by-products, the method in which they are applied, and if applicable, the adjuvents and surfactants used;**

   Please see attached list of Pesticides Used by Napa County MAD. Products may be applied by hand, truck, backpack, hand can, helicopter, or airplane according to label directions.

   See also the following attached documents:

   a) Statement of Best Management Practices for Napa County MAD
   b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD

c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

4. **Description of ALL the application areas* and the target areas in the system that are being planned to applied or may be applied. Provide a map showing these areas;**

There are potentially thousands of mosquito breeding sites within the boundaries of Napa County ranging in size from a few square feet to thousands of acres. The number and size of these sites varies from season to season due to a number of factors including but not limited to water use, land use activity, frequency and amount of precipitation, wind, temperature, etc. Therefore, any site that holds water for more than 96 hours (4 days) can produce mosquitoes. Source reduction is the District's preferred solution, and whenever possible the District works with property owners to affect long-term solutions to reduce or eliminate the need for continued applications as described in the Districts 1999 CEQA document, the Statement of Best Management Practices for Napa County MAD and the MVCAC/CDPH Best Management Practices for Mosquito Control in California. The typical sources treated by this District include:

a) Larvaciding:

Tidal marsh, freshwater marsh, reclaimed marsh, seasonal wetlands, freshwater seeps, creeks, streams, diked marsh, canals, flood control, channels, ditches, storm water detention basins, storm drains, waste water ponds, rainwater gutters, water troughs, water gardens, and various manmade water containers.

b) Adulticiding:

Riparian corridors, oak woodland, tidal marsh, freshwater marsh, reclaimed marsh, seasonal wetland, and diked marsh.

5. **Other control methods used (alternatives) and their limitations;**

With any source of mosquitoes or other vectors, the District's first goal is to look for ways to eliminate the source, or if that is not possible, for ways to reduce the potential for vectors. The most commonly used methods and their limitations are included in the NCMAD 1999 CEQA document, Statement of Best Management Practices for Napa County MAD and the MVCAC/CDPH Best Management Practices for Mosquito Control in California.

Specific methods used by the District include the use of mosquito fish (*Gambusia affinis*), providing educational materials to residents on mosquito development in standing water and encouraging removal of sources on their property, working with property owners to

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**Asterisks indicate terms that are defined in Attachment A of the NPDES Permit for Vector Control* find long-term water management strategies that meet their needs while minimizing the need for public health pesticide applications. The District also works closely with other agencies within the County in order to promote best management practices amongst those who manage water resources and can have a direct impact on the reduction of mosquito breeding without the use of pesticides.

6. **How much product is needed and how this amounts was determined;**
   The need to apply product is determined by surveillance. Actual use varies annually depending on the mosquito activity. The pesticide amounts presented below were taken from the NCMAD's 2010 PUR as an estimate of pesticide use in 2011. Other public health pesticides in addition to those listed below may be used as part of the District's best management practices.

   Please see attached 2010 pesticide use report. Total annual amounts of materials used determined from the summation of all 2010 monthly summary pesticide use reports submitted to the Napa County Agricultural Commissioner's Office. Projected future usage may vary depending on weather pattern (precipitation, wind, ambient temperatures, etc) and management of water and vegetation by landowners.

7. **Representative monitoring locations* and the justification for selecting these monitoring locations**
   Please see the MVCAC NPDES Coalition Monitoring Plan

8. **Evaluation of available BMPs to determine if there are feasible alternatives to the selected pesticide application project that could reduce potential water quality impacts; and**

   Please see the following attached documents:

   a) Statement of Best Management Practices for Napa County MAD
   b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
   c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
   d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
   e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
   f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

   NCMAD utilizes all of these documents in its decision making process in order to minimize the environmental impacts of its activities.

9. **Description of the BMPs to be implemented. The BMPs shall include at a minimum:**

The District's BMPs are described in the NCMAD 1999 CEQA document, the Statement of Best Management Practices for Napa County MAD, MVCAC/CDPH Best Management Practices for Mosquito Control in California and in the California Mosquito-borne Virus Surveillance and Response Plan. Specific elements have been highlighted below under items a-f.

a. **measures to prevent pesticide spill;**
All pesticide applicators receive quarterly spill prevention and response training. District employees ensure daily that application equipment is in proper working order. All vehicles and pesticide storage areas are equipped with spill mitigation and cleanup equipment.

b. **measures to ensure that only a minimum and consistent amount is used**
District application equipment is calibrated quarterly; annual calibration is required by the Department of Pesticide Regulations (DPR) and the terms of a cooperative agreement with the California Department of Public Health (CDPH).

c. **a plan to educate Coalition's or Discharger's staff and pesticide applicator on any potential adverse effects to waters of the U.S. from the pesticide application;**
This is part of NCMAD's pesticide applicators quarterly pesticide application and safety training, continuing education programs, and regional NPDES Permit training programs. The District also conducts monthly safety meetings to remind all district staff of the potential environmental effects of the various pesticides used.

d. **descriptions of specific BMPs for each application mode, e.g. aerial, truck, hand, etc.;**
The NCMAD calibrates truck-mounted and handheld larviciding equipment each quarter to meet application specifications. Supervisors review application records daily to ensure appropriate amounts of material are being used and properly applied. Ultra-low volume (ULV) application equipment is calibrated for output and droplet size to meet label requirements. Aerial larviciding equipment is calibrated by the Contractor. Aerial adulticide equipment is calibrated regularly and droplet size is monitored by the District to ensure droplets meet label requirements. Potential drift is closely monitored to ensure applications remain within the target area and adhere to the Districts guidelines of minimizing non-target effects.

e. **descriptions of specific BMPs for each pesticide product used; and**
Please see the following attached documents for general pesticide application BMPs, and the current approved pesticide labels for application BMPs for specific products.

   a) Statement of Best Management Practices for Napa County MAD

b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

f. descriptions of specific BMPs for each type of environmental setting (agricultural, urban, and wetland).

Please see the following attached documents:

a) Statement of Best Management Practices for Napa County MAD
b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

10. Identification of the problem. Prior to first pesticide application covered under this General Permit that will result in a discharge of biological and residual pesticides to waters of the US, and at least once each calendar year thereafter prior to the first pesticide application for that calendar year, the Discharger must do the following for each vector management area:

a. If applicable, establish densities for larval and adult vector populations to serve as action threshold(s) for implementing pest management strategies;

The NCMAD staff only applies pesticides to sources of mosquitoes that represent imminent threats to public health or quality of life. The presence of any mosquito may necessitate treatment, however higher thresholds may be applied depending on the District's resources, disease activity, or local needs. Treatment thresholds are based on a combination of one or more of the following criteria:

- Mosquito species present
- Mosquito stage of development
- Pest, nuisance, or disease potential

- Disease activity
- Mosquito abundance
- Flight range
- Proximity to populated areas
- Size of source
- Presence/absence of natural enemies or predators
- Presence of sensitive/endangered species or habitats.

Pease see Statement of Best Management Practices for Napa County MAD and NCMAD 1999 CEQA document for further specifics concerning monitoring and treatment thresholds.

b. Identify target vector species to develop species-specific pest management strategies based on developmental and behavioral considerations for each species;

Please see the following attached documents:

a) Statement of Best Management Practices for Napa County MAD
b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

c. Identify known breeding areas for source reduction, larval control program, and habitat management; and

There are potentially thousands of mosquito breeding sites within the boundaries of Napa County ranging in size from a few square feet to thousands of acres. The number and size of these sites varies from season to season due to a number of factors including but not limited to water use, land use activity, frequency and amount of precipitation, wind temperature, etc. Therefore, any site that holds water for more than 96 hours (4 days) can produce mosquitoes. Source reduction is the District's preferred solution, and whenever possible the District works with property owners to affect long-term solutions to reduce or eliminate the need for continued applications as described in the Districts 1999 CEQA document, the Statement of Best Management Practices for Napa County MAD and Best

Management Practices for Mosquito Control in California. The typical sources treated by this District include:

a) Larvaciding:
Tidal marsh, freshwater marsh, reclaimed marsh, seasonal wetlands, freshwater seeps, creeks, streams, diked marsh, canals, flood control, channels, ditches, storm water detention basins, storm drains, waste water ponds, rainwater gutters, water troughs, water gardens, and various manmade water containers.

Pease see Statement of Best Management Practices for Napa County MAD and NCMAD 1999 CEQA document for further specifics concerning source reduction, habitat management and larval control practices.

d. Analyze existing surveillance data to identify new or unidentified sources of vector problems as well as areas that have recurring vector problems.

This is included in the Statement of Best Management Practices for Napa County Mosquito Abatement District, Best Management Practices for Mosquito Control in California and the California Mosquito-borne Virus Surveillance and Response Plan that the Districts uses. The District continually collects adult and larval mosquito surveillance data, dead bird reports, and sentinel chicken test results and uses these data to guide mosquito control activities.

11. Examination of Alternatives. Dischargers shall continue to examine alternatives to pesticide use in order to reduce the need for applying larvicides that contain temephos and for spraying adulticides. Such methods include:

a. Evaluating the following management options, in which the impact to water quality, impact to non-target organisms, vector resistance, feasibility, and cost effectiveness should be considered:

- **No action**
- **Prevention**
- **Mechanical or physical methods**
- **Cultural methods**
- **Biological control agents**
- **Pesticides**

If there are no alternatives to pesticides, dischargers shall use the least amount of pesticide necessary to effectively control the target pest.

The NCMAD uses the principles and practices of integrated vector management (IVM) as described in the Statement of Best Management Practices for Napa County MAD, the Districts 1999 CEQA document, and on pages 26 and 27 of Best Management Practices for Mosquito Control in California. As stated in item #10 above, locations where vectors may exist are assessed, and the potential for using alternatives to pesticides is determined on a case-by-case basis. Commonly considered alternatives include: 1) Eliminate artificial sources of standing water; 2) Ensure temporary sources of surface water drain within four days (96 hours) to prevent adult mosquitoes from developing; 3) Control plant growth in ponds, ditches, and shallow wetlands; 4) Design facilities and water conveyance and/or holding structures to minimize the potential for producing mosquitoes; and 5) Use appropriate biological control methods that are available. Additional alternatives to using pesticides for managing mosquitoes are listed on pages 4-19 of the Best Management Practices for Mosquito Control in California.

Implementing preferred alternatives depends a variety of factors including availability of agency resources, cooperation with stakeholders, coordination with other regulatory agencies, and the efficacy of the alternative. If a pesticide-free alternative does not sufficiently reduce the risk to public health, pesticides are considered, beginning with the least toxic and amount necessary to effectively control the target vector.

Please see the following attached documents:

a) Statement of Best Management Practices for Napa County MAD
b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
e) MVCAC 2003 Integrated Mosquito Surveillance Program Guidelines for California
f) CDPH Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks

b. Applying pesticides only when vectors are present at a level that will constitute a nuisance.

The NCMAD follows an existing integrated vector management (IVM) program which includes practices described in the Districts 1999 CEQA document, Statement of Best Management Practices for Napa County MAD, California Mosquito-borne Virus Surveillance and Response Plan and the MVCAC/CDPH Best Management Practices for Mosquito Control in California.

A "nuisance" is specifically defined in California Health and Safety Code (HSC) §2002(j). This definition allows vector control agencies to address situations where even a low level of vectors may pose a substantial threat to public health. In practice, the definition of a "nuisance" is generally only part of a decision to apply pesticides to areas covered under this permit. As summarized in the California Mosquito-borne Virus Surveillance and Response Plan, the overall risk to the public when vectors and/or vector-borne disease are present is used to select an available and appropriate material, rate, and application method to address that risk in the context of our IVM program.

Please see the following attached documents:

a) Statement of Best Management Practices for Napa County MAD
b) 1999 Final Mitigated Negative Declaration of the Integrated Mosquito Management program of the Napa County MAD
c) CDPH and MVCAC 2010 Best Management Practices for Mosquito Control in California
d) CDPH and MVCAC 2010 California Mosquito-borne Virus Surveillance and Response Plan
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12. Correct Use of Pesticides

Coalition's or Discharger's use of pesticides must ensure that all reasonable precautions are taken to minimize the impacts caused by pesticide applications. Reasonable precautions include using the right spraying techniques and equipment, taking account of weather conditions and the need to protect the environment.

This is an existing practice of the NCMAD, and is required to comply with the Department of Pesticide Regulation's (DPR) requirements and the terms of our California Department of Public Health (CDPH) Cooperative Agreement. All pesticide applicators receive annual safety and spill training in addition to their regular continuing education.

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13. If applicable, specify a website where public notices, required in Section VIII.B, may be found.

http://www.waterboards.ca.gov/

References:

a. Statement of Best Management Practices for the Napa County Mosquito Abatement District

b. Best Management Practices for Mosquito Control in California. 2010. Available by download from the California Department of Public Health—Vector-Borne Disease Section at http://www.cdph.ca.gov/HealthInfo/discond/Pages/MosquitoBorneDiseases.aspx or http://www.westnile.ca.gov/resources.php under the heading Mosquito Control and Repellent Information. Copies may be also requested by calling the California Department of Public Health—Vector-Borne Disease Section at (916) 552-9730 or the Napa County Mosquito Abatement District at 707-553-9610.

c. California Mosquito-borne Virus Surveillance and Response Plan. 2010. [Note: this document is updated annually by CDPH]. . Available by download from the California Department of Public Health—Vector-Borne Disease Section at http://www.cdph.ca.gov/HealthInfo/discond/Pages/MosquitoBorneDiseases.aspx or http://www.westnile.ca.gov/resources.php under the heading Response Plans and Guidelines. Copies may be also requested by calling the California Department of Public Health—Vector-Borne Disease Section at (916) 552-9730 or the Napa County Mosquito Abatement District at 707-553-9610.

d. California Department of Public Health: Operational Plan for Emergency Response to Mosquito-borne Disease Outbreaks. A Supplement to the California Mosquito-Borne Virus Surveillance and Response Plan.

e. Overview of Mosquito Control Practices in California

f. EPA. 2000. Protecting Endangered Species in Napa County.

g. MVCAC. 2003. Integrated Mosquito Surveillance Program Guidelines for California

h. ASTHO. 2004. Public Health Confronts the Mosquito: Developing Sustainable State and Local Mosquito Control Programs.

i. NCMAD. 1999. Final Mitigated Negative Declaration: The Integrated Mosquito Management Program of the Napa County Mosquito Abatement District.

Napa County Mosquito Abatement District

P.O. Box 10053, American Canyon, CA 94503

WESLEY A. MAFFEI
Manager

Phone (707) 553-9610
Fax (707) 553-9611
www.napamosquito.org

May 17, 2011

TO: ALL GOVERNMENT AGENCIES OF NAPA COUNTY

FROM: Napa County Mosquito Abatement District

SUBJECT: Annual Statement of Intent to Apply Pesticides

On March 1, 2011 the State Water Board adopted a new Statewide National Pollutant Discharge Elimination System Permit for Residual Pesticide Discharges to Waters of the United States from Vector Control Applications.

The permit requires the District to provide an annual notice of our intent to discharge pesticides to potentially affected governmental agencies. Since the Napa County Mosquito Abatement District (NCMAD) may potentially treat anywhere within the boundary of Napa County on any given day during the year we are notifying the County, cities and all Special Districts within Napa County.

NCMAD typically uses larvicides for the purpose of reducing mosquito populations. The larvicides can be broken down into several groups, bacterial products, insect growth regulators and larviciding oils. During certain times of the year it is necessary for the district to use adulticides to control treehole mosquitoes or an unusual outbreak of mosquitoes. The adulticides typically used are natural pyrethrins. On rare occasions, when natural pyrethrins are not available, synthetic pyrethroids may be used. Sources treated with the pesticides used by the District require no additional restrictions or precautions to be taken by your employees or the public.

A complete list of all pesticides used by the District along with the EPA registration numbers are listed on the back of this page.

Any questions regarding this statement can be directed to the District Manager, Wesley A. Maffei at (707) 553-9610.

Pesticide Name	Common Name	EPA #
Vectolex CG Biologic	Bacillus sphaericus 7.5% granule	275-77
Vectobac 12AS	Bacillus thuringiensis israelensis 1.2% Liquid	275-66
Vectobac G	Bacillus thuringiensis israelensis 0.2% granule	275-50
Vectobac TP	Bacillus thuringiensis israelensis powder 100%	73049-13
Teknar HPD	Bacillus thuringiensis israelensis 1.6%	73049-404
Vectolex WSP	Bacillus sphaericus 7.5% granule in water soluble packets	73049-20
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FourStar 45 Bti	Bacillus thuringiensis israelensis 7% 45 day briquet	69504-2
FourStar 180 Bs	Bacillus sphaericus 6% Bti 1% 180 day briquet	83362-3
Agnique MMF	water soluable surface film	2302-14
Altosid Briquets	methoprene 7.9% 30 day	2724-375-64833
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Altosid Pellets	methoprene 4% pellet 30 days	2724-448-50809
Altosid XR-G	methoprene 1.5% granule 21 days	2724-451
Altosid WSP	methoprene 4.25% granule in water soluble packs 30 days	2724-448
Altosid SBG	methoprene 0.2% granule 5-10 days	2724-489
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Natular G30	Spinosad 2.5% granules 30 days	8329-83
Golden Bear Oil	Aliphatic Petroleum Hydrocarbons	8898-16
Bva 2	Refined Petroleum distillate	70589-1
Scourge 4%	4.14% Resmethrin 12.42% Piperonyl Butoxide	432-716
Scourge 18%	18% Resmethrin 54% Piperonyl Butoxide	432-667
Pyrenone 25-5	5% Pyrethrins 25% Piperonyl Butoxide	432-1050
MGK Pyrocide	5% Pyrethrins 25% Piperonyl Butoxide	1021-1569
Pyronyl Oil Conc. 525	5% Pyrethrins 25% Piperonyl Butoxide	655-471
Permanone	3.98% Permethrin 8.48% Piperonyl Butoxide	432-1277

NPDES ANNUAL STATEMENT OF INTENT TO APPLY PESTICIDES SENT TO THE FOLLOWING AGENCIES

Congress Valley Water District
Circle Oaks County Water District
American Canyon Fire Protection District
Town of Yountville
City of St. Helena
City of Napa
City of Calistoga
Napa County Board of Supervisors
City of American Canyon
Lake Berryessa Resort Improvement District
Los Carneros Water District
Monticello Public Cemetery District
Napa-Berryessa Resort Improvement District
Napa County Resource Conservation District
Napa County Regional Park & Open Space
Napa County Flood Control
Silverado Community Services District
Pope Valley Cemetery District
Napa River Reclamation District #2109
Napa Sanitation District
St. Helena Unified School District
Calistoga Joint Unified School District
Napa Valley Unified School District
Napa Valley College
U.S. Dept. of Interior, Bureau of Reclamation
Forestry & Fire Protection Department
California Dept. of Fish and Game
Spanish Flat Water District
San Pablo Bay National Wildlife Refuge

State of California—Health and Human Services Agency
California Department of Public Health

MARK B HORTON, MD, MSPH
Director

ARNOLD SCHWARZENEGGER
Governor

October 26, 2010

TO: Agencies Signatory to the Cooperative Agreement with the California Department of Public Health

SUBJECT: COOPERATIVE AGREEMENT WITH THE DEPARTMENT OF PUBLIC HEALTH

Thank you for submitting a 2011 Cooperative Agreement. The California Department of Public Health (CDPH) has reviewed and signed this Cooperative Agreement with your agency. Please note Certified Vector Control Technicians must maintain their certification by paying annual recertification dues and attending required continuing education courses in order for the Cooperative Agreement to remain valid.

The Cooperative Agreement may be canceled for cause by either party by giving 30 days advance notice in writing, setting forth the reasons for the termination.

If you should require additional information or clarification, please contact your VBDS regional office or the Sacramento headquarters at (916) 552-9730.

Jonathan Kwan, MS
Senior Public Health Biologist
Vector-Borne Disease Section

Enclosure

COOPERATIVE AGREEMENT
(PURSUANT TO SECTION 116180, HEALTH AND SAFETY CODE)

Date 13 OCT 2010

This Agreement between the California Department of Public Health and

NAPA COUNTY MOSQUITO ABATEMENT DISTRICT, P.O. BOX 10053, AMERICAN CANYON, CA 94503
(name and address of local vector control agency)

is effective on January 1, 2011 or on the subsequent date shown above, and expires December 31, 2011. It is subject to renewal by mutual consent thereafter.

Operator ID and/or license number to be listed on Monthly Summary Pesticide Use Reports (PR-ENF-060) for 2011:

Operator ID # 28-08-28 VC 039 License # ____________

This agreement may be canceled for cause by either party by giving 30 days advance notice in writing, setting forth the reasons for the termination.

Part I. Pesticides

The vector control agency named herein agrees:

1. To calibrate all application equipment using acceptable techniques before using, and to maintain calibration records for review by the County Agricultural Commissioner.

2. To seek the assistance of the County Agricultural Commissioner in the interpretation of pesticide labeling.

3. To 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).

4. To submit to the County Agricultural Commissioner 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 each pesticide used, the number of applications of each pesticide, and the total number of applications, per county, per month.

5. To report to the County Agricultural Commissioner and the California 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.

6. To require appropriate certification of its employees by the California Department of Public Health 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.

7. To 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.

Part II. Environmental Modification

The vector control agency named herein agrees:

To comply with requirements, as specified, of any general permit issued to the California Department of Public Health as the lead agency, pertaining to physical environmental modification to achieve pest and vector prevention.

For California Department of Public Health

Vicki Kramer

Vicki Kramer, Ph.D.
Chief, Vector-Borne Disease Section

For Local Agency

Wesley A. Maffei, Manager
Print Name and Title

Wesley A. Maffei
Signature

Napa County Mosquito Abatement District

P.O. Box 10053, American Canyon, CA 94503

WESLEY A. MAFFEI
Manager

Phone (707) 553-9610
Fax (707) 553-9611
www.napamosquito.org

27 May 2011

Mr. Philip Isorena
Attn: Trinh Pham
Division of Water Quality, 15th Floor
P.O. Box 100
Sacramento, CA 95812-1000

Subject: 2010 Pesticide Use Summary for Inclusion in Vector NPDES NOI Applications for the Napa County Mosquito Abatement District..

Dear Mr. Isorena:

The following 2010 pesticide use summary sheets were inadvertently left out of the Napa County Mosquito Abatement District's NOI submittal package that was sent out May 25, 2011. Two copies of NCMAD's 2010 pesticide use summaries have been included. Please include these documents with our submittal and accept our apologies for any inconvenience this may have caused your staff as they begin their review process of our submitted materials.

Please feel free to contact me at 707-553-9610 if I can be of any further assistance.

Respectfully,

Wesley A. Maffei

Wesley A. Maffei

enclosures

Napa County Mosquito Abatement District
Pesticide Use Summary
(Active Ingredient)

2010	GB 1111	BVA	A.L.L.	Teknar	A Pellets	Briquets	Abate	Vectolex	Tech pwdr	Permanone	Pyrenone	Pyrocide	Pyronyl	
January	17.3		0.18	0.24	24.7	0.54	22.7							
February	81.38		0.49	0.68	22.8	1.86	7.6	45.02						
March	122.96	13.03	0.99	1.3	43.8	4.9	25.44	126.56						
April	42.53	2.42	0.58	0.94	14.46	2.67	5.52	56.28			0.09		0.12	
May	7.06	0.51	0.17	0.21	63.84	2.18	11.52	15.94	0.82		0.73		0.68	
June	8.82		0.26	0.34	70.14	5.6	15.92	45.96			1.08		0.14	
July	3.38		0.24	0.37	26.34	10.52	8.16	51.12	0.45	0.07	0.98	0.45		
August	15.9		0.34	0.52	16.9	6	4.56	77.8	0.14					
September	9.13	0.29	0.15	0.18	20.16	7.92	4.16	74.02	0.65	0.05				
October	0.49		0.02	0.03	2.22	0.11	3.92	3.72						
November	9.6	1	0.06	0.07	12.42	0.26	2.96							
December	18	0.5	0.06	0.08	16.64	0.96	4.4		2.05					
	336.55	17.75	3.54	4.96	334.42	43.52	116.86	496.42	4.11	0.12	2.88	0.45	0.94	
	gallons	gallons	gallons	gallons	ounces	ounces	ounces	pounds	pounds	gallons	gallons	gallons	gallons	

Napa County Mosquito Abatement District
Pesticide Use Summary
(Active Ingredient)

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May	7.06	0.51	0.17	0.21	63.84	2.18	11.52	15.94	0.82		0.73		0.68
June	8.82		0.26	0.34	70.14	5.6	15.92	45.96			1.08		0.14
July	3.38		0.24	0.37	26.34	10.52	8.16	51.12	0.45	0.07	0.98	0.45	
August	15.9		0.34	0.52	16.9	6	4.56	77.8	0.14				
September	9.13	0.29	0.15	0.18	20.16	7.92	4.16	74.02	0.65	0.05			
October	0.49		0.02	0.03	2.22	0.11	3.92	3.72					
November	9.6	1	0.06	0.07	12.42	0.26	2.96						
December	18	0.5	0.06	0.08	16.64	0.96	4.4		2.05				
	336.55	17.75	3.54	4.96	334.42	43.52	116.86	496.42	4.11	0.12	2.88	0.45	0.94
	gallons	gallons	gallons	gallons	ounces	ounces	ounces	pounds	pounds	gallons	gallons	gallons	gallons

RECEIPT No. 336169

DATE 05/26/11

FROM Matthew Freese - DWQ $ 136.00

DOLLARS

○ FOR RENT
○ FOR County of Napa CK#480662

ACCT.	
PAID	
DUE	

○ CASH
○ CHECK
○ MONEY ORDER
○ CREDIT CARD

FROM ____ TO ____

BY [signature]

A-2501
T-46820

RECEIPT No. 336170

DATE 05/26/11

FROM Matthew Freese -DWQ $ 136.00

DOLLARS

○ FOR RENT
○ FOR County of Napa CK# 480661

ACCT.	
PAID	
DUE	

○ CASH
○ CHECK
○ MONEY ORDER
○ CREDIT CARD

FROM ____ TO ____

BY [signature]

A-2501
T-46820

Statement of Best Management Practices for Napa County Mosquito Abatement District

INTRODUCTION

The Napa County Mosquito Abatement District (NCMAD) is one of the oldest organized programs of mosquito control in California and has been in existence since 1925. The District was formed (pursuant to California Health and Safety Code Sections 2200-2280) by local citizens and governments to reduce the risk of vector-borne disease or discomfort to the residents of Napa County. This includes vector-borne diseases such as mosquito-borne encephalitides and malaria. NCMAD is indirectly regulated by the Department of Pesticide Regulation (DPR). District staff and applicators are licensed by the California Department of Public Health (CDPH). Pesticide use by NCMAD is reported to the County Agricultural Commission (CAC) in accordance with annual Memoranda of Understanding among DPR, CDPH, and the CACs for the Protection of Human Health from the Adverse Effects of Pesticides and with cooperative agreement entered into between DPH and NCMAD, pursuant to Health and Safety Code section 116180.

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

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 20 mosquito species known in Napa County differ in their biology, nuisance and disease potential and susceptibility to insecticides. 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 NCMAD staff 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. NCMAD 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.

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

LARVAL SOURCE TREATMENT CRITERIA

SPECIES	DISTANCE TO POPULATED AREA	TOTAL L/P DENSITY OTHER FACTORS
Ae. dorsalis	0 yards – 8 miles	1 per 10 dips and source 1/10 acre or
Ae. sierrensis	0 – 500 yards	1 per "slurp" with turkey baster
Ae. squamiger	0 – 8 miles	1 per 10 dips and source 1/10 acre or more
Ae. washinoi	0 – 500 yards 500 yards – 2 miles	1 per 10 dips 1 per dip and source ¼ acre or more
Cx. erythrothorax	0 – 500 yards	1 per dip
Cx. pipiens	0– 500 yards 500 yards – 1 mile	1 per 10 dips 3-5 per dip and source ¼ acre or more
Cx. stigmatosoma	0 – 500 yards	1 per 10 dips
Cx. tarsalis	0 – 500 yards 500 yards – 1 mile 1 mile – 5 miles	1 per 10 dips 1 per dip 3-5 per dip and source ¼ acre or more
Cs. incidens	0 – 500 yards 500 yards – 1 mile	1 per dip 5+ per dip source ¼ acre or more
Cs. inornata	0 yards – 2 miles	1-3 per dip source 1/10 acre or more
Cs. particeps	0 – 500 yards	1-2 per dip
An. freeborni	0 yards – 1 mile	2-3 per dip source ¼ acre or more
An. occidentalis	0 yards – 1 mile	2-3 per dip source ¼ acre or more
An. punctipennis	0 – 500 yards 500 yards – 1 mile	1-2 per dip 3-5 per dip source ¼ acre or more

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
- Presence of sensitive species

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 NCMAD IPM program. The goal of source reduction is to eliminate or reduce mosquito production at a particular site through alteration of habitat. Source reduction 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 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 Napa County. Source reduction programs conducted by the NCMAD may be categorized into three areas: "maintenance", "new construction", and "cultural practices" such as vegetation management and water management.

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

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

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

New projects, such as wetland restoration, excavation of new ditches, construction of new water control structures, all require application by NCMAD directly to the USACE. In addition, NCMAD staff work with landowners to manage their lands in a manner that does not promote mosquito development. NCMAD staff also 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 NCMAD. Implementation of these standards may include cultural practices such as water management and aquatic vegetation control.

B. Biological control

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

Mosquitofish (*Gambusia affinis*)

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

NCMAD Mosquitofish Stocking Policy

In an effort to minimize unwanted environmental impacts mosquitofish are not placed in sources known or thought to be habitats for endangered, threatened or rare species. Care must be taken when introducing mosquitofish into sources where they can migrate to habitats used by endangered, threatened or rare species. Mosquitofish can still be used in ornamental fish ponds, water gardens and abandoned swimming pools in urban and suburban areas without worrying about endangered species conflicts.

It is against California Department of Fish and Game regulations for private citizens to plant mosquitofish in waters of the State without a permit (Title 14 CCR, Fish and Game Code, Sections 1.63, 238.5 and 6400).

Mosquitofish provided by Napa County Mosquito Abatement District are intended for mosquito control purposes only and should not be introduced in potential mosquito breeding sources by anyone other than certified mosquito control technicians or Fish and Game personnel.

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

Barriers to Use: Water quality conditions, including temperature, dissolved oxygen, pH and pollutants may reduce or prevent survival and/or reproduction of mosquitofish in certain habitats. Mosquitofish may be preyed upon by other predators. They are opportunistic feeders and may prefer alternative prey when available. Introduction of mosquitofish may modify food chains in small contained pools and have potential impacts on endemic fish and shrimp in such situations.

Some wildlife agencies suspect mosquitofish may impact survival of amphibian larvae through predation. Recent research has shown no significant impact on survival of the threatened California red-legged frog (Lawler et al. 1999), but mosquitofish have been shown to negatively impact the survival of the California tiger salamander (Leyse and Lawler 2000). In light of these findings, the NCMAD restricts introduction of mosquitofish to sources where natural ecosystems will not be impacted.

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

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

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 over mosquito larvae if available and more accessible. Seasonal abundance and developmental rates often lag behind mosquito populations. Introduction or augmentation of natural predators has been suggested as a means of biological control, however there are currently no commercial sources since suitable mass-rearing techniques are not available.

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

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

C. 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: FourStar 150 Bti, FourStar 45 Bti, 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 such as blackflies and some species of midges (Glare and O'Callaghan, 1998). It is available in a variety of liquid, granular and pelleted formulations which provide some flexibility in application methods and equipment. BTI has no measurable toxicity to vertebrates and is classified by the 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. This mosquito larvicide also does not persist or accumulate in the environment.

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.

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 NCMAD as a liquid or sometimes bonded to an inert substrate (e.g. corn cob or sand 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 a district to use less of each product than they normally would if they would use one or the other. Financially, most savings are realized for treatments of mosquitoes with long larval development periods, asynchronous broods or areas with multiple species of mosquitoes.

BTI CORNCOB GRANULES. There are currently two popular corncob granule sizes used in commercial formulations. Aquabac 200G, Bactimos G, and Vectobac G are made with 5/8 grit crushed cob, while Aquabac 200 CG (Custom Granules) and Vectobac CG are made with 10/14 grit cob. Aquabac 200 CG is available by special request. The 5/8 grit is much larger and contains fewer granules per pound. The current labels 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.

***Bacillus sphaericus* (BS)**

Product names: Vectolex CG, Vectolex WSP, Vectolex WDG, VectoMAX CG, FourStar 180 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 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 non-feeding stages such as late 4th instar larvae or pupae. BS is also ineffective against certain mosquito species such as those developing in saltmarshes, seasonal forest pools or treeholes. Toxicity of BS to mosquitoes is due to a single toxin rather than a complex of several molecules as is the case with BTI. Development of resistance has been reported in Brazil. Thailand and France in sites where BS was the sole material applied to control mosquitoes for extended periods of time.

Solutions to Barriers: Information obtained from larval surveillance on the stage and species of mosquitoes present can increase the effectiveness of this material. Restricting it use to sources containing susceptible mosquitoes further enhances its effectiveness. 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.

Formulations and dosages: VECTOLEX CG. VectoLex-CG is the trade name for the granular formulation of *B. sphaericus* (strain 2362). The product has a potency of 50 BSITU/mg (*Bacillus sphaericus* International Units/mg) and is formulated on a 10/14 mesh ground corn cob carrier. The VectoLex-CG label carries the "CAUTION" hazard classification. VectoLex-CG is intended for use in mosquito breading sites that are polluted or highly organic in nature, such as dairy waste lagoons, sewage lagoons, septic ditches, tires, and storm sewer catch basins. VectoLex-CG is designed to be applied by ground (by hand or truck-mounted blower) or aerially at rates of 5-10 lb./acre. Best results are obtained when applications are made to larvae in the 1st to 3rd instars. Use of the highest rate is recommended for dense larval populations

***Saccharopolyspora spinosa* (Spinosad)**

Product names: Natular XRT, Natular G30

Advantages: Spinosad is a fermentation product of the naturally occurring soil bacterium *Saccharopolyspora spinosa.* It has very low vertebrate non-target toxicity and is classified by the EPA as a reduced risk larvicide, with a category III "Caution" label and is also a recipient of the Presidential Green Chemistry award. Spinosad has a unique mode of action by causing excitation of the insect nervous system (activation of the nicotinic acetycholine receptors) which ultimately leads to paralysis and death. This mode of action makes this pesticide a good option for rotational use in the prevention of resistance. This product does not persist in the environment and has very low potential for accumulation in soil or groundwater contamination.

Barriers to Use: Spinosad is affected by exposure to sunlight which can cause it to break down more rapidly. Its action on the target organism is either by contact or ingestion, and as with other bacterial larvicides, activity can be reduced in highly organic water. This insecticide is only effective against larval mosquitoes and will not control pupae.

Solutions to Barriers: Use in water sources that are not high in organic matter. 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: Spinosad is a fermentation product of a naturally occurring bacterium and is generally regarded as environmentally safe. It leaves no residues and is quickly biodegraded. At the application rates used in mosquito control programs, Spinosad is unlikely to have any measurable effect on water quality.

Formulations and dosages: Natular XRT and Natular G30 are multiple brood extended release tablets. Both of these formulations carry a "Caution" label requiring only protective eyewear PPE and can be applied using standard application protocol depending on the source. The dosage rate of extended release tablets is one tablet per 100 square feet of treatment area.

D. Cultural Practices

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

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

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

Water management consists of techniques to control the timing, quantity and flow rate of water circulation in managed wetlands to minimize mosquito development. The NCMAD has established guidelines for water management based on information from University of California Agricultural Extension Service (UCAES). The District provides these guidelines to property owners to promote proper irrigation techniques for wetlands to reduce mosquito development. The operation of structures such as tide gates that control water levels in marshes also minimize mosquito production.

E. 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 NCMAD 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 other equipment.

Vegetation management, one aspect of physical mosquito control, is an effective long-term control strategy that is occasionally employed by NCMAD. This methodology utilizes water management, burning, and physical removal 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.

Burning

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

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 NCMAD utilize small hand tools. This is the most frequently employed management technique once all necessary permits have been obtained and it is performed in all types of habitats. Unfortunately, its effectiveness is temporary and labor intensive, and therefore requires routine maintenance on an annual or at least biennial basis. Other limiting factors include cost, the presence of sensitive species or habitats and the limited time period that NCMAD staff are allowed to perform the activity for many types of mosquito developmental sites.

Chemical control of vegetation

Chemical control of vegetation occurs only in man-made habitats such as terminal water bodies and access roads. Both pre- and post-emergent herbicides are used, with strict attention given to label requirements, weather conditions, potential for runoff and drift, and proximity of sensitive receptors such as special-status species, sensitive habitats, livestock, crops, and people. Routine intensive surveys are conducted to address these factors.

Chemical name: Glyphosate

Product names: Roundup, Rodeo, Aquamaster

Advantages: Glyphosate based herbicides are not applied directly to water, but along the levee tops and margins of wastewater ponds, 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. NCMAD in recent years has only used the Roundup, Rodeo and Aquamaster formulations (Aquamaster being the registered replacement for Rodeo). Glyphosate acts in plants by inhibiting amino acid synthesis. Roundup (41% of the isopropylamine salt of glyphosate with surfactants) and Aquamaster (53% of the isopropylamine salt of glyphosate without surfactants) are applied from March through October for spot control of weed growth. Both of these materials are also occasionally used to control growth of poison oak and blackberry vines that would prevent access 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). Therefore, its use is closely monitored to minimize potential impacts on water quality.

F. Chemical Control of Immature Mosquitoes (larviciding and pupaciding)

Methoprene

Product Names: Altosid briquets, Altosid liquid concentrate, Altosid pellets, Altosid SBG, Altosid XR briquets, Altosid XR-G, Altosid WSP

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 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 to the label concentrations used by mosquito control.

Barriers to Use: Methoprene products must be applied to larval stage mosquitoes since it is not effective against the other life stages. Monitoring for effectiveness is difficult since mortality is delayed. Methoprene is more expensive than most other mosquitocidal agents. Methoprene use is avoided in vernal pools. There may be toxicity to certain nontarget crustacean and insect species (Glare and O'Callaghan, 1999).

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.

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, Glare & O'Callaghan 1999). 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, eight s-methoprene formulations are sold under the trade name of Altosid. These include Altosid Liquid Larvicide (A.L.L.) and Altosid Liquid Larvicide Concentrate, Altosid Briquets, Altosid XR Briquets, Altosid Pellets, Altosid XRG, Altosid WSP, and Altosid SBG (the last three formulations are currently not used by NCMAD). Altosid labels contain the signal word "CAUTION".

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

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[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.

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

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

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

ALTOSID PELLETS. Altosid Pellets contain 4.25% (wt./wt.) s-methoprene (0.04 lb. AI/lb.), dental plaster (calcium sulfate), and charcoal in a small, hard pellet. Like the Briquets discussed above, Altosid Pellets are designed to slowly release s-methoprene as they erode.. Under normal weather conditions, control can be achieved for up to 30 days of constant submersion or much longer in episodically flooded sites (Kramer 1991). Label application rates range from 2.5 lbs. to 10.0 lbs. per acre (0.1 to 0.4 lb. AI/acre), depending on the target species and/or habitat. At maximum label application rates, as with the Briquets, the slow release of material means that the actual concentration of active ingredient in the water never exceeds a few parts per billion.

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

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

Surfactants

Product Names: Golden Bear 1111, Agnique MMF, BVA2

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

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

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

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

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

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

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

BVA 2: This is a relatively new larviciding product that contains 97% petroleum distillate formulated from a structurally modified mineral oil and 3% inert ingredient. It is designed to work quickly and effectively against a wide range of mosquito species controlling both larvae and pupae. The manufacturers recommended dosage is 3-5 gallons of product per acre, depending on the presence and density of vegetation. Lower dosage rates can be used in sources with little or no vegetation but higher rates may be required in sources where vegetation is dense. This product can be applied using backpack or truck mounted sprayers. BVA 2 has been shown to be as effective as Golden Bear 1111 at controlling immature mosquitoes and so is an effective alternative. BVA 2 carries an EPA CAUTION label and has a residual period lasting 1 to 3 days.

G. Chemical Control of Adult Mosquitoes (Adulticiding)

Adult mosquito control is the least preferred method utilized by the District to manage mosquito populations and potential mosquito-borne disease. This last resort methodology is employed when physical, biological and chemical control of immature mosquitoes fails or is otherwise insufficient or a public health emergency has been declared by County or State public health officials.

District staff use hand held or truck mounted ULV (Ultra Low Volume) sprayers to generate aerosol mists of microscopic insecticide droplets (8 - 15 microns in size), which are allowed to drift into and across areas harboring the target species. Insecticides for control of adult mosquitoes are known as adulticides, and the District can select from a wide range of materials registered for this purpose. The adulticide routinely used by the District is Pyrethrum (Pyrethrins). When Pyrethrum is not available the District may use the synthetic pyrethroids Permethrin and Resmethrin.

The effectiveness and efficiency of adulticiding depends on a number of related factors. First, the mosquito species to be treated must be susceptible to the insecticide applied. Thus their tolerance or resistance affects the selection of chemical. Second, insecticide applications must be made during periods of adult mosquito activity, which varies between species. Some mosquito species are diurnal (biting in the daytime), others are crepuscular (biting at dawn or dusk), and still others are nocturnal (biting at night). Aerosol applications should be made when the target mosquitoes are active and can be maximally exposed to the aerosol mist. District criteria emphasize adulticiding as a technique to reduce populations of the Western Treehole Mosquito, *Aedes sierrensis*, (the primary vector of Dog Heartworm) due to the sheer number of treeholes and the concomitant access and worker safety issues associated with the oak woodland and riparian habitats utilized by this mosquito. The large number of residences that exist within Napa County's oak woodlands and along its riparian corridors makes this mosquito a species of concern to its residents and therefore the District. Since this mosquito is primarily a crepuscular species, adulticiding activity primarily takes place at dawn and dusk and is limited to two treatments per site each year between the months of April and August.

Additionally, technical considerations can influence adulticide effectiveness. First, the application must generate a pesticide concentration in the air that is lethal to the target insect. Second, since the aerosol mist must move from the sprayer to the target mosquitoes; the size of the pesticide droplets is critical to ensure proper movement without rapid evaporation, settling to the ground, or drift away from the target site. Third, sufficient insecticide must be distributed to cover the target site with an effective dose. Densely vegetated habitats may require a higher application rate than open areas to allow the wind to sufficiently carry the droplets through the foliage.

Finally, environmental conditions may also affect the results of adulticiding. Wind determines how the ULV droplets will be moved from the sprayer to and within the treatment area. Conditions of no wind will result in the material not moving from the application point. High wind can inhibit mosquito activity and will quickly disperse the insecticide too widely to be effective. Light wind conditions (1-6 mph) are the most desirable both because mosquitoes are most likely to be active and because the aerosol is most likely to maintain the proper concentration as it moves through the target area. Also, ULV applications are generally avoided during hot daylight hours because thermal conditions will cause small droplets to rise, moving them away from mosquito habitats and flight zones. Preferred conditions include the presence of a thermal inversion near the ground, which can trap the aerosol in a mist in the lower ten or twenty feet of the atmosphere, maintaining the proper control dose with minimal material use. Ideal conditions of wind and temperature are generally found around sunrise or sunset, and adulticiding is usually conducted during these times. This practice minimizes exposure of non-target diurnal species such as bees and butterflies. Control of adults of some mosquito species may require modifications of this schedule to accommodate the species flight activity pattern (e.g. Summer Salt Marsh Mosquitoes, *Aedes dorsalis*).

Pyrethrin

Product Names: Pyrenone 25-5, MGK Pyrocide, Pyronyl Oil Concentrate 525

Advantages: Pyrethrin (Pyrethrum) is a natural insecticide extracted from certain varieties of the flower *Chrysanthemum cinerariaefolium* and consists of six active ingredients collectively known as pyrethrins. This insecticide provides effective control of adult mosquitoes and other insect pests at very low dosage and has little residual activity (persistence) due to its sensitivity to sunlight. Pyrethrin is readily oxidized in sunlight and rapidly hydrolyzed by alkali. The lack of persistence allows some formulations of this insecticide to be safely used in and near crops as well as livestock. Napa County is largely agricultural with vast expanses of vineyards, a few small orchards, some organic farms and limited livestock. The lack of persistence also allows for rapid re-colonization of the treated area by non-target organisms without adverse impacts.

Barriers to Use: Pyrethrins are a broad spectrum insecticide that is highly toxic to most insects, especially bees, and moderately toxic to fish and some birds. Pyrethrins must be applied to adult mosquitoes under ideal environmental conditions that maximize its effectiveness for controlling mosquitoes and minimize the amount of insecticide used. Temperature, wind speed, humidity, amount of vegetative cover and the timing of the application during adult mosquito activity are key factors when utilizing this insecticide. Proper droplet size and amount of material applied to the target area is also important. There may also be members of the public that are chemically sensitive or concerned about any form of adulticiding in their areas.

Solutions to Barriers: Surveillance and monitoring can provide information on maximal adult mosquito activity thus limiting the number of applications, the size of the target area required for effective control, total pesticide load and exposure of non-target organisms. The District's current policy is a maximum of two treatments in any one area per season for the Western Treehole Mosquito (*Aedes sierrensis*). Adult mosquito control for the other species of mosquitoes present in Napa County is limited to an unusually high adult emergence posing a clear threat to the health and comfort to a large portion of a nearby population center or the declaration of a public health emergency by the County's public health officer or State public health officials. Assessing vegetative cover and enlisting the aid of the property owner in reducing the density of vegetation helps reduce the amount of pyrethrins required for effective mosquito control. Proper advance notification and education of citizens prior to implementation of adulticiding in their areas minimizes risks to chemically sensitive individuals and addresses the issues of those individuals concerned about adult mosquito control activities. The District does not perform adult mosquito control on private properties unless requested by the owner. However, education of the property owner on water management to minimize mosquitoes and District initiated larval mosquito control activities when possible does still occur. The District also regularly calibrates its application equipment to verify droplet size and that the application rate does not exceed 0.87 ounces per acre. District policies also include restrictions concerning applications occurring during less than optimal conditions. Applications can only occur when wind speeds are less than 6 mph, there is an adequate temperature inversion or ambient temperatures are less than 72 degrees Fahrenheit, and no fog or potential precipitation occurring either during or within 24 hours of the treatment. Additionally, most applications occur between the hours of 2 AM and 7 AM for treatments of crepuscular mosquitoes, therefore impacts to bees and other diurnal insects such as butterflies is significantly minimized. Treatments for diurnal mosquitoes (e.g. the Summer Salt Marsh Mosquito, *Aedes dorsalis,* are exceedingly rare, having occurred twice in the last 14 years. The District makes every effort to minimize having to perform adult mosquito control after 7 AM. All personnel who apply pesticides also receive retraining at least four times per year. This retraining includes reviews of all aspects of the pesticides the applicator will be handling and proper use and calibration of the equipment. Additionally, applicators must also undergo a minimum of 20 hours of formal continuing education each year to maintain their State certification.

Impact on Water Quality: In some instances there is a risk of pyrethrin and its synergist piperonyl butoxide (PBO) being deposited onto the surface of nearby water bodies following a treatment. Adequately translating field application rates into a toxicological risk assessment for water bodies and non-target organisms in natural settings poses some challenges. The District applies a maximum of 0.87 ounces of 5% pyrethrin and 25% PBO per acre for adult mosquito control operations. This translates to 0.0435 ounces of the active ingredient pyrethrin and 0.2175 ounces of PBO per acre. The potential amounts of these materials deposited onto the receiving waters of California is affected by the density of vegetative cover, average droplet size and deposition rate of the pesticide during application, rate of drift of the pesticide, temperature at time of application, volume and surface area of the water body affected, and population density of the target organisms. Coupled with the fact that there may potentially be a significant background level already present due to the widespread use of this pesticide by private citizens and commercial businesses makes accurately assessing the specific impacts of the District's use of this pesticide for mosquito control problematic.

Permethrin

Product Names: Permanone

Advantages: Permethrin is a second-generation synthetic pyrethroid with a broad spectrum of activity against all mosquito species. Permethrin is also effective against a wide range of animal ectoparasites and provides good residual control in stables, livestock areas and animal housing. It exhibits fast action, low volatility, good photostability, low solubility in water and low mammalian toxicity. Its photostability means that permethrin provides some residual activity when applied directly to surfaces. Permethrin has a reported half life in sunlight of 4.6 days. It is also strongly absorbed to soil with a reported half life of 43days.

Barriers to Use: Permethrin's photostability and residual activity when applied to surfaces could become problematic if levels of the insecticide deposited on surfaces from repeated mosquito control activities reaches a threshold toxic to non-target organisms (e.g. bees and butterflies visiting flowers). Permethrin also has a limited label for crops which precludes its use in many agricultural areas. This insecticide is also highly toxic to fish and aquatic invertebrates. Permethrin must be applied to adult mosquitoes under ideal environmental conditions that maximize its effectiveness for controlling mosquitoes and minimize the amount of insecticide used. Temperature, wind speed, humidity, amount of vegetative cover and the timing of the application during adult mosquito activity are key factors when utilizing this insecticide. Proper droplet size and amount of material applied to the target area is also important. There may also be members of the public that are chemically sensitive or concerned about any form of adulticiding in their areas.

Solutions to Barriers: Permethrin is rarely utilized (five times in the last 14 years) by the District due to its restriction in and around crop areas and its high toxicity to aquatic organisms. This insecticide is a last resort material utilized in those areas that strictly meet this insecticides label requirements. Additionally, the limited use of permethrin helps reduce the risk of permethrin accumulation on plants surfaces that could affect visiting non-target invertebrates (e.g. bees). Surveillance and monitoring can provide information on maximal adult mosquito activity thus limiting the number of applications, the size of the target area required for effective control, total pesticide load and exposure of non-target organisms. The District's current policy is a maximum of two treatments in any one area per season for the Western Treehole Mosquito (*Aedes sierrensis*). Adult mosquito control for the other species of mosquitoes present in Napa County is limited to an unusually high adult emergence posing a clear threat to the health and comfort to a large portion of a nearby population center or the declaration of a public health emergency by the County's public health officer or State public health officials. Assessing vegetative cover and enlisting the aid of the property owner in reducing the density of vegetation helps reduce the amount of permethrin required for effective mosquito control. Proper advance notification and education of citizens prior to implementation of adulticiding in their areas minimizes risks to chemically sensitive individuals and addresses the issues of those individuals concerned about adult mosquito control activities. The District does not perform adult mosquito control on private properties unless requested by the owner. However, education of the property owner on water management to minimize mosquitoes and District initiated larval mosquito control activities when possible does still occur. The District also regularly calibrates its application equipment to verify droplet size and that the application rate does not exceed 0.87 ounces per acre. District policies also include restrictions concerning applications occurring during less than optimal conditions. Applications can only occur when wind speeds are less than 6 mph, there is an adequate temperature inversion or ambient temperatures are less than 72 degrees Fahrenheit, and no fog or potential precipitation occurring either during or within 24 hours of the treatment. Additionally, most applications occur between the hours of 2 AM and 7 AM for treatments of crepuscular mosquitoes, therefore impacts to bees and other diurnal insects such as butterflies is significantly minimized. Treatments for diurnal mosquitoes have not occurred with this material. All personnel who apply pesticides also receive retraining at least four times per year. This retraining includes reviews of all aspects of the pesticides the applicator will be handling and proper use and calibration of the equipment. Additionally, applicators must also undergo a minimum of 20 hours of formal continuing education each year to maintain their State certification.

Impact on Water Quality: The possibility of permethrin and its synergist piperonyl butoxide (PBO) being deposited onto the surface of nearby water bodies following a treatment is minimal. Nevertheless, adequately translating field application rates into a toxicological risk assessment for water bodies and non-target organisms in natural settings should still be considered even though it poses some challenges. The District applies a maximum of 0.87 ounces of 3.98% permethrin and 8.48% PBO per acre for adult mosquito control operations. This translates to 0.0346 ounces of the active ingredient permethrin and 0.0738 ounces of PBO per acre. The potential amounts of these materials deposited onto the receiving waters of California is affected by the density of vegetative cover, average droplet size and deposition rate of the pesticide during application, rate of drift of the pesticide, temperature at time of application, volume and surface area of the water body affected, and population density of the target organisms. Coupled with the fact that there may potentially be a significant background level already present due to the widespread use of this pesticide by local citizens makes accurately assessing the specific impacts of the District's use of this pesticide for mosquito control problematic.

Resmethrin

Product Names: Scourge

Advantages: Resmethrin is a first generation synthetic pyrethroid that provides rapid knockdown and quick kill of all species of adult mosquitoes. This insecticide is also effective against many other flying insects although it is slower acting than natural pyrethrins. Resmethrin exhibits very low mammalian toxicity, is considered slightly toxic to humans and is rated USEPA toxicity class III (1 = most toxic, IV = least toxic). This insecticide degrades very rapidly in sunlight (reported half life of 15 minutes) and provides little or no residual activity.

Barriers to Use: Resmethrin is highly toxic to fish and aquatic invertebrates. Resmethrin must be applied to adult mosquitoes under ideal environmental conditions that maximize its effectiveness for controlling mosquitoes and minimize the amount of insecticide used. Temperature, wind speed, humidity, amount of vegetative cover and the timing of the application during adult mosquito activity are key factors when utilizing this insecticide. Proper droplet size and amount of material applied to the target area is also important. There may also be members of the public that are chemically sensitive or concerned about any form of adulticiding in their areas. Resmethrin's label restricts its use in and around crop areas.

Solutions to Barriers: Resmethrin has not been used by the District in more than 20 years due to its restriction in and around crop areas and its high toxicity to aquatic organisms. This insecticide is a last resort material utilized in those areas that strictly meet this insecticides label requirements. This insecticide's rapid degradation in sunlight makes it a reasonable alternative to the use of permethrin as it does not persist in the environment like permethrin. Surveillance and monitoring can provide information on maximal adult mosquito activity thus limiting the number of applications, the size of the target area required for effective control, total pesticide load and exposure of non-target organisms. The District's current policy is a maximum of two treatments in any one area per season for the Western Treehole Mosquito (*Aedes sierrensis*). Adult mosquito control for the other species of mosquitoes present in Napa County is limited to an unusually high adult emergence posing a clear threat to the health and comfort to a large portion of a nearby population center or the declaration of a public health emergency by the County's public health officer or State public health officials. Assessing vegetative cover and enlisting the aid of the property owner in reducing the density of vegetation helps reduce the amount of resmethrin required for effective mosquito control. Proper advance notification and education of citizens prior to implementation of adulticiding in their areas minimizes risks to chemically sensitive individuals and addresses the issues of those individuals concerned about adult mosquito control activities. The District does not perform adult mosquito control on private properties unless requested by the owner. However, education of the property owner on water management to minimize mosquitoes and District initiated larval mosquito control activities when possible does still occur. The District also regularly calibrates its application equipment to verify droplet size and that the application rate does not exceed 0.70 ounces per acre. District policies also include restrictions concerning applications occurring during less than optimal conditions. Applications can only occur when wind speeds are less than 6 mph, there is an adequate temperature inversion or ambient temperatures are less than 72 degrees Fahrenheit, and no fog or potential precipitation occurring either during or within 24 hours of the treatment. Additionally, most applications occur between the hours of 2 AM and 7 AM for treatments of crepuscular mosquitoes, therefore impacts to bees and other diurnal insects such as bees and butterflies is significantly minimized. Treatments for diurnal mosquitoes with this material has not occurred with this insecticide in more than 20 years. The District makes every effort to minimize having to perform adult mosquito control after 7 AM. All personnel who apply pesticides also receive retraining at least four times per year. This retraining includes reviews of all aspects of the pesticides the applicator will be handling and proper use and calibration of the equipment. Additionally, applicators must also undergo a minimum of 20 hours of formal continuing education each year to maintain their State certification.

Impact on Water Quality: The possibility of Resmethrin and its synergist piperonyl butoxide (PBO) being deposited onto the surface of nearby water bodies following a treatment is minimal. Nevertheless, adequately translating field application rates into a toxicological risk assessment for water bodies and non-target organisms in natural settings should still be considered even though it poses some challenges. The District applies a maximum of 0.70 ounces of 18% Resmethrin and 54% PBO per acre for adult mosquito control operations. This translates to 0.126 ounces of the active ingredient Resmethrin and 0.378 ounces of PBO per acre. The potential amounts of these materials deposited on the receiving waters of California is affected by the density of vegetative cover, average droplet size and deposition rate of the pesticide during application, rate of drift of the pesticide, temperature at time of application, volume and surface area of the water body affected, and population density of the target organisms. Coupled with the fact that this insecticide can be used by licensed pest control professionals (other than mosquito control personnel) makes accurately assessing the specific impacts of the District's use of this pesticide for mosquito control problematic.

PROTECTION OF ENDANGERED AND THREATENED SPECIES

Napa County has a diverse environment that encompasses many habitat types such as tidal marshes, vernal pools and riparian areas, some of which may be habitat to species of special concern. It has long been the goal of the District to avoid negative impact on sensitive species. In order to insure that the Districts mosquito control activities do not adversely impact sensitive species, NCMAD maintains a list of endangered and threatened species that occur within the County. NCMAD staff keep informed as to which activities may negatively impact endangered or threatened species and conducts mosquito control efforts in such a way as to minimize impact not only on species of special concern but on any non-target organism which may occur in or around a mosquito breeding source. The District also works in cooperation with state and federal agencies to insure that the Districts mosquito control activities do not impact sensitive species which may occur within state or federal wildlife habit. The following table is a listing of those special status organisms known to occur within Napa County.

Special Status Plants and Animals of Napa County

Common Name	Scientific Name	Status
Plants		
Suisun Marsh Aster	*Symphyotrichum lentum*	SR
Clara Hunt's Milk Vetch	*Astragalus clarianus*	FE, ST
San Joaquin Salt Bush	*Atriplex joaquiniana*	SR
Mt. St. Helena Morning Glory	*Calystegia collina oxyphylla*	SR
Tiburon Indian Paintbrush	*Castilleja affinis neglecta*	FE, ST
Rincon Ridge Ceanothus	*Ceanothus confuses*	FSC
Calistoga Ceanothus	*Ceanothus divergens*	FSC
Sonoma Ceanothus	*Ceanothus sonomensis*	SR
Soft Bird's Beak	*Cordylanthus mollis mollis*	FE, SR
Adobe Lily	*Fritillaria pluriflora*	FSC
Two carpellate Western Flax	*Hesperolinon bicarpellatum*	SR
Brewer's Western Dwarf Flax	*Hesperolinon breweri*	FSC
Drymaria-Like Western Dwarf flax	*Hesperolinon drymarioides*	FSC
Northern California Black Walnut	*Juglans hindsii*	SR
Contra Costa Goldfields	*Lasthenia conjugans*	FE
Delta Tule Pea	*Lathyrus jepsonii jepsonii*	SR
Legenere	*Legenere limosa*	FSC
Mason't lilaeopsis	*Lilaeopsis masonii*	FSC, SR
Sebastopol Meadowfoam	*Limnanthes vinculans*	FE, SE
Hall's Madia	*Harmonia hallii*	SR
Few Flowered Navarretia	*Navarretia leucocephala pauciflora*	FE, ST
Calistoga Popcorn Flower	*Plagiobothrys strictus*	FE, ST
Napa Blue Grass	*Poa napensis*	FE, SE
Marin Knotweed	*Polygonium marinense*	FSC
Marin Checkerbloom	*Sidalcea hickmanii viridis*	SR
Socrates Mine Jewel-Flower	*Streptanthus brachiatus brachiatus*	FSC

Showy Indian Clover	*Trifolium amoenum*	FE
Invertebrates		
California Freshwater Shrimp	*Syncaris pacifica*	FE, SE
Valley Elderberry Longhorn Beetle	*Desmocerus californicus dimorphus*	FT
Vertebrates		
California Red-Legged Frog	*Rana aurora draytonii*	FT
Foothill Yellow-Legged Frog	*Rana boylii*	FSC
Northwestern Pond Turtle	*Emys marmorata marmorata*	FSC
Tricolored Blackbird	*Agelaius tricolor*	FSC
Burrowing Owl	*Athene (=Speotyto) canicularia*	FSC
Western Snowy Plover	*Charadrius alexandrines nivosus*	FT
Saltmarsh Common Yellowthroat	*Gleothypis trichas*	FSC
Bald Eagle	*Haliaeetus leucocephalus*	FSC, SE
California Black Rail	*Laterallus jamaicensis coturniculus*	FSC, ST
California Clapper Rail	*Rallus longirostris obsoletus*	FE, SE
Northern Spotted Owl	*Strix occidentalis caurina*	FT
Townsend's Western Big-Eared Bat	*Plecotus townsendii*	FSC
Salt Marsh Harvest Mouse	*Reithrodontomys raviventris raviventris*	FE, SE
Suisun Shrew	*Sorex ornatus sinuosus*	SR

FE = Federally Endangered FT = Federally Threatened FSC = Federal Species of Concern
SE = State Endangered ST = State Threatened SR = State Rare

TRAINING AND CERTIFICATION

All NCMAD applicators must be certified to apply public health pesticides. The CDPH Vector-Borne 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 that 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 Vector Control) are optional and both require 8 hours of CEU per two-year cycle.

The District also 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 Health Services for final approval. Thirty-six hours of CEU credits are offered each two-year cycle.

OVERSIGHT

The NCMAD operates 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, the District is signatory to the California Department of Health Services Cooperative Agreement (Pursuant to Section 116180, Health and Safety Code) and is 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, Bay Conservation and Development Commission, San Francisco Regional Water Quality Control Board, and others have jurisdiction and oversight over the District's activities. NCMAD works closely with these agencies to comply with their requirements.

PUBLIC EDUCATION

An integral part of the NCMAD BMP is to provide information to the public to assist them in resolving their pest problems and concerns. Specialized staff at the District provide public outreach in the form of presentations to schools, utility districts, homeowner associations, county fairs, home and garden shows, as well as through the media such as newspaper 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.

CLIMATE AND SEASONALITY

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

EVALUATION OF LESS-TOXIC CONTROL METHODS

Pesticide use by NCMAD is only one aspect of the Districts Integrated Pest Management (IPM) strategy. This strategy includes the use of physical and biological control techniques whenever possible and is based on a program of continuous monitoring of both adult and immature mosquito populations. Nonchemical control methods, barriers to their use, and solutions to those barriers are briefly summarized below:

Physical control

Cost: High, requires specialized equipment and expertise, may be labor intensive.
Barriers: High cost; lack of specialized equipment; problems with disturbing habitats of endangered species; wetlands are sensitive habitats and highly regulated; requires extensive and lengthy permit process.
Solutions to barriers: Encourage landowners to do this work; work with agencies who have personnel with expertise in wetlands restoration; work with restoration agencies.
Relative usefulness of this technique: Used whenever possible; first choice because it is a long-term solution that reduces the pesticide load in the environment. If physical control is not feasible, or while working toward a physical control solution, NCMAD will use biological or chemical control techniques.

Water management

Cost: Cost of equipment and engineering can be very high initially; may be labor intensive; requiring someone on hand at all times to monitor water levels and operate gates.
Barriers: Most land NCMAD treats is not under the District's control and it is sometimes difficult to get landowners to cooperate; the District does not always have adequate staff or budget to install and operate floodgates; there can be conflicts with other uses of wetlands such as waterfowl conservation, recreation (hunting).
Solutions to barriers: Work with land owners as much as possible to encourage good water management; treat only when necessary.
Relative usefulness of this technique: Used whenever possible; first choice because it is an excellent non-pesticide solution. When water management fails NCMAD uses biological or chemical control.

Biological control

Mosquito fish
Cost: low
Barriers: Release of non native fish into mosquito breeding sources is controversial and under certain circumstances prohibited; may compete with native fish; requires facilities and personnel to rear and maintain fish.
Solutions to barriers: Use only in appropriate sources; have to get fish from other districts and can only keep a small supply on hand.
Relative usefulness of Mosquito fish: Use of fish is 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 NCMAD will use this strategy.

Bacterial pesticides: The primary larvicides (Bti and Bs) used by NCMAD may be considered a form of biological control.

Bacillus sphaericus* and *B. thuringiensis* var. *israelensis
Cost: These materials can be expensive but are cheaper than the initial short term costs of 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 the larvicides Bti and Bs 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

Cost: These materials can be expensive but cheaper in the short term than physical control.
Barriers: Requires more careful monitoring of mosquito populations and more thorough knowledge of their ecology, resistance.
Solutions to barriers: Monitoring program for mosquitoes; training for technicians, biologists and staff; rotate materials, investigate new materials.
Relative usefulness of this technique: Like biological pesticides these materials are considered when physical control is out of the question and fish cannot be stocked or maintained. Sometimes used in conjunction with stocking fish since these materials have been shown not to adversely affect fish. Decisions on whether to use these materials or bacterial pesticides are based on: stage and species of mosquito present, quality of water, size and number of other sites breeding mosquitoes at the same time, prevailing weather conditions, and 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 least-toxic control methods are considered and that new methods are evaluated on an ongoing basis and, if effective, incorporated into the District's mosquito control program. Implementation of BMPs resulted in the elimination of the routine use of organophosphates and a concomitant increase in the use of least toxic methods including bacterial insecticides and insect growth regulators. This practice has been in effect now for more than twenty years.

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Napa County Mosquito Abatement District

Supporting Documentation for Statement of BMP's and NOI Pertaining to NPDES Permit Application for Residual Pesticide Discharges to Waters of the United States From Mosquito Control Applications

24 May 2011

Pesticides and Public Health: Integrated Methods of Mosquito Management

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Pesticides have a role in public health as part of sustainable integrated mosquito management. Other components of such management include surveillance, source reduction or prevention, biological control, repellents, traps, and pesticide-resistance management. We assess the future use of mosquito control pesticides in view of niche markets, incentives for new product development, Environmental Protection Agency registration, the Food Quality Protection Act, and improved pest management strategies for mosquito control.

Vector-borne diseases (including a number that are mosquito-borne) are a major public health problem internationally. In the United States, dengue and malaria are frequently brought back from tropical and subtropical countries by travelers or migrant laborers, and autochthonous transmission of malaria and dengue occasionally occurs. In 1998, 90 confirmed cases of dengue and 1,611 cases of malaria were reported in the USA (1) and dengue transmission has occurred in Texas (2). Other vector-borne diseases continue to pose a public health threat. Even though the reported incidence of most of these diseases is low (in 1997, 10 cases of eastern equine encephalitis, 115 of LaCrosse, and 14 of St. Louis encephalitis [SLE]), occasional epidemics, e.g., of SLE (1,967 cases in 1975 and 247 cases in 1990, mostly in Florida [3]) have resulted in aerial applications of insecticides, primarily malathion. In addition, new vector-borne threats continue to emerge. In 1999, West Nile virus, an Old World flavivirus related to Saint Louis encephalitis virus, was first recorded in New York (4). The virus, which is transmitted by anthropophilic mosquitoes, caused a serious outbreak (62 cases, 7 deaths) and signaled the potential for similar outbreaks in the Western Hemisphere. Pesticides, which traditionally have been used in response to epidemics, have a role in public health as part of sustainable integrated mosquito management for the prevention of vector-borne diseases. We assess the future use of pesticides in view of existing niche markets, incentives for new product development, Environment Protection Agency (EPA) registration, the Food Quality Protection Act (FQPA), and improved pest management strategies for mosquito control.

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Sustainable Integrated Mosquito Management and Public Health

Mosquito control in the United States has evolved from reliance on insecticide application for control of adult mosquitoes (adulticide) to integrated pest management programs that include surveillance, source reduction, larvicide, and biological control, as well as public relations and education. The major principles of integrated mosquito management are available at a new Public Health Pest Control Manual internet website (5). Adulticides still play a vital role when flooding causes extreme numbers of nuisance mosquitoes or when outbreaks of diseases such as SLE occur.

Surveillance programs track diseases harbored by wild birds and sentinel chicken flocks; vector-borne pathogens in mosquitoes; adult and larval mosquitoes and larval habitats (by aerial photographs, topographic maps); mosquito traps; biting counts; and follow-up on complaints and reports by the public. When established mosquito larval and adult threshold populations are exceeded, control activities are initiated. Seasonal records are kept in concurrence with weather data to predict seasonal mosquito larval occurrence and adult flights.

Source reduction consists of elimination of larval habitats or rendering of such habitats unsuitable for larval development. Public education is an important component of source reduction. Many county or state mosquito control agencies have public school education programs that teach children what they and their families can do to prevent mosquito proliferation. Other forms of source reduction include open marsh water management, in which mosquito-producing areas on the marsh are connected by shallow ditches to deep water habitats to allow drainage or fish access; and rotational impoundment management, in which the marsh is minimally flooded during summer but is flap-gated to reintegrate impoundments to the estuary for the rest of the year.

Biological control includes use of many predators (dragonfly nymphs and other indigenous aquatic invertebrate predators such as *Toxorhynchites* spp. predacious mosquitoes) that eat larvae and pupae; however, the most commonly used biological control adjuncts are mosquito fish, *Gambusia affinis* and *G. holbrooki.* Naturally occurring *Fundulus* spp. and possibly *Rivulus* spp., killifish, also play an important role in mosquito control in open marsh water management and rotational impoundment management. Like many fish, mosquito fish are indiscriminate feeders that may eat tadpoles, zooplankton, aquatic insects, and other fish eggs and fry (6). However, since they are easily reared, they have become the most common supplemental biological control agent used in mosquito control. The entomopathogenic fungus, *Laginidium giganteum,* has been registered for mosquito control by EPA under the trade name Liginex, but products have not become readily available. The pathogenic protozoon, *Nosema algerae,* has also not become available for technical reasons. Entomoparasitic nematodes such as *Romanomermis culicivorax* and *R. iyengari* are effective and do not require EPA registration but are not easily produced and have storage viability limitations. A predacious copepod, *Mesocyclops longisetus,* preys on mosquito larvae and is a candidate for local rearing with *Paramecium* spp. for food.

Mosquito traps (such as the New Jersey and the Centers for Disease Control and Prevention designs) have been used for monitoring mosquito populations for years. New designs using mechanical control to capture adult mosquitoes have now become available. These designs use compressed carbon dioxide, burning propane, and octenol to attract mosquitoes and fans to control air flow. The new technology is expensive: these traps may cost well over $1,000 each. Electric high-voltage insect traps ("bug zappers") with "black" or ultraviolet light sources do not provide satisfactory adult mosquito control and kill insects indiscriminately.

Pesticides

Pesticides used by state or local agencies to control nuisance or public health pests have warning labels and directions to minimize risks to human health and the environment. These pesticides are applied by public health employees who are specifically trained to follow proper safety precautions and directions for use. State or local mosquito control programs are funded by taxes and subject to public scrutiny. The environmental hazards precautionary statements on many mosquito insecticide labels state that insecticides are toxic to birds, fish, wildlife, aquatic invertebrates, and honeybees. Because of the low rates of application used to control mosquitoes and the special public health pest control training of most applicators, hazard to nontargeted organisms is limited. However, honeybees may be killed if exposed when foraging, so proper precautions are warranted. Human exposure in residential areas is also uncommon because of the very low application rates, ultra low-volume methods (ULV), treatment at night when people are indoors, pesticide applicator training, and public prenotification before application. Pesticide applicators who mix, load, and apply the concentrated insecticides use personal protective equipment to avoid exposure and closed systems to pump insecticides from storage to spray equipment.

The Federal Food Drug and Cosmetic Act (FFDCA) 21 USC 9§406 is the regulation that limits the quantity of any poisonous or deleterious substance added to food. A pesticide residue is the pesticide or its metabolites in or on raw agricultural commodities or processed food and feed. A tolerance is the maximum limit of a pesticide residue considered safe. Tolerances are relevant to adult mosquito control because wind drift may carry the pesticide over agricultural crops where residues subject to legal tolerance requirements may occur. Crop tolerances are listed in the Code of Federal Regulations (7).

Larvicides

Detection of large numbers of immature mosquitoes in areas where source reduction or biological control is not feasible may require larvicide treatment to prevent the emergence of adult mosquitoes. Use of larvicides is less controversial than use of adulticides, although use of larvicides may lead to public concern about their effects on untargeted beneficial aquatic arthropods and vertebrates (Table).

Adulticides

Effective sustainable integrated mosquito management programs strive to prevent large

Table. Pesticides used for mosquito control in the United States

Name	Trade name	Formulation	Application	Advantage	Limitation
Temephos	Abate	G, EC	Larvae	Usually lowest cost	Nontarget effects, some resistance
Methoprene	Altosid	G, B, P, LC	Larvae	Residual briquets, nontarget safety	Cannot be certain of performance until too late to retreat
Oils	BVA, Golden Bear	Oil	Larvae, pupae	Acts on pupae	Oil film, subsurface larvae
Monomolecular film	Agnique	Liquid	Larvae, pupae	Acts on pupae	Subsurface larvae
Bacillus thuringiensis israelensis (Bti)	Aquabac, Bactimos, LarvX, Teknar, Dunks	WDG, AS, P,G,B	Larvae	Nontarget safety, Briquets control 30+ days	Short window of treatment opportunity. pupae
Bacillus sphaericus (Bs)	VectoLex	G, WDG	Larvae	Nontarget safety	Pupae, only works in fresh water
Malathion	Fyfanon, Atrapa, Prentox	ULV, thermal fog	Adults	Tolerances	OP, some resistance
Naled	Dibrom, Trumpet	ULV, EC, thermal fog	Adults	Tolerances	OP, corrosive
Fenthion	Batex	ULV	Adults	None specified	OP, Florida only, RUP, tolerances
Permethrin	Permanone, AquaResilin, Biomist, Mosquito-Beater	ULV, thermal fog, clothing treatment	Adults, clothing treatment for ticks and mosquitoes	Low vertebrate toxicity	None specified
Resmethrin	Scourge	ULV, thermal fog	Adults	Low vertebrate toxicity	RUP, no tolerance for residue on crops
Sumithrin	Anvil	ULV, thermal fog	Adults	Low vertebrate toxicity	No tolerance
Pyrethrins	Pyrenone, Pyronyl	ULV, EC	Adults, larvae	Natural pyrethrum, tolerances	May be costly

AS = Aqueous Suspension; B = Briquets; EC = Emulsifiable Concentrate; G = Granules; LC = Liquid Concentrate; P = Pellets; ULV = Ultra Low Volume; WDG = Water-Dispersible Granule; OP = Organophospate insecticide; RUP = Restricted Use Product flights or swarms of mosquitoes through all the measures described above, but heavy precipitation, flooding, high tides, environmental constraints, inaccessible larval habitats, missed breeding sites, human disease outbreaks, as well as budget shortfalls, absent employees, or equipment failures, may necessitate use of adulticides (Table). Some local mosquito control programs would use an integrated program if they had adequate resources, but may be so limited in funding and personnel that adulticiding trucks are the only means of mosquito intervention.

Effective adult mosquito control with insecticides requires small droplets that drift through areas where mosquitoes are flying. The droplets that impinge on mosquitoes provide the contact activity necessary to kill them. Large droplets that settle on the ground or vegetation without contacting mosquitoes waste material and may cause undesirable effects on nontargeted organisms. To achieve small droplets, special aerial and ground application ULV equipment is used. Insecticides are applied in a concentrated form or technical grade and at very low volumes such as 1 oz (29.6 mL) per acre. Typically, aerial applications produce spray droplets of 30 to 50 microns measured as mass median diameter, with $\leq$2.5% of the droplets exceeding 100 microns. Ground ULV applicators produce droplets of 8 to 30 microns, with none >50 microns mass median diameter. Large droplets of malathion, naled, and fenthion in excess of 50 to 100 microns can damage automotive or similar paint finishes.

Adulticide applications, particularly aerial applications and thermal fogging, are quite visible and contribute to public apprehension. Ground ULV application may be less alarming than aerial application but is not effective over large or inaccessible areas. Preferable air currents for ground applications are 3.2 kph to 12.9 kph and not in excess of 16.1 kph. Excessive wind and updrafts reduce control, but light wind is necessary for drifting spray droplets. With insecticide application by air using high-pressure pumps of 2,500 lbs psi, special nozzles, proper aerial application altitude and wind drift, mosquito control is achievable for several miles downwind with minimal spray deposit below the aircraft, as a result of improved atomization of the insecticide. This technology is being developed and needs validation under different conditions with different mosquito species before it can be universally used. Thermal fogging, which was commonly used before ULV applications became prevalent, continues to be used in a few areas in the United States and is still widely used in other countries. The insecticide is diluted with petroleum oil and vaporized with heat into a dense, highly visible fog of very small uniform droplets, which allows tracking the plume downwind to target areas. Although this fog reduces visibility, it may also penetrate vegetation better than a ULV application. Small electric or propane thermal foggers are available for consumer use in retail stores at a cost of approximately $60.00.

Adult mosquitoes are easily controlled with insecticides applied at extremely low rates. For example, malathion is applied at 3 fl oz per acre (219.8 mL/ha) for mosquitoes, while the rate for agriculture is as much as 16 fl oz per acre (1,172 mL/ha).

Insecticide Resistance

Vector resistance to certain larvicides and adulticides has occurred periodically. Failure of mosquito control indicating resistance must be verified by laboratory analysis or use of test kits because other factors (improper equipment calibration, dilution, timing and other application errors, off-specification products, climatic factors) can prevent insecticides from providing satisfactory control in the field. Resistance may occur between insecticides within a class or could be passed from immature to adult stages subject to the same insecticidal mode of action. Additionally, different species of mosquitoes may inherently vary in susceptibility to different larvicides and adulticides. Insecticides with different modes of action can be alternated to prevent resistance. Even though source reduction and use of predators such as larvivorous fish are also used for sustainable integrated mosquito management, only two chemical classes of adulticides (organophosphates and pyrethroids) with different modes of action are available. Biological controls (including birds and bats) may be present, but often not in sufficient numbers to provide satisfactory alternative control, particularly in coastal areas where salt-marsh mosquitoes are abundant or when human disease outbreaks occur. Therefore, sustained integrated mosquito management requires alternative use of different classes of insecticides, in conjunction with resistance monitoring, source reduction, biological control, and public education.

Repellents

Insect repellents, primarily N,N-diethyl-metatoluamide (DEET), are used to prevent nuisance bites from mosquitoes (as well as ticks, biting flies, and mites) and may aid in lowering disease transmission from these pests. However, they should not be relied upon to prevent disease transmission, particularly where Lyme disease or encephalitis are endemic or malaria, yellow fever, or other vector-borne diseases are prevalent. Repellents, mosquito coils, and permethrin clothing treatment products are subject to EPA pesticide registration performance requirements (8). Information on safe use of repellents is located at the EPA Office of Pesticide Programs website (9). Citronella and its oil for mosquitoes and 30 other active ingredients are exempted from EPA pesticide registration (10). However, some of these products may not be efficacious.

Future of Public Health Pesticides

The past decade has seen a sharp rise in public apprehension concerning the use of pesticides, although state and federal regulations are well established for the assessment and mitigation of their human and environmental risks. Response to public concern over safety of pesticides prompted the FQPA, which includes provisions to protect availability of public health pesticides. However, public health pesticides are in jeopardy for the following reasons: In the United States, mosquito control programs are often for nuisance rather than disease vector control and not many insecticides are registered for this use. None of the mosquito adulticides commonly used were developed recently; their registrations are up to 44 years old. Mosquito control is only a niche market compared with agricultural pest control, which includes pesticides for use on corn, soybeans, and cotton, as well as the high-profit home, garden, and structural pest control markets. As pesticide companies have merged to form multinational conglomerates, the most profitable markets are those that drive corporate decisions. At present, it may require $50 million or more to develop and register a new pesticide with EPA. Furthermore, several years of the patent life elapse before costs are recouped and profits accrue.

Vector control uses of existing pesticides, particularly adulticides, often follow agricultural registration and commercialization as a means of expanding sales into new markets. Performance data are not usually required for registration of agricultural pesticides, but these data are required for registration of public health pesticides. For mosquito control, these data are often obtained under an experimental use permit, which requires application to EPA, submission or reference to a portion of the pesticide registration requirements according to CFR 40 § 158 Data Requirements for Registration and Reporting (7,8). Testing for mosquito adulticides or larvicides is typically done by universities and mosquito control or abatement districts, although it may be done by companies or state or federal research organizations, such as the Department of Defense or the U.S. Department of Agriculture. In addition to defining dose rates, formulations, environmental variables, and effects that must be accommodated, testing under an experimental use permit provides a means of market introduction through user and customer experience, presentations at professional society meetings, and journal publications.

Pesticide marketing often involves distributors or dealers who specialize in the market if the manufacturers do not deal directly. Profit margins that add to price are required by distribution chains. Public agencies solicit competitive bids for pesticides, which squeeze margins further, thus affecting marketing incentives. Mosquito adulticides are used at very low rates of active ingredient per acre, which limits sales volumes and margins. Some seasons have few mosquitoes, so sales are low. Product liability also plays an important role in reducing incentives because of possible personal and class-action lawsuits or court injunctions against pesticides applied over populated areas.

The Federal Insecticide, Fungicide, and Rodenticide Act and FQPA

The Federal Insecticide, Fungicide, and Rodenticide Act 7 USC 136 and FFDCA were amended by the FQPA of 1996. Amendments pertinent to mosquito nuisance and vector control include the following: review of a pesticide's registration every 15 years; expediting minor use registrations; special provisions for public health pesticides; aggregate (all modes of exposure from a single pesticide) and cumulative (all pesticides with the same mode of action) risk assessments; an additional safety factor of up to 10 X for children; collection of pesticide use information; and integrated pest management. Special provisions for public health pesticides include the following: risks and benefits considered separately from those of other pesticides; exemption from fees under certain circumstances; development and implementation of programs to control public health pests; Department of Health and Human Services (DHHS)-supported studies required for reregistration when needed; and appropriations of $12 million for the first year after enactment and similar funding as needed in succeeding years to carry out public health pesticide provisions of the Act. The Act describes a consultation process between EPA and DHHS before any public health pesticide registration is suspended or canceled and allows additional time for submission of data. The first group of pesticides under review are the organophosphate cholinesterase inhibitors, including temephos, fenthion, naled, chlorpyrifos, and malathion. Should risk assessments result in detection of risk of concern to the Agency, cancellation or mitigations of use may follow, as exemplified by recent chlorpyrifos and diazinon use cancellations. Risk assessments may be based on data from acute and chronic toxicology and exposure studies, models that simulate exposure scenarios, reports of adverse incidents to humans and wildlife, extrapolation, maximum label use rate assumption, and worst-case exposure scenarios.

Even though the FQPA provisions were intended by Congress to ensure that existing public health pesticide uses are not lost without economically effective alternatives, the provisions may not be adequate. If FQPA results in cancellation of major agricultural uses of a pesticide that is also used in public health, it may become no longer profitable for the manufacturer to produce small quantities for mosquito control, thus ending production of the pesticide. Since adulticides used for mosquito control were registered decades ago, the data supporting their registrations may be insufficient to meet current requirements. The substantial cost involved in updating the data required for reregistration will have to be paid by pesticide registrants or the Federal government though the authorized and appropriated funding in FQPA. Data to support reregistration done at public expense are not proprietary. Registrants need proprietary data to protect their market shares from generic pesticide competition from overseas manufacturers that can use public data to support their own registrations; therefore, they may not consider requesting public funds to pay for new data to support existing registrations. However, if generic safety studies applicable to several public health pesticides are required by EPA for all reregistrations, the data could be generated by a task force of registrants and county, state, and Federal public health agencies, which would then request public funding under the provisions of the Act.

Although the development of new mosquito insecticides, particularly adulticides, is not expected to accelerate in the near future, integrated pest management tools and techniques should improve as a result of FQPA funding and the need to control continued vector-borne disease outbreaks. Integrated pest management tools have strengths and weaknesses, and continued availability of adulticides is critical. Therefore, implementation of the public health pesticide provisions of FQPA must include substantial comparative risk-benefit analyses of the significance of vector-borne disease impacts versus potential human and environmental toxic effects of pesticides used to control public health pests, both in the USA and other countries affected by EPA pesticide regulatory decisions. Public information and legislative campaigns have also become necessary to preserve the availability and use of pesticides for disease vector control as FQPA has been implemented and with the concurrent spread of West Nile virus.

Dr. Rose is an arthropod biotechnologist with the Animal and Plant Health Inspection Service of the U.S. Department of Agriculture.

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http://www.epa.gov/pesticides/citizens/pmcfs.pdf see favorites

United States Environmental Protection Agency
Prevention, Pesticides and Toxic Substances (7506C)
May 2000

EPA Questions & Answers

Pesticides and Mosquito Control

Mosquito-borne diseases affect millions of people worldwide each year. In the United States, some species of mosquitoes can transmit diseases such as encephalitis, dengue fever, and malaria to humans, and a variety of diseases to wildlife and domestic animals. To combat mosquitoes and the public health hazards they present, many states and localities have established mosquito control programs. These programs, which are based on surveillance, can include nonchemical forms of prevention and control as well as ground and aerial application of chemical and biological pesticides.

The mission of the Environmental Protection Agency (EPA) is to protect human health and the environment. EPA reviews and approves pesticides and their labeling to ensure that the pesticides used to protect public health are applied by methods which minimize the risk of human exposure and adverse health and environmental effects. In relation to mosquito control, the Agency also serves as a source of information about pesticide and non-pesticide controls to address the concerns of the general public, news media, and the state and local agencies dealing with outbreaks of infectious diseases or heavy infestations of mosquitoes. The following questions and answers provide some basic information on mosquito control, safety precautions, and information on insecticides used for mosquito control programs.

1. How does EPA ensure the safest possible use of pesticides?

EPA must evaluate and register pesticides before they may be sold, distributed or used in the United States. The Agency is also in the process of reassessing and when appropriate, reregistering all older pesticides (registered prior to 1984) to ensure that they meet current scientific standards. To evaluate a pesticide for either registration or re-registration, EPA assesses a wide variety of potential human health and environmental effects associated with use of the product. The producer of the pesticide must provide data from tests done according to EPA guidelines. These tests determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms. Other tests help to assess the risks of contaminating surface water or groundwater from leaching, runoff or spray drift. If a pesticide meets EPA requirements, the pesticide is approved for use in accordance with label directions. **However, no pesticide is 100 percent safe and care must be exercised in the use of any pesticide.**

2. How are mosquitoes controlled with pesticides and other methods?

The first step in mosquito control is surveillance. Mosquito specialists conduct surveillance for diseases harbored by domestic and non-native birds, including sentinel chickens, and mosquitoes. Surveillance for larval habitats are conducted using maps, aerial photographs, and by evaluating larval populations. Other techniques include various light traps, biting counts; and analyzing reports by the public. Mosquito control programs also put high priority on trying to prevent a large population of adult mosquitoes from developing, so that additional controls may not be necessary. Since mosquitoes must have water to breed, methods of prevention may include controlling water levels in lakes, marshes, ditches, or other mosquito breeding sites, eliminating small breeding sites if possible, and stocking bodies of water with fish species that feed on larvae. Both chemical and biological measures may be employed to kill immature mosquitoes during larval stages. *Larvicides* target larvae in the breeding habitat before they can mature into adult mosquitoes and disperse. Larvicides include the bacterial insecticides *Bacillus thuringiensis israelensis* and *Bacillus sphaericus*, the insect growth inhibitor methoprene, and the organophosphate insecticide temephos. Mineral oils and other materials form a thin film on the surface of the water which cause larvae and pupae to drown. Liquid larvicide products are applied directly to water using back-pack sprayers and truck or aircraft-mounted sprayers. Tablet, pellet, granular and briquet formulations of larvicides are also applied by mosquito controllers to breeding areas.

> **Key Tools in Combating Mosquitoes**
>
> **Public education and prevention around the home** – eliminating mosquito breeding habitats (any standing water) around the home. Proper use of mosquito repellants and common sense measures to reduce exposure to insecticides.
>
> **Larvicide** – insecticide designed to kill mosquitoes during its larval stage. Larvicides are applied to known mosquito breeding areas to kill larvae.
>
> **Adulticide** – insecticide designed to kill adult mosquitoes. Mosquito control professionals apply adulticides with ultra low volume (ULV) spray equipment which releases tiny particles of insecticide solution into the air. The amount of pesticide released is typically a few ounces per acre of treated area. Adulticides may be applied from aircraft, vehicles on the ground, or by professional applicators on foot.

Adult mosquito control may be undertaken to combat an outbreak of mosquito-borne disease, or a very heavy nuisance infestation of mosquitoes in a community. Pesticides registered for this use are *adulticides* and are applied either by aircraft or on the ground employing truck-mounted sprayers. State and local agencies commonly use the organophosphate insecticides malathion and naled, and the synthetic pyrethroid insecticides permethrin, resmethrin and sumithrin for adult mosquito control.

Mosquito adulticides are applied as ultra-low volume (ULV) sprays. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill flying mosquitoes on contact. ULV applications involve small quantities of pesticide active ingredient in relation to the size of the area treated, typically less than three ounces per acre, which minimizes exposure and risks to people and the environment.

3. What can I do to reduce the number of mosquitoes in and around my home?

The most important step is to eliminate potential breeding habitats for mosquitoes. Get rid of any standing water around the home, including water in potted plant dishes, garbage cans, old tires, gutters, ditches, wheelbarrows, bird baths, hollow trees, and wading pools. Any standing water should be drained, including abandoned or unused swimming pools. Mosquitoes can breed in any puddle that lasts more than four days. Make sure windows and screen doors are "bug tight." Replace outdoor lights with yellow "bug" lights. Wear headnets, long sleeve shirts, and long pants if venturing into areas with high mosquito populations, such as salt marshes or wooded areas. Use mosquito repellants when necessary, always following label instructions.

4. Should I take steps to reduce exposure to pesticides during mosquito control spraying?

Generally, there is no need to relocate during mosquito control spraying. The pesticides have been evaluated for this use and found to pose minimal risks to human health and the environment when used according to label directions. For example, EPA has estimated the exposure and risks to both adults and children posed by ULV aerial and ground applications of the insecticides malathion and naled. For all the exposure scenarios considered, exposures ranged from 100 to 10,000 times below an amount of pesticide that might pose a health concern. These estimates assumed several spraying events over a period of weeks, and also assumed that a toddler would ingest some soil and grass in addition to dermal exposure. Other mosquito control pesticides pose similarly low risks. (For more details on health and environmental risk considerations, see the separate EPA fact sheets on the specific mosquito control pesticides).

Although mosquito control pesticides pose low risks, some people may prefer to avoid or further minimize exposure. Some common sense steps to help reduce possible exposure to pesticides include:

* Listen and watch for announcements about spraying in the local media and remain indoors during the application to the immediate area.

* People who suffer from chemical sensitivities or feel spraying may aggravate a preexisting health condition, may consult their physician or local health department and take special measures to avoid exposure.

* Close windows and turn off window-unit air conditioners when spraying is taking place in the immediate area.

* Do not let children play near or behind truck-mounted applicators when they are in use.

5. Where can I get more information?

For more information about mosquito control in your area, contact your state or local health department. The federal Centers for Disease Control and Prevention is also a source of information on disease control, and their Internet web site includes a listing of state health departments. To contact the **Centers for Disease Control and Prevention (CDC):**

Telephone: 970-221-6400
Fax: 970-221-6476
E-mail: dvbid@cdc.gov
web site: http://www.cdc.gov

Information on pesticides used in mosquito control can be obtained from the state agency which regulates pesticides, or from the **National Pesticide Telecommunications Network (NPTN).** The NPTN web site includes links to all state pesticide regulatory agencies.
Toll-free hotline: 1-800-858-7378 (9:30 a.m. to 7:30 p.m. EST) daily except holidays. Callers outside normal hours can leave a voice mail message, and NPTN returns these calls the next business day.
E-mail: nptn@ace.orst.edu
web site: http://ace.orst.edu/info/nptn

Information on mosquito control programs can also be obtained from the **American Mosquito Control Association (AMCA)**
web site: http://www.mosquito.org
This site also lists many county mosquito agencies.

Other Helpful EPA Publications

For Your Information - How to Use Insect Repellents Safely (735-F-93-052R)

For Your Information - Mosquitoes: How to Control Them (735-F-98-003)

For Your Information - Larvicides for Mosquito Control (735-F-00-002)

For Your Information - Naled for Mosquito Control (735-F-00-003)

For Your Information - Malathion for Mosquito Control (735-F-00-001)

For Your Information - Synthetic Pyrethroids for Mosquito Control

For more information regarding the federal pesticide regulatory programs, contact:
EPA Office of Pesticide Programs
Telephone: 703-305-5017
Fax: 703-305-5558
E-mail: opp-web-comments@epa.gov
web site: http://www.epa.gov/pesticides

EPA Regional Offices

Region I - CT, MA, ME, NH, RI, VT
888-372-7341
www.epa.gov/region01

Region II - NJ, NY, PR, VI
212-637-3660
www.epa.gov/region02

Region III - DE, DC, MD, PA, VA, WV
800-438-2474 or **215-814-5000**
www.epa.gov/region03

Region IV - AL, FL, GA, KY, MS, NC, SC, TN
800-241-1754
www.epa.gov/region4

Region V - IL, IN, MI, MN, OH, WI
800-621-8431 (Region V only)
or **312-353-2000**
www.epa.gov/region5

Region VI - AR, LA, NM, OK, TX
800-887-6063 (Region VI only)
or **214-665-6444**
www.epa.gov/region6

Region VII - IA, KS, MO, NE
800-223-0425 or **303-312-6312**
www.epa.gov/region7

Region VIII - CO, MT, ND, SD, UT, WY
800-227-8917 (Region VIII only)
or **303-312-6312**
www.epa.gov/region08

Region IX - AZ, CA, HI, NV, AS, GU
415-744-1500
www.epa.gov/region09

Region X - AK, ID, OR, WA
800-424-4372 (Region X only)
or **206-553-1200**
www.epa.gov/r10earth

http://www.epa.gov/pesticides/citizens/larvfs.pdf

United States Environmental Protection Agency
Prevention, Pesticides and Toxic substances (7506C)
May 2000
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EPA

For Your Information

Larvicides for Mosquito Control

EPA evaluates and licenses pesticides

The Environmental Protection Agency (EPA) evaluates and registers (licenses) pesticides to ensure they can be used safely. These pesticides include products used in the mosquito control programs which states and communities have established. To evaluate any pesticide, EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

mosquito officials select control measures that best suit local conditions

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation. Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito. Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control. Since no pesticide can be considered 100% safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks. This fact sheet provides basic information on larvicides, a type of pesticide used in mosquito control programs.

What are Larvicides?

larvicides kill insect larvae

The mosquito goes through four distinct stages during its life cycle: egg, larva, pupa, and adult (see box). Larvicides kill insect larvae. Larvicides include biological insecticides, such as the microbial larvicides *Bacillus sphaericus* and *Bacillus thuringiensis israelensis*. Larvicides include other chemicals used for controlling mosquito larvae, such as temephos, methoprene, oils, and monomolecular films. Larvicide treatment of breeding habitats help reduce the adult mosquito population in nearby areas.

How are Larvicides Used in Mosquito Control?

larvicides are used as one of several tools in mosquito control

State and local agencies in charge of mosquito control typically employ a variety of techniques in an Integrated Pest Management (IPM) approach, which include *surveillance, source reduction*, *larviciding* and *adulticiding*, to control mosquito populations. Since mosquitoes must have water to breed, source reduction aims to cut down opportunities for breeding, and can be as simple as turning over trapped water in a container to large-scale engineering and management of marsh water. Larviciding involves applying chemicals to habitats to kill pre-adult mosquitoes. Larviciding can reduce overall pesticide usage in a control program by reducing or eliminating the need for ground or aerial application of chemicals to kill adult mosquitoes.

What are Microbial Larvicides?

microbial larvicides are bacteria that are registered as pesticides

Microbial larvicides are bacteria that are registered as pesticides for control of mosquito larvae in outdoor areas such as irrigation ditches, flood water, standing ponds, woodland pools, pastures, tidal water, fresh or saltwater marshes, and storm water retention areas. Duration of effectiveness depends primarily on the mosquito species, the environmental conditions, the formulation of the product, and water quality. Microbial larvicides may be used along with other mosquito control measures in an integrated pest management (IPM) program. The microbial larvicides used for mosquito control are *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus* (Bs).

Mosquito Life Cycle

egg - hatch when exposed to water;

larva - (pl. - larvae) lives in the water; molts several times; most species surface to breathe air;

pupa - (pl. - pupae) non-feeding stage just prior to emerging as adult;

adult - flies short time after emerging and after its body parts have hardened.

- ***Bacillus thuringiensis israelensis*** (*Bti*) is a naturally occurring soil bacterium registered for control of mosquito larvae. *Bti* was first registered by EPA as an insecticide in 1983. Mosquito larvae eat the *Bti* product which is made up of the dormant spore form of the bacterium and an associated pure toxin. The toxin disrupts the gut in the mosquito by binding to receptor cells present in insects, but not in mammals. There are 25 *Bti* products registered for use in the United States. Aquabac, Teknar, Vectobac, and LarvX are examples of common trade names for the mosquito control products.

microbial larvicides are harmful to insects but not mammals

- ***Bacillus sphaericus*** is a naturally occurring bacterium that is found throughout the world. *Bacillus sphaericus* was initially registered by EPA in 1991 for use against various kinds of mosquito larvae. Mosquito larvae ingest the bacteria, and as with *Bti*, the toxin disrupts the gut in the mosquito by binding to receptor cells present in insects, but not in mammals. VectoLex CG and WDG are registered *B. sphaericus* products, and are effective for approximately one to four weeks after application.

Do Microbial Larvicides Pose Risks to Human Health?

The microbial pesticides have undergone extensive testing prior to registration. They are essentially nontoxic to humans, so there are no concerns for human health effects with *Bti*, or *B. sphaericus*, when they are used according to label directions.

microbial larvicides do not pose concerns for human health or the environment when used according to product labels

Do Microbial Larvicides Pose Risks to Wildlife or the Environment?

Extensive testing shows that microbial larvicides do not pose risks to wildlife, non-target species or the environment.

What is Methoprene?

methoprene is an insect growth regulator

Methoprene is a compound first registered by EPA in 1975 that mimics the action of an insect growth regulating hormone and prevents the normal maturation of insect larvae. It is applied to water to kill mosquito larvae and it may be used along with other mosquito control measures in an IPM program. Altosid is the name of the methoprene product used in mosquito control and is applied as briquets (similar in form to charcoal briquets), pellets, sand granules, and liquids. The liquid and pelletized formulations can be applied by helicopter and fixed-wing aircraft.

Does Methoprene Pose Risks to Human Health?

methoprene used in mosquito control programs according to label directions does not pose unreasonable risks to human health or the environment

Methoprene, used for mosquito control according to its label directions, does not pose unreasonable risks to human health. In addition to posing low toxicity to mammals, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes or flooded areas which are not drinking water sources.

Does Methoprene Pose Risks to Wildlife or the Environment?

Methoprene used in mosquito control programs does not pose unreasonable risks to wildlife or the environment. Toxicity of methoprene to birds and fish is low, and it is nontoxic to bees. Methoprene breaks down quickly in water and soil, and will not leach into groundwater. Methoprene is highly toxic to some species of freshwater, estuarine, and marine invertebrates if misused. For that reason, EPA has established specific precautions on the label to reduce such risks.

What is Temephos?

temephos is an organophosphate (OP)

Temephos is an organophosphate (OP) pesticide registered by EPA in 1965, to control mosquito larvae, and is the only organophosphate with larvicidal use. It is an important resistance management tool for mosquito control programs; its use helps prevent mosquitoes from developing resistance to the bacterial larvicides. Temephos is used in areas of standing water, shallow ponds, swamps, marshes, and intertidal zones. It may be used along with other mosquito control measures in an integrated pest management (IPM) program. Abate is the trade name of the temephos product used for mosquito control. Temephos is applied most commonly by helicopter, but can be applied by backpack sprayers, fixed-wing aircraft, and right-of-way sprayers in either liquid or granular forms.

Does Temephos Pose Risks to Human Health?

temephos used according to label directions does not pose unreasonable risks

Temephos, applied according to the label for mosquito control, does not pose unreasonable risks of human health effects. It is applied to water, and the amount of temephos is very small in relation to the area covered, less than one ounce of active ingredient per acre for the liquid and eight ounces per acre for the granular formulations. Temephos breaks down within a few days in water

high dosages of OPs can overstimulate the nervous system

and post application exposure is minimal. However, at high dosages, temephos, like other OPs, can overstimulate the nervous system causing nausea, dizziness, confusion.

Does Temephos Pose Risks to Wildlife or the Environment?

temephos is toxic to bees and it can be toxic to some birds and aquatic species if misused

Because temephos is applied directly to water, it is not expected to have a direct impact on terrestrial animals, but temephos can be highly toxic to some bird species and aquatic organisms if misused, and it is toxic to bees. For that reason, EPA has established specific precautions on the label to reduce such risks. The registrant of temephos has submitted studies on toxicity to aquatic invertebrates, which are being reviewed by EPA.

What is the Current Regulatory Status of Temephos?

EPA is currently reviewing temephos

As part of its responsibility to reassess all older pesticides registered before 1984, EPA is currently reviewing temephos as part of its reregistration process. The review of temephos is scheduled for completion this calendar year. A risk assessment covering all uses of temephos is available to the public on the EPA web site. From the pesticide program home page (see address below), select "OPs," then select "OP Schedule and Documents."

What are Monomolecular Films?

films drown larvae, pupae and emerging adults

Monomolecular films are chemicals that spread a thin film on the surface of the water that makes it difficult for mosquito larvae, pupae and emerging adults to attach to the water's surface, causing them to drown. Films may remain active for typically 10-14 days on standing water, and have been used in the United States in floodwaters, brackish waters, and ponds. They may be used along with other mosquito control measures in an IPM program. They are also known under the trade names Arosurf MSF and Agnique MMF.

Do Monomolecular Films Pose Risks to Human Health?

films do not pose a risk to humans

Monomolecular films, used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes or flooded areas which are not drinking water sources.

Do Monomolecular Films Pose Risks to Wildlife or the Environment?

films pose minimal risks to the environment

Monomolecular films, used according to label directions for larva and pupa control, pose minimal risks to the environment. They do not last in the environment for a long time, and are usually applied only to standing water, such as roadside ditches, woodland pools, or containers which contain few non-target organisms.

What are Oils?

oils form a coating on the water to drown mosquito larvae, pupae and emerging adults

Oils, like films, are used to form a coating on top of water to drown larvae, pupae and emerging adult mosquitoes. They are specially derived from petroleum distillates and have been used for many years in the U.S. to kill aphids on crops and orchard trees, and to control mosquitoes. They may be used along with other mosquito control measures in an IPM program. Trade names for oils used in mosquito control are Bonide, BVA2, and Golden Bear-1111 (GB-1111).

Do Oils Pose Risks to Human Health?

Oils, used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes or flooded areas which are not drinking water sources.

oils do not pose a risk to human health, but may be toxic to aquatic animals if misapplied

Do Oils Pose Risks to Wildlife or the Environment?

Oils, if misapplied, may be toxic to fish and other aquatic organisms. For that reason, EPA has established specific precautions on the label to reduce such risks.

Where Can I get More Information About Larvicides and Mosquito Control?

Centers for Disease Control and Prevention

For more information about mosquito control in your area, contact your state or local health department. The federal Centers for Disease Control and Prevention is also a source of information on disease control, and their Internet web site includes a listing of state health departments. To contact the

Centers for Disease Control and Prevention (CDC):
Call: 970-221-6400 **Fax: 970-221-6476**
E-mail: dvbid@cdc.gov **web site:** http://www.cdc.gov

national toll-free pesticide hotline

Information on pesticides used in mosquito control can be obtained from the state agency which regulates pesticides, or from the **National Pesticide Telecommunications Network (NPTN).** The NPTN web site includes links to all state pesticide regulatory agencies.
Toll-free hotline: 1-800-858-7378 (9:30 a.m. to 7:30 p.m. EST) daily except holidays. Callers outside normal hours can leave a voice mail message, and NPTN returns these calls the next business day.
E-mail: nptn@ace.orst.edu
web site: http://ace.orst.edu/info/nptn

mosquito control professionals

Information on mosquito control programs can also be obtained from the **American Mosquito Control Association (AMCA)** web site at: **http://www.mosquito.org.** This site also lists many county mosquito agencies.

federal pesticide program office

For more information regarding the federal pesticide regulatory programs, contact:
EPA Office of Pesticide Programs (OPP)
Telephone: 703-305-5017
Fax: 703-305-5558
E-mail: opp-web-comments@epa.gov
web site: http://www.epa.gov/pesticides

EPA's 10 Regional Offices are also a source of pesticide information, as well as on pesticide program activities in the individual regions.

10 EPA regional offices

EPA Region I - CT, MA, ME, NH, RI, VT
888-372-7341
www.epa.gov/region01

EPA Region II - NJ, NY, PR, VI
732-321-4391
www.epa.gov/region02

EPA Region III - DE, DC, MD, PA, VA, WV
800-438-2474

EPA Region IV - AL, FL, GA, KY, MS, NC, SC, TN
800-241-1754
www.epa.gov/region4

EPA Region V - IL, IN, MI, MN, OH, WI
800-621-8431 (Region V only) or **312-353-2000**
www.epa.gov/region5

EPA Region VI - AR, LA, NM, OK, TX
800-887-6063 (Region VI only) or **214-665-6444**
www.epa.gov/region6

EPA Region VII - IA, KS, MO, NE
800-223-0425 or **913-551-7020**
www.epa.gov/region7

EPA Region VIII - CO, MT, ND, SD, UT, WY
800-227-8917 (Region VIII only) or **303-551-7020**
www.epa.gov/region08

EPA Region IX - AZ, CA, HI, NV, AS, GU
415-744-1500
www.epa.gov/region09

EPA Region X - AK, ID, OR, WA
800-424-4372 (Region X only) or **206-553-1200**
www.epa.gov/r10earth

Other Helpful EPA Publications

For Your Information - How to Use Insect Repellents Safely
(735-F-93-052R)

For Your Information - Mosquitoes: How to Control Them
(735-F-98-003)

For Your Information - Naled for Mosquito Control
(735-F-00-003)

For Your Information - Malathion for Mosquito Control
(735-F-00-001)

For Your Information - Synthetic Pyrethroids for Mosquito Control
(735-F-00-004)

Questions and Answers - Pesticides and Mosquito Control http://www.epa.gov/pesticides/citizens/synpyfs.pdf

United States
Environmental
Protection Agency

Prevention, Pesticides
and Toxic substances
(7506C)

May 2000
735-F-00-004

EPA FOR YOUR INFORMATION

Synthetic Pyrethroids for Mosquito Control

EPA evaluates and licenses pesticides

The Environmental Protection Agency (EPA) evaluates and registers (licenses) pesticides to ensure they can be used safely. These pesticides include products used in the mosquito control programs which states and communities have established. To evaluate any pesticide, EPA assesses a wide variety of tests to determine whether a pesticide has the potential to cause adverse effects on humans, wildlife, fish and plants, including endangered species and non-target organisms.

mosquito officials select control measures that best suit local conditions

Officials responsible for mosquito control programs make decisions to use pesticides based on an evaluation of the risks to the general public from diseases transmitted by mosquitoes or on an evaluation of the nuisance level that communities can tolerate from a mosquito infestation. Based on surveillance and monitoring, mosquito control officials select specific pesticides and other control measures that best suit local conditions in order to achieve effective control of mosquitoes with the least impact on human health and the environment. It is especially important to conduct effective mosquito prevention programs by eliminating breeding habitats or applying pesticides to control the early life stages of the mosquito. Prevention programs, such as elimination of any standing water that could serve as a breeding site, help reduce the adult mosquito population and the need to apply other pesticides for adult mosquito control. Since no pesticide can be considered 100% safe, pesticide applicators and the general public should always exercise care and follow specified safety precautions during use to reduce risks. This fact sheet provides basic information on synthetic pyrethroids, a class of insecticides used in mosquito control programs.

What are Synthetic Pyrethroids?

synthetic pyrethroids are commonly used for mosquito control

Pyrethroids are synthetic chemical insecticides that act in a similar manner to pyrethrins, which are derived from chrysanthemum flowers. Pyrethroids are widely used for controlling various insects. **Permethrin, resmethrin** and **sumithrin** are synthetic pyrethroids commonly used in mosquito control programs to kill adult mosquitoes.

- **Permethrin** has been registered by EPA since 1977. It is currently registered and sold in a number of products such as household insect foggers and sprays, tick and flea sprays for yards, flea dips and sprays for cats and dogs, termite treatments, agricultural and livestock products, and mosquito abatement products.

- **Resmethrin** has been registered by EPA since 1971, and is used to control flying and crawling insects in the home, lawn, garden, and at industrial sites. It can also be used to control insects on ornamental plants (outdoor and greenhouse use), on pets and horses, and as a mosquitocide. Resmethrin is a Restricted Use Pesticide (RUP) which is available for use only by certified pesticide applicators or persons under their direct supervision because of its toxicity to fish.

- **Sumithrin** has been registered by EPA since 1975, and is used to control adult mosquitoes and used as an insecticide in transport vehicles such as aircraft, ships, railroad cars, and truck trailers. It is also used as an insecticide and miticide in commercial, industrial, and institutional non-food areas, in homes and gardens, in greenhouses, and in pet quarters and on pets.

How are Synthetic Pyrethroids Used in Mosquito Control?

tiny ultra-low volume (ULV) droplets kill mosquitoes on contact

Most pyrethroid mosquito control products can be applied only by public health officials and trained personnel of mosquito control districts. Mosquito control professionals apply pyrethroids as an ultra low volume (ULV) spray. ULV sprayers dispense very fine aerosol droplets that stay aloft and kill mosquitoes on contact. Pyrethroids used in mosquito control are typically mixed with a synergist compound called piperonyl butoxide, which enhances the effectiveness of the active ingredient. The product is applied at rates of between 0.003 and 0.007 pounds of active

Mosquito Life Cycle

egg - hatch when exposed to water;

larva - (pl. - larvae) lives in the water; molts several times; most species surface to breathe air;

pupa - (pl. - pupae) non-feeding stage just prior to emerging as adult;

adult - flies short time after emerging and after its body parts have hardened.

ingredient per acre which is equivalent to 2 to 3.5 fluid ounces of the mixed formulation per acre.

Do Pyrethroids Pose Risks to Human Health?

pyrethroids do not pose unreasonable risks to human health

Pyrethroids can be used for public health mosquito control programs without posing unreasonable risks to human health when applied according to the label. Pyrethroids are considered to pose slight risks of acute toxicity to humans, but at high doses, pyrethroids can affect the nervous system.

Do pyrethroids pose risks to wildlife or the environment?

pyrethroids do not pose unreasonable risks to wildlife or the environment, but are toxic to fish

Pyrethroids used in mosquito control programs do not pose unreasonable risks to wildlife or the environment. Pyrethroids are low in toxicity to mammals, and are practically non-toxic to birds. Mosquito control formulations of permethrin quickly break down in the environment, and high temperatures and sunlight accelerate this process. However, pyrethroids are toxic to fish and to bees. For that reason, EPA has established specific precautions on the label to reduce such risks, including restrictions that prohibit the direct application of products to open water or within 100 feet of lakes, streams, rivers or bays.

What is The Current Regulatory Status of Pyrethroids?

EPA will review pyrethroids in approximately 2002

As part of its responsibility to reassess all older pesticides registered before 1984, EPA has given highest priority to reviewing more acutely toxic pesticides such as organophosphates and carbamates. Organophosphates are currently under review. Comprehensive reviews of the synthetic pyrethroids are scheduled for approximately 2002.

Where Can I get More Information About Pyrethroids and Mosquito Control?

Centers for Disease Control and Prevention

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Other Helpful EPA Publications

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For Your Information - Mosquitoes: How to Control Them (735-F-98-003)

For Your Information - Larvicides for Mosquito Control (735-F-00-002)

For Your Information - Malathion for Mosquito Control (735-F-00-001)

For Your Information - Naled for Mosquito Control (735-F-003)

Questions and Answers - Pesticides and Mosquito Control

Research

A Human-Health Risk Assessment for West Nile Virus and Insecticides Used in Mosquito Management

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West Nile virus (WNV) has been a major public health concern in North America since 1999, when the first outbreak in the Western Hemisphere occurred in New York City. As a result of this ongoing disease outbreak, management of mosquitoes that vector WNV throughout the United States and Canada has necessitated using insecticides in areas where they traditionally have not been used or have been used less frequently. This has resulted in concerns by the public about the risks from insecticide use. The objective of this study was to use reasonable worst-case risk assessment methodologies to evaluate human-health risks for WNV and the insecticides most commonly used to control adult mosquitoes. We evaluated documented health effects from WNV infection and determined potential population risks based on reported frequencies. We determined potential acute (1-day) and subchronic (90-day) multiroute residential exposures from each insecticide for several human subgroups during a WNV disease outbreak scenario. We then compared potential insecticide exposures to toxicologic and regulatory effect levels. Risk quotients (RQs, the ratio of exposure to toxicologic effect) were < 1.0 for all subgroups. Acute RQs ranged from 0.0004 to 0.4726, and subchronic RQs ranged from 0.00014 to 0.2074. Results from our risk assessment and the current weight of scientific evidence indicate that human-health risks from residential exposure to mosquito insecticides are low and are not likely to exceed levels of concern. Further, our results indicate that, based on human-health criteria, the risks from WNV exceed the risks from exposure to mosquito insecticides.
Key words: comparative risk assessment, mosquito control, organophosphates, pesticide exposure, pyrethroids, risk analysis, vectorborne disease. *Environ Health Perspect* 114:366–372 (2006). doi:10.1289/ehp.8667 available via *http://dx.doi.org/* [Online 28 October 2005]

West Nile virus (WNV) has become a major public health concern in North America since 1999, when the first outbreak in the Western Hemisphere occurred in New York City, causing 62 cases of human encephalitis and 7 deaths [Centers for Disease Control and Prevention (CDC) 1999]. The initial outbreak in New York City is thought to have affected 2.6% of the population (Hubalek 2001). In 2000, WNV spread to three states, with 21 human cases of WNV infection and 2 deaths. In 2001, 66 human cases and 9 deaths were reported in 10 states, before WNV spread westward, affecting all but 6 states in 2002 and causing the largest arboviral encephalitis epidemic in U.S. history (Huhn et al. 2003). A total of 4,156 human cases were documented, with 284 deaths reported (CDC 2003), and numbers continued to grow in 2003, when 46 states reported 9,862 human cases with 264 deaths (CDC 2004a). In 2004, 2,539 human cases and 100 deaths were reported in 41 states (Hayes et al. 2005). Since the first appearance of WNV in the United States in 1999, the CDC has reported 16,706 documented human cases and 666 deaths (CDC 2004b; Hayes et al. 2005); however, large numbers of human infections may not be detected because of significant underreporting of milder cases of West Nile fever (Hubalek 2001; Huhn et al. 2003). Given the infection rate observed for previous years, Peleman (2004) estimated that 1.5 million people were infected with the virus in 2003.

As a result of this ongoing disease outbreak, management of mosquitoes that vector WNV throughout the United States and Canada has necessitated using insecticides in areas where they traditionally have not been used or have been used less frequently. This practice has raised concerns by the public about risks from insecticide use. In a survey by Hinten (2000), 54% of 880 people surveyed were either equally afraid of WNV and pesticides or were more afraid of the insecticides. Since 1999, numerous concerns have been raised by the public regarding the safety of using insecticides to control mosquitoes (Cohen 2003; Fehr-Snyder 2004; Fitz 2003). Some of those concerned have even suggested that the health risks from the insecticides exceed those of WNV (Cohen 2003; Ziem 2005). These concerns by the public are not exclusive to the WNV issue, but reflect long-standing perceptions of risk from pesticides (Peterson and Higley 1993; Slovic 1987).

Risk assessment is a formalized basis for the objective evaluation of risk in which assumptions and uncertainties are clearly considered and presented [National Research Council (NRC) 1983, 1996]. Human-health and ecologic risk can be described in quantitative terms as a function of effect (also termed "hazard" or "toxicity") and exposure (NRC 1983). Risk assessment typically uses a tiered modeling approach extending from deterministic models (tier 1) based on conservative assumptions to probabilistic models (tier 4) using refined assumptions [Society for Environmental Toxicology and Chemistry (SETAC) 1994]. In risk assessment, conservative assumptions in lower-tier assessments represent overestimates of effect and exposure; therefore, the resulting quantitative risk values typically are conservative and err on the side of safety.

Unfortunately, few, if any, science-based considerations of the risks of insecticide use versus the risks from vectorborne diseases have been examined. An understanding of the human-health risks for both vectorborne diseases and associated vector controls would aid greatly in decision making by all stakeholders. Therefore, the objective of this study was to use risk assessment methodologies to evaluate human-health risks from WNV and from the insecticides used to control adult mosquitoes.

Materials and Methods

Problem formulation. Although WNV has important effects on horses and birds, our assessment of health risks from WNV focused only on humans. Currently, effect and exposure factors for WNV are poorly understood (Loeb et al. 2005), making quantitative modeling of risk difficult. Therefore, we evaluated documented health effects from WNV infection and determined potential population risks based on reported frequencies. Because of the relatively recent emergence of WNV in North America, information on prevalence of various effects of the disease should be regarded as tentative.

Our tier-1 quantitative assessment of human-health risks associated with insecticides

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used in mosquito control focused on acute and subchronic residential exposures after truck-mounted ultra-low-volume (ULV) spraying of mosquito adulticides. The dissemination of mosquito adulticides by ULV application generates fine aerosol droplets that remain aloft and target flying mosquitoes [U.S. Environmental Protection Agency (EPA) 2002b]. Acute exposures were defined as single-day exposures immediately after a spray event. Subchronic exposures were defined as exposures per day over a 90-day seasonal multispray event. A total of 10 spray events were assumed to occur on days 1, 4, 14, 17, 27, 30, 40, 43, 53, and 56. This design represents a reasonable worst-case mosquito insecticide seasonal application scenario, including during a human epidemic of WNV [Karpati et al. 2004; New York City Department of Health (NYCDOH) 2001]. Chronic exposures (> 6 months) to mosquito adulticides are unlikely. Additionally, extrapolation of subchronic exposures to chronic exposure time frames would result in lower risks than with subchronic risks (NYCDOH 2001). Therefore, chronic risks were not assessed in this study.

Exposures to several population subgroups were estimated to account for potential age-related differences in exposure. Groups included adult males, adult females, infants (0.5–1.5 years of age), and children (2–3, 5–6, and 10–12 years of age). Adult males were assumed to weigh 71.8 kg, which represents the mean body weight for all males > 18 years of age, and adult reproductive females were assumed to weigh 60 kg, which represents the mean body weight for females between 13 and 54 years of age (U.S. EPA 1996). Children 5–6 and 10–12 years of age were assumed to weigh 21.1 and 40.9 kg, respectively. Infants (0.5–1.5 years of age) and toddlers (2–3 years of age) were assumed to weigh 9.4 and 14.3 kg, respectively. All weights for children were derived from mean body weight values for male and female children within their respective age groups (U.S. EPA 1996).

Hazard identification. We conducted human-health risk assessments for six insecticide active ingredients (permethrin, pyrethrins, resmethrin, phenothrin, malathion, and naled) and one synergist (piperonyl butoxide). Malathion and naled are in the organophosphate class of insecticides, and permethrin, pyrethrins, resmethrin, and phenothrin are in the pyrethroid class. The synergist, piperonyl butoxide, is present in many formulations with pyrethroids. All compounds are currently registered by the U.S. EPA for adult mosquito management in the United States.

Toxicity end points. Toxicity and dose–response information for each compound were reviewed for acute and subchronic exposure durations. Toxicity end points in this assessment were chosen based on U.S. EPA regulatory end points.We used inhalation, dermal, and ingestion toxicity end points for each respective exposure route and duration. Ingestion reference doses (RfDs) were used as the toxicity end points (acceptable daily exposures) and were compared with total estimated exposures (total body burden). Acute and subchronic ingestion RfDs were calculated by dividing the most sensitive toxic effect [typically the no observed adverse effect level (NOAEL)] by a series of uncertainty factors (typically a factor of 100 to account for intraspecies and interspecies uncertainty) (Table 1).

Environmental concentrations and fate of insecticides. We used the AERMOD, version 1.0 tier 1 air dispersion model (U.S. EPA 1999) to predict the 7.6 m (25 ft) and 91.4 m (300 ft) air concentrations (micrograms per cubic meter) of each insecticide within 1- and 6-hr time ranges after ULV application by a truck-mounted sprayer. Estimates of environmental concentrations are presented only for truck-mounted ULV applications because our modeling suggested that delivery of ULV applications by aircraft resulted in substantially less aerial and surface deposition (and therefore less human exposure and risk). This was also observed by the NYCDOH (2001).

We used the following conservative assumptions: *a*) each chemical had a 24-hr half-life in air except for naled, which was given a 18-hr half-life; *b*) the insecticides were applied at the maximum application rate as stated on each label; *c*) all of the insecticides were susceptible to the same weather conditions using standardized weather data from Albany, New York, in 1988; *d*) all spray events occurred at 2100 hr; and *e*) each spray release was at 1.5 m. The chemical properties, application rates, and predicted environmental concentrations for each active ingredient are listed in Table 2.

Receptors were established within the model on a Cartesian grid at five intervals of

Table 1. Toxicologic effects and regulatory end points for the active ingredients.

Compound	Acute		Subchronic	
	End point	Study and toxicologic effects	End point	Study and toxicologic effects
Malathion	NOAEL = 50 mg/kg/day[a] RfD = 0.5 mg/kg/day UF = 100	Based on reduction in maternal bw gain in a study with pregnant rabbits[a]	NOAEL = 2.4 mg/kg/day[a] RfD = 0.024 mg/kg/day UF = 100	Based on inhibition of blood enzyme activity at 50 ppm malathion in the diet in a 24-month study in rats[a]
Naled	NOAEL = 1.0 mg/kg/day[b] RfD = 0.01 mg/kg/day UF = 100	Based on inhibition of blood and brain enzymes in a 28-day study in rats[b]	NOAEL = 1.0 mg/kg/day[b] RfD = 0.01 mg/kg/day UF = 100	Based on inhibition of blood and brain enzymes in a 28-day study in rats[b]
Permethrin	NOAEL = 25 mg/kg/day[c] RfD = 0.25 mg/kg/day UF = 100	Acute neurotoxicity study in rats LOEL = 75 mg/kg based on observations of clinical signs such as aggression, abnormal/decreased movement, and increased body temperature[c]	NOAEL = 25 mg/kg/day[c] RfD = 0.25 mg/kg/day UF = 100	Acute neurotoxicity study in rats LOEL = 75 mg/kg based on observations of clinical signs such as aggression, abnormal/decreased movement, and increased body temperature[c]
Resmethrin	NOEL = 10 mg/kg/day[d] RfD = 0.1 mg/kg/day UF = 100	Based on liver weight increases in a 6-month study in dogs[d]	NOEL = 10 mg/kg/day[d] RfD = 0.1 mg/kg/day UF = 100	Based on liver weight increases in a 6-month study in dogs[d]
Phenothrin	NOEL = 70 mg/kg/day[e] RfD = 0.7 mg/kg/day UF = 100	13-week study in rats LOEL = 216 mg/kg-day based on increases in liver weights and decreases in cholesterol in both male and female rats[e]	NOEL = 70 mg/kg/day[e] RfD = 0.7 mg/kg/day UF = 100	13-week study in rats LOEL = 216 mg/kg-day based on increases in liver weights and decreases in cholesterol in both male and female rats[e]
Pyrethrins	NOAEL = 20 mg/kg/day[f] RfD = 0.07 mg/kg/day UF = 300	Acute neurotoxicity study in rats LOAEL = 63 mg/kg/day based on tremors in females[f]	NOAEL = 4.37 mg/kg/day[f] RfD = 0.044 mg/kg/day UF = 100	Rat chronic toxicity study LOAEL = 42.9 mg/kg/day based on increased incidence of thyroid follicular cell hyperplasia in males.[f]
Piperonyl butoxide	NOAEL = 630 mg/kg/day[g] RfD = 6.3 mg/kg/day UF = 100	Developmental toxicity study in rats LOAEL = 1,065 mg/kg/day based on decreases in maternal bw gain[g]	NOAEL = 89 mg/kg/day[g] RfD = 0.89 mg/kg/day UF = 100	Two generation reproduction study in rats LOAEL = 469 mg/kg/day based on decrease in bw gain of F_1 and F_2 pups at postnatal day 2[g]

Abbreviations: bw, body weight; LOAEL, lowest observed adverse effect level. LOEL, lowest observed effect level; NOEL, no observed effect level; UF, uncertainty factor used to determine the RfD.
[a]U.S. EPA 2000c. [b]U.S. EPA 2002a. [c]U.S. EPA 2005c. [d]U.S. EPA 2000a. [e]U.S. EPA 2000b. [f]U.S. EPA 2005b. [g]U.S. EPA 2005a.

25 m at 7.6 m and 91.4 m from the edge of the spray emission area. The receptors were at a height of 1.5 m. Each receptor estimated the 1- and 6-hr average air concentrations for each insecticide. An average was then taken of the estimates from the six receptors at 7.6 m that were not at the edges of the spray zone. The following data were obtained using this network of receptors: the 1-hr average concentration at 7.6 m, the 6-hr average at 7.6 m, and the peak value at 91.4 m.

We used the screening Industrial Source Complex Short-Term (ISCST3) model (U.S. EPA 1995) to estimate particle deposition (milligrams per square meter) at 7.6 m and 91.4 m from the spray area at a 1-hr average. The following assumptions were made in addition to those from AERMOD: *a*) all of the insecticides were susceptible to the same weather conditions using standardized weather data from Salem, Massachusetts; *b*) the ULV particle size applications had 3% of the emitted particles greater than the allowable particle size as stated on the label; and *c*) the particles were assigned a density in accordance with the specific gravity of each insecticide.

A Cartesian grid was used for ISCST3 that was similar to that used in AERMOD. Receptors were added at 15.24-m intervals between 7.6 m and 91.4 m from the spray source to obtain a more accurate estimate of the average deposition within 91.4 m of the source. The receptors were also at the same height of 1.5 m. All of the same methods were used to calculate the average deposition at 7.6 m and 91.4 m. The middle receptors were included to calculate an average deposition within 91.4 m. The following data were obtained from this information: deposition at 7.6 m, deposition at 91.4 m, and the average deposition within 91.4 m of the spray source.

For estimating subchronic exposures, we used the estimated deposition values within 91.4 m for each insecticide in an exponential decay model to characterize their persistence on surfaces such as soil within a spray program that included 10 sprays on days 1, 4, 14, 17, 27, 30, 40, 43, 53, and 56. Insecticide concentrations for each spray event were followed through day 90 using the following multiple degradation model:

$$D = \sum_{j=i}^{90} Pe^{(r_1+r_2)t}, \qquad [1]$$

where D is the sum of the deposition over one spray, P is the peak deposition after a spray event, r_1 is the rate of decay calculated by using the aerobic soil half-life of each active ingredient, r_2 is the rate of decay calculated by using the soil photolysis half-life of each active ingredient, t is the time in hours, and j is the spray day. The average daily exposure was then determined by dividing the deposition sum by 90.

The same deposition and degradation model was used to characterize deposition and persistence on garden produce by using a Kenaga nomogram to estimate the deposition (milligrams per kilogram dry weight) of each insecticide on respective plant parts. Because the nomogram represents a linear relationship between application rate and maximum residues, it can be used to estimate the maximum residues on plant surfaces for a given application rate (Fletcher et al. 1994). For this analysis, maximum application rates were used for each insecticide, and each estimated concentration was then applied to the model above, using the surface photolysis half-life to estimate the rate of degradation.

Acute exposure. We assumed that multi-route exposures immediately after a single-spray event were limited to 24 hr. Routes of insecticide exposure included inhalation, dermal contact with spray, hand-to-mouth ingestion by infants and toddlers from spray deposition on hands, and ingestion of garden produce. We also assumed that residents did nothing to limit their exposure to the spray. In its assessment of acute and subchronic exposures from several mosquito adulticides, the NYCDOH (2001) concluded that exposures from potable water and swimming were negligible. Using environmental fate models, we also concluded that the chemical properties of the insecticides result in negligible concentrations in water. Therefore, we did not include these exposures in our assessment.

Acute inhalation exposure. Acute inhalation exposures were estimated as

$$PE = (EEC \times RR \times D \times CF) \div bw, \qquad [2]$$

where PE is potential exposure [milligrams per kilogram body weight (bw)], EEC is the 6-hr average estimated environmental concentration of an active ingredient in the air 1.5 m high at 7.6 m from the spray source (micrograms per cubic meter), RR is the respiratory rate under moderate activity (cubic meters per hour), D is the duration of exposure (hours), CF is the conversion factor to account for the conversion of units from micrograms per cubic meter to milligrams per cubic meter, and bw is body weight (kilograms).

RRs were assumed to be 1.6 m^3/hr for adults and 1.2 m^3/hr for children, including infants. These rates are indicative of moderate physical activity (U.S. EPA 1996). The duration of exposure was 6 hr. Therefore, the assumption was that the person was outside and 7.6 m from the spray truck when it passed him or her. Moreover, the person remained outside, 7.6 m from the emission, for the following 6 hr, respiring as if under moderate physical activity during the entire time. Body weight for the different age groups is discussed above.

Acute dermal exposure from spray deposition. Acute dermal exposures from deposition of spray drift on skin were estimated as

$$PE = (TDE \times AB) \div bw, \qquad [3]$$

where PE is potential exposure (milligrams per kilogram bw), TDE is total dermal exposure (milligrams), AB is dermal absorption rate, and bw is body weight (kilograms). There is no publicly available information on dermal deposition immediately after truck-mounted ULV sprays. Therefore, we used the U.S. EPA Pesticide Handler Exposure Database (PHED; U.S. EPA 1998) as a conservative surrogate. The PHED contains pesticide-handler scenarios derived from field studies and exposure estimates based on physical factors such as application rate, hectares treated per day, type of clothing worn, methods of application, and

Table 2. Application rates, chemical properties, and predicted environmental concentrations of active ingredients.

Property	Active ingredient						
	Piperonyl butoxide	Phenothrin	Permethrin	Resmethrin	Malathion	Naled	Pyrethrins
Application rate (kg ai/ha)	0.0392	0.004	0.0078	0.0078	0.0639	0.0224	0.009
Density (g/mL)	0.898[a]	0.898[a]	0.8657[b]	0.87[c]	1.23[d]	1.67[e]	0.81[f]
Surface photolysis half-life (days)	NA[g]	6[c]	23[h]	0.14[i]	6.5[i]	2.4[i]	0.5[j]
Soil aerobic half-life (days)	14[i]	7[i]	37[k]	30[h]	1[h]	1[h]	1[j]
Acute air concentration (μg/m^3)[l]	7.39	0.81	1.55	1.61	9.76	1.68	1.7
1-Day acute produce concentration (mg/kg dry wt)	0.525	0.054	0.105	0.105	0.855	0.3	0.12
90-Day mean surface concentration (mg/m^2)[m]	15.42	0.43	4.14	0.22	2.18	0.65	0.54
90-Day mean produce concentration (mg/kg dry wt)	2.88	0.055	0.096	0.012	0.73	0.13	0.21

Abbreviations: ai/ha, active ingredient per hectare; NA, not available; wt, weight.
[a]Clarke Mosquito Control Products (1999b). [b]Clarke Mosquito Control Products (1999a). [c]Bayer Environmental Science (2004). [d]Griffin (2001). [e]AMVAC (2003). [f]McLaughlin Gormley King Co. (2004). [g]Surface and produce concentrations determined from soil aerobic half-life only. [h]U.S. Department of Agriculture (USDA 2005). [i]NYCDOH (2001). [j]Food and Agricultural Organization (2000). [k]U.S. EPA (2005c). [l]6-Hr mean concentration at 7.6 m from spray source. [m]90-Day mean surface concentration within 91.4 m of the spray source.

formulation type. We used the PHED scenario in which a flagger (person marking the location for pesticide application while the application is occurring) was exposed to a liquid application. We assumed that the person was not wearing clothing and that the exposure was 10 times greater than the flagger scenario. We believe this scenario conservatively estimated residential dermal exposure for two reasons: *a*) we added a 10-fold increase in exposure, and *b*) the U.S. EPA has not considered acute dermal contact from ULV applications for pyrethrins, piperonyl butoxide, and permethrin because it was believed to be negligible (U.S. EPA 2005a, 2005b, 2005c). The values for percent dermal absorption were 0.22% for pyrethrins (U.S. EPA 2005b), 2% for piperonyl butoxide (U.S. EPA 2005a), 10% for malathion and resmethrin (U.S. EPA 2000a, 2000c), 15% for permethrin (U.S. EPA 2005c), 70% for phenothrin (U.S. EPA 2000b), and 100% for naled (U.S. EPA 2002a).

Acute hand-to-mouth exposure from spray deposition on hands. Acute hand-to-mouth exposures were estimated for only two subgroups (toddlers and infants), because young children are more likely than adults to be exposed to pesticides as a result of hand-to-mouth contact (Cohen Hubal et al. 2000). Exposures were calculated as

$$PE = [(THD \div HSA) \times AHS \times SEF] \div bw, \quad [4]$$

where *PE* is potential exposure (milligrams per kilogram bw), *THD* is total hand dermal exposure (milligrams), *HSA* is adult hand surface area (square meters), *AHS* is adjusted hand surface area for each subgroup (square meters), *SEF* is saliva extraction factor, and *bw* is body weight (kilograms). Total hand dermal exposure was determined using the PHED database and the assumptions discussed above. The hand surface area of toddlers (2–3 years of age) was assumed to be 0.035 m^2, which represents the 50th percentile total surface area values for males and females in the 2–3 and 3–4 year age groups, multiplied by the mean percentage of the total body represented by hands for males and females of that age (U.S. EPA 1996). The hand surface area for infants was assumed to be 0.007 m^2 and was also calculated as a percent of total body surface area for infants (U.S. EPA 1996). We calculated the total body surface area of infants using the formula by Current (1998). We assumed that, on the day of application, 50% of the insecticide deposited on the hand was available through saliva extraction (U.S. EPA 2005a, 2005c).

Acute ingestion of garden produce. We assumed that the insecticide settled onto a tomato garden and that the resident picked, processed, and ate tomatoes the next day. The estimated maximum insecticide residue deposited on tomatoes is discussed above. We assumed that the resident did not wash the tomatoes after picking. The residue concentration also did not change with processing of the tomatoes. The amount of insecticide ingested was estimated as the product of the residue concentration and the quantity of food consumed. Tomato consumption patterns were determined using the Dietary Exposure Evaluation Model [(DEEM)-Food Commodity Intake Database (FCID) version 2.04; Exponent, Washington, DC]. The model determines dietary consumption for the U.S. population and several subgroups by using individual food consumption records collected by the U.S. Department of Agriculture (USDA) Continuing Surveys for Food Intake by Individuals for 1994–1998. Translation factors used to convert foods-as-eaten to commodities are based on a U.S. EPA/USDA FCID recipe set. For this assessment, we determined the acute food consumption patterns by subgroup using the 95th percentile 1-day consumption values for tomatoes, tomato baby food, tomato paste, tomato paste baby food, tomato puree, tomato puree baby food, dried tomato, dried tomato baby food, and tomato juice. Therefore, the respective individuals in these subgroups ate all of these tomato food products within 1 day of application at the 95th percentile of U.S. national consumption.

Subchronic exposure. We assumed multiroute exposures per day over 90 days after multispray events. Routes of insecticide exposure included inhalation, dermal contact with spray, ingestion of garden produce, hand-to-mouth ingestion by infants and toddlers from spray deposition on hands, hand-to-mouth ingestion by infants and toddlers from deposition on surfaces, dermal contact with soil and other surfaces, and soil ingestion.

Subchronic inhalation, dermal, and hand-to-mouth exposures. Exposures for each exposure type were estimated as

$$PE = (PE_{acute,\ type} \times SE) \div D, \quad [5]$$

where *PE* is the potential exposure (milligrams per kilogram bw per day), $PE_{acute,\ type}$ is the acute exposure type (e.g., acute inhalation) from each spray event (milligrams per kilogram bw), *SE* is the number of spray events, and *D* is the duration of exposure (days). We assumed that the insecticides were sprayed on days 1, 4, 14, 17, 27, 30, 40, 43, 53, and 56 (10 spray events per season) in any given area. The exposure duration was 90 days.

Subchronic hand-to-mouth exposure from deposition on surfaces. Subchronic hand-to-mouth exposures were estimated for only two subgroups (toddlers and infants) based on the rationale discussed above. Exposures were calculated as

$$PE = (EEC \times SEF \times SA \times DR \times FA \times D) \div bw, \quad [6]$$

where *PE* is potential exposure (milligrams per kilogram bw per day), *EEC* is the 90-day average environmental concentration of the active ingredient deposited on soil or turf within 91.4 m from the spray source (milligrams per square meter), *SEF* is saliva extraction factor, *SA* is surface area for three fingers (square meters), *DR* is dislodgeable residue, *FA* is frequency of activity (events per hour), *D* is exposure duration (hours), and *bw* is body weight (kilograms). Assumptions for estimating subchronic environmental concentrations are discussed above. The saliva extraction factor was assumed to be 50% (U.S. EPA 2005a, 2005c), and the palmar surface area for three fingers was assumed to be 20 cm^2 (U.S. EPA 2005c). Dislodgeable insecticide residue from soil or turf grass was assumed to be 20% (U.S. EPA 1997). The frequency of hand-to-mouth activity in children was assumed to be 20.5 events/hr and is based on the maximum frequency observed (Freeman et al. 2005). The duration of exposure was assumed to be 4 hr/day. Therefore, the toddler or infant was assumed to be engaging in hand-to-mouth activities outside each day for 4 hr over 90 days.

Subchronic ingestion of garden produce. Our assumptions for subchronic ingestion of garden produce were the same as for acute ingestion of produce, with the following differences: *a*) the insecticide was deposited onto both tomatoes and head- and leaf-lettuce, *b*) all tomato and lettuce consumption by the residents over the 90 days was from the garden, and *c*) tomato and lettuce consumption patterns were determined using chronic food consumption patterns (3-day average).

Subchronic dermal contact with soil and other surfaces. Exposures from contact with soil, turf, and other outdoor surfaces were calculated as

$$PE = (EEC \times SA \times SS \times AB \times DR \times CF) \div bw, \quad [7]$$

where *PE* is potential exposure (milligrams per kilogram bw per day), *EEC* is the 90-day average environmental concentration of the active ingredient deposited on soil or turf within 91.4 m from the spray source (milligrams per square meter), *SA* is body surface area in contact with surface (square centimeters), *SS* is weight of soil adhered to skin (milligrams per square centimeter), *AB* is dermal absorption rate, *DR* is dislodgeable residue, *CF* is the conversion factor to account for square meters to square centimeters, and *bw* is body weight (kilograms). The body surface area in contact with the surface was assumed to be the sum of surface areas for face (head ÷ 2), hands, arms, legs, and feet (U.S. EPA 1996). Therefore, we assumed residents were minimally clothed while outside. Contact with surfaces was associated with certain human activities. The activities were assumed to be gardening for adults (0.55 mg soil/cm^2 skin) and soccer for children, including infants (0.164 mg soil/cm^2 skin) (U.S. EPA 1996). We assumed that these activities occurred each day over the 90 days. The assumptions for dermal absorption rate and dislodgeable residues are discussed above.

Subchronic soil ingestion. Exposures from incidental ingestion of soil were calculated as

$$PE = [(EEC \div SW) \times SI] \div bw, \qquad [8]$$

where PE is potential exposure (milligrams per kilogram bw per day), EEC is the 90-day average environmental concentration of the active ingredient deposited on soil or turf within 91.4 m from the spray source (milligrams per square meter), SW is soil weight (milligrams per cubic meter), SI is soil ingestion (milligrams per day), and bw is body weight (kilograms). Because the insecticide would only be surface-deposited on soil, we assumed that the concentration (milligrams per square meter) would be the same for a cubic meter of soil. Soil weight was assumed to be 3.86 kg/m^3 based on reported densities for Scotts lawn soil (The Scotts Company, Marysville, OH). Soil ingestion rates were assumed to be 100 mg/day for children and 50 mg/day for adults (U.S. EPA 1996). We assumed that all soil ingestion each day was from soil containing residues of the active ingredients.

Risk characterization. Human-health risks in this study were assessed by integrating toxicity and exposure. We assessed risks using the risk quotient (RQ) method. For each population subgroup, an RQ was calculated by dividing the PE by the appropriate toxicity end point (e.g., the RfD). Therefore, the RQ is the ratio of exposure to effect. RQs < 1 are typically below regulatory levels of concern.

Exposures by similar route of exposure and duration (e.g., subchronic dermal contact with spray and surfaces) were compared with the appropriate RfD (e.g., subchronic dermal RfD). Multiroute exposures (dermal + ingestion + inhalation) were compared with the ingestion RfD. The ingestion RfD provided a conservative toxicity end point because it typically was based on the most sensitive NOAEL. Therefore, it represented the largest dose in which no adverse effects on human health would occur during the relevant exposure duration.

Results

West Nile virus risks. According to a seroepidemiologic survey conducted by Mostashari et al. (2001), for every diagnosed case of West Nile (WN) meningoencephalitis, there were approximately 30 additional people with WN fever, and approximately 2.6% of the population in outbreak areas in New York were infected during the epidemic of 1999. Loeb et al. (2005) reported a 3.1% outbreak infection rate in Oakville, Ontario, Canada, in 2002. Unfortunately, the seroprevalence of WNV antibodies across larger time and geographic scales has not been determined. Overall, 20% of infected persons develop mild febrile illness (Mostashari et al. 2001), and 0.67% develop neurologic disease (Fratkin et al. 2004). A total of 0.43% develop encephalitis, and 0.24% develop meningitis (Asnis et al. 2001; Brilla et al. 2004; Emig and Apple 2003; Klee et al. 2004; Sejvar et al. 2003a; Weiss et al. 2001).

Case-fatality rates in the United States ranged from 4 to 18% among hospitalized patients (Brilla et al. 2004; Emig and Apple 2003; Nash et al. 2001b; Pepperell et al. 2003; Sejvar et al 2003a; Weiss et al. 2001) and from 2.7 to 14% among cases reported to the CDC (CDC 2004b).

No difference in distribution of WNV infection among age groups and between sexes is apparent (Nash et al. 2001a, 2001b; Tyler 2001), but for unknown reasons, males seem to be at higher risk for WN neuroinvasive illness (O'Leary et al. 2004; Petersen and Marfin 2002). Children infected with WNV usually show no symptoms or have only a mild fever (Hayes and O'Leary 2004). The incidence of encephalitis and death increases with age (Nash et al. 2001a, 2001b; O'Leary et al. 2004; Tsai et al. 1998; Weinberger et al. 2001). Weiss et al. (2001) reported that persons ≥ 50 years of age were more likely to present meningoencephalitis and had increased mortality rates; other reports show that the incidence of neurologic symptoms and death may increase 10- to 20-fold among persons ≥ 50 years of age (Nash et al. 2001a; Sampathkumar 2003; Tyler 2001). The risk increases 43 times for persons ≥ 80 years of age (Sampathkumar 2003).

Few data exist regarding long-term morbidity after WNV infection. Substantial morbidity may follow hospitalization for WNV infection (Petersen et al. 2003) and is observed in patients with WN fever (Watson et al. 2004). Encephalitis cases seem to have more variable outcomes than meningitis cases, which tend to recover well (Granwehr et al. 2004). A poor prognosis and very limited recovery have been observed in acute flaccid paralysis cases (Saad et al. 2005; Sejvar et al. 2003a, 2003b).

Although patients with WN fever tend to recover well, median recovery time was 60 days for patients in Illinois in 2002 (Watson et al. 2004). The disease also has a significant effect on the lifestyle of patients with WN fever. Of 98 respondents with WN fever, 57 (58%) missed work/school, 82 (84%) had household activities limited, 47 (49%) had difficulty walking, and 89 (91%) had outside-of-home activities limited (Watson et al. 2004).

In a long-term follow-up study on 42 WN encephalitis survivors 1 year after illness onset, only 37% presented full physical, functional, and cognitive recoveries, and there was a substantially higher prevalence of impairment compared with baseline (Nash et al. 2001a). Similarly, only 2 of 8 patients in a study in New York presented full recovery after 1 year; 3 patients had neurologic sequelae, and 1 patient had minimal impairment after 18 months (Asnis et al. 2001).

Acute risks from insecticides. Table 3 shows the calculated RQs for each active ingredient in terms of total acute PE. Exposures and risks also were determined for each exposure route. Potential acute inhalation exposures of the six human subgroups to the adulticides ranged from 0.00011 to 0.0075 mg/kg bw, and the environmental concentrations were lower than

Table 3. Acute RQs for the active ingredients for each subgroup.[a]

Subgroup	Malathion	Naled	Permethrin	Resmethrin	Phenothrin	Pyrethrins	Piperonyl butoxide
Adult males	0.0076	0.1496	0.0020	0.0052	0.0004	0.0081	0.0004
Adult females	0.0079	0.1576	0.0021	0.0055	0.0004	0.0085	0.0004
Children (10–12 years)	0.0105	0.2123	0.0029	0.0072	0.0006	0.0113	0.0006
Children (5–6 years)	0.0177	0.3631	0.0049	0.0123	0.0010	0.0190	0.0009
Toddlers (2–3 years)	0.0225	0.4726	0.0063	0.0159	0.0013	0.0245	0.0012
Infants (0.5–1.5 years)	0.0188	0.4495	0.0058	0.0147	0.0012	0.0218	0.0010

[a]RQ = total acute PE ÷ RfD.

Table 4. Subchronic RQs for the adulticides for each subgroup.[a]

Subgroup	Malathion	Naled	Permethrin	Resmethrin	Phenothrin	Pyrethrins	Piperonyl butoxide
Adult males	0.0360	0.0259	0.0007	0.0004	0.0001	0.0056	0.0032
Adult females	0.0363	0.0269	0.0007	0.0004	0.0001	0.0056	0.0032
Children (10–12 years)	0.0470	0.0290	0.0008	0.0005	0.0001	0.0074	0.0043
Children (5–6 years)	0.0676	0.0447	0.0012	0.0009	0.0002	0.0104	0.0059
Toddlers (2–3 years)	0.1815	0.1294	0.0204	0.0037	0.0009	0.0270	0.0262
Infants (0.5–1.5 years)	0.2074	0.1661	0.0301	0.0054	0.0013	0.0292	0.0325

[a]RQ = total subchronic PE ÷ RfD.

the inhalation reference concentrations for all active ingredients evaluated. Potential acute dermal exposures to the adulticides ranged from 0.0000001 to 0.0011 mg/kg bw, with RQs ranging from 0.0000005 to 0.0113. For acute exposure due to ingestion (hand-to-mouth exposure from spray deposition on hands and ingestion of produce), total PEs ranged from 0.0001 to 0.0061 mg/kg bw, with RQs ranging from 0.00014 to 0.2142. Total acute RQs ranged from 0.0004 to 0.4726.

Subchronic risks from insecticides. Table 4 shows the calculated RQs for each active ingredient in terms of total subchronic PE. Potential subchronic inhalation exposures of the six subgroups to the adulticides ranged from 0.000012 to 0.00083 mg/kg bw. For subchronic dermal exposures to the adulticides (dermal and contact with soil), total PEs ranged from 0.00000006 to 0.00015 mg/kg, with RQs ranging from 0.0000001 to 0.0015. Potential subchronic exposures due to ingestion (ingestion of produce and soil, hand-to-mouth activity after contact with surfaces, and hand-to-mouth activity after contact with spray drift) ranged from 0.00001 to 0.0283 mg/kg bw, with RQs ranging from 0.00007 to 0.1709. Total subchronic RQs ranged from 0.00014 to 0.2074.

None of the subgroups had RQs ≥ 1.0 (i.e., PEs did not equal or exceed the RfDs) for any of the active ingredients evaluated. The lowest acute RQs were to phenothrin and piperonyl butoxide for adults and the highest acute RQ was to naled for toddlers (Table 3). The lowest and highest subchronic RQs were to phenothrin for adults and malathion for infants, respectively (Table 4).

Discussion

Conservatism. Based on the exposure and toxicity assumptions above, we believe our assumptions were sufficiently conservative and most likely overestimated risk. For example, assuming an acute RR of 0.8 m^3/hr for 2 hr and no dermal or ingestion exposures [which were the U.S. EPA assumptions for mosquito control uses of permethrin (U.S. EPA 2005c)], there would be a 90% reduction in exposure for toddlers compared with our value. Indeed, draft tier 1 risk assessments recently conducted for malathion, piperonyl butoxide, pyrethrins, and permethrin by the U.S. EPA also suggest that our results are sufficiently conservative (U.S. EPA 2000c, 2005a, 2005b, 2005c). Because of the conservative exposure assumptions used, we believe higher-tiered risk assessments using more realistic exposures would result in risk values significantly lower than those presented here.

The conservatism of our risk assessments for insecticides used in adult mosquito control is supported by residential biomonitoring and epidemiologic studies. Currier et al. (2005) assessed human exposure to ULV-applied naled, permethrin, and phenothrin in Mississippi, North Carolina, and Virginia as a result of emergency large-scale mosquito abatement. Using biomonitoring of urine, they did not observe an increase in insecticide metabolite concentrations among exposed residents. Karpati et al. (2004) and O'Sullivan et al. (2005) did not observe increases in hospital emergency department visits for asthma after wide-scale spraying of residential neighborhoods.

Uncertainties. Despite the conservatism of our risk assessment, uncertainties were revealed. Many of the uncertainties associated with residential exposure estimates are discussed above. The principal uncertainty was for environmental concentrations of the active ingredients. Data for actual aerial concentrations and surface deposition of active ingredients need to be generated to more accurately characterize risks. Because of the nature of ULV application methods, it is likely that concentrations of active ingredients are much lower than those predicted using the AERMOD and ISCST3 tier 1 models. Toxicologic uncertainties include mammalian toxicities to combinations of piperonyl butoxide and adulticides and to inert ingredients in the formulated products. The addition of piperonyl butoxide to the adulticides increases the mosquito toxicity of the pyrethroids approximately 10-fold, but mammalian toxicity is not likely to be proportionally increased (Knowles 1991). Even if mammalian toxicity were increased 10-fold to the pyrethroids, RQs would still be well below levels of concern. Human exposures to solvents and other inert ingredients are likely to be low, resulting in low risks (NYCDOH 2001). Future research should be directed toward reducing toxicity and exposure uncertainties associated with mosquito adulticides. In addition, future assessments should address ecologic risks.

Comparing risks. Although it is difficult to compare the risks directly, several conclusions can be drawn by considering both human risks from exposure to WNV and insecticides used to control adult mosquitoes. In a situation where application of mosquito adulticides occurs because of known human cases of WNV, an adult human female may have at least a 3% probability of being infected by WNV. An adult female in that same area conservatively may have a 100% probability of being exposed to a particular mosquito adulticide. Her probability of exposure to the insecticide may be greater than WNV infection, but the consequences (i.e., the risks) of the exposures would be very different. Once infected with WNV, an adult human female has approximately a 20% probability of expressing clinical signs of illness (WN fever) and, depending on age, a 0.67% probability of expressing neurologic disease. Depending on the insecticide, her acute exposure would be 0.0415–15.76% of the RfD (0.0004–0.1576% of the NOAEL). Consequently, her acute risks from the insecticide would be lower than her acute risks from WNV. Subchronic insecticide risks would also be negligible (Table 4), whereas subchronic and chronic WNV risks (disease sequelae) would be greater. Therefore, once exposed to the insecticide (based on the tier 1 exposure assumptions from this study), the risk of any adverse health effects to the adult female would be negligible.

Results from our risk assessment and the current weight of scientific evidence (Currier et al. 2005; Karpati et al. 2004; NYCDOH 2001; O'Sullivan et al. 2005; U.S. EPA 2000c, 2005a, 2005b, 2005c) indicate that human-health risks from residential exposure to mosquito adulticides are very low and are not likely to exceed levels of concern. Further, by virtually any current human-health measure, the risks from infection by WNV exceed the risks from exposure to mosquito insecticides. Therefore, perceptions that human-health risks from the insecticides used to control adult mosquitoes are greater than the risks from WNV currently cannot be supported by current scientific evidence. Our results, and the results from other studies, should be used by the U.S. EPA, public health officials, and the general public to make better-informed decisions about risk–risk tradeoffs.

Correction

In the original manuscript published online, the acute air concentration for naled in Table 2 and the RQ ranges for acute inhalation exposures and acute subchronic dermal exposures were incorrect. These have been corrected here.

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Pesticide Spraying for West Nile Virus Control and Emergency Department Asthma Visits in New York City, 2000

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Pyrethroid pesticides were applied via ground spraying to residential neighborhoods in New York City during July–September 2000 to control mosquito vectors of West Nile virus (WNV). Case reports link pyrethroid exposure to asthma exacerbations, but population-level effects on asthma from large-scale mosquito control programs have not been assessed. We conducted this analysis to determine whether widespread urban pyrethroid pesticide use was associated with increased rates of emergency department (ED) visits for asthma. We recorded the dates and locations of pyrethroid spraying during the 2000 WNV season in New York City and tabulated all ED visits for asthma to public hospitals from October 1999 through November 2000 by date and ZIP code of patients' residences. The association between pesticide application and asthma-related emergency visits was evaluated across date and ZIP code, adjusting for season, day of week, and daily temperature, precipitation, particulate, and ozone levels. There were 62,827 ED visits for asthma during the 14-month study period, across 162 ZIP codes. The number of asthma visits was similar in the 3-day periods before and after spraying (510 vs. 501, $p = 0.78$). In multivariate analyses, daily rates of asthma visits were not associated with pesticide spraying (rate ratio = 0.92; 95% confidence interval, 0.80–1.07). Secondary analyses among children and for chronic obstructive pulmonary disease yielded similar null results. This analysis shows that spraying pyrethroids for WNV control in New York City was not followed by population-level increases in public hospital ED visit rates for asthma. *Key words:* asthma, obstructive airway disease, ozone, particulates, pesticides, pollutants, pyrethroids, West Nile virus. *Environ Health Perspect* 112:1183–1187 (2004). doi:10.1289/ehp.6946 available via *http://dx.doi.org/* [Online 8 July 2004]

Outbreaks of encephalitis caused by West Nile virus (WNV) have occurred in the late summer and early autumn months yearly in New York City since 1999. Birds are the reservoirs for WNV, and transmission to humans occurs via mosquito vectors (Roehrig et al. 2002). One component of the New York City Department of Health and Mental Hygiene's (DOHMH) response to the emergence of WNV was to initiate a citywide adult mosquito control program, which included the application of aerosolized pesticides via truck spraying to residential and commercial neighborhoods and to other areas such as parks and cemeteries. Beginning in 2000, the dates and ZIP codes of pesticide spraying were guided by the results of WNV testing of trapped mosquitoes and dead birds and by surveillance for human cases of WNV infection.

The active ingredients in the brand of pesticide used in 2000 were sumithrin (10%), a pyrethroid, and piperonyl butoxide (10%), a benzodioxole, which acts as a microsomal enzyme inhibitor. Exposure to pyrethroid pesticides or their synergists can cause respiratory irritation, hypersensitivity pneumonitis, exacerbation of asthma, and death (Carlson and Villaveces 1977; He et al. 1988; Kolmodin-Hedman et al. 1982; Lessenger 1992; Moretto 1991; Newton and Breslin 1983; Wax and Hoffman 1994); however, we could find no data on population-level respiratory effects of large-scale mosquito control programs using pyrethroids. Exacerbations of existing respiratory illness such as asthma after pyrethroid pesticide spraying is a concern, particularly given the high rates of asthma in some New York City communities. Public concern for respiratory effects of pesticides applied for WNV control has been high (Gonzalez 2001; Zhao 2001).

In this analysis we focused on the 2000 WNV season, the first year in which the New York City mosquito control program exclusively used a pyrethroid pesticide. Pyrethroids continue to be the only adulticide (a pesticide effective in killing adult mosquitoes, as opposed to larvae) used by the DOHMH and are used extensively in other areas of the United States. We conducted a time-series analysis across ZIP codes in New York City to determine whether truck-based ground spraying of pyrethroid pesticides precipitated an increase in asthma exacerbations requiring emergency department (ED) treatment during the 2000 WNV season.

Materials and Methods

We analyzed the dates and locations of pyrethroid spraying and ED visits to public hospitals for asthma exacerbations for all residential ZIP codes in four of the five New York City boroughs for the 14-month study period from 1 October 1999 through 30 November 2000. Because the DOHMH organized and instituted the pesticide application by ZIP code, we compiled daily counts of ED visits for each ZIP code. We used a time-series approach at the ZIP-code level to avoid confounding by intrinsic differences between sprayed and nonsprayed ZIP codes (e.g., in underlying asthma rates or patterns of public hospital use) and to maximize sensitivity to temporal determinants of asthma-related visit rates. Because the analysis compares visit counts in each ZIP code on each day with counts on other days, each ZIP code's population serves as its own control. The unit of analysis was therefore the ZIP-day. All ZIP codes in New York City were included except those in Staten Island, which lacks a public hospital. Pesticide application was performed between July and September 2000; however, 14 months of data were included in the analysis to increase the power of models to account for potential confounders.

Pesticide exposure assessment. In 2000, the DOHMH applied pesticides to localized residential areas, defined by ZIP code, after surveillance revealed local evidence of actively circulating WNV (i.e., presence of WNV-positive mosquitoes or dead birds, or a human case of WNV infection). Consequently, different ZIP codes in the city were sprayed on different days throughout the season (late summer through early fall). Rarely was a given ZIP code sprayed on consecutive days. Through radio, television, and print media,

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the public was notified 48 hr in advance of possible pesticide use. Before any spray action, instructions were given to residents to remain indoors and close all windows during spray times. Pesticides were applied to residential areas at night from trucks that drove through the streets between approximately 2200 hr and 0500 hr. In most cases, all streets in the ZIP code were sprayed. In some instances, only some of the streets were sprayed, depending on the size of the area and its proximity to the surveillance event (e.g., the location of the dead bird) that prompted the spraying. Truck-based spraying from streets was the only method employed in the study area; no more direct application (e.g., to back yards) was performed. Locations and dates of pesticide application were compiled from records of the DOHMH.

We defined a ZIP code as exposed to spraying on the date on which spraying began, which was usually at approximately 2200 hr. The principal exposure measure was a dichotomous variable defining the date for a given ZIP code as "exposed" if any portion of the ZIP code was sprayed and "unexposed" only if none of the ZIP code was sprayed on that day. We also constructed two other exposure variables for sensitivity analyses: a dichotomous variable in which "exposure" was attributed only if ≥ 90% of the area of the ZIP code was sprayed, and a continuous variable defining exposure by the percentage of the area of the ZIP code that was sprayed.

Asthma exacerbations. We were interested in all asthma exacerbations requiring ED treatment in New York City; however, for this analysis, data were available only for public hospitals. These data were obtained from the New York City Health and Hospitals Corporation (HHC). The study outcome was therefore asthma-related visits to the 11 New York City public hospital EDs (including urgent care clinics), which are located in four of the five boroughs (Manhattan, the Bronx, Brooklyn, and Queens). These 11 EDs accounted for approximately 28% of the citywide ED volume in 1998 (Greater New York Hospital Association 2000). ED visits for asthma were defined by *International Classification of Diseases, 9th Revision* (ICD-9; 1997) coded discharge diagnoses (ICD-9 codes 493.0–493.9). Cases were attributed to the date of visit and the ZIP code of residence. We used the guarantor's ZIP code to define the residence of each patient.

Secondary analyses included one restricted to asthma visits among children < 15 years of age and an analysis expanding the outcome of interest to include visits for exacerbations of chronic obstructive lung disease (COPD) and acute and chronic bronchitis (ICD-9 codes 466, 490–492, 496).

Additional variables. We obtained air-quality data for the 14-month study period from the New York State Department of Environmental Conservation, Bureau of Air Quality Surveillance (unpublished data). Meteorologic data were obtained from the National Weather Service database (National Weather Service 2003). Daily minimum, maximum, and mean levels were calculated from hourly data for particulates [< 10-µm in diameter (PM_{10})] and ozone; temperature was obtained as daily minimum, maximum, and mean, and precipitation as a 24-hr total, which we dichotomized into a binary variable (zero or trace vs. more than trace). PM_{10} data were obtained from two real-time monitoring stations (one in Manhattan, one in the Bronx), ozone from three stations (in Manhattan, the Bronx, and Queens), and meteorologic data from one station (in Queens). For the air-quality measures, ZIP codes were assigned values measured at the site closest to the center of the ZIP code. For particulates, 19 days of data were missing from one station and 55 days from the other; data were missing from both stations on 2 days. For ozone, one station had 1 day of missing data, another station had 5 days, and the third had 14 days; on one day two stations' data were missing, and on no days were all three stations missing data. We imputed missing data for PM_{10} and ozone as follows: If data from one station were missing on a given day, the other station's value or mean of the two other stations for that day was used. If data were missing from all stations on a given day, values were imputed by averaging the measurements taken 5 days before and after the missing day. Additional time-varying variables were day of the week, date (for seasonal trend), and whether the day was a holiday.

Although non-time-varying differences in rates across ZIP codes would not be confounders of this time-series analysis, we extracted ZIP-code-level measures from the 2000 U.S. Census (New York City Department of City Planning 2003) for descriptive purposes. These were population size, median household income, median age, and percentage of population reporting non-Hispanic white race/ethnicity. We also calculated the distance between the ZIP code center and the nearest public hospital.

Statistical analysis. We first conducted a bivariate analysis in which we counted the number of ED visits for asthma across all sprayed ZIP codes in the 3 days before and after spraying. Days on which spraying had occurred within the prior 7 days were excluded (n = 30, 11% of spray events). We calculated the proportion of visits that occurred in the 3 days after spraying; under the null hypothesis of no association between spraying and visit rates, this proportion would be 0.5. This proportion was tested as a one-sample test using the normal-theory method. This analysis was also performed using 1- and 2-day time windows.

We then used a time-series analysis of the number of cases per day within individual ZIP codes to assess the temporal relationship of spraying and asthma. To model seasonal, day-to-day, climatic, and pollution trends, we used 14 months of data from all included ZIP codes, whether or not they were sprayed. We estimated the effect of pesticide spraying on the daily number of ED asthma visits in each ZIP code by fitting a generalized additive model with a Poisson distribution. The natural log of ZIP-code population size was included as a variable with coefficient of 1 (offset). To account for differences between ZIP codes in mean visit rates and in the proportion of asthma exacerbations that result in ED visits, we estimated random effects for ZIP codes and included non-time-varying ZIP-code characteristics as covariates. Variables were added to the model based on likelihood ratio testing, and the optimal form of the variables (linear vs. nonlinear effects, daily maximum, minimum, or mean) was chosen through minimization of the Bayesian Information Criteria (Schwartz 1978). Nonlinear relationships, such as seasonal trends in asthma visits and temperature, were modeled using natural splines. Day-of-the-week and holiday effects were estimated using indicator variables. Lagged effects of the main exposure variable were assessed for lags of 0–6 days (and of potential confounders, from 1 to 2 days). Statistical significance was defined

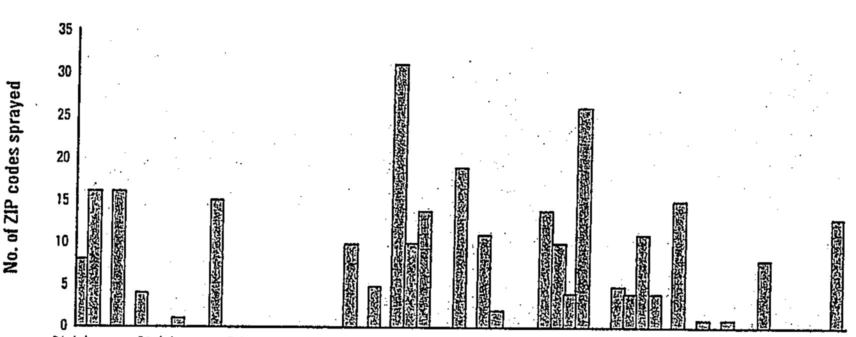

Figure 1. Pesticide application schedule, New York City, 24 July through 24 September 2000.

as a two-tailed p-value < 0.05. Models were implemented using both SAS version 8.2 (SAS Institute, Cary, NC) and S-Plus 6 (Insightful Corporation, Seattle, WA).

Results

The analysis included 162 ZIP codes and 427 days between 1 October 1999 and 30 November 2000, yielding 69,174 ZIP-days.

Pesticide application. The number of ZIP codes sprayed per day is shown in Figure 1. Partial or complete spraying occurred in 1–31 ZIP codes per day on 27 days between 24 July and 24 September 2000, for a total of 278 ZIP-days of exposure. In Figure 2, of the 162 ZIP codes shown on the map, 143 (88%) were sprayed at least once (median = 2 days; range, 1–5 days). Fifty-seven percent of spraying events covered the entire area of the ZIP code; 80% of spraying events covered > 50% of the ZIP code area.

ED visits for asthma. The range of ED visits for asthma per ZIP-day for all ages was 0–20 (median = 0 visits) and for children < 15 years of age, 0–11 (median = 0 visits) (Table 1). Over the 14-month analysis period, the rate of asthma ED visits across all ages was 28 per 10,000 population (interquartile range = 9–85), and for children 0–14 years of age, 68 per 10,000 population (interquartile range = 18–185). Figure 3 shows the daily number of asthma visits in all study hospitals. The sawtooth pattern indicates day-of-the-week variability. Notable seasonal trends include a midwinter peak, summer trough, and late summer/early autumn rise. Similar patterns were evident for those who were < 15 years of age. The pesticide application schedule coincided with both the summer trough and the subsequent autumn increase in asthma visits.

Characteristics of covariates. Table 1 also summarizes the time-varying covariates, which include air quality and weather factors. Although there was considerable day-to-day variability in air quality, daily values across monitoring sites were highly correlated across the city (mean Pearson's correlation coefficient = 0.90; range, 0.83–0.94); data are shown for a single monitoring station. Highly elevated particulate and ozone levels were rare; compared with national standards, mean daily PM_{10} levels exceeded 50 µg/m^3 on 13 days, and maximum hourly ozone levels, according to the U.S. EPA database (U.S. EPA 2003), exceeded 0.12 ppm on 1 day. Table 1 also lists non-time-varying characteristics of ZIP codes from the U.S. Census (New York City Department of City Planning 2003) and distance from ZIP-code center to the nearest public hospital.

Pesticide application and ED visits for asthma. There were 1,011 ED visits for asthma during the 3-day period that preceded spraying and the 3-day period that followed spraying across all sprayed ZIP codes. Of these, 510 (50.4%) occurred in the period that preceded spraying and 501 (49.6%) occurred in the period that followed spraying (p = 0.78). Using 1- and 2-day windows, the proportions of all visits that followed spraying were 0.47 (p = 0.32) and 0.49 (p = 0.70), respectively.

In the multivariate analysis, exposure to pesticide spraying was not associated with elevated ED visits for asthma on the day after spraying (Table 2). The multivariate rate ratio (RR) for exposure to pesticide spraying, defined as any part of the ZIP code being sprayed, was 0.92 [95% confidence interval (CI), 0.80–1.07]. ED visits for asthma also did not increase in the days after spraying. Multivariate models that incorporated lags between spraying and ED visits for asthma of 2–6 days showed no increase in ED visits for asthma (e.g., multivariate RR for ED asthma visits lagged 5 days after exposure was 0.94; 95% CI, 0.82–1.08). ED visits for asthma were also not elevated after a second or more

Table 1. ED asthma visit rates and meteorologic and air quality measures, October 1999 through November 2000, and ZIP code characteristics, 2000, New York City.[a]

Characteristic	Median	Interquartile range
Daily ED visits for asthma (within ZIP codes)		
All ages	0	0–1 (range 0–20)
Children < 15 years of age	0	0–0 (range 0–11)
Time-varying measures		
Ozone (daily maximum, ppm)	0.02	0.01–0.03
PM_{10} (2-day mean, µg/m^3)	19.3	14.6–27.2
Temperature (daily minimum, °F)	49	38–60
Precipitation (daily total, inches)	0	0–0.04
Non-time-varying measures (ZIP-code characteristics)		
Population	42,309	26,000–65,576
Median household income (dollars)	31,800	21,900–40,800
Median age (years)	34	32–38
Percent non-Hispanic white	38	8–64
Distance to nearest public hospital (miles)	1.9	1.2–3.0

[a]Staten Island has no public hospitals; therefore, ZIP codes in that borough were excluded from the analysis.

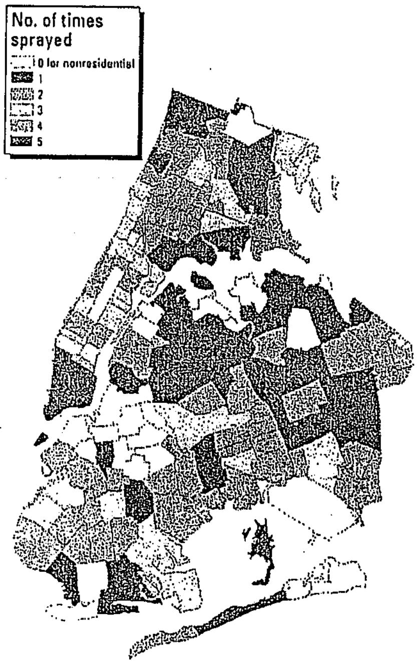

Figure 2. ZIP codes sprayed for WNV control in New York City, 24 July 2000 through 24 September 2000.

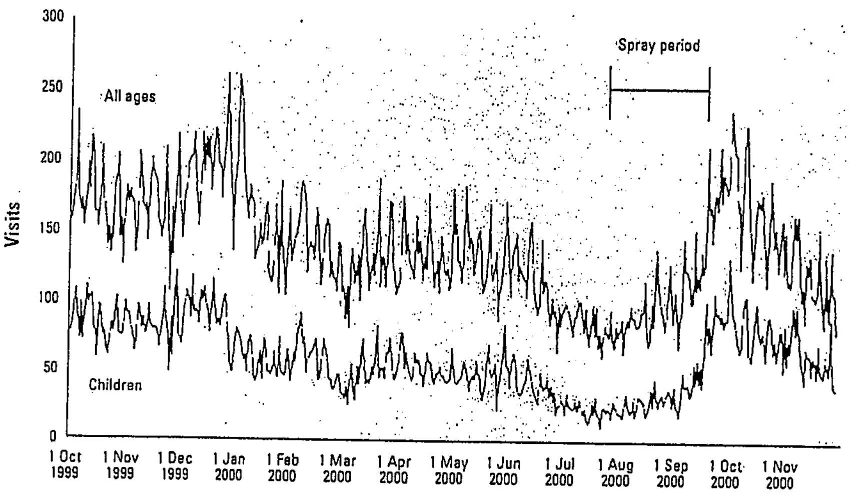

Figure 3. Daily number of asthma-related ED visits to public hospitals in New York City, October 1999 through November 2000.

application of pesticide in the 85 ZIP codes that received repeated spraying (e.g., multivariate RR for 2 spray events vs. no events, 0.93; 95% CI, 0.73–1.19).

Separate analyses examining possible associations in vulnerable populations demonstrated no effect of spraying. The analysis restricted to children < 15 years of age showed a multivariate RR of 0.78 (95% CI, 0.61–1.01). The analysis that included ED visits for exacerbations of COPD similarly showed no association (RR = 0.91; 95% CI, 0.80–1.04). Findings were similar in sensitivity analyses using different definitions of exposure to spraying and various smoothing spans for the seasonal term. In no case did the spray variable reach statistical significance, nor was there a trend toward increasing asthma rates.

Particulate matter, other covariates, and asthma. In contrast to findings for pesticide spraying, daily PM_{10} and ozone were significantly associated with daily ED visits for asthma (Table 2). Each increase in PM_{10} of 20 $\mu g/m^3$ was associated with a 7% rise in ED visits for asthma, and each 0.02-ppm increase in ozone was associated with a 4% rise in ED visits for asthma. Minimum daily temperature, precipitation, and whether the day was a holiday were also associated with ED visits for asthma. The increase in the ED visit rate for asthma comparing days at 50°F versus 70°F daily minimum temperature was approximately 30%.

Non-time-varying characteristics of ZIP codes were included in models for descriptive purposes rather than for control of confounding between ZIP codes (because comparisons were made within, rather than between, ZIP codes). These ZIP code characteristics were significantly associated with rates of ED visits for asthma as described in Table 2.

Discussion

In this study we examined the question of whether ground-based application of pyrethroid pesticides to urban residential areas was associated with population-level increases in asthma exacerbations requiring emergency care. We found no significant association between neighborhood spraying and subsequent rates of ED visits for asthma. Similarly null findings were obtained for pediatric asthma and for COPD exacerbations and in various sensitivity analyses using different lag times and exposure definitions.

Many jurisdictions in the United States use aerosolized pyrethroid pesticides to control insect populations, for either nuisance reduction or prevention of insect-borne diseases (Crockett et al. 2002; Groves et al. 1997; Rose 2000). These compounds (as well as the solvents in which they are suspended) can potentially stimulate asthma through allergic or irritant pathways. Symptoms that have been described after short-term exposures to pyrethroid insecticides include stuffy, runny nose, sneezing, and scratchy throat, as well as wheezing, shortness of breath, and chest tightness. Evidence suggests that pyrethroid pesticides may aggravate preexisting respiratory conditions in certain individuals. For example, one study found that exposure to a pesticide containing pyrethroids and piperonyl butoxide (a synergist) produced bronchospasm in seven persons with asthma several minutes after exposure (Newton and Breslin 1983). Most reports of respiratory effects of pyrethroids, however, involve few exposed subjects who are exposed to relatively high doses of pesticide, often in occupational settings. This report is the first of which we are aware that addresses the question of whether similar effects would be observed at a population level, where individual exposure would potentially be widespread and include more sensitive individuals but levels of exposure would likely be low.

Because the spraying program was implemented at the ZIP code level and occurred only on specific days in each ZIP code, we examined daily, ZIP code–level measures of asthma. The results, therefore, apply to the population level; spraying may have triggered asthma exacerbations in certain particularly susceptible or heavily exposed individuals. Also, although we used a residence-based exposure definition, exposure to pesticides might have occurred in other settings (e.g., occupational) for certain individuals. Our results, however, suggest that the number of individuals whose asthma was affected severely enough that they required ED treatment was not large. Also, public announcements were made before spraying to alert local residents. It is possible that residents with asthma or other respiratory illnesses took particular precautions (staying indoors, taking medication prophylaxis) to avoid exposure to or potential effects of the sprayed pesticides. The null results of the analysis should therefore be viewed as referring to the pesticide application program as a whole, rather than specifically addressing causal relations between the agents and asthma exacerbations.

The count of ED visits for asthma before and after spraying suggested no increase in asthma rates. The additional multivariate-modeling technique was designed to address potential confounding of the relationship between pesticide exposure and visit rates by a number of time-varying factors, such as time of year, day of week, weather, and air quality. The models also incorporated determinants of baseline heterogeneity in asthma visit rates between neighborhoods, such as sociodemographic characteristics. The results confirmed previously identified effects of air quality (e.g., particulate levels and ozone) and weather (e.g., temperature) on day-to-day variability in asthma rates (Brunekreef et al. 1995; Schwartz et al. 1993) and revealed

Table 2. Adjusted RRs (95% CIs) for truck-based pyrethroid spraying for WNV and other time-varying predictors of asthma-related ED visits to public hospitals in New York City,[a] 1999–2000.

Characteristic	RR[b] (95% CI)
Time-varying covariates	
Truck-based pyrethroid spraying[c]	0.92 (0.80–1.07)
PM_{10} (per 20-$\mu g/m^3$ increase in 2-day mean)	1.07 (1.05–1.09)
Ozone (per 0.02-ppm increase in daily maximum, 2-day lag)	1.04 (1.02–1.05)
Holiday	0.93 (0.88–0.98)
Precipitation	0.97 (0.95–0.99)
Non-time-varying covariates	
Median income (per $10,000 increase)	0.69 (0.68–0.70)
Median age [years (quantiles)]	
24–31	Reference
31–33	0.74 (0.73–0.76)
33–35	0.71 (0.68–0.74)
35–38	0.88 (0.85–0.93)
> 38	0.94 (0.90–0.98)
Non-Hispanic white ethnicity [percent of population (quantiles)]	
0–4	Reference
4–18	0.56 (0.55–0.57)
18–51	0.47 (0.46–0.48)
51–68	0.34 (0.33–0.36)
68–98	0.25 (0.23–0.26)
Distance to nearest public hospital [miles (quantiles)]	
0.1–1.0	Reference
1.0–1.6	0.49 (0.48–0.50)
1.6–2.2	0.43 (0.42–0.44)
2.2–3.2	0.42 (0.41–0.43)
3.2–8.4	0.19 (0.18–0.20)

[a]Staten Island has no public hospitals; therefore, ZIP codes in that borough were excluded from the analysis. [b]RRs were also adjusted for temperature, day of week, and a smoothed seasonal trend. [c]Application of pesticide to any part of a given ZIP code, lagged by 1 day from the date on which application began.

expected ecologic determinants of asthma visit rates to New York City public hospitals, such as neighborhood socioeconomic status, racial composition, and proximity to such facilities. These positive findings suggest that the null association of pesticide exposure with visit rates was not caused by model misspecification or insensitivity to population-wide effects.

Only data from public hospitals were available for this analysis, rather than data from all New York City EDs. However, the absence of complete population-level data should not have had a biasing effect on the temporal variability of asthma visit rates from particular ZIP codes because the propensity of residents of a particular ZIP code to visit certain hospitals would likely not have changed significantly over the study period. Public hospital ED users might, in fact, be a more sensitive population for detecting triggers of asthma in the population, because they might preferentially use ED services rather than physicians' clinics and tend to have less well-controlled asthma (Ortega et al. 2001). Another potential limitation is that ZIP code of residence was defined as that of the guarantor of the patient, rather than explicitly as the patient's home address. Although it is possible that these addresses may differ for some patients, it is unlikely that this phenomenon occurred with sufficient frequency to substantially bias the results. Also, although Staten Island was the most heavily sprayed borough in 2000 and this analysis does not include data from that area, the null results found even in multiply sprayed ZIP codes suggest that the population-level experience might have been similar there.

As the circulation of WNV and the emergence of WNV-associated illness increases in the United States, public health agencies are increasingly called on to make risk–benefit calculations regarding vector control programs. Our results suggest that modest to large increases in ED visits for asthma did not occur in New York City during and after pyrethroid spraying for WNV control in 2000.

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Human Exposure to Mosquito-Control Pesticides — Mississippi, North Carolina, and Virginia, 2002 and 2003

Public health officials weigh the risk for mosquito-borne diseases against the risk for human exposure to pesticides sprayed to control mosquitoes (*1*). Response to outbreaks of mosquito-borne diseases has focused on vector control through habitat reduction and application of pesticides that kill mosquito larvae. However, in certain situations, public health officials control adult mosquito populations by spraying ultra-low volume (ULV) (<3 fluid ounces per acre [oz/acre]) mosquito-control (MC) pesticides, such as naled, permethrin, and d-phenothrin. These ULV applications generate aerosols of fine droplets of pesticides that stay aloft and kill mosquitoes on contact while minimizing the risk for exposure to persons, wildlife, and the environment (*2*). This report summarizes the results of studies in Mississippi, North Carolina, and Virginia that assessed human exposure to ULV naled, permethrin, and d-phenothrin used in emergency, large-scale MC activities. The findings indicated ULV application in MC activities did not result in substantial pesticide exposure to humans; however, public health interventions should focus on the reduction of home and workplace exposure to pesticides.

Mississippi, 2002

The 2002 West Nile virus (WNV) epidemic in Mississippi prompted an increase in MC activities, including application of ULV permethrin by truck-mounted foggers (Figure). Because of concerns about potential health effects from pesticides, the Mississippi Department of Health and CDC assessed whether MC activities increased individual urine pesticide metabolite concentrations. During September 8–19, 2002, investigators selected a geographically-random sample of 125 persons by using maps of two regions where public health officials applied MC pesticides and 67 persons from

FIGURE. Ultra-low volume, truck-mounted spraying for mosquito control — Mississippi, 2002

Photo/CDC

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two control regions. Each participant completed a questionnaire describing home and occupational use of pesticides and provided a spot urine sample for analysis of pesticide metabolites 1–4 days after MC (i.e., within 5 half-lives). By using a cross-sectional design, investigators compared urine pesticide metabolite concentrations of exposed and unexposed study participants. Exposure to permethrin was verified by cross-referencing the global positioning systems location of participants with local MC spray routes. Permethrin was applied in MC regions at a concentration of 0.032 oz/acre.

Urine samples were analyzed at CDC by using tandem mass spectrometry (*3*). Urinary metabolite concentrations of 3-phenoxybenzoic acid (3pba), a metabolite of synthetic pyrethroid pesticides such as permethrin, did not differ significantly between MC and non-MC regions (geometric mean [GM] = 1.25 μg/L versus 1.13 μg/L, respectively). Although 3pba concentrations did not differ between participants who used pesticides at home or at work and those who did not, participants who used pesticides on pets (n = 17) had significantly higher (p = 0.02) mean 3pba concentrations than those who did not (n = 174) (4.27 μg/L versus 1.07 μg/L, respectively). These findings indicated that local MC activities did not lead to increased pesticide metabolite concentrations in the urine of participants.

North Carolina, 2003

Hurricane Isabel made landfall in North Carolina on September 18, 2003. Because of ensuing rains and flooding, mosquito populations were expected to surge. To control mosquitoes and prevent transmission of WNV and other arboviruses, the North Carolina Department of Environmental and Natural Resources (NCDENR) sprayed ULV naled and permethrin.

The North Carolina Department of Health and Human Services, NCDENR, and CDC conducted a prospective exposure assessment of ULV spraying of pesticides. Investigators recruited 90 persons from a random sample of census blocks (that accounted for the population density) marked for spraying. Participants then completed a pre-spray questionnaire about household and occupational exposure to pesticides and provided urine samples to quantify concentrations of pesticide metabolites. On September 30, aircraft in North Carolina sprayed ULV naled at 0.7 oz/acre. In addition, trucks sprayed ULV permethrin (Biomist 30+30®) at 0.0014 lbs/acre. Eighteen hours after aerial spraying (approximately one half-life), each participant completed a post-spray questionnaire about household and occupational exposure to pesticides and provided a second urine sample. Urine samples were analyzed at CDC by using tandem mass spectrometry (*3*).

Of the 90 persons recruited to participate in this exposure assessment, 75 (83%) provided pre-spray and post-spray questionnaires and urine samples. The concentrations of all pre- and post-spray pesticide metabolites measured in participant urine samples were low (Table). Dimethylphosphate (DMP), a metabolite of organophosphate pesticides such as naled, was detected in 46% of pre-spray and 49% of post-spray urine samples (limit of detection [LOD] = 0.5 µg/L). The GM 3pba concentration from post-spray urine sampled was 0.2 µg/L. Generalized estimating equations (GEE) indicated no statistically significant differences in the urine concentrations of naled and permethrin metabolites before and after spraying. Participants who ate fresh fruits or vegetables ≤3 days before completing the pre-spray (n = 58) or post-spray (n = 37) questionnaires had significantly higher urine concentrations of dimethylthiophosphate than participants who did not pre-spray (n = 16) or post-spray (n = 37) (pre-spray: 3.2 µg/L versus 1.4 µg/L; GEE p = 0.02) (post-spray: 3.3 µg/L versus 1.2 µg/L; GEE p = 0.01). Two participants who worked on farms and/or handled pesticides had significantly higher urine concentrations of nonspecific organophosphorus pesticide metabolites (e.g., dimethyldithiophosphate, diethylthiophosphate, and diethylphosphate) than participants who did not work on farms (n = 73) or handle pesticides (n = 72).

Virginia, 2003

To control mosquitoes and prevent transmission of arboviruses after Hurricane Isabel, the Virginia Department of Health (VDH) decided to spray ULV naled and d-phenothrin. VDH and CDC assessed exposure to ULV spraying of pesticides by randomly selecting 95 residents of high population-density census blocks marked for spraying. Participants then completed pre-spray questionnaires about household and occupational exposure to pesticides and provided urine samples to quantify concentrations of pesticide metabolites.

On September 30, aircraft sprayed ULV naled at 0.5 oz/acre while trucks sprayed ULV of d-phenothrin (Anvil 10+10®) at 0.0036 lbs/acre. Eighteen hours after spraying (approximately one half-life), each participant completed a post-spray questionnaire about household and occupational exposure to pesticides and provided a second urine sample. Urine samples were analyzed at CDC by using tandem mass spectrometry (*3*).

Of the 95 persons recruited for the assessment, 83 (87%) provided pre-spray and post-spray exposure questionnaires and urine samples. The concentrations of all pesticide metabolites measured in participants' urine samples were low (Table). DMP was detected in 42% of pre-spray and 48% of post-spray urine samples (LOD = 0.5 µg/L). The geometric mean 3pba concentration from post-spray urine samples was 0.6 µg/L. GEEs indicated no overall difference in the urine concentrations of naled and d-phenothrin metabolites before and after spraying.

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Editorial Note: Although ULV applications of naled and synthetic pyrethroids have a low toxicity to humans, occupational

TABLE. Pre-spray and post-spray geometric mean concentrations (µg/L) of urine pesticide metabolites — North Carolina and Virginia, 2002 and 2003

Metabolite	North Carolina (n = 75)		Virginia (n = 83)		
	Pre-spray	Post-spray	Pre-spray	Post-spray	95th percentile
Dimethylphosphate*	†	†	†	†	13.0
Dimethylthiophosphate§	2.7	1.9	2.5	2.0	46.0
Dimethyldithiophosphate§	0.6	0.9	0.7	0.8	19.0
Diethylphosphate§	0.6	1.3	0.8	1.6	13.0
Diethylthiophosphate§	1.6	0.5	1.7	0.5	2.2
Diethyldithiophosphate§	†	†	†	†	0.9
3-Phenoxybenzoic acid¶	†	0.2	0.3	0.6	3.4
4-Fluoro-3-phenoxybenzoic acid	†	†	†	†	0.3
cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropanecarboxylic acid**	†	†	†	†	0.5
trans-3-(2,2-dichlorovinyl) 2,2-dimethylcyclopropanecarboxylic acid**	0.5	0.5	0.5	0.7	1.4
cis-3-(2,2-dibromovinyl)-2,2-dimethylcyclopropanecarboxylic acid**	†	†	†	†	0.3

* Nonspecific metabolite of naled and other organophosphate pesticides.
† Metabolite concentrations were quantitated in <50% of samples.
§ Nonspecific metabolite of organophosphate pesticides (excluding naled).
¶ Nonspecific metabolite of permethrin/d-phenothrin and other synthetic pyrethroid pesticides.
** Nonspecific metabolite of synthetic pyrethroid pesticides (excluding permethrin/d-phenothrin).

studies suggest that excessive exposure to these pesticides can cause serious health effects (*4*). Prolonged exposure to high concentrations of naled and synthetic pyrethroids can cause dermatitis, reactive airway disease, gastrointestinal distress, central nervous system depression, paralysis, and death (*5*). Exposure often results from use of these pesticides in food production, treatment of wool, wood products, and pest-control efforts; however, few studies have quantitated the level of human exposure to MC pesticides in nonoccupational settings (*6*).

The studies described in this report represent the first efforts to quantitate human exposure to MC pesticides during large-scale MC activities. Two of these studies used a prospective crossover design that compared urine metabolite concentrations after ULV spraying of pesticides with baseline concentrations. Use of sensitive analytic methods in these studies indicated that the urine pesticide metabolite concentrations measured were low (parts per billion). The concentration of urine metabolites in these studies are comparable with those measured in the general population (*6,7*). In addition, these three studies did not indicate an overall increase of pesticide metabolite concentrations in the urine of participants after spraying during MC activities. The concentrations of naled, permethrin, and d-phenothrin during emergency ULV applications might be too low to cause important human exposure.

In certain participants, investigators found an association between home and/or work application of pesticides and pesticide metabolite concentrations. The concentrations in participants who had histories of exposure were within the range of the general U.S. population (*8*). These findings are consistent with occupational studies in which prolonged exposure to pesticides through several hours of work in plant nurseries and greenhouses was associated with low but measurable concentrations of urine pesticide metabolites (*9*). These findings also are compatible with a prospective study that quantitated higher 3pba concentrations in the urine of pest-control operators 1 day after spraying pyrethroids (*10*).

The findings in this report are subject to at least three limitations. First, although naled, permethrin, and d-phenothrin remain in the environment for a short period (e.g., naled has a 1-day half-life), CDC did not conduct environmental sampling to confirm the presence of pesticide on the ground after spraying. Second, the study did not quantify the effects of synergists such as piperonyl butoxide in Anvil 10+10®, which help increase the efficacy of synthetic pyrethroids. Finally, the use of self-reported questionnaire data limits the ability to quantify actual home or occupational pesticide exposure.

Aerial spraying with ULV naled and truck-mounted spraying with permethrin/d-phenothrin were not associated with an increase in urine pesticide metabolite concentrations among residents of these rural, suburban, and urban communities. These findings suggest that ULV application of naled, permethrin, and d-phenothrin is safe to humans as part of integrated vector control. The findings are noteworthy because ULV applications of pesticides that kill adult mosquitoes are an important tool in the public health response to WNV. Future studies should address the long-term safety of low-concentration exposure to naled and synthetic pyrethroid applications. In addition, public health interventions might be needed to reduce home and workplace exposure to pesticides.

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www. cdpr. ca. gov/docs/emon/pubs/methofate.pdf

Environmental Fate of Methoprene

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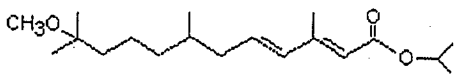
Nov 18, 2004

This document summarizes the environmental fate and the effects of methoprene, with a emphasis on its extensive use against Dipteran pests. Methoprene is an insect growth regulator that acts as a juvenile growth hormone, which interferes with the insects' life cycle and disrupts normal development of insects. Methoprene was first registered as a biological pesticide by the EPA in 1975 and later re-classified by the EPA as a biochemical pesticide.

Chemical (IUPAC) name: isopropyl (E,E)-(RS)-11-methoxy-3,7,11-trimethyldodeca-2,4-dienoate. **CAS number:** 40596-69-8. Molecular formula: $C_{19}H_{34}O_3$ and structural formula of methoprene:



General Information and Mode of Action

Methoprene is a long chain hydrocarbon ester, characterized as an amber or pale yellow liquid with a faint fruity odor (Farm Chemicals Handbook, 1997). It is classified as an insect growth regulator and selective larvicide. Methoprene is used principally against mosquitoes, but is effective against a range of insects, including the orders Diptera, Lepidoptera and Coleoptera (Glare and O'Callaghan 1999).

Common trade names of methoprene include Altosid®, Apex®, Diacon®, Dianex®, Kabat®, Minex®, Pharoid®, Precor®, and Z-515® (Glare and O'Callaghan 1999). The available forms of methoprene are solid (sustained release pellets, boluses and briquettes), liquid, and aerosol. Methoprene is commonly applied directly to water for the control of mosquitoes.

Methoprene is an insect growth regulator that interferes with the normal maturation process of insects, preventing them from completing their life cycle and reaching adulthood, thus ultimately preventing them from reproduction. Reported sublethal effects from methoprene usage include abnormal morphology and development, reduced fertility, alterations in pheromone production, and altered behavior patterns (Glare and O'Callaghan 1999). Morphogenetic abnormalities of insects are normally irreversible and it is the most readily observed effect of methoprene.

These insect growth regulators are found in high concentrations in the hemolymph of particular stages of larval insects, where their function is to maintain the larval stage or prevent metamorphosis (Glare and O'Callaghan 1999). The character and magnitude of the response differs among insects, but generally it is the last instar of larvae or nymph, or pupal stages, which are most affected by methoprene (Staal 1975).

The exact mode of methoprene's action is not completely understood. In mosquitoes, methoprene was reported to interrupt the lysis and re-absorption of old endocuticle, thus halted the synthesis and deposition of new, complex procuticle by the epidermal cells. Cocke, et al. (1979) concluded that the tissues examined were suggestive of possible changes in membrane permeability and selectivity due to disrupted mitochondria and other vesicles.

Molecular Structure

Table 1. Physiochemical Characteristics of Methoprene

Molecular weight $_b$	310.48 g/mole
Water solubility $_b$	1.4 mg/L (at 25° C)
Solubility in other solvents $_b$	Miscible in organic solvents
Boiling point $_a$	100° C at 0.05 mm Hg
Vapor pressure $_d$	$2.36x10^{-5}$ mm Hg (at 25° C)
Henry's law constant $_a$	$6.9x10^{-6}$ atm m^3/mole
Octanol-water partition coefficient $_c$	log Kow 5.50
Flash point $_a$	96 ° C (closed up)
Specific gravity $_a$	09261 g/ml (at 20° C)
K_{OC} (estimated) $_e$	23,000

$_a$ Farm Chemicals Handbook, 1997
$_b$ Kidd and James, 1991
$_c$ Hansch, et al., 1995
$_d$ Tomlin, 1997
$_e$ Toxnet, 2003

Toxicological properties of methoprene

Dapnia magna[a]	LC_{50}	900 µg/L
Mysidopsis bahia[a]	LOEC	2 µg/L
Hyallela azteca[a]	LC_{50}	1250 µg/L
Rat [b]	Acute oral LC_{50}	> 34,600 mg/kg
Dog [b]	Acute oral LC_{50}	> 5000 mg/kg
Rabbit [b]	Acute dermal LC_{50}	> 3500 mg/kg
Chicken [b]	LC_{50}	> 4640mg/kg
Bluegill sunfish [b]	LC_{50}	4.6 mg/L (96 hour)
Trout [b]	LC_{50}	4.4 mg/L (96 hour)
Channel catfish [b]	LC_{50}	> 100 mg/L (96 hour)

a – Siemering 2004. b - Glare and O'Callaghan 1999

Environmental Fate and Toxicity

Air: Methoprene has a moderate Henry's law constant and vapor pressure (Table 1). Consequently methoprene has the potential to volatilize from water or moist soil. However volatilization is mitigated by the affinity of methoprene for soils and sediment as indicated by its moderately high K_{OC} (Table 1).

Vapor phase methoprene may be degraded by reaction with photochemically produced hydroxyl radicals and ozone in the atmosphere. The half-lives for these reactions are calculated to be 1.5 hours (hydroxyl radicals) and 48 minutes (ozone) (Toxnet, 2003). The photodegradation of methoprene is expected to be very rapid due to its absorbance in the environmental spectrum (λ >290 nm) (Toxnet, 2003).

Water: When methoprene is released into water, it is expected to adsorb to suspended solids and sediments based on its estimated Koc value of 23,000 (Toxnet, 2003). Methoprene showed rapid degradation in both sterile and nonsterile pond water exposed to sunlight, more than 80% of applied methoprene was degraded within 13 days (U.S. EPA, 1982).

Briquettes, pellets, granules, and sustained-release methoprene formulations release methoprene slowly into water, resulting in low acute and chronic risk to aquatic non-target organisms such as arthropods as compared to liquid formulations (USEPA 2001 Fact Sheet). Methoprene briquettes have been reported as having relatively long half-lives in water, where mean degradation of the briquettes was 19% by weight after 150 days of submergence, with full degradation estimated after 1.5 years under water (Boxmeyer et al., 1997). The methoprene content of briquettes decreases more rapidly in air as opposed to when immersed in water.

Schooley et al. (1975a) studied the dissipation of methoprene in pond water and sewage at dose rates of 0.001 and 0.01 mg/L, respectively. Methoprene showed a half-life of approximately 30 hours at 0.001mg/L and 40 hours at 0.01 mg/L in pond water, and a 60-70 hour half-life in sewage.

Soil and Groundwater: When applied, methoprene is relatively immobile, tending to reside in the top few centimeters of the soil as expected based on its estimated Koc of 23,000. As a result methoprene is unlikely to leach. Biodegradation of methoprene has been reported to be relatively fast in a variety of soils and environmental conditions. In aerobic sandy loam, radio-labeled methoprene was reported to have a half-life of approximately 10 days after it was applied at a surface treatment rate of 1 kg/Ha. Methoprene showed rapid photodegradation on inert surfaces, such as soil, forming methoxycitronellal (Toxnet 2003).

Methoprene degradation has been shown to be much slower on autoclaved soil than untreated soil. Traces of non-polar metabolites were isolated, including the hydroxy ester,

resulting from O-demethylation (0.7% of the applied dose), and more than half of the applied dose was converted to $^{14}CO_2$ (Schooley et al., 1975b).
Radioactivity from labeled methoprene was conjugated into humic acid, fulvic acid and humin fractions of sandy loam. This data indicate that microbial degradation of methoprene is an important dissipation route in soil.

Biota

Extensive studies have shown that methoprene breaks down rapidly in the environment and displays relatively low risk to non-target organisms (USEPA 1991). Methoprene undergoes demethylation, hydrolysis and oxidative cleavage in microbes, insects and plants and is rapidly metabolized in fish, birds and mammals (Glare and O'Callaghan 1999).

Insects and Aquatic Arthropods: Methoprene has been shown to be toxic to insects closely related to mosquitoes in the order Diptera, as well as those in the orders Lepidoptera and Coleoptera. Methoprene has been studied to undergo ester hydrolysis, O-demethylation and oxidative cleavage at the C-4 double bond in insects. Acute, short-term and subchronic aquatic effect studies have been conducted on non-target adult and immature arthropods, including Crustacea, Insecta, and Mollusca. These studies reported 24 and 48 hours LC_{50} values greater than 900 ppb (Glare and O'Callaghan 1999). Other non-target organisms in early life stages (nymph, larvae) and non-target organisms that are closely related to mosquitoes such as dragonfly (order Odonata or suborder Anisoptera) are not affected by methoprene up to 1,000 ppb (Glare and O'Callaghan 1999). Methoprene are slightly toxic to aquatic macroinvertebrates such as Daphnia, Mysid and Hyallela (Siemering 2004).

Fish: Methoprene is moderately toxic to cold water and freshwater fish and practically non-toxic to warm water fish. The reported LC_{50} are 4.62 ppm for bluegill, 4.39 ppm for trout, and >100 ppm for channel catfish and largemouth bass. Evidence of methoprene bioaccumulation, was observed in the edible tissues of crayfish and bluegill sunfish (Glare and O'Callaghan 1999).

Mammals: In one study, rats and mice were exposed to methoprene in their daily diet for two years. Methoprene was orally administered to rats at doses up to 34,000 mg/kg of body weight and did not show clinical signs of acute toxicosis (Glare and O'Callaghan 1999). Nagano et al. (1977) concluded that the maximum intake of methoprene that is non-toxic to rats is 400 ppm in their food or 20 mg/kg body weight per day. In dogs studied, methoprene showed very low toxicity with acute oral LD_{50}'s ranging from 5000 to 10,000 mg/kg. A variety of studies indicate that methoprene is not an oncogen, developmental toxicant, or mutagen. Further studies indicate no detectable endocrine effects in mammals (USEPA 2001).

Plants: Studies have been conducted on the metabolic fate of methoprene in rice and alfalfa. When methoprene was applied at a rate of 1,000 g/ha on alfalfa, it showed a half-life of less than two days and less than one day on rice. It was established that methoprene was metabolized rapidly in both and yielded products that were further metabolized into natural product such as cellulose, chlorophylls and carotenoids (Glare and O'Callaghan 1999).

Conclusion

Methoprene is an insect growth regulator, which controls a variety of insect species including mosquitoes, beetles, horn flies, tobacco moths, and fleas. It is considered a biochemical pesticide, because rather than killing the target species via direct toxicity, methoprene disrupts the insects' metamorphosis and life cycle, thus hindering their ability to reach adulthood and successful reproduction. Special slow-release formulations are commonly used for mosquito control, especially breeding in floodwater sites, rice cultivations, storm drains, ponds and water treatment works.

Based on an estimated Koc value of 23,000, methoprene is expected to be immobile in soil. Methoprene has relatively low persistence in soil, with a reported soil half-life in both sand and silty loam soil of 10 days.

Both the Henry's Law constant and vapor pressure of methoprene are moderate. Consequently methoprene does have some potential to volatilize. Adsorption of methoprene in soil is expected to attenuate volatilization. It has been shown, that methoprene is also rapidly photodegraded in aqueous environments and on inert surfaces such as soil, with one principal degradate being methoxycitronellal.

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Effects of mosquitofish (*Gambusia affinis*) on California tiger salamander (*Ambystoma californiense*) larvae in permanent ponds

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Background and objectives

This research project is the continuation of our 1998 field study of the effects of mosquitofish, *Gambusia affinis*, on the larvae of the California tiger salamander, *Ambystoma californiense*. Mosquitofish have been introduced throughout much of the world for mosquito control. In California, they have been stocked in both permanent and temporary waters. Mosquitofish are known for their high reproductive rate and efficiency as mosquito predators. They are known to prey not only on mosquito larvae, but also on aquatic organisms such as crustaceans, amphibian larvae, and other invertebrates. Past research has indicated that mosquitofish may modify seasonal (vernal) pool and permanent pond communities.

A. californiense, a declining species, is endemic to the Central Valley and Coast Range of California. Factors implicated its decline include conversion of its grassland and oak-woodland vernal pool habitat to agriculture and urban development, and introduction of exotic predators. The larvae of this species require approximately 3 months to reach metamorphosis. Therefore, breeding is most often associated with longer lasting, large vernal ponds. Recent surveys of *A. californiense* occurrence indicate that they breed permanent ponds, but that larvae seldom occur in such ponds when fish, including mosquitofish, are present. Because bullfrogs and mosquitofish, along with other fish, often inhabit the same ponds, investigators have not been able to determine whether presence of mosquitofish alone suppress *A. californiense* larvae. Observational data have suggested that mosquitofish harm *A. californiense* larvae, but before our initial study in 1998, no field experiments had tested the observations. From February through June 1998, we conducted a study that tested the effects of mosquitofish on *A. californiense* in 6 experimental ponds where hydrologic conditions simulated a vernal pool setting. That study tested the effect of mosquitofish when fish were stocked at recommended initial stocking densities of 12 fish per small pond. In that study we found no detectable effects of *G. affinis* on *A. californiense*.

In locations where the salamanders rely on permanent ponds such as stock ponds for breeding, mosquitofish may occur at much higher densities than occur in seasonal pools during the *A. californiense* breeding period. Permanent ponds, in contrast with temporary ponds, allow predator populations to build from one season to the next. In such circumstances, introduced mosquitofish might reduce populations of *A. californiense* through either intraguild predation or competition for resources. Predation most likely occurs before larvae have grown too large for fish to consume. Mosquito abatement districts need to know where the use of mosquitofish may pose a threat to native species. The objective of this study was to use replicated ponds to test the effects of average overwintering densities of mosquitofish on *A. californiense* growth and survival.

Procedures

We tested the effects of *G. affinis* on *A. californiense* in 12 experimental ponds (3.05m x 6.1m x 1m) located at the San Joaquin Mosquito and Vector Control District's White Slough Mosquitofish Rearing Facility. Pond bottoms were configured to the depth of small permanent ponds (1m), and lined with plastic and soil. Each pond was surrounded by a 30 cm high drift fence of aluminum flashing that extended approximately 15 cm below the soil surface. Three shaded pitfall traps were placed within each pond enclosure along the drift fence. Ponds were filled with untreated well water in early January 2000, then were inoculated with temporary pond water containing zooplankton. Ponds were open to colonization by invertebrates and to visitation by vertebrates, such as birds and raccoons. Bullfrogs that occasionally invaded the ponds were removed. A float valve system kept the ponds full of well water for the duration of the experiment.

Ambystoma californiense larvae and eggs were difficult to locate. In early March, we collected 300 *A. californiense* larvae from Great Valley Grasslands State Park (GVGSP). On March 12th, we added 50 larvae from GVGSP (Total Length: Mean= 22.61mm, SD = 4.12) to each of six ponds, which became Block 1. We subsequently added 300 mosquitofish to each of 3 ponds in Block 1 (Added 3/12 and 15, Total Length: Mean = 32.91, SD = 7.08) and 3 ponds in Block 2 (Added 3/15-18, Mean = 32.61, SD = 7.16). To obtain additional small larvae, we later collected 300 eggs from permanent ponds in the Los Vaqueros watershed. Eggs were hatched in the lab, then hatchlings were added to the six remaining ponds (Block 2) in increments as they hatched, between March 17 and April 6. Fish were collected from the White Slough fish rearing ponds and from a pond in the Los Vaqueros watershed. The number of fish used in each pond was based on MVCD estimates of 20–50% over-winter survival and the mean final numbers of fish counted in 2 previous experiments in the same ponds. (In November 1996, Dr. Sharon Lawler's study of the effects of mosquitofish and bullfrog tadpoles found an average ending mosquitofish population of 1,011 fish per pond, while our 1998 study ended with an average of 922 fish per pond at the end of June.) To replicate natural pond conditions, algae and macrophytes were not removed, with one exception. Two unidentified ponds were cleared of algae and emergent cattails by MVCD staff on May 30, a week after the first metamorphs began to emerge from ponds. By request, remaining ponds were left undisturbed.

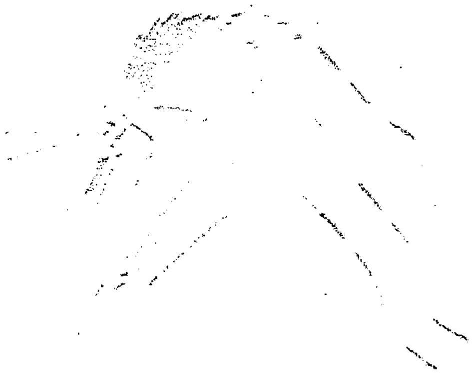
We took zooplankton samples each month from March through June, using 1 m sweeps (8 surface and 8 subsurface) with a square handnet frame (24.5 cm x 17.5 cm) fitted with a 0.35 mm mesh net. For each pond, samples were pooled in 4.2 L of spring water, then subsampled 3 times with an 8 cm x 6.7 cm silk aquarium net. Macroinvertebrates were sampled from March through September using four 1 m draws, collecting the

Mosquitofish reduced the survival of salamander larvae. Survival of salamanders was significantly higher in control ponds (mean = 43) than in fish ponds (mean = 11). The presence of mosquitofish also was associated with delayed metamorphosis. All survivors from fish ponds had tail injuries resulting in shortened tails, while no injuries were apparent in control ponds. Because of tail injuries, growth data were analyzed using only snout-vent lengths and weight. Survivors from control ponds weighed significantly more and were significantly larger than those from fish ponds. The snout-vent lengths and weights of metamorphs from control ponds increased throughout the season, while those from fish ponds remained constant.

The time span of metamorphosis for all ponds varied from our expectations. Salamander larvae began to metamorphose from control ponds beginning on May 24 (Block 1) and June 28 (Block 2). We collected the first metamorph from a fish pond on June 11 (Block 1). Metamorphs continued to exit the ponds in small increments throughout the summer and fall. When the ponds

Public Health Confronts the Mosquito:

Developing Sustainable State and Local Mosquito Control Programs



Interim Recommendations
of the National Mosquito Control Collaborative

ASTHO
Association of State and
Territorial Health Officials

PUBLIC HEALTH CONFRONTS THE MOSQUITO:

DEVELOPING SUSTAINABLE STATE AND LOCAL MOSQUITO CONTROL PROGRAMS

INTERIM RECOMMENDATIONS OF THE MOSQUITO CONTROL COLLABORATIVE

A PROJECT OF THE
ASSOCIATION OF STATE AND TERRITORIAL HEALTH OFFICIALS

In partnership with
The National Association of County and City Health Officials

Supported by the
U.S. Centers for Disease Control and Prevention

July 2004

If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org.
You can submit comments electronically, by fax or by mail.

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Joseph Sanzone, Metropolitan Mosquito Control District, St. Paul, Minnesota

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ASTHO is the national non-profit organization representing state and territorial public health agencies of the United States, the U.S. Territories, and the District of Columbia. ASTHO's members, the chief health officials of these jurisdictions, are dedicated to formulating and influencing sound public health policy and to assuring excellence in state-based public health practice.

National Association of County and City Health Officials (NACCHO)
NACCHO is the national organization representing local public health agencies. NACCHO supports efforts that protect and improve the health of all people and all communities by promoting national policy, developing resources and programs, seeking health equity, and supporting effective local public health practice and systems.

TABLE OF CONTENTS

Executive Summary and Major Recommendations

Mosquito control is an important and basic public health function. The rapid spread of West Nile virus across the U.S. in the last five years speaks to the continuing need for organized mosquito control activities. States and local communities are challenged to develop and maintain these essential vector control programs, especially in tight budgetary times and when emergency situations have quieted.

The Mosquito Control Collaborative

In response to needs voiced by the mosquito control community, the Centers for Disease Control and Prevention, National Center for Infectious Disease, Division of Vector-Borne Infectious Disease sponsored ASTHO to develop a set of recommendations for creating sustainable state and local mosquito control programs. Because mosquito control involves many players, ASTHO convened the Mosquito Control Collaborative (MCC or the Collaborative), a body comprised of state, local, and federal representatives from public health, environmental, and agricultural agencies, as well as other organizations intimately involved with vector control and public health. Because mosquito control efforts begin at the community level, ASTHO invited the National Association of County and City Health Officials (NACCHO) to join the project as a partner.

The following document consists of the interim recommendations developed by the MCC from February through June 2004. The purpose of this document is to serve as a catalyst for discussion. As state and local agencies learn more about effective mosquito control practices during the 2004 mosquito season, the interim recommendations, by necessity, will evolve. ASTHO is broadly soliciting feedback on the interim recommendations on behalf of the Collaborative from June through September 2004. After reviewing the comments, the Collaborative will develop final recommendations in winter 2005.

Summary of Recommendations

The Collaborative identified four major components of successful mosquito control efforts. Each section includes a series of planning and action checklists to aid states and localities in their planning activities.

Plan Ahead

Developing an effective mosquito control program takes time and preparation. Timely action, collaboration with other jurisdictions, and development of a plan to manage the challenges of mosquito control are over-arching requirements that impact all other recommendations and findings. Governments should not wait for a crisis to prepare. The Mosquito Control Collaborative has identified numerous strategies for effective planning and ordering of activities. Understanding the structures and roles of the state, local and federal participants, defining workforce and training requirements, identifying legal authorities and funding alternatives, and developing strategies for evaluating programs are elements that should be included in any successful planning effort.

The structure chosen to implement mosquito control activities is critical to their success. States, localities, and the federal government all have active roles in mosquito control. The exact roles of each will differ among the individual states and localities. Whatever structure is chosen, it should be based on solid legal authority to act. The structure of the funding mechanism for mosquito control activities also impacts the ultimate sustainability of the program or activities.

Each government unit must also assess the capacity of its workforce to accomplish its mosquito control goals, including identifying tasks it has the ability to accomplish in-house and those that may need to be obtained from the private sector. Regardless of how mosquito control is accomplished, governments must also consider the impact of the intended control strategy on the public's health and the environment. Finally, a thorough evaluation of mosquito control activities is imperative to establish credibility with those directly impacted by control activities, supporters and funders, and to learn from past mistakes.

Involve Others

The foundation to any successful mosquito control action is involving key participants early in the process. Governments should develop a strategy for involving others, which includes identifying and engaging a wide variety of stakeholders. Because mosquito control issues can be contentious, successful programs look to identify all points of view early, present relevant scientific information in a transparent format, and work to a negotiated agreement, where necessary.

Governments should take care to identify the individuals, organizations, and agencies with a stake in mosquito control decisions. A variety of mechanisms should be used to target appropriate outreach to stakeholders. Special care should also be given to provide decision makers solid information upon which to base policy.

USE THE BEST SCIENCE AND DATA

It is critical that science drives the assessment of local and state needs, strategies selected, and design and monitoring of mosquito control programs. There are numerous proven methodologies and practices that guide the best mosquito control programs. All programs need to be based on an identified need that is matched with local and state resources and technically sound strategies.

A quality mosquito control program has at its foundation a solid understanding of the timing and distribution of human and animal disease cases of mosquito-borne diseases. Access to epidemiologic capacity to conduct surveillance of mosquito-borne diseases in the human population, and monitor disease and the distribution of relevant animal and insect populations, is critical to begin any mosquito control activity. States and localities must also determine their mosquito control needs. A scientific response to combat a nuisance mosquito may look very different from a program to combat mosquitoes carrying disease.

Control strategies can focus on preventing the emergence of adult mosquitoes (larviciding), addressing mature insects (adulticiding), and other prevention measures such as breeding pool reduction and bite prevention. The mix of strategies used by each state and local community will vary based on their individual political, legal, environmental, geographic, and funding concerns. The Collaborative outlines the following three program levels for mosquito control activities based on available resources:

- *Level I Minimal Program* – Describes the activities a community can take with no resources to support a mosquito control program.
- *Level II Intermediate Program* – Identifies activities communities with little to moderate resources can undertake even if they cannot mount a comprehensive program.
- *Level III Comprehensive Program* – Details the activities, by season, that a community with moderate to full resources can accomplish.

INFORM THE PUBLIC

Mosquito control programs need the support of an informed public. Many of the successful strategies for control involve individuals, their families and their neighborhoods. The public also has concerns about the problems related to mosquito populations and about insecticides and spraying. Development of a communications plan that includes public education about preventing the breeding of mosquitoes, personal protection guidance, and the activities and success of the agencies involved is critical to the success of the program.

INTRODUCTION AND BACKGROUND

THE MOSQUITO CONTROL COLLABORATIVE

In early 2004, the Association of State and Territorial Health Officials (ASTHO) assembled the Mosquito Control Collaborative (MCC or the Collaborative). The purpose of the Collaborative is to develop a set of recommendations to address state and local needs in establishing, maintaining, and funding mosquito control programs. The Collaborative is comprised of representatives of state, local, and federal public health, environmental, and agricultural agencies as well as other organizations intimately involved with mosquito control and public health. Because mosquito control efforts begin at the community level, ASTHO involved the National Association of County and City Health Officials (NACCHO) as a partner early in the project. Funding for this project was provided by the Centers for Disease Control and Prevention's (CDC) Division of Vector-Borne Infectious Disease.

Discussions at the 2003 West Nile Virus conference in New Orleans prompted the formation of the MCC. At that meeting, public health organizations and agencies discussed the problem of the deteriorating infrastructure for preventing mosquito-borne disease in the United States. Mosquito control is an important and basic public health function that must be recognized and supported. One solution identified was to develop recommendations to help states and localities in their mosquito control activities.

Further motivation for forming the MCC came from the Mosquito Abatement for Safety and Health (MASH) Act (Public Law 108-75). The Act authorizes grants to states for coordinating mosquito control programs and assisting local governments with assessment and planning activities. Grants are also authorized to localities for mosquito prevention and control activities. As of June 1, 2004, Congress had not appropriated any funds to cover the cost of the MASH Act. The MCC's recommendations will serve as a resource to states and localities should funds for MASH Act implementation ultimately become available.

While the 2004 mosquito season has already begun in many jurisdictions, it is important to realize that the work of the Collaborative will aid vector control efforts well beyond this year. The dialogue and recommendations identified through the Collaborative provide guidance into the future for local and state jurisdictions as they address mosquito borne illnesses.

PUBLIC HEALTH CONFRONTS THE MOSQUITO: INTERIM RECOMMENDATIONS

The following document consists of the interim recommendations developed by the MCC from February through June 2004. The purpose of the document is to serve as a catalyst for discussion. As state and local agencies learn more about effective mosquito control practices during the 2004 mosquito control season, the interim recommendations, by necessity, will evolve. To this end, ASTHO is soliciting feedback on the interim recommendations from June 2004 through September 2004 from individuals and organizations interested in mosquito control. After reviewing the comments, the Collaborative will develop final recommendations in winter 2005.

Because mosquito control is a multi-faceted issue, by design some sections of the interim recommendations contain information that overlaps with other sections in the document. After each section there is a "Planning and Action Checklist" that highlights the major decision points and recommendations from that section. Finally, the interim recommendation document, while comprehensive, does not capture every available resource on the issue of mosquito control.

A list of resources is included at the end of the document. During summer 2004, ASTHO will continue to gather and post relevant resources on the web version of this document.

If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org. You can submit comments electronically, by fax or by mail.

History of Mosquito Control and the Threats to Public Health

Mosquito-transmitted diseases have existed in the Americas since long before European settlement. Eastern (EEE), and Western (WEE) equine and St. Louis (SLE) encephalitis viruses are examples of such long-term threats (Scott TW & SC Weaver, *Adv. Virus Res.* 37:2377-328;1989). With the coming of the Europeans to the New World, additional diseases, such as malaria, dengue and yellow fever were added to the mix of vector-borne diseases. Most people today are unaware that malaria extended throughout the United States and into southern Canada in the 1800s (Ackerknecht EH. *Bull. Hist. Med.* Suppl. No.4:1-142;1945). Before the widespread use of motor vehicles, EEE and WEE viruses caused major epidemics in the horse population that resulted in substantial economic losses.

In recent years, with increasing intercontinental movement of goods, people and animals, a variety of new and exotic disease problems have been encountered. These emerging infectious diseases include Severe Acute Respiratory Syndrome (SARS), Ebola virus (Reston strain) and West Nile virus (WNV). These diseases are zoonoses, or diseases of animals that can be transmitted to humans. Many zoonoses, such as WNV, are transmitted by vectors, such as mosquitoes or ticks. WNV has spread from coast to coast in only five years. Given the increasing globalization of travel and commerce, it is likely that other exotic agents will be transported and established in the United States or in other areas of the Americas.

The first organized mosquito control programs were established in the early 1900s. One of the earliest programs began controlling nuisance mosquitoes around the San Francisco Bay area in 1903. By 1997, a national survey found 345 mosquito control districts or programs in the United States (*Directory of Mosquito Control Agencies in the United States*, American Mosquito Control Association, 1999). These programs served a population of over 97 million, at an estimated cost of $231.7 million (slightly more than $2.00 per person per year).

The cost of vector-borne disease prevention is normally less than the cost of control after an epidemic begins. Not only is emergency control more expensive, but there is also the added cost to treat disease cases that might otherwise have been prevented. The average cost per patient hospitalized with WNV infection in Louisiana in 2002 was $51,826 (A. Zohrabian, unpublished report, www.cdc.gov/ncidod/dvbid/westnile/conf/February_2003.htm). The cost of WNV to the U.S. equine industry may be in the billions of dollars. These numbers fail to address the additional emotional cost to families of victims of mosquito-transmitted disease, changed quality of life of the victims and similar issues.

In addition to the impact on human and veterinary health, arboviruses frequently have a major impact on wildlife, including threatened and endangered species. In 2002 alone, it was estimated that more than 2 million birds, including endangered species, died from WNV infection (CDC, unpublished data). In 1984, 7 of 39 captive whooping cranes, an endangered species, died from EEE infection in Patuxent, Maryland (Dein FJ, et. al. *J. Am. Vet. Med. Assoc.* 189:1006-1010;1986).

PLAN AHEAD

Developing an effective mosquito control program takes time and preparation. Timely action, collaboration with other jurisdictions, and development of a plan to manage the challenges of mosquito control are over-arching requirements that impact all other recommendations and findings. Governments should not wait for a crisis to prepare.

The Mosquito Control Collaborative has identified numerous strategies for effective planning and ordering of activities. Understanding the structures and roles of the state, local and federal participants, defining workforce and training requirements, identifying legal authorities and funding alternatives, and developing strategies for evaluating programs all should be included in successful planning efforts.

STRUCTURES AND ROLES

The structure chosen to design, implement, and evaluate a mosquito control program is critical to the success of the program. Organizationally, a challenge will be to assure that the programs will protect the public's health; that policies developed to give direction to the programs are appropriate; and that there will be a proper assessment of actions taken.

The options available for structuring a mosquito control program are diverse. Control programs in the United States may include independent mosquito control districts; county/city/parish health departments; decentralized and non-specialized agencies, such as public works; or private companies, such as mosquito control contractors and pest control operators. The best choice for a particular entity depends on many variables that are ideally identified at the beginning of the selection process. Funding of mosquito control is usually dictated by local conditions and may relate to the program structure chosen. Some of the options are: dedicated mill levy, usually through a voter-approved special taxing district; fixed charges added to each household water meter account; local sales tax; or the general revenue fund.

Local, state, and federal agencies all have important roles and inter-relationships. Because mosquito control is often primarily a local responsibility, citizens will look to local government as their first contact. State and federal governments are also recognized as playing an important role by providing additional resources and technical assistance to local leaders. The state has a responsibility for overall planning, guidance, and leadership, especially during public health emergency situations. However, the role of the state in mosquito control varies from state to state, with some states providing direct mosquito control services for local communities. While acknowledging the many variations among states and localities, traditional divisions of responsibility can be generalized.

Federal Roles

The federal government oversees issues of national concern. Congress, the Executive Branch, the federal legal system, and federal agencies create indicators and standards, and disburse funds to the states and local governments to be used to respond to the problem. Federal agencies such as the Centers for Disease Control and Prevention (CDC) are available to provide technical assistance to state and local governments. Additionally, the resources of federal agencies, including CDC and the Federal Emergency Management Agency (FEMA) may be available in the event of a disaster declaration. The requirements for accessing emergency resources are stringent, and thorough record keeping is mandatory. Also, the U.S. Department of Agriculture (USDA) is concerned with mosquitoes because they are livestock pests and transmit livestock diseases. Some of these diseases, like certain encephalitis viruses and West Nile virus, are zoonoses that also affect humans.

Specific federal roles as they relate to mosquito control include:

- Allocation of available resources to state and local governments
- Creation of standards and indicators
- Scientific analysis of trends in the mosquito population
- Weather forecasting
- Development of public information strategies and campaigns
- Maintenance of web sites on mosquito control and mosquito-borne illnesses
- Technical assistance to state and local jurisdictions

CDC has forged partnerships with other federal agencies and national organizations concerned with mosquito control and mosquito borne-illness. Annual conferences on emerging infectious diseases and West Nile virus have provided opportunities for dissemination of scientific information and training of state and local officials and other interested parties. Furthermore, community awareness of mosquito control issues has been enhanced by the development of national public information campaign materials and the maintenance of web sites and list serves to provide timely, credible information to state and local governments and the public.

State Roles

The implementation of mosquito control strategies differs considerably among states. States often assume mosquito and mosquito-borne disease control responsibilities during and after emergencies when local resources are compromised or overwhelmed. Additionally, because of organizational or geographic considerations, some states also provide direct mosquito control services to communities.

Generally, the state oversees issues of state-wide concern and provides support services to local governments. The states are a strategic resource (political, technical, and legal) to local governments just as the federal government is a strategic resource to the states. Interstate and international relationships and agreements may be needed to deal with border areas. State agencies work with the media to assure that consistent messages are communicated statewide to physicians, veterinarians, and the public, and provide educational materials to the clinical community and the general public. State public health laboratories also play an important role in mosquito-borne disease control efforts.

Mosquito control policy continues to evolve as new issues emerge. A compilation of state-specific mosquito control statutes by the National Conference of State Legislatures illustrates the many different approaches to mosquito control policy and implementation of programs. Many states delegate responsibilities for mosquito control and mosquito-borne illness to one or more state agencies while others have established mosquito control districts.

Often the lead state agency is charged with developing a statewide planning process to address new and emerging mosquito control issues. Some states have already developed statewide plans for mosquito control. Representation from key stakeholders is important to the success of a planning process.

State roles include:

- Development, collection, and analysis of state-specific data on mosquito-borne illness
- Development of state level policy recommendations
- Implementation of laws and regulations regarding mosquito control, disease surveillance, and reporting
- Coordination with federal agencies and neighboring states
- Development of state plans to address mosquito control
- Allocation of available resources to assist with local programs for mosquito control
- Maintenance of state information hotlines and web sites
- Development of statewide public information campaigns
- Technical assistance to local jurisdictions
- Evaluation of statewide efforts to combat mosquito-borne illness
- Public health laboratory services

Local Roles

Local governments implement mosquito control programs by creating tactical responses to emergency or ongoing threats to urban and rural citizenry. Support for this effort (financially, scientifically, legally, legislatively) may or may not come from the state. In order to garner public support for an integrated mosquito control program, all levels of government are expected to work together. Some of the challenges in mosquito control can come from disagreements on how to handle federal land, state land, and local parks and natural areas. Strategies to shape action should be developed well in advance of a response action being taken. It should not be expected that any single agency can effectively respond alone to an environmental public health emergency of the magnitude of mosquito-borne illness.

Local level roles include:

- Designation of lead agency and authority within jurisdiction
- Development of mosquito control program within available resources
- Coordination among local agencies including public health, medical and veterinary communities
- Coordination with neighboring jurisdictions
- Surveillance, monitoring and reporting of virus activity and mosquito-borne illness
- Coordination with state lead agency
- Education of local officials
- Development of public information campaigns to educate public (especially high-risk groups)
- Evaluation of mosquito control efforts

Special Districts

Special mosquito control districts that carry governmental authority will also have license to make decisions that impact constituents living within district boundaries. Boundaries between districts and local governments may overlap. Intergovernmental agreements can be used frequently to assign responsibility, accountability, and to add clarity to programs that occur within multiple jurisdictions. To maximize economies of scale, multiple local communities can participate in cooperative agreements.

Mosquito control districts can be the option of choice to handle mosquito-borne public health threats over multiple seasons. Many states have enabling statutes that allow districts to be established by voter approval. These districts establish an infrastructure for monitoring and control actions, as well as provide a mechanism for funding. They can be one town, multi-county, or even state-wide. Mosquito control districts institutionalize mosquito control locally.

THE ENVIRONMENT

Mosquito control activities, by their very nature, have an effect on the environment. The ecosystem consists of a web of inter-relationships among organisms. Every practical effort must be made to reduce the negative consequences of mosquito control on the environment.

One way to do this is to use scientifically collected information to narrow the target of mosquito control. Not all mosquitoes are harmful and some are considered beneficial. Targeting is done by identifying and controlling only the mosquitoes that are nuisance and disease vectors. But even if control actions could be limited to a single species in a specific location, it should be realized that one cannot totally eliminate the environmental impact on other species in the system. There are, however, options that have differing degrees of effects on the environment. The goal is to choose the control tactic for the situation that has the least negative environmental impact.

It is prudent to use the less targeted controls, such as adulticide spraying, only when more targeted controls, such as source reduction and larviciding have failed to adequately reduce populations. Narrow spectrum larvicides (e.g., biological toxins, insect growth regulators) are to be preferred over broad spectrum larvicides. The overarching caution is to keep negative impacts on non-target species to the absolute minimum.

Whether the effect of an action is negative or positive is often a matter of values and opinion, and also often difficult to evaluate. For example, eliminating infected mosquitoes could help a bird population by preventing disease, but also could eliminate a food source upon which other animals feed. Nevertheless, it is important to evaluate environmental impacts of a mosquito control program.

To the level possible and practical, these programs should include an environmental review to assess the potential environ-mental impacts of the various control methods planned. Only with good information about the benefits and consequences can policy makers and the public make appropriate choices about the kind of mosquito control program they want in their community. A decision matrix can help everyone understand the issues and decision points. [See Appendix A]

Plan Ahead–Planning and Action Checklist

- ☐ Determine if the state has legal authority for mosquito control planning and action at the state level. Are current statutes and lawful authority adequate to support decisions that must be made? Which agency will have the authority at the state level? If not identified in statute, the Governor may designate a lead agency for mosquito control, or legislation may need to be enacted to designate the lead agency and their responsibilities.
- ☐ Determine if the locality has necessary legal authorities to conduct mosquito control activities. Which agency will have the authority at the local level?
- ☐ Consider how best to structure mosquito control activities and programs. Are special districts a good answer for the community?
- ☐ Identify a collaborative format for elected officials and their appointees to address the problem.
- ☐ Determine a method among governments to assign mosquito control responsibility based on the level of expertise and capacity of the agencies involved.
- ☐ Clearly identify and understand the roles and responsibilities of the lead state and local agencies.
- ☐ Determine how will funding be structured and where will the money come from.
- ☐ Identify how existing environmental public health programs will be maintained if resources are overwhelmed by the emerging threat, such as West Nile virus. Identify a plan to keep other important programs functioning and at what level.
- ☐ Evaluate agency capability to fit into a response system that can "grow" as the event becomes larger and "shrink" as it decreases. Determine how to create such a system and how it will be activated.
- ☐ Determine how federal, state and local parks and natural areas be will handled. Establish or activate agreements to facilitate negotiations and action.
- ☐ Assign a designated spokesperson with responsibility to interact among governmental agencies and with the public and media.

Local and state health agencies may have entomologists and environmental specialists who can help mosquito control programs evaluate environmental impacts. Some agencies also have environmental epidemiologists, toxicologists, and other professionals who evaluate health risks. Close dialogue between these agencies and mosquito control programs during planning will pay off many times over when the program is implemented and people react to control activities in their community. If a local government has a mosquito control consultant, she or he may be able to advise the agency about how to find resources for an environmental review.

Another area of potential concern is mosquito control in wetlands. Special care must be given to wetlands and sensitive natural areas. Wetlands, streams, and even man-made drainage systems can provide habitat for a vast array of wildlife, including amphibians, mammals, birds, and insects. Wetlands also help control flooding, improve water quality, and provide recreational opportunities. Draining healthy wetlands is a controversial and usually inappropriate response, while controlling breeding sites like sewer catch basins, puddles, containers, and poorly managed wet areas has broad support.

High levels of mosquito production frequently occur in wetlands that are used to treat domestic sewage (often referred to as man-made or constructed wetlands). While aquatic plants added to oxidation ponds improve wastewater treatment, they also lead to increased mosquito populations. Different physical designs and operating strategies of aquatic plant-based wastewater treatment systems can increase or decrease mosquito problems. Therefore, engineering considerations are important in the design of aquatic plant systems used for the treatment of wastewater. Careful design before construction and monitoring after construction can keep mosquito breeding within acceptable levels. Early input by mosquito-control professionals can keep man-made or constructed wetlands from becoming a public health risk.

Keeping the public and environmental interest groups informed about relative risks is also critical. It is important to include the public and environmental interest groups in formative meetings leading up to implementation of a mosquito control program.

Another important consideration is that there is a major difference in what can and should be done for routine, integrated mosquito control actions, and what is done during a major public health emergency. The concepts of relative risk and human values are obviously different in these different circumstances.

In the final estimation, fundamental to our democratic society is the ability of individuals and communities to have input in and ultimately determine the actions of their government. Americans place a high value on a healthy environment. How virus-infected mosquitoes are controlled in a community is a public decision to be based on many factors of science, emotion, the level and quality of information, economics, legalities, technology, politics, and importantly, human values.

ENVIRONMENT—PLANNING AND ACTION CHECKLIST

- ☐ Identify the environmental interest groups in the community.
- ☐ Involve the appropriate professionals and environmental interest groups early on in the process.
- ☐ Determine the community's levels of confidence in: a) its local government, and b) the available scientific information regarding risks to the public and the environment.
- ☐ Perform an environmental review of potential impacts prior to program implementation.
- ☐ Identify the scientific resources available to the community's program to evaluate risks and benefits of mosquito control actions.
- ☐ Set up a program to collect and identify mosquitoes by species and numbers to enable targeted control efforts.
- ☐ Analyze how to control mosquitoes in a way that protects the environment while still reducing the risk of disease-carrying and nuisance mosquitoes for the public.
- ☐ Make the results of the environmental review available to a broad public audience.
- ☐ Chose a knowledgeable and articulate spokesperson to carry environmental risk information to politicians and the public.

LEGAL CONSIDERATIONS

Communities and states must have a solid legal foundation for their mosquito control activities. An analysis of existing state and local laws, regulations, inter-jurisdictional agreements, and other legal mechanisms should be an activity of every control program. Many states and local governments are already well prepared with the necessary legal infrastructure. Examples of laws from these state and local governments, and template laws, provide an excellent start for those less prepared. Moreover, West Nile virus concerns may provide another opportunity to revise and update those authorities.

In many states, specific statutory provisions and protections outline the legal parameters for a mosquito control program. Some states provide general statutory guidance through general health statutes and rules and general liability limitations. Depending on the existing laws in a given state, the public health threat level, and the existing political circumstances, it may be prudent to develop and introduce specific legislation dealing with the legalities of mosquito control. Government agency managers need to work closely with elected officials and the public to respond to any outbreak of mosquito-borne disease. These discussions should occur in advance of an outbreak.

There are hundreds of mosquito control programs throughout the country, each one with a different set of enabling authorities under which it operates.

However, there are commonalities that exist in the authorities that are required to manage a successful program. These are: (1) legal authority to exist and operate as a public entity; (2) general or specific definition of function; (3) enforcement authority; and (4) funding authority (discussed in the following section "Funding Alternatives").

Establish Clear Legal Authority

The legal authority for a local mosquito control effort can be derived from state, county, and municipal laws. It can be general, such as general health or safety powers, or it can be specific, such as a mosquito control district. Below are examples of legal authority options that may give governmental leaders ideas for initiating or upgrading authority for their programs. The options are listed as a spectrum from basic to complex.

- **General Public Welfare and Safety.** Counties and municipalities have under their articles of incorporation a duty to maintain public safety. These are broad powers that can be used to authorize mosquito abatement. Lack of specificity usually means that a mosquito control program so authorized may have to continually justify its existence, procedures, and funding.

- **Local Public Health Authority.** This usually is characterized by a local board of health and a local health agency. Their enabling authority often has more specific language to protect the public from epidemics and nuisances. Environmental health programs historically include vector control to prevent encephalitis, even if mosquito control activities are not currently funded. Recent outbreaks of West Nile virus have caused many local public health agencies to build control programs on these authorities.

- **Statutory Enabling Authority.** State legislatures can provide enabling legislation to allow a county or municipality to operate a mosquito control program. Usually, there are funding opportunities provided by the statute.

- **Statutory Enabling Authority to Establish Mosquito Control Districts.** This option is a preferred way of institutionalizing a mosquito control effort because it is specific, sustaining, and provides a proven funding mechanism.

- **Statutory Statewide Mosquito Control Program with Options for Participation by County and Municipal Governments.** This type of program is found where there is a major problem with pest mosquitoes. Complex regulations are promulgated by a commission, which prescribes parameters for control activities for counties and municipalities. Local governments can form districts and programs at their option.

Define the Lead Agency and Its Functions

Issues related to legal authority for mosquito control actions include defining in law who is responsible for those actions and efforts. An important question is, "What agency should have (or gain) authority for a mosquito control program in a given area?" Usually, control activities are the job of local government. Authority at the state level can empower local agencies and authorize their control activities. If there is an existing agency that is already involved, such as local public health or public works agency, its role could be expanded more economically than starting a new agency. State agencies may operate services in rural areas where local communities lack resources or initiative to develop a program.

The more sophisticated local government response is to establish a mosquito control commission and district. The district and its governing body become the focus of legal, as well as technical, public, media, and funding issues. Establishing a mosquito control district creates a funding mechanism for abatement actions through the ability to assess a tax. A district also defines responsibility. Where pest mosquitoes are an obvious community problem generally, mosquito control districts or even state mosquito control agencies are created.

In the absence of a district, local municipalities and county governments are responsible by default. In the case of recent West Nile virus activity, many political leaders were in that position for the first time with little expertise, funding, and legally prescribed guidance. A city or county with no mosquito control district may have a local health agency. Many cities and counties have funded and authorized local health agencies to control mosquitoes. Others have contracted the work to private mosquito control companies. The benefits of privatization include quick response in an emergency, workforce benefits due to the seasonal nature of the work, and, importantly, shifting liability to the private sector.

Enforcement Authority

All states and counties have provisions in law dealing with public nuisances. Most have provisions to declare a property a public health nuisance or hazard and require mitigation by the owner. In the case of significant mosquito breeding harborages, such as tire piles, control authority is best when it is specific. Authority should include the ability to order mitigation, to levy fines if the owner is non-compliant, and to allow access for surveillance and control activities.

Environmental Permits and Regulations

Permits are required to apply pesticides, including for mosquito control purposes. The Federal Insecticide, Fungicide and Rodenticide Act of 1947 (FIFRA) requires detailed record keeping of pesticide uses and conditions. The U.S. Environmental Protection Agency and state departments of environment or agriculture have jurisdiction over pesticide use and require applicators to be trained and licensed. Additionally, state and federal water and wetland protection laws may require additional permits. Emergency public health orders and declarations may reduce the need to obtain some of the permits and approvals. Each state is different in the permits they require and the exemptions for emergencies that are provided. Ongoing control programs are usually not exempted from permitting requirements. Most state wildlife agencies have provisions for the sampling and killing of wildlife for public health surveillance.

Anticipate and Define Liabilities

There are significant legal issues associated with the application of pesticides. In addition to governmental agencies charged with environmental protection, there are individuals and organizations that may strongly oppose pesticide use. Legal action and lawsuits can come from these groups, as well as from disease victims and their families who believe that government did not act fast enough or do enough mosquito control.

Liabilities include impacts on the environment, such as effects on beneficial insects and animals, water supplies, plants, and also inanimate objects such as car finishes. Ways to limit liabilities include assuring proper and specific legal authority, following legal and labeling guidance, using state-of-the-art integrated pest management techniques, carefully managing practices and employees, promulgating liability limiting legislation, and contracting control actions to reputable companies. When contracting for services, it is important to clearly define liabilities and indemnification in the contract. Personal liabilities are involved not only with pesticide exposure to the public, but also with exposure of the applicators themselves.

Consequence Management

The development and operation of a mosquito control program requires careful consideration of all the consequences—including the negative ones—of its component activities. Some involve immediate reactions with legal liabilities; others may be subtle, long-term effects. In general, operation of a mosquito control program will require regular consultation with the appropriate legal counsel and risk management officer for the agency. Many of these consequences can be managed through relevant inclusions in state and local laws and through precautionary procedures. Listed below are potential consequences to be aware of when initiating or managing a mosquito control effort. Clearly, this list is not inclusive, as there are myriad circumstances and environments, and every community is different.

- **Pesticide use.** Pesticide use involves permitting and legal responsibilities. There are very specific parameters prescribing their safe and legal usage. Compliance with state and federal clean water laws and acquiring the appropriate permits are critical. Certain people and groups have special issues related to pesticide use, such as chemically hypersensitive individuals, aquaculturalists, organic farmers, and bee keepers. Consequences of pesticide use include adverse regulatory action, personal lawsuits alleging injury, damage to the environment (both acute toxicity and longer term effects), damage to insects considered beneficial, and damage to inanimate objects such as automobile paint.

- **Biological controls.** There could be a possible negative reaction due to perceived adverse and unknown effects of biological agents on the environment. Mosquito-larvae-eating fish (*Gambusia*) and other biological controls may be considered exotic species and regulated or prohibited by a state wildlife agency. The lead mosquito control agency should regularly consult with the state wildlife agency if using biological controls.

- **Property rights.** A mosquito harborage may exist on private or preserved land. Even with clear legal authorities, these situations may require negotiations at high levels for resolution. Right-of-entry lawsuits may be minimized by including access provisions for mosquito purposes in public health laws.

- **Funding and ballot initiatives.** The political consequences of raising any kind of taxes for mosquito control could be significant. Governments must consider how the public will react and what other social programs will be impacted.

- **Liability for contractor negligence.** Contractors can make high-impact mistakes that bring with them the potential for liability to the government agency. Contracts should be written that protect public agencies from lawsuits. [See Appendix B: Bid and Contract Specifications]

- **Employees at risk.** The physical safety of employees working with potentially dangerous pesticides and other hazards is an important concern. Federal and state laws require adequate supervision and thorough training in pesticide handling for employees.

- **Personal privacy.** Medical and personal information is necessary for epidemiological investigation. This information is confidential and sensitive, and should be treated as such, with procedures developed for its protection.

- **Public education and risk communication.** Public education about risks and precautions can be seen by some as a threat to tourism economies. Meeting with tourism groups, business leaders, and local politicians assures that they understand the importance of public education to reduce illness and unnecessary deaths. Also, spokespersons should be sensitive to business interests as they craft the message they send to the public.

- **Personal responsibility.** People may reduce their efforts to protect themselves from mosquitoes if they believe that government is controlling the disease. Information campaigns must stress the continued importance of personal protection activities to prevent mosquito bites, as part of the overall community mosquito control activities.

LEGAL CONSIDERATIONS — PLANNING AND ACTION CHECKLIST

- ☐ Review existing legal authorities and determine if they are specific enough to enable an adequate mosquito control program. Are current emergency powers authorities sufficient to use in an outbreak? Are specific state statutes and/or local ordinances needed to establish ongoing mosquito control activities?
- ☐ Determine if current laws, ordinances, and regulations provide sufficient enforcement authority to perform mosquito control activities.
- ☐ Regularly consult with legal counsel for issues of potential liabilities. Do the general public health and safety provisions adequately prevent liabilities?
- ☐ Inventory the pesticides and other control methods used in mosquito control activities. Determine the applicable regulations and permits covering the control activities.
- ☐ Contact all regulatory and land use authorities prior to any control activities.
- ☐ Carefully review all elements of the mosquito control activities to determine the possible consequences of each element. Develop a strategy to minimize and address these consequences.

- **No action.** There are significant consequences to doing nothing or having an inadequate response to West Nile or other mosquito-borne disease threats. Individuals who became ill and their families have sued agencies for lack of adequate response. Program directors and elected officials have been held responsible in the past by the public for failing to take action. Governments must be prepared to manage the consequences if they choose not to have an active mosquito control response.

Funding Alternatives

Financial options follow the organizational and legal decisions. Communities and states have choices regarding how to fund mosquito control programs. Alternatives can range from dedicated mill levies and surcharges on utility bills to general tax revenue and special assessments of properties. Each community must decide the level of funding that they are willing to devote to mosquito control and the best ways to raise or commit those resources.

One of the most difficult tasks in initiating and maintaining a mosquito control program is identifying and acquiring sustainable funding for the program. Mosquito control programs usually have more than one funding source. The benefits of diversified funding are obvious and include flexibility, stability, and the ability to add cumulative resources in times of an epidemic. Options for funding mosquito control activities include:

- **County and Municipal General Fund.** These funds can be one-time or sustaining. They usually go to a local office or agency (such as a local health department), but can go directly to a contractor for mosquito control services. A mosquito control program can seek support from multiple counties and municipalities to reach an economy of scale adequate to support a reasonable program.
- **Mill Levy.** This is a property tax, generally collected through a special tax district (mosquito control district or other district), that usually requires voter approval. Mosquito control districts may have borders independent of existing political boundaries. Resources collected by local governments are published and can be monitored by control program support groups.
- **Benefit Assessments.** Some states and regions use benefit assessments for property owners based on particular benefits to that property. These may be levied by a mosquito control district or other entity.
- **Utility Bill Surcharge.** Added to consumer billing, a utility bill surcharge has low administrative overhead to collect and can often be added without voter approval. This mechanism is useful when a city or county has its own utility program, such as electricity or trash pickup.
- **State General Fund.** Legislative funding can be one-time or sustaining. Sustaining funds are usually associated with a statutory statewide program.
- **Federal Grants.** As seen during the current West Nile virus epidemic, the CDC may provide emergency money to state and local governments in need, as pass through dollars from state agencies.
- **State and Federal Emergency Funds.** Federal, state, county, and municipal governments have emergency accounts for disaster relief. Control efforts for epidemics may qualify for this source of support.
- **Private Grants.** Where special land and wildlife resources are at risk or responsible for mosquito harborages, grants may be available to defray control activities. Private entities that maintain wetlands for parks or wildlife refuges have contributed to the cost of control efforts.
- **Reimbursement by Government Agencies.** Other government entities, especially federal agencies, can be sources of funds. Agencies whose operations or land holdings add to the magnitude of a mosquito control program, such as the Army Corp of Engineers or the National Park Service, have contracted with local control programs for services.

Funding Alternatives — Planning and Action Checklist

- ☐ Identify funding sources that are currently available for a mosquito control program. Survey agencies that have successful programs to find an appropriate funding model. Talk to people who have experience in acquiring funding for programs.
- ☐ Identify the right program for the jurisdiction before asking for funds.
- ☐ Develop strong and diverse support from the community for the program. Is there a local elected or appointed official who is identified as a leader in fiscal matters that can become a champion for the program?
- ☐ Seek funds from multiple sources.
- ☐ Seek sustained funding sources, at least as the base for a program.
- ☐ Use scientifically sound data to support funding efforts.
- ☐ In the case of emergencies, determine in advance if funds can be temporarily diverted from a lower priority program.
- ☐ Determine if there an existing special district (e.g., park district) that might be used to carry an additional program to control mosquitoes.

New funding may be available in the future from the Mosquito Abatement for Safety and Health Act of 2003 (MASH Act). The MASH Act authorizes grants through the Centers for Disease Control and Prevention to states for coordination of mosquito control programs within a state and assisting localities by providing assessment and planning grants. The MASH Act also authorizes operating grants directly to localities that have conducted assessments and have coordinated with the state to prevent mosquito-borne diseases. Funds have not yet been appropriated for the MASH Act.

Workforce and Training Issues

It is important that a team responding to a mosquito-borne illness or any environmental public health emergency possess both technical and communication skills. Credibility is enhanced if the person communicating the crisis to citizens has an understanding of how to converse in terms the public can comprehend. Everyone has the capacity to learn enough from a scientifically rich discussion to make an informed decision. Underestimating the capability of a lay person to understand an issue can be a fatal mistake and cause a program to fail, no matter how good the intentions. The workforce must acquire skills, knowledge, and abilities that go beyond the scientific or technical skills. There are several workforce and training issues that are important to a mosquito control program.

- **Certification of applicators.** Individuals who apply pesticides must be licensed, in the appropriate category (usually public health) by the responsible state agency (usually the department of agriculture).
- **Entomologists.** At least one individual must be available who has a thorough background in mosquito biology and identification and can identify all common species occurring locally.
- **General training in mosquito biology and control.** All technical staff must have sufficient understanding of the biology of mosquitoes so that they can perform the activities associated with surveillance and control. Such training is often available through government agencies, state or regional mosquito and vector control associations, university extension, or commercial sources, including home study courses.

Workforce and Training — Planning and Action Checklist

- ☐ Identify the staffing and expertise needed for a comprehensive mosquito control and surveillance program. Differentiate between full-time and temporary worker responsibilities.
- ☐ Identify skill levels of each worker and compare those to the job responsibilities being assigned to that person. What qualifications will be needed to compose a well rounded team that will have the support of the citizens? Make sure properly credentialed people are filling roles appropriate for their skills, knowledge, and abilities.
- ☐ Determine who will make up the primary response team and how they be selected. Will staff be paid or voluntary or both?
- ☐ Determine whether adequate staff, equipment, and other resources exist within the governmental agencies responsible for the program. If they do not exist, investigate the use of private contractors.
- ☐ Confirm that the personnel system is equipped to handle the staffing and expertise needed for the program and for maintenance of other programs impacted by mosquito control demands.
- ☐ Determine how to incorporate temporary personnel if they will be used to implement a mosquito control program. How will they be paid? What skills and professional disciplines will be required of temporary personnel?
- ☐ Establish an organizational chart specific for the response action.
- ☐ Determine a communication protocol for the effective release of technical information and educate all staff about the protocol.
- ☐ Consider adding lay people from the community who can represent and advise on the interests of the citizens.
- ☐ Investigate liability issues when using volunteer and/or contract workers.
- ☐ Implement an accounting system to keep track of all of the resources used, including paid and volunteer staff.
- ☐ Create an evaluation process for private contractors and incorporate that evaluation into the contracts.

- **Other specialists.** Individuals who take blood samples from sentinel chicken flocks or wild birds must have appropriate training. Special permits or licenses are required for wild bird sampling. It is highly advisable for ongoing control programs to have an individual who can perform insecticide resistance testing. Other specialties might include a media and public relations specialist, GIS technician, and an ecologist or biologist.

- **Zoonoses Epidemiologist.** This individual will track human and animal cases through case reporting systems, as well as map the results of mosquito pool testing. The position is responsible for analysis of the data and making recommendations related to the level of control actions needed. Such positions are usually housed in state health agencies.

State agencies should assess their workforce needs and may be able to initiate training opportunities and financial support for workforce development. State universities and local colleges can partner with health agencies to implement training programs. Professional associations can also provide pertinent training, often in partnership with state agencies.

To bridge gaps in capacity, communities may want to consider hiring consultants to provide temporary leadership, assist with hiring private contractors, and supply hard-to-find expertise as well as continuity.

Evaluation of Mosquito Control Programs

The nature of the decisions made as part of mosquito control activities can be of great public significance. To determine the success of a mosquito control program, an agency should create an evaluation protocol. The program assessment should be objectively implemented with the ultimate goal of improving the program. Such a review must be done to establish credibility with those directly impacted by control activities, supporters and funders, and to learn from past mistakes. Without a rigorous effort to identify how well the program performed, there may be unsubstantiated objections from many observers. There are examples available of evaluation tools that may be helpful in developing assessments for mosquito control programs.

At least three aspects of a mosquito control program should be evaluated individually in order to determine the effectiveness of mosquito abatement efforts: public response, technical issues, and legal issues. Once completed as stand-alone reviews, they should be combined in the aggregate to complete the picture. As part of the evaluation, an agency must consider both process and outcome measures to provide understandable measures of performance to the public.

Public Response

A government should determine the public's response to two different facets of its mosquito control activities—process and action. The public is broadly construed to include: residents, visitors, elected officials, interest groups, and the media. An agency should evaluate if the public felt included in the decision making process about the control program. A survey can be used to gauge public opinion: were they included in the decision making? Were they listened to and their ideas acted on in a positive way? If their individual or collective ideas were not a part of the final control plan, was a proper explanation given before the program was activated? Were the elected and appointed officials given sufficient information to make good policy decisions?

Additionally, mosquito control programs include community awareness strategies that encourage citizens to participate and not depend wholly on government or district personnel to solve the problem. A follow-up survey, polling or face-to-face meetings should take place to determine if the messages were heard and if they were acted upon satisfactorily. For example: did individuals voluntarily drain standing water from their property? Did they use insect repellent? Did they immunize their livestock? Did they empty water from bird baths, discarded tires, and other containers that can hold water and serve as a breeding ground for mosquitoes?

Technical Issues

An evaluation of all of the technical aspects of mosquito control is a significant undertaking and includes an appraisal of issues such as science, surveillance, epidemiology, medical interventions, and integrated pest management. A specific appraisal of each of these will involve establishing objective criteria that can be peer reviewed and withstand challenge from many fronts. The technical section may be the most questioned due to the complexity of how each individual component fits with the others to create a scientifically defensible action. Using the best available science to support a mosquito control program is central to minimizing public concern and protecting the environment from unwanted outcomes.

Many governmental agencies and special mosquito control districts may not have the capacity to design and implement a mosquito control program due to resource constraints. A private contractor may be the best choice to perform the work of mosquito control. Specially patterned review criteria will be necessary to determine how well the work was administered. Work performance standards should be created to provide an objective view of the success of the program. Performance standards should be included in all contracts. [See Appendix B: Bid and Contract Specifications].

There is a certain component of mosquito control that is non-negotiable and is required by regulatory agencies: the need to track all chemicals used to combat insects. Specific requirements administered by various agencies such as EPA or USDA mandate an inventory of products from cradle-to-grave—each chemical must be traceable from point of origin to point of application—to track where the material is at any given time.

A more detailed breakdown of the actual use of the chemical used is also important. Such as:

- Where was the chemical applied?
- How much was used?
- How was it applied?
- What were the spray volumes?
- Who did the application?
- Was GIS mapping used to define areas treated?
- What was the application rate, especially for adulticides?
- For adulticide applications, which areas or premises were not treated (no-spray sites)?

Legal Issues

As detailed earlier, grounding a jurisdiction's mosquito control activities in law is vitally important. Legal issues may be evaluated separately from the others due to their unique nature, but an assessment should be regularly undertaken in cooperation with legal counsel. What legal authority exists that can support mosquito control? Was the authority used properly? Did those with the authority reach beyond the margins established by the law without properly following legal protocol? Were those in charge unable, for whatever reason, to use the legal authority to its fullest in order to obtain a more successful program result? Was the intent of the law applied and was it adequate to meet intended consequences? What enforcement activities were aided by the law? What enforcements were hindered due to limitations in legal authority?

Develop Process and Outcome Measures

A successful evaluation progression will include both process and outcome measures. These include inputs, outputs, and quantitative outcomes of the mosquito control program. It is important to craft measures that are easy to understand, yet provide real information about progress on mosquito control efforts.

The process measures include how many or how much was expended in the effort. For example:

- How much money was spent?
- How many people did it take to operate the program?
- How much and what type of control agents were used?
- How many mosquitoes were collected and identified?
- How many light traps were used?
- How many miles were traveled or covered while adulticide spraying?
- How many complaints were registered?

This type of information is invaluable when designing and creating a budget for a program. It is important to keep track of these data to satisfy those who want to know the numbers and compare their community's program with other programs.

The outcomes are more difficult to measure. Outcomes go beyond the counting of activities and inputs. There is increasing pressure for accountability and informing citizens of the actual benefit of programs. The public wants to know if they will be at decreased risk for disease if a program is implemented. They wish to know the impact on livestock infection from disease with the program being planned. Is adulticide spraying now necessary because the risk to human health from mosquito-borne illness is greater than that posed by the chemicals? These impact statements should be substantiated by science and conveyed to the public in a persuasive manner by credible people. Some non-subjective, easily measured outcome statistics are:

- Average percent reduction in numbers of mosquitoes (larvae or adults) based on pre- and post-treatment sampling (dipping or light traps, respectively)

- Reduction in numbers of mosquito complaint calls compared to previous years, to the long-term average, or to neighboring areas without mosquito control

- Changes in infection rates for humans and livestock

Evaluation — Planning and Action Checklist

General Evaluation Considerations

- ❑ Determine who will perform the mosquito control program evaluation.
- ❑ Identify what criteria will be used to objectively review pre- and post-program implementation activities.
- ❑ Decide how the evaluation outcomes will be used to improve future program success.
- ❑ Develop evaluation outcomes that are transparent and can be openly communicated to the citizens.
- ❑ Create an evaluation tool that is flexible enough to provide needed information from an evolving program.
- ❑ Determine what "outcomes" of the program will most accurately offer a critique of the program in terms the public can understand.

Public Response

- ❑ Contact recognized community leaders to include in evaluation activities. This may include a member of the media, stakeholder groups, and citizen representatives.
- ❑ Create a feedback mechanism to determine how the public feels about their role in the decision making process.
- ❑ Establish a follow-up mechanism such as a survey to determine the success of volunteer efforts.
- ❑ Determine the success of public education and outreach campaigns in getting the public to act on mosquito control recommendations.

Legal Issues

- ❑ Inventory all applicable statutes, laws, ordinances, rules and guidelines that give authority to perform a mosquito abatement program.
- ❑ Determine if the existing laws are sufficient to support the program.
- ❑ If existing laws are not adequate, investigate what changes are needed to perform the functions of the program.
- ❑ Establish whether laws were properly administered. Review any legal challenges brought or decided about the mosquito control activities.

Technical Issues

- ❑ Create a peer review process of scientific data and recommendations.
- ❑ Determine if the communication protocol for the effective release of technical information has been followed.
- ❑ Track resources used for the program.
- ❑ If private contractors are used, create an evaluation process for assessing their performance and incorporate measures into bids and contracts.

Involve Others

The foundation to any successful mosquito control action is involving key participants early in the process. Governments should develop a strategy for involving others, which includes identifying and engaging a wide variety of stakeholders. Special care should be given to informing decision makers to give them solid information upon which to base policy.

Develop a Plan for Involving Others

Communities and states may organize task forces or advisory committees that involve other agencies, neighboring jurisdictions, stakeholders, other interested parties, and the public. Mosquito control decisions, like all potentially controversial and important public decisions, are made in a political environment. Elected officials may be on the firing line as they deal with options for the community. Health officials can provide scientific, technical, and medical information to support decision makers.

Where there is disagreement over the proper course of action to address a public health situation, advocates for the action and those opposing will be present. The presence of strong leadership is critical to emerge from such a situation with a negotiated outcome that serves the majority of citizens. In a situation with diverse opinions, it is essential to present the relevant scientific and public health information in the clearest and most transparent manner possible. If there is agreement on defining the problem, attention shifts to how best to respond to the threat. If there is debate around the problem, focused discussion to resolve differences must precede any subsequent steps.

A proactive approach to responding to differences of opinion is valuable to the general public. Citizens living in an area that is proposed for aerial spraying for mosquitoes, for example, will have varying opinions as to how and when it should occur, or if it should occur at all. Having a well thought out approach instills confidence. The importance of providing unbiased information to the debate cannot be overstated. Such information will carry the dialogue forward and must use language that is understood by the general public.

Developing a sound plan for stakeholder participation and community awareness begins with a compilation of information. This includes:

- Historical approaches to mosquito control in the jurisdiction
- Review of legislation or regulation governing mosquito control
- Description of current efforts
- Collection of all available data on mosquito-borne illness and nuisance mosquitoes
- List of key constituency groups that have expressed interest in the issue or have strongly opposed controls
- Compilation of best practices from similar jurisdictions
- Identification of mechanisms for working with the media

The primary responsibility for developing a stakeholder participation plan will generally be delegated to staff of a local governmental agency. Unless a designated mosquito control district has been established, this work will typically be tasked to the local public health agency, environmental protection agency, or public works agency.

Actively Involve Stakeholders

Inclusion of people and organizations representing a wide array of backgrounds and opinions is paramount in creating ongoing support for mosquito control programs and developing consensus on the best approach for mosquito control. Examples of key stakeholders to involve include:

- Business, civic and governmental organizations such as chambers of commerce, neighborhood associations, cooperative extension services, parks and recreation, zoos, service clubs (e.g., Rotary club, 4-H) and industry groups (e.g., pest control operators, outdoor recreation sites).

- Environmental advocacy groups, bee keepers, organic farmers, ranchers, fish farmers, and outdoor recreation enthusiasts.

- Medical/hospital providers, veterinarians, emergency personnel, schools, the media, and advocates for special populations (e.g., the elderly, immunocompromised).

- Other participating agencies bring strengths to the program and that these attributes should be capitalized upon by properly applying them to the larger effort.

Jurisdictions can look to other examples of public health programs in their community for models of stakeholder participation. Examples may include tobacco control, HIV prevention programs, child and adult immunization programs, injury prevention (e.g., seat belt, safety seat and impaired driving prevention) and environmental protection programs (e.g., lead poisoning prevention, air pollution etc.).

Methods for stakeholder participation may include surveys, focus groups, telephone polling, public meetings and hearings, and roundtable discussions. Creation of mailing lists and e-mail list serves will provide additional points of contact and discussion among community partners.

Involvement of the media in promoting understanding of the problem, enlisting editorial support, and disseminating information is important. Most print and electronic media have specialists assigned to health and environmental issues. Local media can assist by providing information to the public regarding upcoming meetings and opportunities for input.

Inform Policy and Decision Making

Officials at the city, county, and state level all need to engage in discussions regarding mosquito control. Members of boards of health have a vital role to play in advocating for protection from mosquito-borne illnesses. To accomplish this, elected and appointed officials need accurate, clear, and concise data to make informed decisions about mosquito control. Policy makers will generally prefer brief written materials that identify a single contact person. Information presented to policy makers should include: surveillance data and current epidemiological trends regarding mosquito-borne illnesses; scientific information regarding mosquito habitats and seasonal patterns; options for a basic mosquito control program; costs associated with mosquito control; public awareness campaign plans; and legal and regulatory implications. Examples of successful models and options from places with demographic and geographic similarities may also be of help.

Successful programs typically identify one or more champions who understand the issues and are willing to serve as an advocate and spokesperson in their legislative body (e.g., state legislatures, town council, county commissioners, district, etc.). Champions are often individuals who have been directly impacted by the issue. They may have a family member or constituent who became ill or they may have credibility with the public on issues of public health. Colleagues usually look to them for advice on health issues.

Involve Others — Planning and Action Checklist

General Stakeholder Considerations

- ☐ Consider how elected officials and their appointees will work in a collaborative format to address the problem. How will agencies work with elected and appointed officials?
- ☐ Determine how collaborating government officials and agencies will enlist citizens in the decision-making process and create a fluid mechanism that will get things done in a timely manner.
- ☐ Determine how divergent views will be addressed and resolved.
- ☐ Determine how leaders of advocacy groups and those in opposition will be chosen. Who will sit at the negotiating table?
- ☐ Once agreement is reached between all parties, decide how the message will be communicated to citizens to maintain support when implementation of the plan begins.

State Actions

- ☐ The lead agency for mosquito control should develop a planning process. This may include meetings of stakeholders, surveys, regional focus groups or town meetings, and other mechanisms to gain input and support for the plan.
- ☐ The lead agency should identify other stakeholders to include in statewide planning efforts, which may include:
  - Elected and appointed officials including such state boards and committees as state boards of health
  - Other state agencies (public health, environmental protection, natural resources, agriculture, emergency management)
  - Conservation groups (land, water, air)
  - Statewide organizations representing local government (counties and municipalities)
  - Business and industry (agriculture, tourism, medical/hospital, veterinary, pest control)
  - Public health (public health association, environmental health association, local health departments)
  - Recreation groups (fishing, outdoor sports)
  - Statewide media
- ☐ Consider input from private and quasi-governmental agencies, such as special districts, as experts in a particular function of the program.
- ☐ The lead agency should develop partnerships with land grant universities and medical and veterinary schools that have expertise and research and outreach capabilities.
- ☐ The lead agency should complete a plan for mosquito control, disseminating the plan to all stakeholders at the state and local level.
- ☐ Develop mutual aid agreements or memorandums of understanding with all partner city and county agencies, states, and countries.
- ☐ Establish a response system that is universally accepted and can be understood by all participants in the project if an epidemic is occurring. Look to existing response systems such as the Incident Command System as an option to manage the event if an epidemic is occurring.
- ☐ The lead agency should evaluate the success of mosquito control strategies and identify plans for addressing emerging issues.

Local Actions

- ☐ Identify lead agency for mosquito control at local level.
- ☐ Review state plans and consult with lead state agency for mosquito control.
- ☐ Identify jurisdictional boundaries and forge partnerships with neighboring counties and municipalities.
- ☐ Develop and implement a plan for stakeholder participation and community awareness. Key elements include:
  - Identification of one or more champions for mosquito control who are willing to serve as advocates and spokespeople in their legislative bodies.
  - Develop briefing materials on such items as historical approaches to mosquito control; current surveillance data; lists of key constituency groups; a compilation of best practices from similar jurisdictions; financial, legal and regulatory options for local plans; and public awareness campaigns for local officials.
  - Develop methods for stakeholder participation that may include surveys, focus groups, telephone polling, public meetings, and roundtable discussions.
  - Create mailing and e-mail lists to provide additional points of contact and discussion among community stakeholders.
  - Identify a primary spokesperson to inform the community about implementation of a mosquito control plan and to address issues and concerns regarding spraying, and if necessary, the presence of mosquito-borne illness.
  - Work with the local media to develop public information strategies and assist with campaigns to prevent mosquito-borne illness and promote community understanding and acceptance of the mosquito control program.

USE THE BEST SCIENCE AND DATA

It is critical that science drives the assessment of state and local needs, strategies selected, and design and monitoring of mosquito control programs. More is being learned each year as scientists and other experts continue to study mosquito control and disease transmission. These historical lessons and current best practices must guide the development, implementation, and evaluation of quality mosquito control programs.

There are numerous proven methodologies and practices that guide the best mosquito control programs. All programs need to be based on an identified need that is matched with state and local resources and technically sound strategies. There may be gaps in knowledge in some areas such as outcome evaluations.

Focal or homeowner-based mosquito control strategies may be perceived as an alternative for the public in affected communities. There has been a rapid proliferation of backyard mosquito control equipment and technologies, as well as suggestions for new or unproven alternatives to currently recognized effective mosquito repellents. There is little data on the efficacy of these methods, machines, and materials either for area-wide or focal programs, especially for mosquito-borne disease control. If the public believes that these alternatives are best for them (for example, because of intensive advertising), they could rationalize not authorizing public support for community-wide mosquito control. Therefore, organized mosquito control programs could suffer. These methods also do not adequately address the need for surveillance, monitoring, source reduction, or larval control—all basic components of integrated mosquito management. In addition to not providing area-wide protection, focal strategies usually are more expensive than the annual per person cost of organized mosquito control.

THE SCIENCE OF MOSQUITO CONTROL

A quality mosquito control program has as its foundation a solid understanding of the biology of the mosquito species that occur locally. This includes such information as where the larvae are found, where the adults rest, what time of day the adults look for a blood meal, and what control measures are most effective against each species. In addition, control of disease-transmitting mosquitoes requires information on the timing and distribution of human and animal cases.

Epidemiology

Public health mosquito control efforts are driven by information accumulated and analyzed using the science of epidemiology. Epidemiologists at CDC, state health agencies, and local health agencies work cooperatively to monitor mosquito-borne illnesses. Monitoring the timing and distribution of both human and animal cases of mosquito-borne illness provides the basis and the targets for mosquito control in the field.

As identified by CDC, the goals of surveillance for human cases are to:

1. assess the local, state and national public health impact of West Nile virus and other mosquito transmitted diseases and monitor national trends;
2. demonstrate the need for public health intervention programs;
3. allocate resources;
4. identify risk factors for infection and determine high-risk populations;
5. identify geographic areas in need of targeted interventions; and
6. identify geographic areas in which it may be appropriate to conduct analytic studies of important public health issues.

Human case surveillance involves receiving and recording reports of illness; confirming diagnoses; interviewing doctors and patients to determine the timing, geographic location, and conditions of infection; and scientifically analyzing the data accumulated.

Monitoring human cases alone is considered inadequate when dealing with mosquito-borne disease. Using epidemiological techniques to monitor equine and avian cases is very important in establishing early trends and allowing reasonable response times for control activities. Reporting networks for animal cases involve veterinarians, laboratories, wildlife agencies, agriculture agencies and organizations, and also the general public. These reporting systems require proactive and ongoing effort to implement and maintain. State health agencies collaborate with these partners to establish, maintain, and analyze these databases. The state also helps define the parameters of reportable cases and keeps physicians informed of changes in case definitions, routes of transmission and treatment regimes. Developing guidelines and fact sheets on clinical features and treatment for physicians and personal protection guides for the public are ways the state health agency can provide important services to the medical community and the public.

Surveillance of Animal and Insect Populations

Zoonoses are different from human-to-human diseases because they involve other animal hosts (and, frequently, insect or tick vectors). Much of the activity (transmission) of zoonotic pathogens takes place out of sight of, and physically removed from, humans. However, attacking the zoonotic cycle has the greatest impact in reducing the threat of disease in humans and domestic animals. By the time these diseases are detected in the human population it is often too late to have any impact on the transmission cycle. In fact, the zoonotic portion of the cycle may already be declining when human cases appear. At that point, the only effective strategies are avoidance, personal protection, and chemical control of the adult vectors (mosquitoes in this case).

To understand surveillance and monitoring strategies, it is necessary to know something about the ecology of the area, the mosquito species present, and the disease agents likely to be found. This information will set most of the parameters for the layout of the surveillance system. In general, adult mosquito collections (e.g., from light traps or gravid traps) are highest when traps are placed in an ecotone (the junction between two habitat types, such as forest and grassland, park land and urban housing, etc.). In monitoring for virus activity, roosting or nesting habitats of the bird hosts should also be considered in deciding where to place traps. Note that this is different from the placement of traps to detect the emergence of adult mosquitoes from larval habitats.

The objective of public health mosquito control is to prevent transmission of mosquito-borne diseases to humans, domestic animals, and livestock. Reduction of nuisance mosquito species may be an added objective, particularly in areas where tourism and other outdoor activities are major contributors to the local economy. Nuisance mosquito management frequently focuses on different species (and different habitats) than public health mosquito control. However, a well organized integrated mosquito management (IMM) program can provide the basis for effective management of vector species.

Monitoring or surveillance as a part of a nuisance-based mosquito control program differs somewhat from virus surveillance programs. In the latter case, the objective is to detect activity of the vector species at the earliest possible point in time. Collections of larval mosquitoes in new or previously identified habitats often form the core of nuisance-focused surveillance. Adult mosquito surveillance is used mainly as an assessment tool to judge the effectiveness of control measures in nuisance based control programs. In disease prevention and control programs, adult mosquito surveillance plays a much larger role, since the risk of pathogen transmission is often linked to adult mosquito density, infection rates, and age structure of the female population.

Planning a Mosquito Control Strategy

Communities need to define their desire and need for mosquito control before they create a program. A scientific response to combat a nuisance mosquito may look very different from a program to combat mosquitoes carrying disease. However, it is important to remember that there is not a clear distinction between "nuisance" and "vector" species of mosquitoes. For example, *Aedes vexans*, perhaps the most widely distributed nuisance species, also appears to be involved in transmission of West Nile virus, as well as transmission of eastern equine encephalitis virus in some areas.

It is important to recognize that mosquito and mosquito-borne disease control programs cannot be created at a moment's notice, as too many agencies across the U.S. have learned in the wake of West Nile virus. As detailed in the "Plan Ahead" section, effective, efficient, and publicly embraced programs need to be planned and initiated well in advance of the onset of a disease outbreak or mosquito control emergency following a disaster. The best disaster or emergency responses come from ongoing programs with trained personnel, adequate equipment, and good procedures already in place and operating.

Communities need assistance in assessing the existing and necessary scientific and technical infrastructure for a program. Citizens need to know what proactive and reactive options are available. Communities need models of successful programs to weigh against their resources. They need information about minimum criteria and standards for programs with limited resources. They also need models for threat assessment that are timely and site-specific.

Mosquito Control Strategy Basics

There are several ways to prevent the emergence of adult mosquitoes, which is generally the most economical strategy. Larvae are confined to the aquatic habitat, which can be clearly identified and treated. Methods include:

- Source reduction (remove, cover, drain, fill)
- Chemical control (larvicides)
- Biological control (mosquito fish, pathogenic fungi, etc.)
- Public education (role of the homeowner in reducing peridomestic larval habitats)—schools, service clubs, radio and TV, other focal points in the community

All larviciding operations should be monitored by dipping or other accepted technique to assess the efficacy of the application.

If larval control fails, is inadequate, or not feasible in a given setting, it may be necessary to control the adult mosquitoes that emerge from the larval habitats. Adult mosquito control must cover a larger area, since adults of many species can fly long distances (ten miles or more for some species), which can drastically increase the cost of protection. Adult mosquito control methods include:

- Personal protection (use of repellents, clothing, maintain door/window screens)
- Public education (educate, gain public support for the program, source reduction around the home)
- Adulticides (usually applied as ultra-low volume-ULV-sprays by truck- or aircraft-mounted equipment)

Because adulticiding can be a divisive issue in many communities, its use should be clearly justified by using a decision matrix that specifies what events will trigger a given level of response. A decision matrix specifies a range of activities or responses to a given set of predictive parameters. [See Appendix A: Decision Matrix]. For example, recent temperature and rainfall, mosquito density, levels of virus transmission in sentinels, etc., can be factored into decision-making. The decision matrix helps policy makers avoid indecision and provides justification and confidence for a particular course of action.

Use area maps to indicate treated and untreated areas, indicating reason for not treating an area (environmentally sensitive, opt-out, outside district boundary, etc.). Environmental parameters, such as temperature, wind speed and wind direction should be recorded during each application.

All adulticiding operations must be closely monitored, and the efficacy of the application should be assessed by pre- and post-treatment trapping, landing counts, or other techniques. All relevant application parameters (e.g., droplet size, flow rate, etc.) must be monitored in accordance with the product label.

Once communities have identified that mosquitoes are presenting a threat to the community, action must be taken based on the resources available to the state or community and the severity of the threat. Human disease and mosquito surveillance programs are necessary components for a public health mosquito-borne disease control program. Hit-or-miss programs will be ineffective.

Mosquito Control Strategy–Planning and Action Checklist

- ☐ Determine the community's need surveillance for vector-borne disease.
- ☐ Determine what is involved in vector-borne disease surveillance. What agencies or groups will be involved in carrying out the surveillance program? How will coordination and communication be handled between the participating agencies?
- ☐ Identify the options for establishing a vector-borne disease surveillance and control program. What strategies work best for a given locality? What is the state's role?
- ☐ Discuss how the community can control or reduce mosquito populations effectively and with the least cost and environmental disruption.
- ☐ Coordinate local mosquito control programs with state and federal public health agencies to receive training for the operation of surveillance systems.
- ☐ Get local agencies involved in gathering data about disease and mosquito population patterns. Monitoring networks require maintenance and resources.

Options for Mosquito Control Activities and Programs

Once the community has decided that there is a need for some sort of organized response to a mosquito or mosquito-borne disease problem, it is necessary to decide on the type of response and the magnitude of the effort. These decisions will be impacted by a variety of considerations, such as the severity of the problem, the financial resources of the community, public perceptions and attitudes, and the availability of technical expertise. This section deals with the technical aspects of organized mosquito control.

A primary focus of the MCC effort is to define the range of options for local mosquito programs from the simplest, but still effective, program, to the ideal program where resources are not the primary limiting factor. This document assumes that the programs described focus on both disease vector control and nuisance control. It also assumes that the area to be protected has been defined through some process (buffers around the community, city/county boundary, etc.). The following options describe three program levels:

- Level I (Minimal)–no resources to support mosquito control activities
- Level II (Intermediate)–little to moderate resources to support a program
- Level III (Comprehensive)–moderate to adequate resources to fund a complete mosquito control program

Level I – Minimal Program
(No Resources to Support a Program)

Even when there is no staff or budget within the local community, there are things that can be done to reduce the threat of mosquito-transmitted disease and, to some extent, the irritation of pest mosquitoes. Here are some low-cost or no-cost options that will be helpful in many situations.

Public education. Remember that some aspects of mosquito control are personal responsibilities. Each citizen should be made aware of ways in which they can prevent mosquito breeding on and near their property; how they can reduce the risk of being bitten by observing personal protection measures; and how they can help to inform local health agencies by reporting bird deaths or other unusual events. However, knowledge does not always lead to action. Public recognition or other rewards may increase action by the community.

- Many public information brochures and other materials are available from the CDC and from state and local health departments. These can be reproduced at minimal cost and distributed with monthly utility bills or other community mailings.

- The public schools can be an excellent means of educating the public. The American Mosquito Control Association, the CDC, and other groups have teaching materials for the K-12 grades, and these may be available-free or for a small charge.

- Citizen action groups can be an extremely effective resource to spread information about mosquito control, homeowner participation, and similar issues. Be sure to refer citizens to sites with reliable information.

- Educate and inform the local media. They are an important resource for delivering mosquito control messages to the public.

Elements of a Minimal Program

- ❑ Institute a public information program emphasizing personal responsibility, ways in which people can prevent mosquito breeding, and how they can reduce the risk of being bitten by observing personal protection measures.
- ❑ Encourage reporting of unusual events, such as dead birds or sick domestic animals, to local health agencies.
- ❑ Institute community cleanup programs to eliminate larval habitats from back yards, commercial sites and abandoned premises.
- ❑ Citizen participation (reporting suspected mosquito larval habitats, reporting dead birds or other unusual events) is essential for efficient data gathering.
- ❑ Educate and inform the local media.

Source reduction. Community cleanup programs can be an effective way to eliminate larval habitats from back yards, commercial sites, and abandoned premises. Service groups (e.g., Rotary, Lions, Kiwanis, Sertoma), churches, scouts, and similar programs can be enlisted in the effort to increase community awareness and to support cleanup programs.

Level II – Intermediate Program
(Little to Moderate Resources to Support a Program)

Communities with little to moderate resources available will have some capacity to conduct mosquito control activities, but cannot mount a comprehensive program. In this situation, the first question often is, "Should we use a contractor or should we develop an in-house program?" The answer depends on what other resources are available. In particular, the knowledge and training of individuals in the local health department (or mosquito control program if one is being developed) are factors. Other issues that will impact the decision include the size of the community being served, proximity to other communities (with or without existing mosquito control programs), ecology of the region, and support by the community.

- In the absence of existing local expertise, it may be advisable to use a reliable contractor or, if feasible, form a collaborative or other arrangement with an adjoining county, parish, or municipality with an existing mosquito control program. Responsibility for program oversight and monitoring must be assigned to the appropriate agency. That agency should have the knowledge base and physical resources to carry out the program effectively.

- Regardless of which approach is selected, there should be a clearly defined statement of services or deliverables, and a clear performance evaluation document. What activities will be performed? What resources (equipment, staff, insecticides, etc.) will be provided? How often will inspections be conducted? How will efficacy be measured? What happens in the event of non-performance?

The second common question deals with where to allocate the scarce resources. The answer will again depend somewhat on local conditions, but there are some generalizations that can be made. The end objective is to have a fully integrated mosquito management program that relies on a thorough understanding of the ecology of the mosquitoes of the area, the extent of the disease threat or nuisance problem, and the history of the community.

- The program should include all of the public education and source reduction activities identified in Level I above. Some funding could be directed at improving programs in the public schools or, if needed, additional source reduction activities (e.g., draining or filling extensive larval breeding sites).

- The next step will be to focus on larval mosquito control, begun early in the season. This requires some knowledge of the local mosquito species and their ecology. Where are the larval habitats? When do they appear in the spring or summer? Thus, some mapping and record keeping will be needed. If insecticides are used, records must be kept of when, where, and how much of each material was used on any given day. In some localities, pre- and post-treatment larval counts are required to show whether the treatment was effective.

ELEMENTS OF AN INTERMEDIATE PROGRAM

- ☐ Continue measures established in the minimal-level program described above. Augment public education and source reduction efforts.
- ☐ Decide on the program format (e.g., in-house, contract, multi-jurisdictional collaborative).
- ☐ Decide who will be responsible (e.g., which agency has the resources and expertise to conduct the program?).
- ☐ Define the scope of the program—including such things as area to be covered and services to be performed—in relation to the available resources. Emphasize public education and source reduction, augmented by larval control. Consider adult mosquito control if sufficient resources are available.
- ☐ Ensure that all staff are appropriately trained and certified or licensed.
- ☐ Institute basic mosquito population monitoring to define the problem.
- ☐ Use passive disease monitoring (e.g., dead bird reporting) as an indicator of possible disease activity. Submit birds and/or mosquitoes for virus testing if such services are available.

- One or two mosquito traps should be purchased and placed in operation (the CDC portable light trap or any of several similar traps have been shown to be effective). These traps can be placed at crucial sites within the community, perhaps where past experience has indicated particularly severe pest problems or increased disease activity. This will aid in assessing the effectiveness of the program. For example, trap counts before and after a particular control activity can be compared.

- If additional funds are available, it may be worthwhile to purchase or contract for equipment for adult mosquito control (ULV sprayers, etc.). Since mosquitoes can fly substantial distances (from less than 1 mile to more than 15 miles, depending on the species and conditions), it may be difficult to protect communities with large outlying areas that can generate millions of mosquitoes. However, these methods can increase protection of the community from mosquitoes if an adequate area can be covered and the insecticides are applied appropriately (usually at dusk or after sunset, depending on the species being controlled).

Level III – Comprehensive Program
(Moderate to Full Resources for a Program)

Communities with moderate to full resources will be able to develop and implement more comprehensive mosquito control programs. The recommendations in this section are drawn largely from the American Mosquito Control Association's Bulletin #4, *Organization for Mosquito Control* (1990). Please refer to that document or to the many excellent training manuals developed by state mosquito control associations for additional guidance in organizing a full-scale program.

A general principle of integrated control programs is that a specific control measure is only instituted when an action threshold, or "trigger," is met. An example of thresholds and suggested responses for West Nile virus activity is shown in Appendix A, Decision Matrix. These are broadly defined thresholds, and individual states or communities may wish to institute more precise thresholds that reflect local experience and concerns.

One of the first things to recognize, once funding becomes available, is that mosquito control is a year-round activity. The information in this section gives a general picture of the activities that will be needed for the minimal program over the course of a year.

Pre- or Off-Season Activities

General Issues

Many activities of the mosquito control program will normally be carried out in the "off season" when mosquitoes are not a problem—usually during the winter. These activities include staff training and certification; equipment purchase, repair and calibration; budgeting and other financial activities; and analysis of the previous year's data. In some areas, source reduction activities (see below) can also be done at this time.

Much of the information collected during mosquito control activities consists of maps, tables, and charts. Most of the information also is linked to a physical location. For this reason, it is useful to have a mapping program available to the mosquito control program. This can be done by coordinating with another city or county department that already has a geographical information systems (GIS) section or activity. Alternatively, there are inexpensive software programs that can be used if the expertise is available within the control program. The CDC offers a free software package, EpiInfo, which also contains a simple GIS program (EpiMap). This provides an inexpensive entry into the world of in-house data management and mapping. EpiInfo can also be used to design data collection forms, data entry screens, and elementary graphing capabilities.

Surveillance

Surveillance, as applied to vector-borne disease, is the organized monitoring of levels of virus activity, vector populations, infections in vertebrate hosts, human cases, weather, and other factors to detect or predict changes in the transmission dynamics of arboviruses. Since all of this information is rarely collected by a single agency, it is extremely important that the various data-collecting agencies actively communicate and exchange information.

- Review all published data, past health department records, and other data to determine the types of mosquito-borne diseases, numbers of cases by year and date of onset (or diagnosis), economic and other costs, if known. Review complaint calls for nuisance mosquitoes by year and date, and determine the peak periods of nuisance problems.

- Collect and review historical meteorological data for the area: temperature, rainfall, humidity, and wind direction. Plot this information against mosquito abundance (or nuisance calls) to see if there are any predictors of high mosquito abundance, disease transmission, etc.

- Map the locations of high-risk populations (e.g., elderly citizens), using local census or other community data. This will allow the program to prioritize resources if an epidemic should occur.

- Collect and review topographic maps, aerial photography, and other similar resources to help in locating probable larval habitats, concentrations of bird or other hosts of mosquito-transmitted viruses.
- Use the data collected above to decide where to place light traps or other sampling stations, and where to concentrate efforts to monitor larvae.
- Based on the foregoing information, select the areas at greatest risk within the service area (city, district, county, etc.) and plan to concentrate the available resources in those areas.

Species Delimitation

In some respects, a mosquito control program can be compared to a military campaign: it is crucial to know the enemy. The more that is known about the important species in the area, the more likely they can be effectively and economically controlled.

- **Habitat mapping.** The off-season is a good time to map the locations of larval habitats within the mosquito control district. It may also be useful to map major sources of mosquitoes that may be located outside the boundaries of the control district, if these are known or suspected sources of problems during the mosquito season.
- **Seasonal characteristics.** If not already done, take this opportunity to construct graphs of seasonal abundance of mosquitoes, by species. This should be done for larval surveys as well as adult surveys. Over several years, it will be possible to construct an average count for each species, by week. When the current counts for a particular species rise above the long-term average, this may indicate an emerging problem.

Control Activities

This is the most visible part of the program, but its success is strongly dependent on attention to the points covered above.

- **Source reduction.** Several types of source reduction can be carried out during the off-season: clearing of stream channels, community cleanup (e.g., door-to-door inspections, tire amnesty programs), and similar activities.
- **Larval control.** Most control is done later in the season, but some areas can be treated before they become flooded by spring rains or runoff.
- **Adult control.** No adult control is done at this time.
- **Public education.** Public education, especially activities focused on K-12 school programs, can be carried out at any time of the year. Arrange for presentations at meetings of civic groups, nature groups, service clubs, and other groups that have an impact on the local community. To reach the agricultural community, coordinate activities with local county extension agents where those services are available.

EARLY-SEASON ACTIVITIES

Surveillance

In early-season activities, as above, surveillance gathers the intelligence data needed to combat the mosquitoes and prevent disease transmission.

- **Larvae.** With the arrival of spring warming and rain or flooding, *Aedes* and *Ochlerotatus* eggs will hatch, and diapausing *Culex* females will emerge, take a blood meal, and begin laying eggs. This is the time to begin monitoring larval populations. Triggers for control action should be determined: how many larvae per dip represent a health threat or a nuisance problem?

- **Adults.** Similarly, light traps, gravid traps, or other methods should be used regularly to monitor adult mosquito abundance. Triggers for control action should be determined: how many females per trap night of a particular species pose a health threat or a nuisance problem?

- **Disease surveillance.** Vertebrate hosts (e.g., dead birds as indicator for West Nile virus) should be monitored for evidence of virus activity. This may be simply recording and mapping the locations of dead birds reported by the public. Depending on other resources, a state laboratory or other facility may be available to perform virus testing on dead birds. Test kits are available for testing dead birds and mosquito pools without elaborate laboratory facilities. Mosquito infection rates can be an important indicator of a disease threat. The state health laboratory or other facility may be able to provide this service. Infection in domestic animals (horses, etc.) and humans is an indicator of impending trouble and an indication that immediate action is required. [See Appendix A: Decision Matrix]

Species Delimitation

- Habitat mapping should be continued during the course of the mosquito season. New locations should be plotted on the map or entered into the GIS database. New locations should be added to the inspection and treatment routes of the field staff.

- Seasonal abundance characteristics may give evidence of approaching problems. Are the numbers of *Culex pipiens* far above normal? What about *Culex tarsalis* (western states)? Is *Aedes vexans* more abundant than normal?

Control Activities

- **Source reduction.** Activities can continue during this period. Efforts should concentrate increasingly on the elimination of potential disease vector species larval habitats.

- **Larval control.** Biocontrol agents, such as mosquito eating fish (*Gambusia* spp. and others), copepods, or other agents, can help to balance out a good control program. "Biological pesticides" such as *Bacillus thuringiensis* var. *israelensis* (B.t.i.) and *Bacillus sphaericus* are effective mosquito control agents.

- **Chemical control of larvae includes a variety of materials.** Larvicidal oils and monomolecular films cover the water surface and prevent the larvae from breathing. Growth regulators, such as methoprene, affect the development of the mosquito larvae, preventing the adult from emerging from the pupa. Several other materials are available in some areas or for particular applications.

- **Adult control.** Selective use of adulticides may be advisable if there is evidence of virus activity early in the season, or if nuisance species are at high levels.

- **Public education.** Newspaper, radio, and television announcements can be prepared to increase public awareness of the threat of mosquito-transmitted disease. Coordination with local media can increase the community's awareness of the types of work done by the mosquito control program.

MID- AND LATE-SEASON ACTIVITIES

Activities for the remainder of the mosquito control season will be much the same as for the early season, with the exception that more and more effort will be dedicated to larviciding and, when needed, adulticiding. Disease surveillance data will guide the level of mosquito control, especially control of adult mosquitoes. Public education and close contact with media resources will be a continuing need.

As mosquito populations decline with the onset of cold weather, the program will return to the pre-season/off-season routine, in preparation for the next year.

Elements of a Comprehensive Program

- Continue measures established in the intermediate-level program described above. Augment public education and source reduction efforts.
- In collaboration with other relevant agencies and stakeholders, define the full scope of the expanded program.
- Establish an advisory board or similar structure to provide feedback and communication between the program and relevant stakeholders.
- Hire and train appropriate professional staff needed to fulfill the requirements of the expanded program.
- Procure the necessary equipment, chemicals and other materials needed to carry out the expanded program.
- Build on the existing monitoring program, establishing a long-term database for comparison to current-year data.
- Prepare an emergency response plan for dealing with vector-borne disease outbreaks.
- Increase disease surveillance activities by instituting sentinel flocks, mosquito testing or other techniques as appropriate.
- Build risk maps to assign priorities to areas within the district using census data, mosquito abundance data, disease incidence and other relevant data.
- Maintain good communication among the Centers for Disease Control and Prevention, state public health and local public health agencies.
- Evaluate the governmental disease surveillance network.
- Evaluate and improve the disease reporting system among physicians, hospitals, laboratories and public health agencies.
- Develop and maintain a responsive animal and vector disease reporting system among veterinarians, wildlife agencies, the public, mosquito control contractors, laboratories and state and local public health agencies.
- Keep the public and public officials informed regarding disease incidence projections, cases identified and response planning.

Inform the Public

Mosquito control programs need the support of an informed public. Many of the successful strategies for control involve individuals, their families and their neighborhoods. The public also has concerns about the problems related to the mosquito populations and about insecticides and spraying.

Informing the public shows a respect for the community and will lead to a stronger, better supported program that is tailored to the community and its values. Development of a communications plan that includes public education about preventing the breeding of mosquitoes, personal protection guidance, and the activities and success of the agencies involved is critical to the success of the program.

Define the Goals for Public Information

The public information challenges of mosquito control are many. Mosquito control includes two areas of responsibility: individual and public. Areas of individual responsibility relate to personal actions residents can take to reduce personal risk from mosquitoes, such as eliminating breeding pools on their property and using insect repellants. Public responsibility relates to the development and maintenance of community-wide mosquito control activities and programs. Public information strategies will vary based on which area of responsibility is being impacted and the goal to be achieved. The information needs vary depending on whether the goal is to:

- Educate policy makers and gain their support for policy issues;
- Inform the public about mosquito control generally;
- Provide instructions to the public to prevent exposure and lower risk;
- Influence the public regarding a permanent control strategy;
- Deal with a public health crisis, such as West Nile virus;
- Inform the public of pesticide risks and benefits;
- Inform the public about the use and timing of pesticides in their community; or
- Gain support for financial resources for mosquito control.

A respected spokesperson should be identified. This may be the local health official or another public official with credibility and profile in the community. The spokesperson(s) could come from academia, the medical community, the local hospital, or public health. The lead agency at the local level will want to designate a public information officer or team to develop materials, inform the press, respond to questions, and network with information officers in related organizations, such as emergency medical services, hospitals, county or city manager's offices, the state, etc.

Strategies to inform the public can include press education prior to the mosquito season; educational meetings with policy-makers such as city councils and county commissioners; preparation of materials for the public; web-site development; plans for a hotline and recorded messages; and regular information to the public about mosquito surveillance and disease incidence.

Create Effective Messages

A proactive approach will involve developing a simple message, easily understood that resonates and is memorable. Many states have already initiated public health campaigns such as the 2003 "Fight the Bite" campaign. When developing campaigns, it is important to have a unified message across the state. Other public health campaigns may serve as models for community awareness. A successful campaign:

- Utilizes web sites, public service announcements and information hotlines as tools for community education and involvement;
- Develops multiple strategies to reach people at home, work, school, in shopping areas and in places of worship;
- Provides succinct messages to the public throughout the year and emphasizes prevention as the best protection against illness; and
- Assures that programs are sustainable even in the absence of mosquito-borne illness in the community.

INFORM THE PUBLIC – PLANNING AND ACTION CHECKLIST

- ☐ Develop an information exchange process that will keep the public in tune with decisions and anticipated actions.
- ☐ Determine who should be included in the public information network to plan for the information campaign or campaigns. What sister agencies or neighboring jurisdictions need to be involved?
- ☐ Decide if there will be proactive press education prior to the mosquito season.
- ☐ Determine who will develop and update web sites. What links will be established?
- ☐ Decide what specific information can be given to the public about the use and timing of pesticide applications.
- ☐ Identify language barriers that need to be considered when developing campaigns.
- ☐ Anticipate objections to the program by a minority opinion that may be vocal enough to disrupt the project or lead to minority reports.
- ☐ Establish a follow up mechanism such as a survey to determine the success of education and outreach.
- ☐ Develop a pre-season campaign to educate the public.
- ☐ Designate a spokesperson to handle medical questions and work with the coroner's office and the hospitals if death and/or illness occur.
- ☐ Prepare fact sheets for physicians and the public.
- ☐ Educate key decision-makers.
- ☐ Maintain statewide data and coordinate information campaigns with a single, unified message to the public on prevention of mosquito-borne illness.

If you would like to comment on the MCC's interim recommendations or would like to suggest additional resources and references, please visit the ASTHO website at www.astho.org. You can submit comments electronically, by fax or by mail.

Resources for More Information

There are many resources to help in establishing a mosquito control program. The following list provides a basic sampling of these resources from government agencies, professional associations, and universities.

Books

Beaty, B. J. and W. C. Marquardt (Eds.). 1996. *Biology of Disease Vectors*. Niwot, CO, Univ. Press of Colorado [Second edition is in press, expected 2004].

Monath, T. P. (Ed.). 1988. *The Arboviruses: Epidemiology and Ecology* (5 vols.). Boca Raton, FL, CRC Press.

Service, M. W. 1993 *Mosquito Ecology. Field Sampling Methods*. 2d Ed. London, Elsevier Applied Science.

Smolinski, M. S., M. A. Hamburg, and J. Lederberg (Eds.). 2003. *Microbial Threats to Health: Emergence, Detection, and Response*. Washington, DC, National Academy Press. 2003.

Journals

Bulletin of the Society for Vector Ecology (S.O.V.E., 1966 Compton Ave., Corona, CA 92881) - www.sove.org

Emerging Infectious Diseases (Centers for Disease Control and Prevention, 1600 Clifton Rd., Atlanta GA 30333) – www.cdc.gov/ncidod/EID/index.htm

Journal of the American Mosquito Control Association. (American Mosquito Control Association, P. O. Box 234, Eatontown, NJ 07727-0234) - www.mosquito.org

Wing Beats (Florida Mosquito Control Association & AMCA, P.O. Box 60005, Fort Myers, FL33906) - www.floridamosquito.org

Bulletins and Manuals

AMCA. 1990. *Organization for Mosquito Control.* Bulletin #4. Eatontown, NJ, American Mosquito Control Association.

CDC. 2001. *Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance, Prevention, and Control.* Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO www.cdc.gov/ncidod/dvbid/westnile/resources/wnvguidelines2001.pdf.

CDC. *Vector-Borne Disease Control.* Self-study course 3013-G. Public Health Service, Centers for Disease Control and prevention, Atlanta, GA. Available from Public Health Foundation www.phf.org .

Durso, S. L. (Ed.). 1996. *The Biology and Control of Mosquitoes in California.* Mosquito and Vector Control Association of California, Elk Grove, CA 95624. (Many state mosquito control organizations produce similar manuals, designed to prepare technicians for pesticide licensing or other training).

Moore, C. G., R.G. McLean, et al. 1993. *Guidelines for Arbovirus Surveillance in the United States*. Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO.

Agencies and Organizations

Americana Mosquito Control Association - P. O. Box 234, Eatontown, NJ 07727-0234) - www.mosquito.org

Association of State and Territorial Health Officials (ASTHO) www.astho.org

Centers for Disease Control and Prevention - 1600 Clifton Rd., Atlanta GA 30333 – www.cdc.gov

National Association of County and City Health Officials (NACCHO) www.naccho.org

Society for Vector Ecology (S.O.V.E., 1966 Compton Ave., Corona, CA 92881) - www.sove.org

State health departments - See www.StatePublicHealth.org

State Public Health Vector Control Conference (SPHVCC) - c/o Nolan H. Newton, North Carolina Department of Environment and Natural Resources, 1631 Mail Service Center, Raleigh, NC 27699-1631

U.S. Department of Agriculture (USDA) - www.aphis.usda.gov/lpa/issues/West Nile Virus/West Nile Virus.html

U.S. Environmental Protection Agency (EPA) www.epa.gov/pesticides/factsheets/mosquitocontrol.htm

National Pesticide Information Center, Oregon State University, Corvallis, OR. www.npic.orst.edu/

University extension and research medical/veterinary entomology programs

MISCELLANEOUS

CDC Evaluation Working Group - Examples of evaluation tools and resources that may be helpful during the formation and implementation of a mosquito control program can be found at www.cdc.gov/eval/resources.htm.

The Mosquito Abatement for Safety and Health Act (MASH Act) – A copy of the Act and its status can be found at http://thomas.loc.gov/cgi-bin/bdquery/z?d108:SN01015:|TOM:/bss/d108query.html. A summary of the Act can be found at www.ncsl.org/statefed/health/HR4793summary.pdf.

MosquitoZone – Information about community action can be found at www.mosquitozone.com/home. This site requires visitors to register before viewing all information.

Public Health Foundation – For insight to non-technical skills that may be required of the workforce, visit www.train.org. Click on the Core Competencies prompt and then scroll through the background documents found on the left side of the page. It is important to read the introduction in order to properly apply the skills described later in the document.

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APPENDIX A

Suggested Guidelines for Phased Response to West Nile Virus Surveillance Data*

Risk category	Probability of human outbreak	Definition	Recommended response
0	None	Off-season: adult vectors inactive; climate unsuitable.	Develop West Nile Virus response plan. Secure surveillance and control resources necessary to enable emergency response. Initiate community outreach and public education programs. Conduct audience research to develop/ target education & community involvement. Contact community partners.
1	Remote	Spring, summer, or fall: areas anticipating West Nile Virus (WNV) epizootic based on previous WNV activity in the region; no current surveillance findings indicating WNV epizootic activity in the area.	Response as in category 0, plus: conduct entomologic survey (inventory and map mosquito populations, monitor larval and adult mosquito density); initiate source reduction; use larvicides at specific sources identified by entomologic survey and targeted at likely amplifying and bridge vector species; maintain avian mortality, vector and virus surveillance; expand community outreach and public education programs focused on risk potential and personal protection, and emphasize residential source reduction; maintain surveillance (avian mortality, mosquito density/IR, human encephalitis/meningitis and equine illness).
2	Low	Summer, or fall: areas with limited or sporadic WNV epizootic activity in birds and/or mosquitoes. No positives prior to August.	Response as in category 1, plus: increase larval control, source reduction, and public education emphasizing personal protection measures, particularly among the elderly. Enhance human surveillance and activities to further quantify epizootic activity (e.g., mosquito trapping and testing). Implement adulticide applications if vector populations exceed locally established threshold levels, emphasizing areas where surveillance indicates potential for human risk to increase.
3	Moderate	Spring, summer, or fall: areas with initial confirmation of epizootic WNV in birds before August; a horse and/or a human case; or sustained WNV activity in birds and/or mosquitoes.	Response as in category 2, plus: intensify adult mosquito control in areas where surveillance indicates human risk; initiate adult mosquito control if not already in progress; initiate visible activities in community to increase attention to WNV transmission risk (speaker, social marketing efforts, community mobilization for source reduction, etc.);work with collaborators to reduce risks to elderly (e.g., screen repair).
4	High	Spring, summer, or fall: quantitative measures indicating WNV epizootic activity at a level suggesting high risk of human infection (*e.g.*, high dead bird densities), In early summer, sustained high mosquito infection rates, multiple positive mosquito species, horse or mammal cases indicating escalating epizootic transmission, or a human case and high levels of epizootic activity. Areas with early season positive surveillance indicators where WN epidemic activity has occurred in the past.	Response as in category 3, plus: expand public information program to include TV, radio, and newspapers (use of repellents, personal protection, continued source reduction, risk communication about adult mosquito control); increase visibility of public messages, engage key local partners (e.g., government officials, religious leaders) to speak about WNV; intensify and expand active surveillance for human cases; intensify adult mosquito control program, repeating applications in areas of high risk or human cases.
5	Outbreak in progress	Multiple confirmed cases in humans; conditions favoring continued transmission to humans (*e.g.*, persistent high infection rate in mosquitoes, continued avian mortality due to WNV).	Response as in category 4, plus: intensify emergency adult mosquito control program repeating applications as necessary to achieve adequate control. Enhance risk communication about adult mosquito control. Monitor efficacy of spraying on target mosquito populations. If outbreak is widespread and covers multiple jurisdictions, consider a coordinated widespread aerial adulticide application; emphasize urgency of personal protection through community leaders and media; and emphasize use of repellent at visible public events.

*Local and regional characteristics may alter the risk level at which specific actions must be taken.[*CDC. 2001. Epidemic/Epizootic West Nile Virus in the United States: Revised Guidelines for Surveillance, Prevention, and Control. Centers for Disease Control and Prevention, Public Health Service, Fort Collins, CO. Available at www.cdc.gov/ncidod/dvbid/westnile/resources/wnvguidelines2001.pdf.*]

APPENDIX B

Suggested Components for Bids or Contracts for a Mosquito Control Program

Governmental agencies may need to purchase mosquito control services from private vendors. The following reflects components that may be included in bid and/or contract specifications for a quality program and effective results. Any agency contracting for services should contact their agency attorney for guidance.

Description of Services

- ❑ Surveillance, mapping and monitoring of potential mosquito sites
- ❑ Monitoring and suppression of larval and adult populations
- ❑ Requirement to use Integrated Pest Management control methods and materials sanctioned for use by the United States Environmental Protection Agency, the Centers for Disease Control and Prevention, the U.S. Department of Agriculture, and the American Mosquito Control Association.
- ❑ Public outreach program including:
  - 24 hour phone line
  - 24 hour response/resolution timeline
  - printed materials and media advertisements
  - information presentations
  - advanced public notices of scheduled sprayings
  - provisions to exclude properties from being sprayed at owner's request
- ❑ Reports detailing all larviciding, trapping and adulticiding activities
- ❑ Reports of public outreach and citizen interaction activities
- ❑ Year end reports summarizing the season's results and activities with recommendations for the following year's program.
- ❑ Copies of all maps, records, logs, complaints and correspondence upon request.
- ❑ Description of proposed staffing levels
- ❑ Description and number of major equipment items
- ❑ Description of the activities, methods and materials to be used including:
  - Pesticides with EPA Establishment Number and Registration Numbers
  - Requirement to use pesticides consistent with FIFRA (Federal Insecticide, Fungicide and Rodenticide Act)
  - Application rate
  - Acreage to be covered
  - Times of coverage
  - Details of reporting
  - Need for neighborhood notification
  - Hotline, if necessary. Or 24 hour local customer access telephone number for complaints and information.
  - Monitoring data
  - Time lines, including whether contract is multi-year, due dates, etc.
  - Methods used for surveillance
  - Control methods
  - Evaluation plan
  - Access to real time surveillance, mapping, and control data, including maps
  - Access to contractor personnel during regular hours and after-hours emergency access
  - Standards for resolution of complaints, e.g. 24 hour

Description of Contractor

- ❑ Name and address of company or corporation with notarized signature page
- ❑ Name of designated contact person with contact information
- ❑ Names and addresses of the principal employees or officers with description of their qualifications
- ❑ Proof of licenses and certificates required for services
- ❑ Proof of insurance, bonds or other surety
- ❑ Indemnifications of governmental agency
- ❑ Training and certification of employees
- ❑ List of references

Financial Arrangements

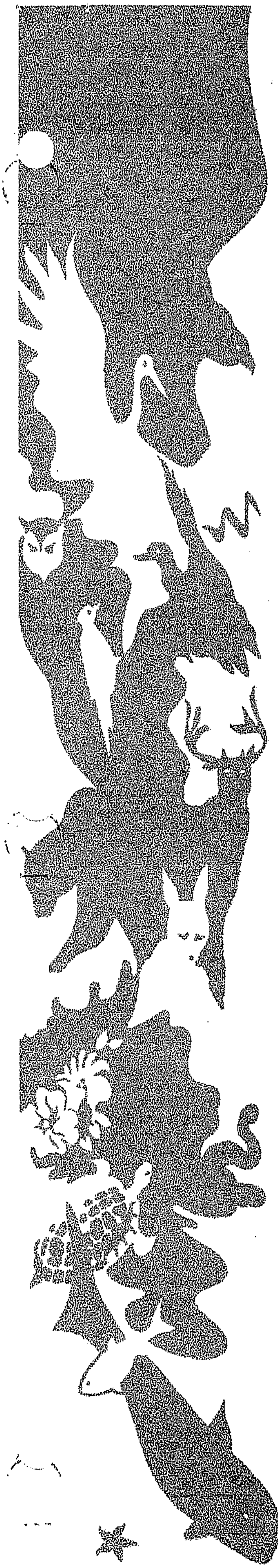
- ❑ Payment, terms of payment, cost of per acre (if applicable), larviciding per basin or drain, larval site inspection services, surveillance cost per trap per night
- ❑ Assurance that all goods are free of all liens, encumbrances and security interests
- ❑ Warranties of any equipment to run to contracting agency and its successors
- ❑ Contract subject to availability of funding

Responsibilities of Governmental Agency

- ❑ Terms of bid opening and date and time of submission
- ❑ Activities to be performed by governmental staff
- ❑ Payments will be paid for all goods and services 30 days after receipt of services
- ❑ Staff contact with phone numbers and address
- ❑ Provision for extension or expansion of services
- ❑ Circumstances justifying cancellation of agreement

Standard Contract Items

- ❑ Equal Employment Opportunity assurance
- ❑ Workers Compensation
- ❑ Comprehensive general liability insurance and automobile insurance



United States
Environmental Protection
Agency

March 2000

Pesticides And Toxic Substances (H-7506C)

Protecting Endangered Species

Interim Measures for Use of Pesticides in Napa County

The federal Endangered Species Act is intended to protect and promote the recovery of animals and plants that are in danger of becoming extinct due to human activities. Under the Act, the U.S. Environmental Protection Agency (U.S. EPA) must ensure that the use of pesticides it registers will not result in harm to the species listed as endangered or threatened by the U.S. Fish and Wildlife Service, or to habitat critical to those species' survival. This program will protect endangered and threatened species from harm due to pesticide use.

The information provided in this bulletin is similar to what U.S. EPA expects to distribute once the Endangered Species Protection Program is in effect. Individuals who use pesticides during this interim period are not legally required to comply with these suggested measures. At the present time, compliance with the requirements specified on the pesticide product labeling will satisfy all legal requirements regarding pesticides and endangered species protection. While these pesticide use conditions do not yet have the force of law, they are being provided now for your use in voluntarily protecting endangered and threatened species.

Your comments are needed regarding the information presented in this publication. Please contact us to let us know whether the information is clear and correct. Also tell us to what extent following the recommended measures would affect your pesticide use program. This information will be considered by U.S. EPA during the final stages of program development.

Please submit comments to:
DPR Pesticide Registration Branch
830 K Street
Sacramento, CA 95814
(916) 324-3881
rmarovich@cdpr.ca.gov
http://www.cdpr.ca.gov/docs/es/index.htm

About This Publication

This publication contains a map of the county including a shaded area where pesticide use should be limited to protect listed species. In the Section List, you will find additional information on the individual species that occur in each section, indexed by county, township, range and section.

The Species Descriptions table lists the taxonomic groups for each species. The Active Ingredients tables list certain pesticides and the activity category (mode of action, etc.) of the pesticide and the taxonomic groups they could adversely affect. The use limitations in this bulletin apply only to listed pesticides where the hazard class of the pesticide matches the hazard class (sensitivity of the taxonomic group) of the species that occur in the section where the pesticide will be used. Within a given section, use limitations only apply to sites that are consistent with habitat as noted in the Species Descriptions table. The Use Limitation Codes table indicates which use limitation codes apply to each species. The Use Limitations table translates limitation codes to use limitations.

Does This Information Apply To You?

To determine whether this information applies to your use of a pesticide, review the questions below. The information applies only if you answer "yes" to all three of these questions:

- Do you intend to use pesticides within the shaded area on the map (p 3) that is further detailed in the Section List (p 40)? If so, note the species from the Section List.
- Are any of the ingredients included in your pesticide product named in the Active Ingredients tables (p 7, 14, 18, 21, 24)?
- If so, does the hazard class(es) of the pesticide you intend to use match one or more of the taxonomic groups of the species as shown in the Species Descriptions table (p 31)?

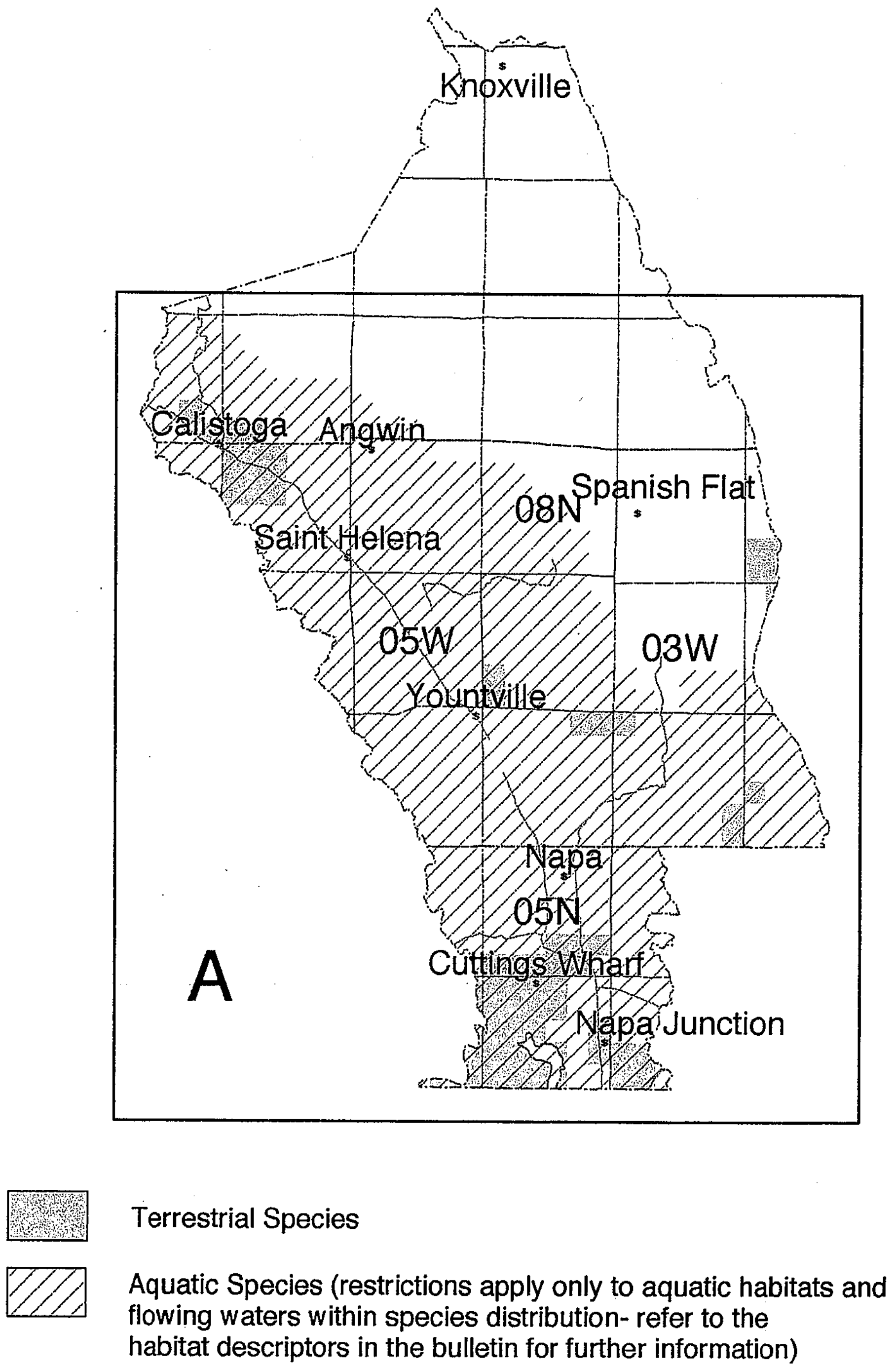
If you answer "yes" to all three questions, you should follow the instructions on "How to Use This Information" (p 2) to help protect listed species.

If you answer "no" to any of the above questions, this bulletin does not apply to you.

How to Use This Information

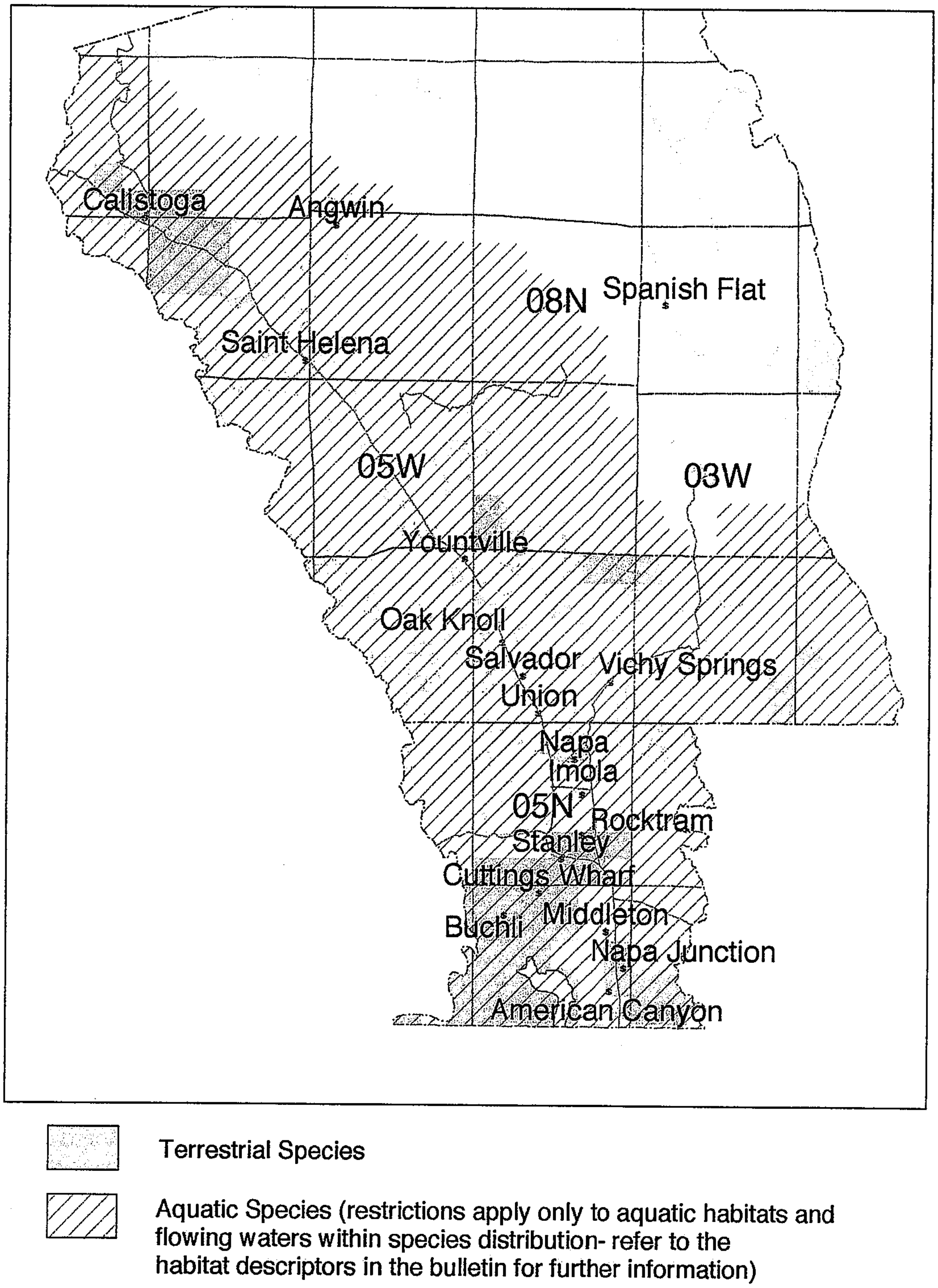
See worksheets for each class of pesticide that you intend to use:

Distribution of Species Addressed in This Bulletin



Overview Map

Distribution of Species Addressed in This Bulletin



Detail Map A

Worksheet for Herbicides

For each section where you will apply herbicides:

1. Is the section inside of the shaded area on the county map (p 3)? Yes ( ) No ( )
   (if yes, or if you are unsure go on to #2, if no, this bulletin does not apply)

2. Is the section listed in the Section List (p 40)? Yes ( ) No ( )
   (if yes, go on to #3, if no, this bulletin does not apply)

3. Is the active ingredient of the herbicide(s) you intend to use listed in the Active Ingredients table (p 7-10)?
   (if yes, go on to #4, if no, this bulletin does not apply) Yes ( ) No ( )

4. For each active ingredient, note the hazard class and activity category (from the Active Ingredients table).

herbicide active ingredient(s) (list each)	Hazard Class (check all that apply)			Activity Category (check one)				
	AQ	PD	PM	a	b	c	d	e
________________	( )	( )	( )	( )	( )	( )	( )	( )
________________	( )	( )	( )	( )	( )	( )	( )	( )
________________	( )	( )	( )	( )	( )	( )	( )	( )
________________	( )	( )	( )	( )	( )	( )	( )	( )
________________	( )	( )	( )	( )	( )	( )	( )	( )

5. For each species in the section to be treated, look up the hazard class (taxonomic group) in the Species Descriptions table (p 31) and check all that apply.

AQ	PD	PM
( )	( )	( )

6. Does one or more hazard class(es) of the herbicide(s) from #4 match the hazard class (taxonomic group) for any of the species from #5? (if yes to any, go on to #7, if no, this bulletin does not apply) Yes ( ) No ( )

7. Look up the use limitation codes by hazard class and activity category in the Use Limitation Codes table in this section for each pesticide that you intend to use and check all use limitation codes that apply.

Limitation Codes

11 ( ) 15 ( ) 16 ( ) 17 ( ) 19 ( )

8. Follow the use limitations corresponding to each code as shown in the Use Limitations table (p 26). If more than one code applies and there is a conflict, follow the most restrictive limitation. Note that use limits apply only to sites that that match or (where buffer zones apply) are adjacent to sites that match the habitat descriptions in the Species Descriptions table (p 31) for each species.

Active Ingredients Tables

Active ingredients of pesticides covered by this bulletin are listed in separate tables on the following pages by classification as herbicides, insecticides, fungicides or rodenticides. The active ingredients table for each pesticide class specifies the activity category of each active ingredient and one or more hazard classes that are subsequently used to determine appropriate pesticide use limitations.

Herbicide Exposure Categories

Herbicides are grouped by activity categories (a-e) that broadly define mode of action and use patterns that in turn determine potential routes of exposure to listed species. The activity category of an herbicide is the exposure component that is used with the hazard class of the pesticide and the taxonomic group of the species to define which pesticide use limitations (if any) to apply.

Activity Category	Description
a	Broad spectrum foliar active herbicides with systemic or contact activity and without pre-emergent or residual soil activity.
b	Herbicides with foliar activity on broadleaved plants (dicots) only.
c	Herbicides with foliar activity on grasses (monocots) only.
d	Broad spectrum herbicides with residual soil activity.
e	Broad spectrum, seedling stage, pre-emergent herbicides.

Active Ingredients (Herbicides)

Active Ingredients	Activity Category	Hazard Class		
		Aquatic Animals (AQ)	Plants	
			Dicot (PD)	Monocot* (PM)
2,4-D	b		X	
2,4-D, butoxyethanol ester	b		X	
2,4-D, dimethylamine salt	b		X	
2-(2,4-DP), dimethylamine salt	b		X	
4(2,4-DB), dimethylamine salt	b		X	
alachlor	d		X	X
atrazine	d		X	X
benefin	e	X	X	X
bensulfuron methyl	d		X	X
bensulide	d		X	X
bentazon, sodium salt	a		X	X
bromacil	d		X	X
bromoxynil	a	X	X	X
butylate	d		X	X
cacodylic acid	a		X	X
carfentrazon-ethyl	a		X	X
chlorsulfuron	d		X	
chlorthal-dimethyl	e		X	X
clethodim	c			X
clopyralid	b		X	
copper	a	X		
copper ethanolamine complex	a	X		

* and gymnosperms

Active Ingredients (Herbicides)

Active Ingredients	Activity Category	Hazard Class		
			Plants	
		Aquatic Animals	Dicot	Monocot*
copper sulfate (basic)	a	X		
copper sulfate pentahydrate	a	X		
cyanazine	d		X	X
cycloate	d		X	X
desmedipham	e		X	X
dicamba, dimethylamine salt	b		X	
dichlobenil	d		X	X
diclofop-methyl	c	X		X
difenzoquat methyl sulfate	a			X
diquat dibromide	a		X	X
dithiopyr	d	X	X	X
diuron	d		X	X
endothall, dipotassium salt	d		X	X
endothall, mono [N,N-dimethyl alkylamine] salt	d		X	X
EPTC	d		X	X
ethafluralin	e	X	X	X
ethofumesate	d		X	X
fenoxaprop	c			X
fluazifop-butyl	c			X
glufosinate	a		X	X
halosulfuron	d		X	X
imazethapyr	d		X	X
isoxaben	d		X	X

* and gymnosperms

Active Ingredients (Herbicides)

Active Ingredients	Activity Category	Hazard Class		
			Plants	
		Aquatic Animals (AQ)	Dicot (PD)	Monocot* (PM)
glyphosate, isopropylamine salt	a		X	X
glyphosate, monoammonium salt	a		X	X
hexazinone	d		X	X
imazapyr	d		X	X
linuron	d		X	X
MCPA, dimethylamine salt	b		X	
MCPP, dimethylamine salt	b		X	
metalochlor	d		X	X
metam-sodium	d	X	X	X
metribuzin	d		X	X
molinate	d		X	X
MSMA	a		X	X
napropamide	d		X	X
nicosulfuron	a		X	X
nonanoic acid	a		X	X
norflurazon	d		X	X
oryzalin	e		X	X
oxadiazon	e	X	X	X
oxyfluorfen	e	X	X	X
paraquat dichloride	a		X	X
pebulate	e		X	X

* and gymnosperms

Active Ingredients (Herbicides)

Active Ingredients	Activity Category	Hazard Class: Aquatic Animals (AQ)	Plants: Dicot (PD)	Plants: Monocot* (PM)
pendimethalin	e	X	X	X
petroleum hydrocarbons	a		X	X
petroleum oil, unclassified	a		X	X
phenmedipham	b		X	
prometon	d		X	X
prometryn	d		X	
pronamide	d		X	X
propanil	a		X	X
pyrazon	d		X	X
pyrithiobac	b		X	
rimsulfuron	d		X	X
sethoxydim	c			X
simazine	d		X	X
sulfometuron, methyl	d		X	X
tebuthiuron	d		X	X
thiazopyr	d		X	X
thiobencarb	a		X	X
triclopyr, butoxyethyl ester	b		X	
triclopyr, triethylamine salt	b		X	
trifluralin	e	X	X	X

* and gymnosperms

Limitation Codes (Herbicides)

The following table identifies use limitation codes for each combination of hazard class (AQ, PM or PD) and herbicide activity category (a-e). Use the hazard class row(s) that corresponds with both (1) the pesticide (from the Active Ingredients table) and (2) the hazard class (taxonomic group) of the species in the section to be treated (as found in the Species Descriptions table) and the activity category column(s) that corresponds with the herbicide(s) you intend to use. If either (1) the hazard class (taxonomic group) of one or more species does not match at least one of the hazard class(es) of the herbicide you intend to use or (2) if the combination of activity category and hazard class results in a double dash (- -), then no use limitations apply. Note all applicable codes (11-19). These codes are translated in the Use Limitations table (p 26)

Hazard Class	Herbicide Activity Category				
	a	b	c	d	e
AQ	11, 17	11, 17	11, 17	11, 15, 16, 17	11, 17
PM	11, 17	- -	11, 17	11, 16, 17, 19	11
PD	11, 17	11, 17	- -	11, 16, 17, 19	11

Worksheet for Insecticides

For each section where you will apply insecticides:

1. Is the section inside of the shaded area on the county map (p 3)? Yes ( ) No ( )
   (if yes, or if you are unsure go on to #2, if no, this bulletin does not apply)

2. Is the section listed in the Section List (p40)? Yes ( ) No ( )
   (if yes, go on to #3, if no, this bulletin does not apply)

3. Is the active ingredient of the insecticide(s) you intend to use listed in the Active Ingredients table (p 14-15)?
   (if yes, go on to #4, if no, this bulletin does not apply) Yes ( ) No ( )

4. For each active ingredient, note the hazard class and activity category (from the Active Ingredients table).

insecticide active ingredient(s) (list each)	Hazard Class (check all that apply)				Activity Category
	AQ	AV	IN	PD	i
________________	( )	( )	( )	( )	(x)
________________	( )	( )	( )	( )	(x)
________________	( )	( )	( )	( )	(x)
________________	( )	( )	( )	( )	(x)
________________	( )	( )	( )	( )	(x)

5. For each species in the section to be treated, look up the hazard class (taxonomic group) in the Species Descriptions table (p 31) and check all that apply.

AQ	AV	IN	PD
( )	( )	( )	( )

6. Does one or more toxicity class of the insecticide(s) from #4 match the hazard class (taxonomic group) for any of the species from #5? (if yes to any, go on to #7, if no, this bulletin does not apply) Yes ( ) No ( )

7. Look up the use limitation codes by hazard class and activity category in the Use Limitation Codes table in this section for each insecticide that you intend to use and check all use limitation codes that apply.

Limitation Codes

10 ( ) 15 ( ) 16 ( ) 17 ( )

8. Follow the use limitations corresponding to each code as shown in the Use Limitations table (p 26).
   If more than one code applies and there is a conflict, follow the most restrictive limitation. Note that use limits apply only to sites that that match or (where buffer zones apply) are adjacent to sites that match the habitat descriptions in the Species Descriptions table (p 31) for each species.

Activity Categories of Insecticides

There is currently only one activity category for insecticides.

Activity Category	Description
i	Insecticides applied by any method

Active Ingredients (Insecticides)

Active Ingredients	Activity Category	Hazard Class			
		Aquatic (AQ)	Avian (AV)	Insects (IN)	Plants-Dicot* (PD)
acephate	i			X	X
aldicarb	i	X	X		
amitraz	i	X		X	
avermectin	i	X		X	X
azinphos-methyl	i	X	X	X	X
Bacillus thuringiensis	i			X**	
bendiocarb	i	X	X	X	X
bifenthrin	i	X		X	X
buprofezin	i	X		X	X
carbaryl	i	X		X	X***
carbofuran	i	X	X	X	X
carbophenothion	i	X	X	X	X
chlorfenapyr	i	X		X	X
chlorpyrifos	i	X	X	X	X
cyfluthrin	i	X		X	X
cypermethrin	i	X		X	X
cyromazine	i			X	X
diazinon	i	X	X	X	X
dicofol	i	X	X	X	X
dicrotophos	i	X	X	X	X
diflubenzuron	i	X	X	X	
disulfoton	i	X	X	X	X
endosulfan	i	X	X	X	X
esfenvalerate	i	X		X	X
ethion	i	X		X	
ethoprop	i	X	X	X	X
fenitrothion	i	X	X	X	X

* Non-granular formulations, only when in bloom, to avoid possible adverse impacts on pollination.
** Different strains of Bacillus thuringiensis are selective for different insects. Most strains target Lepidopterous pests only. See your county agricultural commissioner for details.
*** Except XLR formulation.

Active Ingredients (Insecticides)

Active Ingredients	Activity Category	Hazard Class			
		Aquatic (AQ)	Avian (AV)	Insects (IN)	Plants-Dicot* (PD)
fenpropathrin	i	X		X	X
fenthion (livestock use)	i	X	X		
fenvalerate	i	X		X	X
fluvalinate	i	X		X	X
fonofos	i	X	X	X	X
imidacloprid	i			X	X
malathion	i	X		X	X
methamidophos	i		X	X	X
methidathion	i	X	X	X	X
methiocarb	i		X		X
methomyl	i	X	X	X	X
methyl parathion	i	X	X	X	X
mevinphos	i	X	X		X
naled	i	X		X	X
oxamyl	i	X	X	X	X
oxydemeton-methyl	i	X	X	X	X
parathion	i	X	X	X	X
permethrin	i	X		X	X
phorate	i	X	X	X	X
phosmet	i	X		X	X
profenphos	i	X		X	X
propargite	i	X		X	
pyrethrin	i	X		X	X
pyriproxyfen	i	X		X	
spinosad	i			X	X
tebufenozide	i	X		X	X
temephos	i	X	X	X	X
terbufos	i	X	X	X	X
thiodicarb (1)	i	X		X	X
tralomethrin (1)	i	X		X	X
trichlorfon (2)	i	X		X	

Use Limitation Codes for Insecticides

The following table identifies use limitation codes for each combination of toxicity class (AQ, AV or IN) and activity category (i). Use the hazard class row that corresponds with the taxonomic group(s) of species in the section to be treated. Note all applicable codes (11-17). The double dash (- -) indicates that no use limitations apply. These codes are translated in the Use Limitations table (p 26).

Hazard Class	Insecticide Activity Category
	i
AQ	10, 15, 16, 17
AV	10, 17
IN	10, 17
PD	10

Worksheet for Fungicides

For each section where you will apply fungicides:

1. Is the section inside of the shaded area on the county map (p 3)? Yes ( ) No ( )
   (if yes, or if you are unsure go on to #2, if no, this bulletin does not apply)

2. Is the section listed in the Section List (p 40)? Yes ( ) No ( )
   (if yes, go on to #3, if no, this bulletin does not apply)

3. Is the active ingredient of the fungicide(s) you intend to use listed in the Active Ingredients table (p 18)?
   (if yes, go on to #4, if no, this bulletin does not apply) Yes ( ) No ( )

4. For each active ingredient, note the hazard class and activity category (from the Active Ingredients table).

fungicide active ingredient(s) (list each)	Hazard Class	Activity Category
	AQ	f
________________	(x)	(x)
________________	(x)	(x)
________________	(x)	(x)
________________	(x)	(x)
________________	(x)	(x)

5. For each species in the section to be treated, look up the hazard class (taxonomic group) in the Species Descriptions table (p 31) and check all that apply.

   AQ
   (x)

6. Does one or more hazard class of the fungicide(s) from #4 match the hazard class (taxonomic group) for any of the species from #5? (if yes to any, go on to #7, if no, this bulletin does not apply)
   Yes ( ) No ( )

7. Look up the use limitation codes by hazard class and activity category in the Use Limitation Codes table in this section for each fungicide that you intend to use and check all use limitation codes that apply.

   Limitation Codes

   10 (x) 15 (x) 16 (x) 17 (x)

8. Follow the use limitations corresponding to each code as shown in the Use Limitations table (p 26). If more than one code applies and there is a conflict, follow the most restrictive limitation. Note that use limits apply only to sites that that match or (where buffer zones apply) are adjacent to sites that match the habitat descriptions in the Species Descriptions (p 31) table for each species.

Active Ingredients (Fungicides)

Active Ingredients	Activity Category	Hazard Class Aquatic (AQ)
Azoxystrobin	f	X
Benomyl	f	X
Captan	f	X
Carboxin	f	X
Chlorothalonil	f	X
Copper	f	X
Copper Ammonium Carbonate	f	X
Copper Ammonium Complex	f	X
Copper Hydroxide	f	X
Copper Octanoate	f	X
Copper Oxychloride	f	X
Copper Oxychloride Sulfate	f	X
Copper Salts of Fatty and Rosin Acids	f	X
Copper Sulfate (Basic)	f	X
Copper Sulfate (Pentahydrate)	f	X
Dazomet	f	X
Difenoconazole	f	X
Dimethomorph	f	X
Fenbuconazole	f	X
Fludioxonil	f	X
Mancozeb	f	X
Maneb	f	X
Manganese Sulfate	f	X
Oxythioquinox	f	X
PCNB	f	X
Piperalin	f	X
Propiconazole	f	X
Tebuconazole	f	X
Thiabendazole	f	X
Thiram	f	X
Triflumizole	f	X
Ziram	f	X
Zineb	f	X

Use Limitation Codes for Fungicides

The following table identifies use limitation codes for the hazard class (AQ) and fungicide activity category (f). Note all applicable codes (10-17). These codes are translated on page 26.

Hazard Class	Fungicide Activity Category
	f
AQ	10, 15, 16, 17

Worksheet for Grain Bait Rodenticides

For each section where you will apply grain bait rodenticides:

1. Is the section inside of the shaded area on the county map (p 3)? Yes ( ) No ( )
   (if yes, or if you are unsure go on to #2, if no, this bulletin does not apply)

2. Is the section listed in the Section List (p 40)? Yes ( ) No ( )
   (if yes, go on to #3, if no, this bulletin does not apply)

3. Is the active ingredient of the pesticide(s) you intend to use listed in the Active Ingredients table (p 21)?
   (if yes, go on to #4, if no, this bulletin does not apply) Yes ( ) No ( )

4. For each active ingredient, note the hazard class and activity category (from the Active Ingredients table).

Rodenticide active ingredient(s) (list each)	Hazard Class							Activity Category		
	BB	CB	GB	HM	KF	KR	LH	g	h	k
__________	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
__________	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
__________	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
__________	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )
__________	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )

5. For each species in the section to be treated, look up the hazard class (taxonomic group) in the Species Descriptions table (p 31) and check all that apply.

BB	CB	GB	HM	KF	KR	LH
( )	( )	( )	( )	( )	( )	( )

6. Does one or more hazard class of the pesticide(s) from #4 match the hazard class (taxonomic group) for any of the species from #5? (if yes to any, go on to #7, if no, this bulletin does not apply) Yes ( ) No ( )

7. Look up the use limitation codes by hazard class and activity category in the Use Limitation Codes table in this section for each pesticide that you intend to use and check all use limitation codes that apply.

Limitation Codes

1A ( )	1B ( )	1C ( )	1D ( )	2 ( )	3 ( )
4 ( )	7 ( )	8 ( )	33 ( )	34 ( )	

8. Follow the use limitations corresponding to each code as shown in the Use Limitations table (p 26). If more than one code applies and there is a conflict, follow the most restrictive limitation. Note that use limits apply only to sites that that match or (where buffer zones apply) are adjacent to sites that match the habitat descriptions in the Species Descriptions table (page 31) for each species.

Active Ingredients (Rodenticides)

Active Ingredients	Activity Category	Hazard Class						
		Bait Box (BB)	Carni-vorous Birds (CB)	Grani-vorous Birds (GB)	Salt Marsh Harvest Mouse (HM)	Kit Fox (KF)	Kangaroo Rats (KR)	Very Limited Habitat (LH)
Brodifacoum	k	X	X	X	X	X	X	X
Bromadiolone	k	X	X	X	X	X	X	X
Bromethalin	k	X	X	X	X	X	X	X
Chlorophacinone	g	X	X	X	X	X	X	X
Difenacoum	k	X	X	X	X	X	X	X
Difethialone	k	X	X	X	X	X	X	X
Diphacinone	g	X	X	X	X	X	X	X
Pival	k	X	X	X	X	X	X	X
Vitamin D3	k	X	X	X	X	X	X	X
Warfarin	k	X	X	X	X	X	X	X
Zinc Phosphide	h	X	X	X	X	X	X	X

Activity Categories of Grain Bait Rodenticides

Activity Category	Description
g	Field use chronic toxicant grain bait
h	Field use acute toxicant grain bait
k	Structural use rodenticide

Use Limitation Codes for Rodenticide Grain Baits

The following table identifies use limitation codes for each combination of hazard class (BB, CB, etc.) and rodenticide activity category (g-k). Use the row(s) that corresponds with the hazard class (taxonomic group) of the species in the section to be treated and the rodenticide activity column(s) that corresponds with the rodenticide(s) you intend to use. Note all applicable codes (1-34). The double dash (- -) indicates that no use limitations apply. These codes are translated in the Use Limitations table (p 26)

Hazard Class	Rodenticide Grain Bait Activity Category		
	g	h	k
BB	7	7	7
CB	1D	- -	7
GB	1B, 1C	1B, 1C	7
HM	7 or 34	7 or 34	7
KF	1, 2, 3, 4	3	7
KR	8	8	7
LH	33	33	33

Worksheet for Fumigant Rodenticides

For each section where you will apply fumigant rodenticides:

1. Is the section inside of the shaded area on the county map (p 3)? Yes ( ) No ( )
   (if yes, or if you are unsure go on to #2, if no, this bulletin does not apply)

2. Is the section listed in the Section List (p 40)? Yes ( ) No ( )
   (if yes, go on to #3, if no, this bulletin does not apply)

3. Is the active ingredient of the pesticide(s) you intend to use listed in the Active Ingredients table (p 24)?
   (if yes, go on to #4, if no, this bulletin does not apply) Yes ( ) No ( )

4. For each active ingredient, note the hazard class and activity category (from the Active Ingredients table).

Rodenticide active ingredient(s) (list each)	Hazard Class					Activity Category
	S1	S2	LH	WW	HR	j
____________________	(x)	(x)	(x)	(x)	(x)	(x)
____________________	(x)	(x)	(x)	(x)	(x)	(x)
____________________	(x)	(x)	(x)	(x)	(x)	(x)
____________________	(x)	(x)	(x)	(x)	(x)	(x)
____________________	(x)	(x)	(x)	(x)	(x)	(x)

5. For each species in the section to be treated, look up the hazard class (taxonomic group) in the Species Descriptions table (p 31) and check all that apply.

S1	S2	LH	WW	FS
( )	( )	( )	( )	( )

6. Does one or more hazard class of the pesticide(s) from #4 match the hazard class (taxonomic group) for any of the species from #5? (if yes to any, go on to #7, if no, this bulletin does not apply) Yes ( ) No ( )

7. Look up the use limitation codes by hazard class and activity category in the Use Limitation Codes table in this section for each pesticide that you intend to use and check all use limitation codes that apply.

Limitation Codes

5 ( ) 30 ( ) 31 ( ) 32 ( ) 33 ( )

8. Follow the use limitations corresponding to each code as shown in the Use Limitations table (p 26). If more than one code applies and there is a conflict, follow the most restrictive limitation. Note that use limits apply only to sites that that match or (where buffer zones apply) are adjacent to sites that match the habitat descriptions in the Species Descriptions table (p 31) for each species.

Active Ingredients (Rodenticides - Burrow Fumigants)

Active Ingredients	Activity Category	Hazard Class				
		Seasonal Limitation 1 (S1)	Seasonal Limitation 2 (S2)	Limited Habitat (LH)	Waterways (WW)	Fossorial (Burrowing) Species (FS)
Acrolein	j	X	X	X	X	X
Aluminum phosphide	j	X	X	X	X	X
Magnesium phosphide	j	X	X	X	X	X
Sodium Nitrate	j	X	X	X	X	X
Potassium Nitrate	j	X	X	X	X	X

Activity Categories of Burrow Fumigant Rodenticides

Activity Category	Description
j	Burrow Fumigants

Use Limitation Codes for Fumigant Rodenticides

The following table identifies use limitation codes for each combination of hazard class (S1, S2, etc.) and fumigant rodenticide activity category (j). Use the hazard class row(s) that corresponds with the hazard class of the species (taxonomic group) in the section to be treated and the herbicide activity column(s) that corresponds with the fumigant(s) you intend to use. Note all applicable codes (5-32). These codes are translated in the Use Limitations table (p 26).

Hazard Class	Fumigant Rodenticide Activity Category
	j
S1	31, 5
S2	32, 5
LH	33
WW	30
FS	5

Use Limitations

1A	**Bait station applications:** *Formulation:* The active ingredient shall not exceed 0.005% in the formulated bait.
1B	*Bait Station Design and Use:* Bait stations shall be designed with an opening that prevents access to non-target species (not to exceed 3") and controls bait spillage by feeding rodents. See your county agricultural commissioner for recommended designs and suggestions to retrofit existing stations. Bait stations shall be secured (e.g. staked) upright to prevent tipping and access by non-target animals. Bait stations shall not be filled beyond design capacity and in no case shall bait stations be filled with more than 10 lbs of bait.
1C	*Station Monitoring:* While treated baits are in use, bait stations shall be inspected for spillage, evidence of disturbance by non-target animals, excess moisture from irrigation systems, etc. Problems shall be corrected before baiting is resumed. Any spilled baits shall be promptly cleaned up (scattering limitied quantities of spilled bait in non-crop areas is acceptable if allowed by labeling). Bait stations shall be replenished with treated baits as needed to provide continuous exposure. After treated baits are accepted, as evidenced by consumption of baits, depletion of bait in the bait station shall be inspected at least weekly for depletion of bait and refilled until feeding ceases. Treated baits shall be promptly removed (or bait stations shall be sealed) from all stations after feeding has ceased. If subsequent baiting is needed, a two week period without use of treated baits shall be observed before baiting is resumed. This is to keep the period when treated bait is exposed to a minimum without jeopardizing good pest control.
1D	*Carcass Survey and Disposal:* Carcass survey and disposal shall be performed in the treated area beginning on the third day following the initial exposure of toxic baits. Any exposed carcasses shall be disposed of (e.g., completely buried) in a manner inaccessible to wildlife. Carcass surveys shall continue for at least 5 days after toxic baiting has ceased and thereafter until no more carcasses are found. Carcasses should be handled with care to avoid contact with parasites such as fleas.
1E	*Pre-baiting (optional):* Pre-baiting of bait stations with non-toxic (untreated) grains such as oats, oat groats or barley is optional, but may reduce the time period for carcass surveys. Pre-baiting will acclimate the pest species to feed in bait stations and should be continued until most of the target population is feeding from the stations. The period of toxic bait exposure may be shortened as will the period when pest carcasses may be exposed. The untreated grain need not be the same as the treated grain, but milo or cracked corn **should be strictly avoided** due to their attractiveness to birds.

Use Limitations

2A	**Broadcast (mechanical) and spot (hand) applications** ***Formulation:*** The active ingredient shall not exceed 0.01% in the formulated bait.
2B	***Test Baiting/Bait Acceptance***: Prior to the main application of toxic baits by spot or broadcast method, a small amount of the bait shall be applied to determine bait accep-tance Test baits shall be broadcast by the same method that will be used for control baiting.
2C	***Use of Treated Baits***: Use of treated baits shall begin only when bait acceptance is confirmed by consumption of test baits. Piling of baits shall be avoided. No addi-tional applications shall be made whenever significant quantities of previously applied bait remain. Do not place baits directly into burrows. Do not exceed label application rates. **Spot Baiting** - Scatter a handful of bait (about 10 handfulls per pound) evenly over 40 to 50 square feet near active burrows or runways. Repeat every other day until feeding ceases. **Mechanical Spreader** - Apply at the rate of 10 pounds per swath acre through infested area. Follow with a second application in 2 to 3 days.
2D	***Carcass Survey and Disposal:*** See Limitation Code 1D.
3	Use of pelletized formulations for control of ground squirrels is prohibited, except in bait stations as described in Limitation Code 1 (A, B, C, E).
4	Jackrabbits may be controlled by using self-dispensing bait stations provided that: Bait acceptance is first determined. Carcasses are removed and stations are monitored as described in Limitation Codes 1C and 1D respectively. Baiting ceases when feeding stops. Baits are placed only where jackrabbits are active. Use of pelletized baits is prohibited.

Use Limitations

5	Use shall be supervised by a person (wildlife biologist, county agricultural commissioner, university extension advisor,state or federal official or others)who is trained to distinguish dens and burrows of target species from those of non-target species. Use shall occur only in the active burrows of target species. The person responsible for supervision shall be aware of the conditions at the site of application and be available to direct and control the manner in which applications are made (per Section 6406 of Title 3, California Code of Regulations). Contact your county agricultural commissioner for information on training.
7	For commensal rodent control, outdoor use must be in tamper resistant bait boxes placed in areas inaccessible to wildlife.
8	Use is prohibited EXCEPT under any ONE of the following conditions (in all cases where toxic baits are applied, any spilled baits shall be immediately removed or buried to prevent exposure to non-target species): For commensal rodent control, outdoor use must be in tamper resistant bait boxes placed in areas inaccessible to wildlife. An approved bait station (see yourcounty agricultural commissioner for approved designs) is used that is fitted with an entrance that provides selective access to pest species but does not allow access to kangaroo rats, OR Bait is placed only in bait stations that are elevated to preclude exposure to kangaroo rats, and designed to prevent spillage by rodents feeding (see your county agricultural commissioner for specifications), OR Baits are placed in bait stationsduring daylight hours only and are removed (or entrances are closed) by dusk each day, OR Broadcast application of baits is allowed in fields under active cultivation with the maintenance of a 10 yard wide border of untreated crops where fields are adjacent to areas of natural vegetation. For purposes of this provision, fields under active cultivation means fields that have been tilled within the last one year or that such fields are irrigated by furrow, flood or overlapping sprinkler method.
10	Do not use in currently occupied habitat (see Species Descriptions table for possible exceptions).

Use Limitations

Code	Limitation
11	Do not use in currently occupied habitat except: (1) as specified in Habitat Descriptors, (2) in organized habitat recovery programs, or (3) for selective control of invasive exotic plants.
15	Provide a 20 foot minimum strip of vegetation (on which pesticides should not be applied) along rivers, creeks, streams, wetlands, vernal pools and stock ponds or on the downhill side of fields where run-off could occur. Prepare land around fields to contain run-off by proper leveling, etc. Contain as much water "on-site" as possible. The planting of legumes, or other cover crops for several rows adjacent to off-target water sites is recommended. Mix pesticides in areas not prone to run-off such as concrete mixing/loading pads, disked soil in flat terrain or graveled mix pads, or use a suitable method to contain spills and/or rinsate. Properly empty and triple-rinse pesticide containers at time of use.
16	Conduct irrigations efficiently to prevent excessive loss of irrigation waters through run-off. Schedule irrigations and pesticide applications to maximize the interval of time between the pesticide application and the first subsequent irrigation. Allow at least 24 hours between application of pesticides listed in this bulletin and any irrigation that results in surface run-off into natural waters. Time applications to allow sprays to dry prior to rain or sprinkler irrigations. Do not make aerial applications while irrigation water is on the field unless surface run-off is contained for 72 hours following the application.
17	For sprayable or dust formulations: when the air is calm or moving away from habitat, commence applications on the side nearest the habitat and proceed away from the habitat. When air currents are moving toward habitat, do not make applications within 200 yards by air or 40 yards by ground upwind from occupied habitat. The county agricultural commissioner may reduce or waive buffer zones following a site inspection, if there is an adequate hedgerow, windbreak, riparian corridor or other physical barrier that substantially reduces the probability of drift.
19	Do not apply within 30 yards upslope of habitat unless a suitable method is used to contain or divert runoff waters.

Species Descriptions

CALIFORNIA CLAPPER RAIL

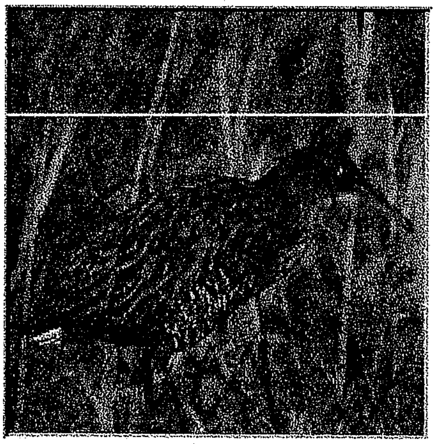


Photo: B. Elliot, CDFG

Scientific Name: *RALLUS LONGIROSTRIS OBSOLETUS*

Federal Status: Endangered

Species Description:

A secretive olive-brown bird with dark brown streaks, a cinnamon-colored breast, black & white bars on its flanks that stands about 14 to 16.5 inches tall with a wingspread of about 20 inches. It is compact with a short neck and long curved beak.

Habitat Description:

ASSOCIATED WITH ABUNDANT GROWTHS OF PICKLEWEED, BUT FEEDS AWAY FROM COVER ON INVERTEBRATES FROM MUD-BOTTOMED SLOUGHS. SALT-WATER & BRACKISH MARSHES TRAVERSED BY TIDAL SLOUGHS IN THE VICINITY OF SAN FRANCISCO BAY.

Hazard Class: **AQ, AV**

CALIFORNIA FRESHWATER SHRIMP

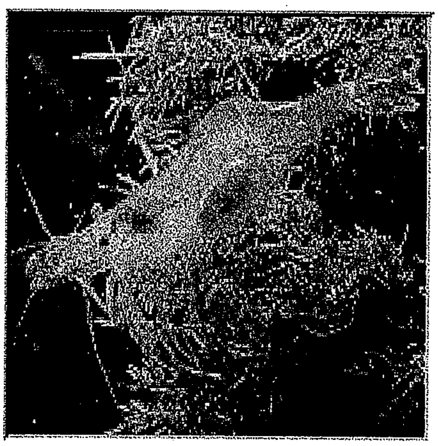


Photo: Larry Serpa

Scientific Name: *SYNCARIS PACIFICA*

Federal Status: Endangered

Species Description:

Up to 2.5 inches long, generally translucent, but larger females turn deep brown with tan dorsal stripe. Breed in September, females carry eggs until Spring, individuals can live up to three years.

Habitat Description:

SHALLOW POOLS AWAY FROM MAIN STREAMFLOW. WINTER: UNDERCUT BANKS W/EXPOSED ROOTS. SUMMER: LEAFY BRANCHES TOUCHING WATER. ENDEMIC TO MARIN, NAPA, & SONOMA COS. FOUND IN LOW ELEV, LOW GRADIENT STREAMS WHERE RIPARIAN COVER IS MODERATE TO HEAVY.

Hazard Class: **AQ**

CALIFORNIA RED-LEGGED FROG

Photo: John Brode, CDFG

Scientific Name: *RANA AURORA DRAYTONII*

Federal Status: Threatened

Species Description:

Up to 5 in. long, undersides of adults largely red; backs have black flecks and blotches, on a brown, gray, olive, or reddish background color; tadpoles range from 0.6 to 3.1 long, are dark brown and yellow with darker spots.

Habitat Description:

REQUIRES 11-20 WEEKS OF PERMANENT WATER FOR LARVAL DEVELOPMENT. MUST HAVE ACCESS TO ESTIVATION HABITAT. LOWLANDS & FOOTHILLS IN OR NEAR PERMANENT SOURCES OF DEEP WATER WITH DENSE, SHRUBBY OR EMERGENT RIPARIAN VEGETATION.

Hazard Class: **AQ, FS**

CALISTOGA POPCORN-FLOWER

Photo: Marianne McDern

Scientific Name: *PLAGIOBOTHRYS STRICTUS*

Federal Status: Endangered

Species Description:

Annual with erect stems 4-16 inches with small white flowers in March to April in a slender, unbranched stalk. The fruit is an egg-shaped nutlet about 0.6 in. long, keeled on the back, with wart-like projections without any prickles.

Habitat Description:

ALKALINE SITES NEAR THERMAL SPRINGS AND ON MARGINS OF VERNAL POOLS IN HEAVY, DARK, ADOBE-LIKE CLAY. 90-160M. BROADLEAFED UPLAND FOREST, MEADOWS AND SEEPS, VALLEY AMD FOOTHILL GRASSLAND, VERNAL POOLS. ENDEMIC TO NAPA COUNTY.

Hazard Class: **PD**

Species Descriptions

CHINOOK SALMON (CC-ESU)

Photo: NMFS

Scientific Name: *ONCORHYNCHUS TSHAWYTSCHA*

Federal Status: Threatened

Species Description:

Chinook are largest of the salmon, adults often exceed 40 pounds. They use a variety of freshwater habitats, but it is more common to see them spawn in larger mainstem rivers than other salmon species.

Habitat Description:

INCLUDES NATURALLY SPAWNED SPRING AND FALL CHINOOK IN COASTAL STREAMS FROM REDWOOD CREEK (HUM. CO.) SOUTH TO THE RUSSIAN RIVER

Hazard Class: **AQ**

CHINOOK SALMON (CVSR-ESU)

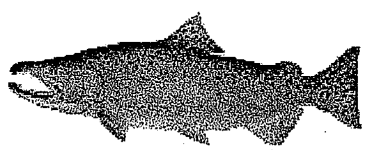


Photo: NMFS

Scientific Name: *ONCORHYNCHUS TSHAWYTSCHA*

Federal Status: Threatened

Species Description:

Chinook are largest of the salmon, adults often exceed 40 pounds. They use a variety of freshwater habitats, but it is more common to see them spawn in larger mainstem rivers than other salmon species.

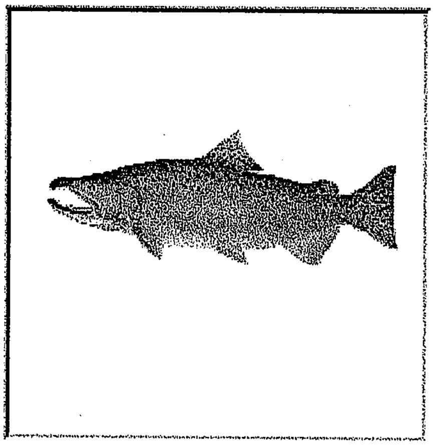
Habitat Description:

INCLUDES NATURALLY SPAWNED SPRING RUN CHINOOK IN THE CENTRAL VALLEY.

Hazard Class: **AQ**

Species Descriptions

CHINOOK SALMON (SRWR-ESU)



Scientific Name: *ONCORHYNCHUS TSHAWYTSCHA*

Federal Status: Threatened

Species Description:

Chinook are largest of the salmon, adults often exceed 40 pounds. They use a variety of freshwater habitats, but it is more common to see them spawn in larger mainstem rivers than other salmon species.

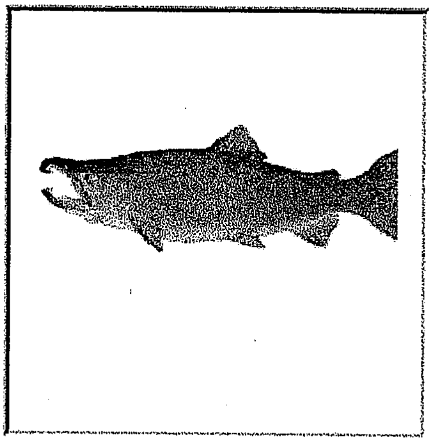
Photo: NMFS

Habitat Description:

OCCURS IN THE SACRAMENTO RIVER BELOW IMPASSABLE BARRIERS, ENTERS THE RIVER NOVEMBER TO JUNE AND SPAWNS FROM LATE APRIL TO MID-AUGUST.

Hazard Class: **AQ**

COHO SALMON (CCA-ESU)



Scientific Name: *ONCORHYNCHUS KISUTCH*

Federal Status: Threatened

Species Description:

Spawning occurs in mid-winter; eggs incubate up to 4 months; juveniles remain in freshwater up to 15 months.

Photo: NMFS

Habitat Description:

Once inhabited most coastal streams in northern and central California, currently protected from the Oregon border to the San Lorenzo River (Santa Cruz Co.)

Hazard Class: **AQ**

Species Descriptions

CONTRA COSTA GOLDFIELDS

Photo: Brousseau Collection

Scientific Name: *LASTHENIA CONJUGENS*

Federal Status: Endangered

Species Description:

A showy spring annual that grows to 12 inches tall with leaves opposite, light green, and usually have a feather-like arrangement with narrow clefts extending more than halfway toward the stem; flowers in terminal yellow heads from March to June.

Habitat Description:

VERNAL POOLS, SWALES, LOW DEPRESSIONS, IN OPEN GRASSY AREAS. 1-445M. VALLEY AND FOOTHILL GRASSLAND, VERNAL POOLS, CISMONTANE WOODLAND. EXTIRPATED FROM MOST OF ITS RANGE; EXTREM. ENDANGERED.

Hazard Class: **PD**

FEW-FLOWERED NAVARRETIA

Photo: Niall McCarten

Scientific Name: *NAVARRETIA LEUCOCEPHALA SSP PAUCIFLORA*

Federal Status: Endangered

Species Description:

A low-growing, spreading, and much-branched annual herb in the phlox family (Polemoniaceae) that grows to a height of 0.4 to 1.6 in with nearly hairless, linear leaves 0.4 to 1.0 in. long. Flowers blue or white (fading to blue) from May to June.

Habitat Description:

VOLCANIC ASH FLOW, AND VOLC SUBSTRATE VERNAL POOLS. 400-855M. VERNAL POOLS. ENDEMIC TO LAKE AND NAPA COUNTIES.

Hazard Class: **PD**

Species Descriptions

NAPA BLUE GRASS

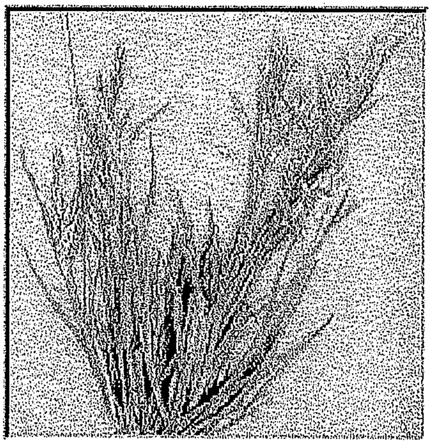


Photo: "Weeds of the West"

Scientific Name: *POA NAPENSIS*

Federal Status: Endangered

Species Description:

An erect, tufted perennial bunchgrass to 4 inches high; leaves folded, stiffly erect, 0.04 in wide, 6-8 inches long with erect flowering stems to 27 inches high, with pale green to purple seed head 4 to 6 inches long and 0.8 to 2.0 inches wide.

Habitat Description:

MOIST ALKALINE MEADOWS FED BY RUNOFF FROM NEARBY HOT SPRINGS. 100-125M. MEADOWS AND SEEPS, VALLEY AND FOOTHILL GRASSLAND. ENDEMIC TO NAPA COUNTY.

Hazard Class: **PM**

SALT-MARSH HARVEST MOUSE

Photo: B. "Moose" Peterson/WRP

Scientific Name: *REITHRODONTOMYS RAVIVENTRIS*

Federal Status: Endangered

Species Description:

About the size of a house mouse, to 7 inches in length, weighing about 0.3 ounces, black and cinnamon fur with a tawny lateral stripe with blackish ears, tufts of hair at the anterior base of the ears, with distinctively calm demeanor.

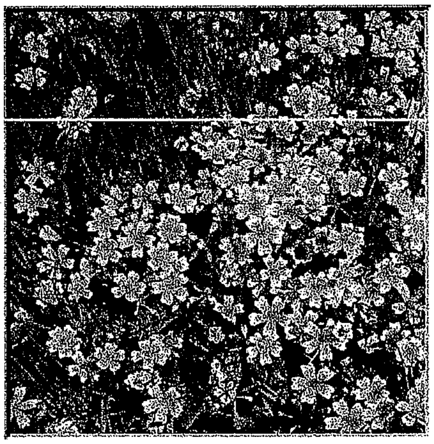
Habitat Description:

PICKLEWEED IS PRIMARY HABITAT. DO NOT BURROW, BUILD LOOSELY ORGANIZED NESTS. REQUIRE HIGHER AREAS FOR FLOOD ESCAPE. ONLY IN THE SALINE EMERGENT WETLANDS OF SAN FRANCISCO BAY AND ITS TRIBUTARIES.

Hazard Class: **HM**

Species Descriptions

SEBASTOPOL MEADOWFOAM



Scientific Name: *LIMNANTHES VINCULANS*

Federal Status: Endangered

Species Description:

Annual to 12 inches, flowers white with yellow bases, veins often dark.

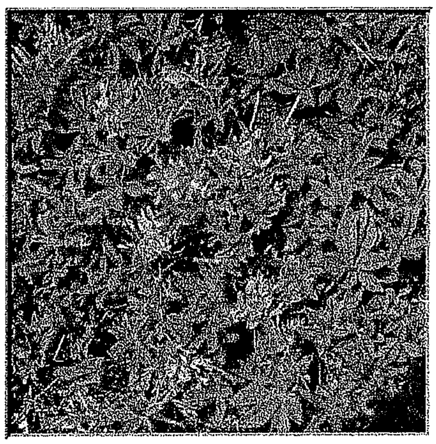
Photo: Brousseau Collection (A. Br

Habitat Description:

SWALES, WET MEADOWS AND MARSHY AREAS IN VALLEY OAK SAVANNA; ON POORLY DRAINED SOILS OF CLAYS AND SANDY LOAM. 15-115M. MESIC MEADOWS, VERNAL POOLS, VALLEY AND FOOTHILL GRASSLAND. ONLY KNOWN FROM NAPA AND SONOMA COUNTIES.

Hazard Class: **PD**

SHOWY INDIAN CLOVER



Scientific Name: *TRIFOLIUM AMOENUM*

Federal Status: Endangered

Species Description:

Annual plant, hairy, erect to 4 to 27 inches high, leaves are pinnately compound, widely obovate, and 0.8 to 1.2 inches long, flowers purple with white tips, 0.5 to 0.6 inches long and occur in dense, round or ovoid heads from April to June.

Photo:

Habitat Description:

SOMETIMES ON SERPENTINE SOIL, OPEN SUNNY SITES, SWALES. MOST RECENTLY SITED ON ROADSIDE AND ERODING CLIFF FACE. 5-560M. VALLEY AND FOOTHILL GRASSLAND, COASTAL BLUFF SCRUB.

Hazard Class: **PD**

STEELHEAD TROUT (CCV-ESU)

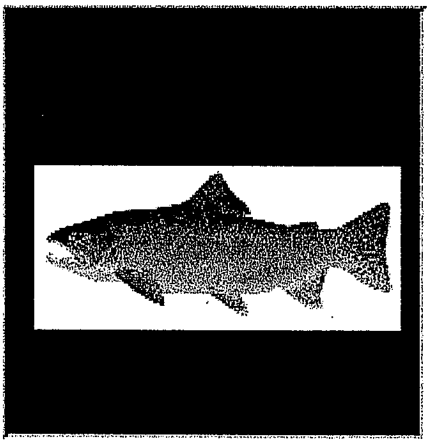


Photo: NMFS

Scientific Name: *ONCHORYNCHUS MYKISS*

Federal Status: Threatened

Species Description:

A genetically distinct and evolutionarily significant anadromous or freshwater fish related to rainbow and cutthroat trout.

Habitat Description:

COASTAL STREAMS

Hazard Class: **AQ**

STEELHEAD TROUT (SCC-ESU)

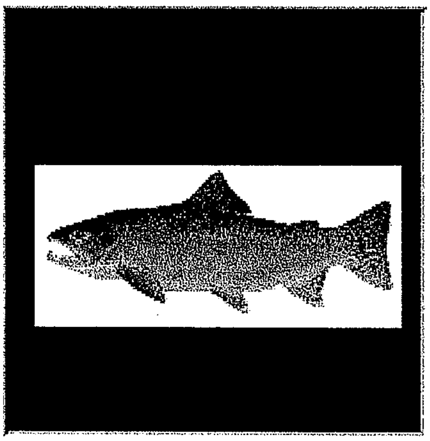


Photo: NMFS

Scientific Name: *ONCHORYNCHUS MYKISS*

Federal Status: Threatened

Species Description:

A genetically distinct and evolutionarily significant anadromous or freshwater fish related to rainbow and cutthroat trout.

Habitat Description:

COASTAL STREAMS

Hazard Class: **AQ**

Species Descriptions

VALLEY ELDERBERRY LONGHORN BEETLE

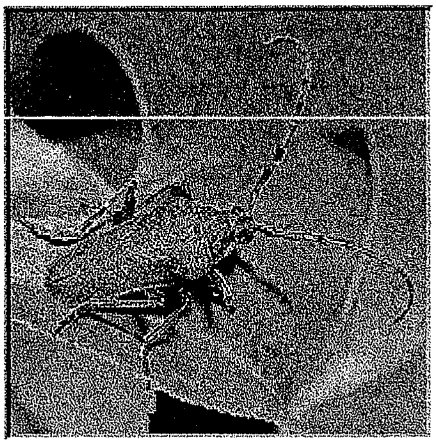


Photo: Richard A. Arnold

Scientific Name: *DESMOCERUS CALIFORNICUS DIMORPHUS*

Federal Status: Threatened

Species Description:

Adults to 3/4-inch long, forewings on females dark metallic green with flame trimmings, males similar or red-black with dark green spots and prominent segemented antennae, appearing from elderberry bloom until June.

Habitat Description:

PREFERS TO LAY EGGS IN ELDERBERRRIES 2-8 INCHES IN DIAMETER; SOME PREFERENCE SHOWN FOR "STRESSED" ELDERBERRIES. OCCURS ONLY IN THE CENTRAL VALLEY OF CALIFORNIA, IN ASSOCIATION WITH BLUE ELDERBERRY (SAMBUCUS MEXICANA).

Hazard Class: **IN**

WESTERN SNOWY PLOVER

Photo: Don Baccus

Scientific Name: *CHARADRIUS ALEXANDRINUS NIVOSUS (NESTING)*

Federal Status: Threatened

Species Description:

A shore bird with compact body, short neck, large eyes, dark legs and beak, dark partial neckband, males with black forehead and breast markings, females with dark brown markings. Calls include a low pitched "krut" and "ku-wheet."

Habitat Description:

REQUIRES SANDY, GRAVELLY OR FRIABLE SOIL SUBSTRATE FOR NESTING. SANDY BEACHES ON MARINE AND ESTUARINE SHORES, ALSO SALT POND LEVEES AND THE SHORES OF LARGE ALKALI LAKES.

Hazard Class: **AV**

Section List - Napa County

Sections	Species
04N03W: S19-20	California Red-legged Frog, Steelhead Trout (SCC-ESU)
04N03W: S21,28	Steelhead Trout (SCC-ESU)
04N03W: S29-30	California Red-legged Frog, Steelhead Trout (SCC-ESU)
04N03W: S31-33	Steelhead Trout (SCC-ESU)
04N03W: S4-9,16-18	Steelhead Trout (SCC-ESU)
04N04W: S1-2	Steelhead Trout (SCC-ESU)
04N04W: S10	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
04N04W: S11-12	Steelhead Trout (SCC-ESU)
04N04W: S13	Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N04W: S14-15	Steelhead Trout (SCC-ESU)
04N04W: S16	California Clapper Rail, Steelhead Trout (SCC-ESU)
04N04W: S17	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N04W: S18-19	California Clapper Rail, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N04W: S20	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N04W: S21-22	California Clapper Rail, Steelhead Trout (SCC-ESU)
04N04W: S23	Steelhead Trout (SCC-ESU)
04N04W: S24	Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N04W: S25-26	Steelhead Trout (SCC-ESU)
04N04W: S27-28	California Clapper Rail, Steelhead Trout (SCC-ESU)
04N04W: S29-30	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N04W: S3	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
04N04W: S31-32	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
04N04W: S33-35	California Clapper Rail, Steelhead Trout (SCC-ESU)
04N04W: S36	Steelhead Trout (SCC-ESU)
04N04W: S4	California Clapper Rail, Salt-marsh Harvest Mouse, Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N04W: S5	California Clapper Rail, Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N04W: S6	Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N04W: S7	California Clapper Rail, Showy Indian Clover, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N04W: S8-9	California Clapper Rail, Salt-marsh Harvest Mouse, Showy Indian Clover, Steelhead Trout (SCC-ESU)
04N05W: S1,12	California Clapper Rail, Steelhead Trout (SCC-ESU)

Section List - Napa County

Sections	Species
04N05W: S13,24-25	California Clapper Rail, Steelhead Trout (SCC-ESU), Western Snowy Plover
04N05W: S26	Chinook Salmon (SRWR-ESU), Steelhead Trout (SCC-ESU)
04N05W: S27-28,33-34	California Clapper Rail, Chinook Salmon (SRWR-ESU), Steelhead Trout (SCC-ESU)
04N05W: S35	Chinook Salmon (SRWR-ESU), Steelhead Trout (SCC-ESU)
04N05W: S36	Steelhead Trout (SCC-ESU)
05N03W: S4-9,15-22,28-33	Steelhead Trout (SCC-ESU)
05N04W: S1-24	Steelhead Trout (SCC-ESU)
05N04W: S25-26	Contra Costa Goldfields, Steelhead Trout (SCC-ESU)
05N04W: S27	Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
05N04W: S28-30	Steelhead Trout (SCC-ESU)
05N04W: S31-32	Showy Indian Clover, Steelhead Trout (SCC-ESU)
05N04W: S33-34	California Clapper Rail, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
05N04W: S35	Contra Costa Goldfields, Salt-marsh Harvest Mouse, Steelhead Trout (SCC-ESU)
05N04W: S36	Steelhead Trout (SCC-ESU)
05N05W: S1-3,10-15,22	Steelhead Trout (SCC-ESU)
05N05W: S23-26	California Freshwater Shrimp, Steelhead Trout (SCC-ESU)
05N05W: S35-36	Steelhead Trout (SCC-ESU)
06N02W: S15	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
06N02W: S16-18	Steelhead Trout (SCC-ESU)
06N02W: S19	Steelhead Trout (SCC-ESU), Valley Elderberry Longhorn Beetle
06N02W: S20-22,27-34	Steelhead Trout (SCC-ESU)
06N02W: S4	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
06N02W: S5-9	Steelhead Trout (SCC-ESU)
06N03W: S1-5	Steelhead Trout (SCC-ESU)
06N03W: S25	Steelhead Trout (SCC-ESU), Valley Elderberry Longhorn Beetle
06N03W: S26-35	Steelhead Trout (SCC-ESU)
06N03W: S36	Steelhead Trout (SCC-ESU), Valley Elderberry Longhorn Beetle
06N03W: S6	Contra Costa Goldfields, Few-flowered Navarretia, Steelhead Trout (SCC-ESU)
06N03W: S7-24	Steelhead Trout (SCC-ESU)
06N04W: S1-2	Few-flowered Navarretia, Steelhead Trout (SCC-ESU)
06N04W: S3-36	Steelhead Trout (SCC-ESU)
06N05W: S1-18,20-28,33-36	Steelhead Trout (SCC-ESU)
06N06W: S1	Steelhead Trout (SCC-ESU)
07N02W: S30-31	Steelhead Trout (SCC-ESU)
07N02W: S32	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
07N02W: S5	Valley Elderberry Longhorn Beetle

Section List - Napa County

Sections	Species
07N03W: S25-26	Steelhead Trout (SCC-ESU)
07N03W: S27,30	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
07N03W: S31	Steelhead Trout (SCC-ESU)
07N03W: S32,34	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
07N03W: S35-36	Steelhead Trout (SCC-ESU)
07N04W: S12-13	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
07N04W: S14-23	Steelhead Trout (SCC-ESU)
07N04W: S2-11	Steelhead Trout (SCC-ESU)
07N04W: S24	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
07N04W: S25-29	Steelhead Trout (SCC-ESU)
07N04W: S30-31	Sebastopol Meadowfoam, Steelhead Trout (SCC-ESU)
07N04W: S32-36	Steelhead Trout (SCC-ESU)
07N05W: S1-36	Steelhead Trout (SCC-ESU)
07N06W: S1-3	Steelhead Trout (SCC-ESU)
07N06W: S10-15,23-26,35-36	Steelhead Trout (SCC-ESU)
07N06W: S4	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
07N06W: S5	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
07N06W: S9	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N02W: S29-32	Valley Elderberry Longhorn Beetle
08N04W: S16-22	Steelhead Trout (SCC-ESU)
08N04W: S26	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
08N04W: S27-35	Steelhead Trout (SCC-ESU)
08N04W: S7	Steelhead Trout (SCC-ESU)
08N04W: S8	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
08N05W: S11-12	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
08N05W: S13-36	Steelhead Trout (SCC-ESU)
08N05W: S3	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
08N05W: S4-10	Steelhead Trout (SCC-ESU)
08N06W: S1-3	Steelhead Trout (SCC-ESU)
08N06W: S10-15	Steelhead Trout (SCC-ESU)
08N06W: S16-17	Calistoga Popcorn-flower, Steelhead Trout (SCC-ESU)
08N06W: S18	Calistoga Popcorn-flower, Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N06W: S19-20	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N06W: S21-28	Steelhead Trout (SCC-ESU)

Section List - Napa County

Sections	Species
08N06W: S29,32	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N06W: S33	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N06W: S34-36	Steelhead Trout (SCC-ESU)
08N06W: S4-5	Calistoga Popcorn-flower, Steelhead Trout (SCC-ESU)
08N06W: S6	Calistoga Popcorn-flower, Napa Blue Grass, Steelhead Trout (SCC-ESU)
08N06W: S7-9	Calistoga Popcorn-flower, Steelhead Trout (SCC-ESU)
08N07W: S1	California Freshwater Shrimp, Steelhead Trout (SCC-ESU)
08N07W: S11-12	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N07W: S13	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N07W: S2	Steelhead Trout (SCC-ESU)
08N07W: S3	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
08N07W: S4,10	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N05W: S30	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N05W: S31-32	Steelhead Trout (SCC-ESU)
09N05W: S33	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N06W: S18-20	Steelhead Trout (SCC-ESU)
09N06W: S21-24	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N06W: S25-30	Steelhead Trout (SCC-ESU)
09N06W: S31	Calistoga Popcorn-flower, Napa Blue Grass, Steelhead Trout (SCC-ESU)
09N06W: S32	Calistoga Popcorn-flower, Steelhead Trout (SCC-ESU)
09N06W: S33-36	Steelhead Trout (SCC-ESU)
09N06W: S7,17	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N07W: S1-2	Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N07W: S10	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N07W: S11-14	Steelhead Trout (SCC-ESU)
09N07W: S15	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N07W: S16,21	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N07W: S22-24	Steelhead Trout (SCC-ESU)
09N07W: S25	California Freshwater Shrimp, Steelhead Trout (SCC-ESU)
09N07W: S26	Calistoga Popcorn-flower, Napa Blue Grass, Steelhead Trout (SCC-ESU)

Section List - Napa County

Sections	Species
09N07W: S27	Steelhead Trout (SCC-ESU)
09N07W: S28,33	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N07W: S3	Chinook Salmon (CVSR-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)
09N07W: S34	Chinook Salmon (SFB-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
09N07W: S35	Steelhead Trout (SCC-ESU)
09N07W: S36	California Freshwater Shrimp, Calistoga Popcorn-flower, Napa Blue Grass, Steelhead Trout (SCC-ESU)
09N07W: S9	Chinook Salmon (CC-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (SCC-ESU)
10N07W: S34	Chinook Salmon (CVSR-ESU), Coho Salmon (CCA-ESU), Steelhead Trout (CCV-ESU), Steelhead Trout (SCC-ESU)

Overview of Mosquito Control Practices in California

This document provides information about mosquito control practices used in California, and links to additional information about mosquito control related topics.

Fundamentals of Organized Mosquito Control Programs in California

Mosquito control programs conducted by government agencies in California are based on the principles of Integrated Pest Management.

Mosquitoes

Definition of mosquitoes as a pest

Mosquitoes are defined as a pest because their biting is a nuisance and they can transmit diseases to humans and domestic animals.

Disease Transmission:

Some mosquitoes transmit ("vector") disease-causing viruses to humans and domestic animals when they bite. As the number of biting mosquitoes increases, so does the chance that humans and domestic animals may get diseases such as West Nile virus (WNV), Saint Louis encephalitis, and western equine encephalomyelitis.

Annoyance:

Many species of mosquitoes that bite humans and domestic animals do not transmit disease-causing organisms to humans; nevertheless, their bites cause allergic reactions in many people. When populations of mosquitoes are high, they can harm livestock productivity, drive tourists away from outdoors-related businesses, and decrease the quality of life.

Biting Adult Mosquito

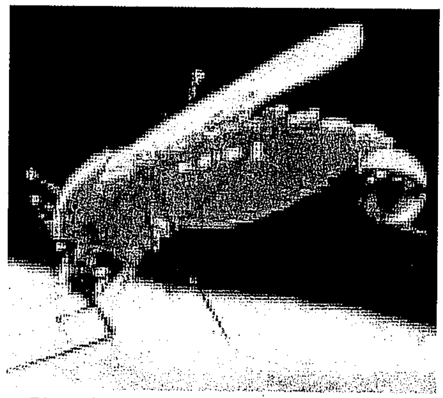


Photo Courtesy of Dr. Robert K. Washino
And Sacramento-Yolo MVCD
Web site: www.fightthebite.net/vectors

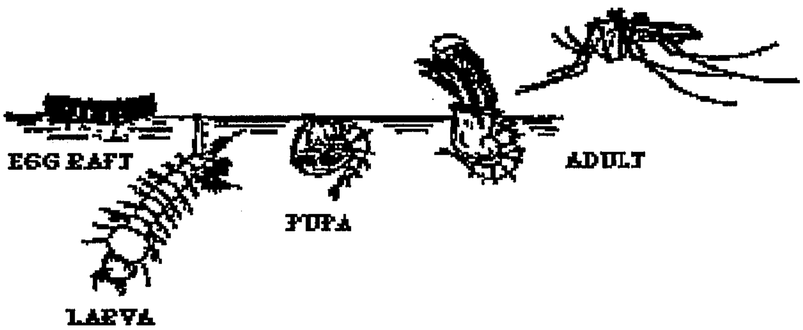
Why do mosquitoes need to be controlled?

Mosquitoes need to be controlled because they are pests and can vector disease-causing organisms, particularly when mosquito populations build to undesirable levels.

Mosquito biology

Mosquitoes have a life cycle that includes egg, larva, pupa, and adult. Standing water is required for the completion of every life stage except the adult.

Mosquito Life Cycle



Graphic Courtesy of American Mosquito Control Association Web Site. www.mosquito.org

The speed of larval development depends on water temperature and may take from 4 days to more than a month for the mosquito to mature from egg to adult. Only adult mosquitoes can fly and bite. After they emerge as adults, mosquitoes can fly up to several miles.

Adult male mosquitoes are not a direct health concern as they feed only on nectar from flowers, and usually live a few days to couple of weeks. In contrast, adult females can live for several months, and feed on nectar and blood.

Mosquitoes live in every area of California, and can be a threat to the health of humans and domestic animals throughout the state.

More information about mosquito biology is available by following the following links to the American Mosquito Control Association (AMCA) web site.

Information about mosquito biology: http://www.mosquito.org/mosquito-information/biology.aspx

Information and frequently asked mosquito questions: http://www.mosquito.org/mosquito-information/faq.aspx

Preventing Mosquito Problems

Citizen responsibilities

It is important for California residents to take action to prevent mosquito production and reduce the number of mosquitoes around their homes while local vector control agencies reduce mosquito populations over large geographic areas.

Californians are responsible for protecting themselves

California residents can take simple and inexpensive precautions to avoid being bitten by mosquitoes, and to eliminate mosquito breeding sites.

You are responsible for your own health!

Photo Courtesy of CDC web site. http:// ww.cdc.gov/ncidod/dvbid/westnile

These include:

- Use insect repellent while outdoors – particularly at dawn and dusk when vector mosquitoes are most active. Repellents come in many brands and formulations. Repellents containing DEET, oil of lemon eucalyptus, or picaradin are most effective.

Repellents come in many brands and formulations

- Wear loose fitting clothing with long pants and sleeves while outdoors.
- Use screen doors and ensure that window screens are in good repair.

** Use of brand names does not imply endorsement by the California Department of Health Service

It is virtually impossible to prevent mosquitoes from biting domestic animals. Some mosquito-vectored disease such as WNV in horses and dog heart worm can be dramatically reduced through the use of vaccines or other preventive medicines. In some instances high value animals may be protected through repellents approved for use on livestock, and by housing the animal indoors and excluding or controlling mosquitoes inside the enclosure.

Sonic devices have proven universally ineffective at repelling mosquitoes when subjected to rigorous scientific scrutiny. (1)

Mosquito breeding site - source reduction

Over watering turf and watering trash cans produces mosquitoes in municipal parks

Photo Courtesy of Tim Howard

Mosquito populations in many areas can be reduced by eliminating larval development (breeding) sites. Larvae can develop anywhere water stands for at least 5 days. Vector species prefer stagnant water.

In an urban or suburban setting, homeowners can prevent mosquitoes from developing on their property by eliminating containers holding water and making sure that ponds and fountains are clean and well maintained. Containers that produce mosquitoes in yards include buckets, wading pools, ponds, flower pots, trash receptacles and recycling bins, irrigation control box lids, boats (covered and uncovered), aquariums on porches, bird baths, rain gutters and down spouts. Regular cleaning and maintenance can eliminate many of these mosquito breeding sites. In much of California, residents watering gardens, grass, and potted plants provide the water for backyard mosquito breeding.

Filling in tire ruts, avoiding over-irrigation, maintaining irrigation systems and preventing sprinkler systems from filling trash barrels are management / maintenance practices that can reduce mosquito production. It is also important to maintain swimming pools so that they are free of algae and mosquitoes.

Tire ruts can produce many mosquitoes!

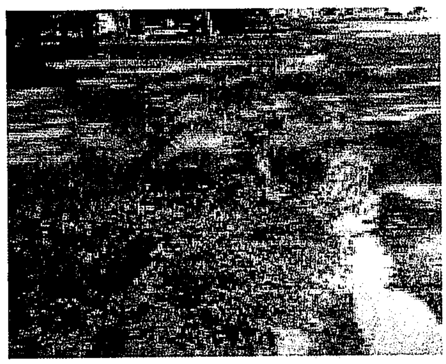
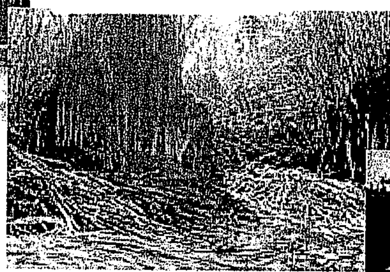


Photo Courtesy of Fairfax County, Virginia Health Department web site. http://www.co.fairfax.va.us/service/hd/westnile/wnveliminate.htm

Inside cities and developed areas, runoff from landscape watering, car-washing, and storms often collects in retention devices long enough to produce mosquitoes. Regular inspection and maintenance of these devices reduces water retention and mosquito production.

Catch basin mosquito problem

Removing cattails



Problem eliminated – Temporarily

In agricultural areas, farmers who use drip or other low volume irrigation systems reduce runoff and mosquito production.

Everyone can participate in eliminating mosquito larval development sites!

** Catch basin photos courtesy of Marco Metzger, Ph.D. California Dept. of Health Services DCDC-VBDS Caltrans project.

Harborage reduction

Adult mosquitoes seek cool, shady, humid areas of lush vegetation or structures (e.g. under wooden decks, under eaves, in buildings, pipes and culverts) to rest during the daytime. These resting places are called harborage areas.

Mosquito populations can be reduced by mowing grass and weeds as short as possible and thinning shrubs to allow air circulation through plants. Maintenance activities such as screening areas under porches and gazebos; and removing leaves, tree bark, boards, and other debris also reduce mosquito harborage areas.

Vector Control Programs

Role of public agencies in mosquito control

In the past, diseases such as malaria and yellow fever caused significant human suffering and death in the United States. West Nile virus (WNV), Saint Louis encephalitis virus and western equine encephalomyelitis are found in California and can cause serious disease. Public agencies must also maintain vigilance for foreign mosquito-borne diseases such as dengue fever, Japanese encephalitis, and Rift Valley fever that could be introduced into California.

Government agencies at the national, state, and local level have the responsibility to supplement the preventive activities of individual citizens toward protecting humans and domestic animals from mosquito- and other vector-borne diseases. Public health agencies track cases of mosquito-borne diseases. Mosquito and vector control agencies monitor mosquito populations and take actions to reduce mosquito population size.

Governing laws and regulations

In California, local vector control agencies have the authority to conduct surveillance for vectors, prevent the occurrence of vectors, and abate production of vectors. (California Codes: Health and Safety Code Section 2040).
Vector control agencies also have authority to participate in review, comment, and make recommendations regarding local, state, or federal land use planning and environmental quality processes, documents, permits, licenses, and entitlements for projects and their potential effects with respect to vector production. (California Codes: Health and Safety Code Sections 2041)
Web link: http://caselaw.lp.findlaw.com/cacodes/hsc/2040-2055.html

Additionally, agencies have broad authority to influence landowners to reduce or "abate" the source of a vector problem. Actions may include imposing civil penalties of up to $1000 per day plus costs associated with controlling the vector. Agencies have authority to "abate" vector sources on private and publicly owned properties. (California Codes: Health and Safety Code Section 2060-2065).
Web link: http://caselaw.lp.findlaw.com/cacodes/hsc/2060-2067.html

Many Federal and State Laws govern the activities of vector control agencies, including the Clean Water Act (CWA), the Endangered Species Act (ESA), and the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Pesticide application by vector control agencies in California is regulated under FIFRA. FIFRA is administered through the Environmental Protection Agency, and regulates the registration, labeling, and sales of pesticides in the United States. In California, mosquito control agencies are also regulated by sections of the California Health and Safety Code, Food and Agriculture Code, California Code of Regulations, and others.

Mosquito and vector control programs that enter into a cooperative agreement with the California Department of Health Services are exempted from some pesticide related laws under Title 3 of the California Code of Regulations section 6620. Specifically, these agencies are exempted from "Consent to Apply" (Title 3 California Code of Regulations Section 6616), "Notice" (Title 3 California Code of Regulations Section 6618), and the "Protection of Persons, Animals, and Property" (Title 3 California Code of Regulations Section 6614). Essentially, these provisions obviate the vector control agency from having to notify or get permission from landowners prior to applying a pesticide to their property in the interest of preserving the public health.
Web link: http://www.dcpr.ca.gov/docs/legbills/calcode/030201.htm

A vector control technician working at a vector control agency must be a "certified technician" or work under the direct supervision of a "certified technician" to apply pesticides. Vector control technicians achieve certification through an examination process administered by the California Department of Health Services.

Vector control agencies cannot use any pesticide not registered for use in California, and are required to keep detailed records of each pesticide application, including date, location, and amount applied. All pesticides must be applied in accordance with the labeling of the product as registered with the EPA..

Surveillance

Vector control agencies determine the need for mosquito control by conducting routine surveillance. These regular surveillance activities enable the agency to monitor mosquito populations, species composition and help determine where and when control activities should be initiated.

Mosquito Surveillance

Vector control agencies regularly inspect areas of standing water for immature mosquitoes. Mosquito larvae will develop in nearly any standing water, from marshes and flooded fields to urban runoff catch basins and backyard swimming pools.

Dipper with mosquito larvae

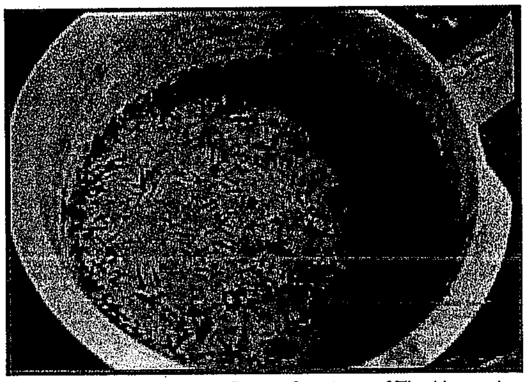


Photo Courtesy of Tim Howard

Adult mosquito monitoring trap
carbon dioxide baited

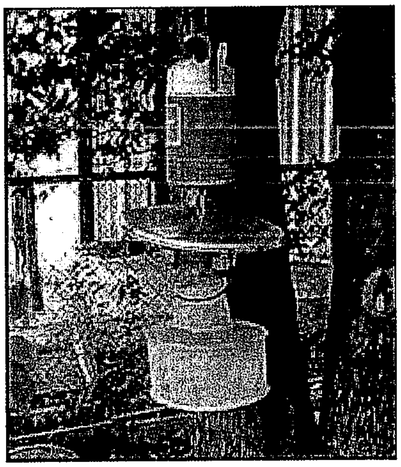


Photo Courtesy of Tim Howard

Adult mosquitoes are monitored with mosquito traps and reports of mosquito annoyance.

Virus Surveillance

Vector control programs monitor mosquito-borne viruses through testing adult mosquitoes and chickens from special flocks. With the appearance of WNV, cataloguing and testing of dead birds can provide additional information about virus transmission in areas of California that have no other surveillance system in place.

Dead American Crow
(*Corvus brachyrhynchos*)

Photo Courtesy of Center for Disease Control and Prevention

Finally, public health and agriculture agencies share information on cases of mosquito-borne virus infections in humans and horses with vector control agencies. All these sources of information are important in determining which actions will have the most effect in reducing vector populations, and when and where action should be taken to reduce mosquito populations.

Integrated Pest Management

When surveillance efforts indicate that mosquito control is necessary, vector control agencies rely on a multi-pronged approach called integrated pest management (IPM). IPM is a strategy that incorporates a variety of methods to control mosquitoes. These methods include habitat modification, biological predators, and chemical application. When properly implemented, IPM is an effective, environmentally sensitive, and cost-effective approach to mosquito control. Regular internal and external review ensure that IPM programs in California meet these objectives while adhering to the highest scientific and safety standards available.

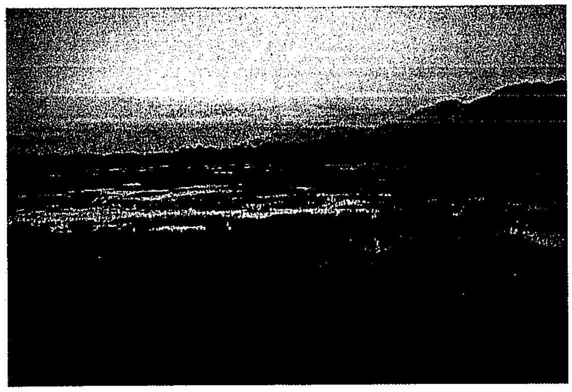
Habitat Modification

Wetlands, swamp lands, and salt marshes can be important areas for mosquito production. In the past, marshes and wetlands were drained to reduce mosquito populations. The recognized value of these limited resources as vital components of the ecosystem has led to their protection under state and federal environmental laws. Mosquito control districts in California currently work with many other government agencies and conservation groups to implement practices that decrease mosquito production without harming these environmentally sensitive areas. Some of these approaches include:

- Ditching to maintain water circulation into and out of the marshes. This disperses stagnant water and provides natural biological control organisms like fish improved access to the marshes.

- Periodically burning cattail, bull rush, and other wetland vegetation on a several year rotation to reduce dead vegetation in the system, and maintain water movement. Burning has the ancillary benefit of also destroys some mosquito eggs.

Dusk at Carpinteria Salt Marsh Reserve – Santa Barbara County



Link to the UC Davis web site: http://www.mosquitoes.org/downloads/8117.pdf to find additional information about mosquito control on constructed wetlands In California.

Photo Courtesy of University of California Natural Reserve System
http://nrs.ucop.edu/reserves/carpinteria/Carpinfo.html

Biological Mosquito Control

Biological control of mosquito larvae is the preferred method in many permanent mosquito breeding sites when site modification or elimination is not possible or practical.

Mosquito fish

Mosquito Fish (*Gambusia affinis*)

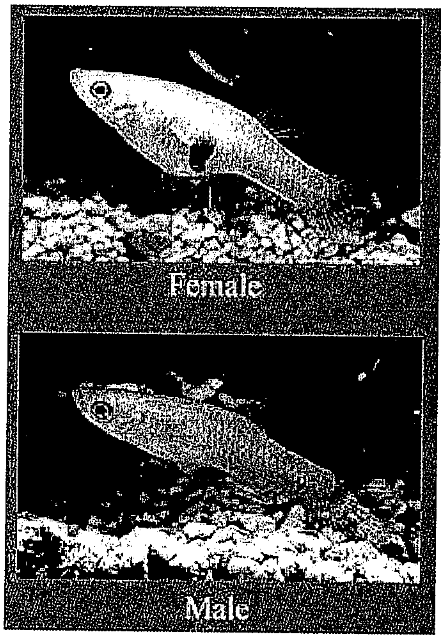


Photo Courtesy of Shasta MVCD web site
http://www.snowcrest.net/mosquito

In California, many mosquito control agencies rear and stock small fish (*Gambusia affinis*) that eat mosquito larvae. These fish can be placed in ornamental ponds, stock watering tanks, ponds without game fish, and a variety of other locations as a biological control for mosquito larvae. Although the fish are not native to California, the California Department of Fish and Game and the US Fish and Wildlife Service allow their use in most areas. Other fish species including guppies (*Poecilia reticulata*) are also used for larval control.

Biological control reality and myths

There are many myths about the ability of bats, birds, dragonflies, and other species to control mosquito populations. All of these species (and many others) do prey upon mosquitoes; however in most mosquito producing habitats, their contribution to reducing mosquito numbers is insignificant compared with the other methods described here.

In general, permanent water bodies with stable water conditions do not produce large numbers of mosquitoes. Wave action in larger water bodies and a diverse community of predatory aquatic invertebrates reduce mosquito production in these habitats. Most mosquito sources that produce large populations of mosquitoes are either temporary in nature, highly variable in water level, or are in other ways not conducive to an overall diverse invertebrate community.

Bats and birds

Little Brown Bat
(*Myotis lucifugus*)

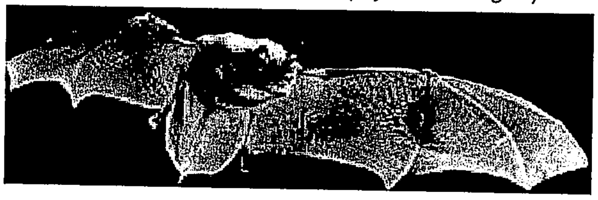


Photo Courtesy of Missouri Department of Conservation
www.conservation.state.mo.us/help/copyrite.html

Bats and birds (such as martins and swallows) do consume some mosquitoes; however the bulk of their diet consists of larger organisms and their impact on mosquito populations is negligible.

Setting out martin boxes and bat roost boxes may benefit these species and is not harmful if the boxes are placed away from homes or other buildings; however this will not affect the local mosquito population. (2, 3, 4)

Frogs

Adult frogs in California consume adult mosquitoes; however the bulk of their diet is larger organisms. Adult frogs do not eat enough mosquitoes to have a significant impact on mosquito populations.

Immature frogs (tadpoles) are commonly thought to consume mosquito larvae. Tadpoles actually feed on algae and other small organic debris and are not a significant predator on mosquito larvae.

Others

Many aquatic invertebrate species such as dragonfly naiads, damselfly nymphs, and aquatic beetles feed on mosquito larvae. Some of these organisms may be useful for biological mosquito control; however there are practical limitations and unanswered biological questions that prevent using them for mosquito control at the present time.

California dragonfly – Skimmer
(Libellula sp.)

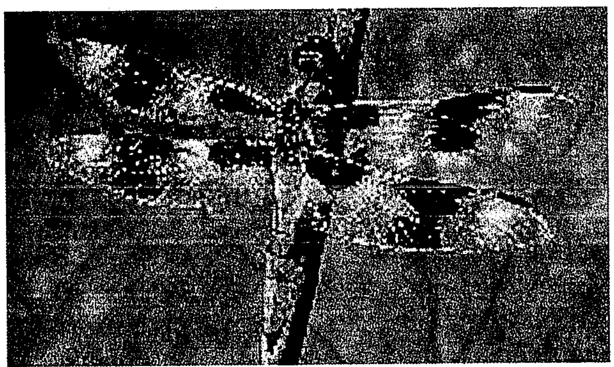


Photo courtesy of Rod Miller California Dragonflies and Damselflies www.sonic.net/dragonfly

Biological mosquito control is an important tool – one that scientists in California continue to develop as new control organisms are considered or alternative methods of using existing organisms are identified.

Chemical Control of Mosquitoes

To prevent or control large populations of mosquitoes, vector control agencies implement more direct efforts to combat them. Often these measures entail the application of chemicals. Each local program manager uses mosquito and virus surveillance data to determine how and when chemical control of mosquitoes is required.

Mosquito Control Decisions

Larval development site inspection and treatment

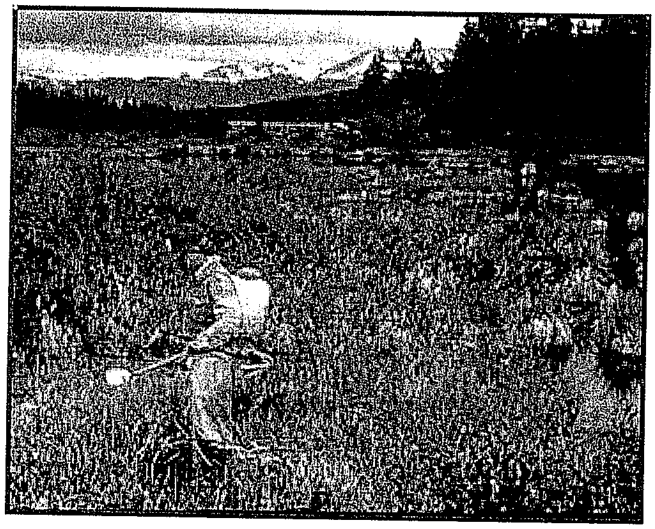


Photo Courtesy of Lewis C. Keenan

Chemical control of mosquitoes is implemented when mosquito populations reach a level that health officials feel represents an unacceptable increase in the risk of disease transmission to humans or domestic animals, or when biting mosquitoes become intolerable to the local population. The action level or "threshold" is determined by each mosquito control program and varies according to local conditions.
The threshold for larval control is usually quite low, often a single larva in one dipper full of water.
The threshold for adult mosquito control is variable and depends on several local factors including:

- The tolerance of local citizens to nuisance mosquitoes
- Presence of mosquito-borne disease in the region
- Percentage of mosquito population that are vector species
- The local citizen's acceptance of mosquito control activities

Way above any treatment threshold!
(460,000 mosquitoes from one trap in one night)

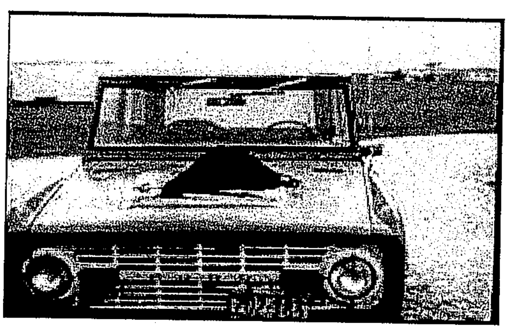


Photo Courtesy of Thomas Janousek, Ph.D.

Pesticides

Pesticide basics

According to the United States Environmental Protection Agency (US EPA) Web Site:

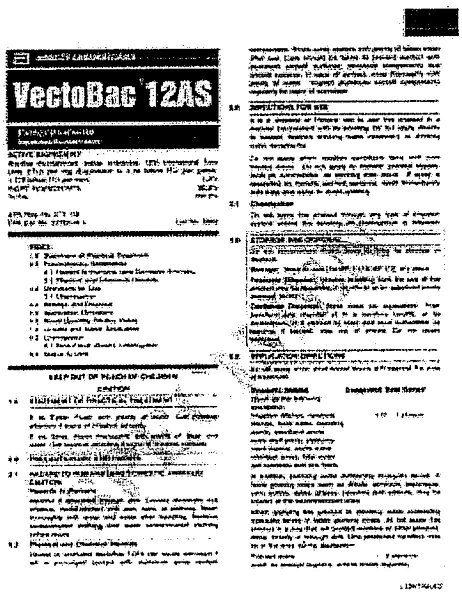
> A pesticide is any substance or mixture of substances intended for: preventing, destroying, repelling, or mitigating any pest.

Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. (Web address: http://www.epa.gov/pesticides/about)

Pesticide related industries are some of the most highly regulated in the United States. Scientific scrutiny of the effectiveness of the product, the potential harmful effects to humans, and the potential non-target effects is intense.

Pesticide labels are legal documents that direct the use of the product for each pest species and location where it can be used. In addition to the label, a Material Safety Data Sheet (MSDS) has been prepared for each pesticide. The MSDS gives a great deal of additional information about the product.

Pesticide label - Larvicide



Links to product labels and MSDS for at least one product with each active ingredient used in California are provided in Tables 1 and 2.

Information about every pesticide registered for use in California by the US EPA and the California Environmental Protection Agency - Department of Pesticide Regulation (DPR) is available at: http://www.cdpr.ca.gov/docs/label/m4.htm

Pesticide resistance

Mosquito control programs have worked to reduce mosquito populations in California since 1909. Pesticides have been applied to kill mosquitoes in California for over 70 years. During that time there have been some small but important genetic changes that have made the mosquitoes able to survive exposure to some pesticides. The increased ability to survive pesticide exposure is called resistance. Development of resistance to a pesticide can produce resistance to other pesticides with a similar active ingredient or that work in a similar manner. The ability to survive exposure to a chemical is often passed on genetically and will spread through a population.

Pesticide resistance to older pesticides including organophosphates has been documented in many mosquito populations in California. Resistance to pyrethroid insecticides has been demonstrated in some species of mosquitoes in limited areas of California. This means that some pesticides should not be used in some areas of California because only a portion of the mosquito population would be killed when sprayed at the maximum legal rate.

Throughout California, mosquito control professionals in conjunction with state and federal agency personnel and university researchers are working to develop effective mosquito control strategies that maximize the efficiency of pesticides and minimize their use. This helps ensure that when chemical control of mosquitoes is necessary, there will be effective chemicals to use against them.

Larval Control

Control of larval mosquitoes is the backbone of most mosquito control programs in California. Pesticides added to the water to kill mosquito larvae are called larvicides. These products may be applied by hand, with a power backpack, from all terrain vehicles (ATV's) or trucks, and in very large or inaccessible areas with helicopters and airplanes.

Larval control products

There are 4 families of larvicides with a total of 7 active ingredients registered for use in California. (Table 1).

1. Bacterial Products

Bacillus thuringiensis var. *israelensis* (Bti) and *B. sphaericus* (Bs) sold under various trade names are bacterial products that are commonly put into the water to control mosquito larvae. When a larva consumes the bacteria, proteins produced by the bacteria bind with and destroy the stomach lining of the mosquito larva. The products remain effective for about 24 to 48 hours. Bs products contain live bacteria and if conditions are favorable remain effective for more than 30 days. These are very mosquito-specific products and when properly used pose little threat to non-target species, including humans.

2. Surface Agents

Mosquito larvae and pupae breathe at the water's surface through special tubes that extend above the water surface. Surface agents are highly refined mineral oils or monomolecular films that spread across the surface of the water. Mineral oil works by clogging the breathing tubes causing the immature mosquitoes to suffocate. Mono-molecular films work by reducing the surface tension of the water causing larvae and pupae to drown. Surface products are effective for a few hours to a few days, depending on the product. These products may also affect other organisms (like aquatic beetles) that have do not have gills and breathe at the water's surface. Surface agents are the only products effective against mosquito pupae.

3. Insect Growth Regulators (IGR's)

Early spring larviciding

Photo Courtesy of Lewis C. Keenan

Methoprene and dimilin are chemicals that are added to the water to disrupt the normal maturation process of mosquito larvae. The effective life of the product varies with the formulation. One formulation of methoprene has an effective life of 150 days. Methoprene can be applied in known larval development sites prior to flooding.

Dimilin is a restricted use pesticide because it is potentially toxic to aquatic invertebrates. Methoprene is not a restricted use product, and has minimal non-target effects.

Like Bti, methoprene poses little health concern for mammals and is safe to use in human drinking water sources.

4. Chemical Larvicides

Temephos is currently the only organophosphate registered for use as a larvicide in California. This product can be safely and effectively utilized in areas of temporary water where there are few non-target organisms and livestock are not present. Effective life span of temephos is up to 30 days depending on formulation of the product. This product can be applied to known larval development sites prior to flooding.

Common larvicides registered for use in California are listed in Table 1.

Table 1: Larvicides Registered in California

Classification	Active Ingredient	Trade Name	EPA Reg. #
Bacteria	*Bacillus sphaericus (Bs)*	Vectolex CG	275-77
		Vectolex WDG	73049
		Vectolex WSP	73049-20
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	Bacillus thuringiensis var. *israelensis* (Bti)	Vectobac 12AS	73049-38
		Vectobac G	73049-10
		Vectobac G	275-50
		Vectobac technical powder	73049-13
		Aquabac 200G	72637-3
		Bactimos briquettes	6218-47
		Teknar HP-D	73049-404
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
Surface film	monomolecular film	Agnique MMF	2302-14
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	petroleum oil	GB-1111	8329-72
Label and MSDS link: Http://www.clarkemosquito.com/product_detail.cfm?productid=112&categoryid=6&parentlist=4,6			
Insect growth regulator	dimilin	Dimilin 25W	400-465
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
	S-methoprene	Altosid pellets	2724-448
		Altosid ALL	2724-446
		Altosid briquettes	2724-375
		Altosid SBG	2724-489
		Altosid XR-G	2724-451
Label and MSDS link: http://www.adapcoinc.com/product_larvicides.jsp			
Organophosphate	temephos	5% Skeeter abate	8329-70
		Abate 2-BG	8329-71
Label and MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=106&categoryid=6&parentlist=4,6			

Refer to Appendix 1 for explanation of pesticide formulation abbreviations.

Adult Mosquito Control

Adult mosquito control is a means to rapidly knockdown biting adult mosquitoes. This can become necessary when larval control measures are insufficient or not feasible. Adult mosquito spraying is an important part of an IPM mosquito control program. In some areas of California, chemical control of adults is the only mosquito control option. Chemicals used for adult mosquito control can be dispersed into the air to target flying mosquitoes, or applied to vegetation and structures to kill resting mosquitoes.

ULV spraying

Most products used for adult mosquito control (adulticides) are formulated for use via ultra-low volume (ULV) spray technology. ULV spraying (also occasionally called cold fogging) is the process of putting very small amounts of liquid (typically 4 ounces per acre or less) into the air as a fine mist of droplets. These droplets float on the air currents for up to 1 hour and quickly kill mosquitoes that come into contact with them. ULV adulticides are applied when mosquitoes are most active – typically sunset and early evening.

Truck mounted ULV spraying

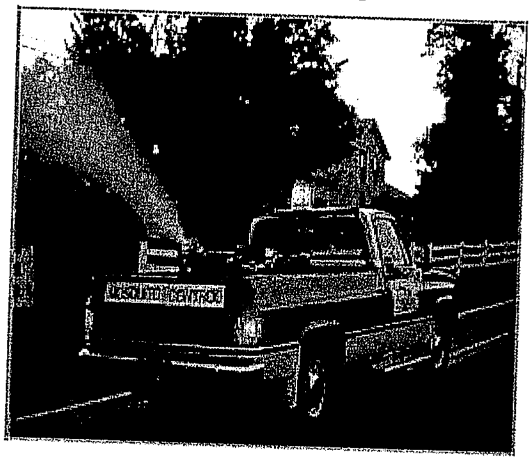


Photo Courtesy of Mike McGinnis

ULV spraying is usually done over large geographic areas consisting of several acres to several square miles. Unlike agricultural or structural pesticide applications where the chemical is applied directly to a crop or structure, a ULV formulation is sprayed into the air column where it can contact and kill active mosquitoes. Aerial movement of the ULV product is an essential part of the application. ULV applications are only done during environmental conditions that insure desirable product movement.

Aerial ULV in a mountain valley

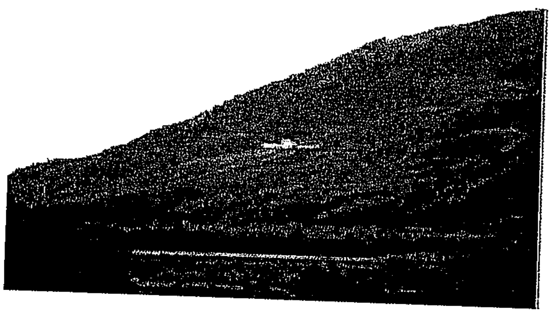


Photo Courtesy of Mike McGinnis

ULV products are most effective when applied during the period just before sunset into the early evening. A shorter window of time around dawn can also be an effective time to spray.

ULV applications can be done from the ground using vehicle mounted sprayers, or from the air using helicopters or airplanes. All spray equipment is required to be regularly calibrated to insure safe and effective applications.

Non-Target Effects

In general, the risk of adverse effects from ULV applications to people living in the area being sprayed is low. Nevertheless, individuals with existing health problems such as severe asthma, emphysema, other respiratory impairments, or highly chemically sensitive conditions should contact the local vector control agency when they move into an area. Often, the local vector control agency will be able to provide individuals with information on which products are used and when the products will be applied. Some local agencies maintain lists of residents who indicate their property should be excluded from adult mosquito spraying.

By spraying a very small volume of insecticide per acre, using small droplets, and spraying after sunset or at dawn, ULV applications are able to target mosquitoes while minimizing the affects to other insects.

Barrier spraying

Backpack barrier spray

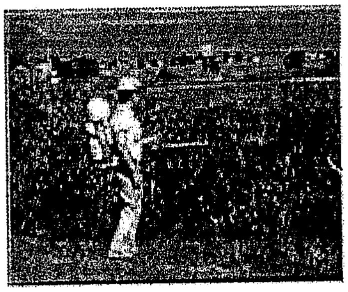


Photo Courtesy of Lewis C. Keenan

The other common type of adult mosquito control application is a "barrier" spray. This process is typically used prior to an outdoor event (like a wedding reception or family reunion). Barrier applications can be done on private property by a vector control agency, a private pest control contractor, or a private individual on their own property. Treatment may be effective in an area of up to several acres for a few days.

In a barrier application, a broad spectrum insecticide is applied directly to vegetation and other surfaces where a mosquito may land (under decks, gazebos, etc.). When mosquitoes land on the treated area they absorb a fatal amount of pesticide.

Non-target effects

Barrier sprays are effective because they use a higher rate of pesticide application than other adult mosquito control activities. The increased amount of pesticide will kill most insects for a few days where the product is applied. Pesticides used for barrier applications in California break down into inert chemicals rapidly under environmental conditions and have very low toxicity to mammals.

Adult Control Products

As of June, 2008, there are at least 2 families of pesticide with a total of 9 active ingredients registered for adult mosquito control in California.

1. Organophosphates

Organophosphates (OPs) are neurotoxins that cause uncontrolled, repeated firing of neurons. Malathion and naled are OPs registered for use in California. Malathion is most frequently used early and late in the season, with pyrethroids being used as adulticides during the bulk of the mosquito control season.

2. Pyrethrin (natural)

Pyrethrins are natural insecticides derived from plants, primarily chrysanthemums. Pyrethrins act to block chemical signals at nerve junctions. Pyrethrins are broad spectrum insecticides that are widely used in agricultural and structural pest control.

2. Pyrethroids (synthetic)

Permethrin, resmethrin, sumithrin, and deltamethrin are all active ingredients classified as pyrethroid insecticides. Pyrethroids are synthetic pesticides that are very similar to natural pyrethrum in their chemical structure and mode of action.

Insecticides with either natural pyrethrins or synthetic pyrethroids as the active ingredient usually incorporate a synergizing agent, piperonyl butoxide (PBO). PBO reduces the ability of the insect to break down the active ingredient, allowing the insecticides to be effective with less active ingredient than would otherwise be required.

Pyrethroids can be toxic to fish. These products will not affect fish when used according to the label instructions, because there is a large safety margin built into the label restrictions. The products have very low toxicity in mammals, including domestic animals and people. In fact, flea and tick sprays that are applied directly on dogs and cats have much larger amounts of pyrethroids than mosquito control products but are not harmful to the animal.

A list of products commonly used to control adult mosquitoes in California is presented in Table 2. Links to labels and MSDS for each adult control product are provided, as well as links to commonly asked questions for at least one product from each family of adulticide.

In addition, the exciting agent prallethrin is combined with the toxicant sumithrin in the Clarke mosquito control product "Duet".

Table 2: Adulticides Registered in California

Classification	Active Ingredient	Trade Name	EPA Reg. #
Organophosphate			
	malathion	Fyfanon ULV	4787-8
Information Link: http://www.health.state.ny.us/nysdoh/westnile/education/2740.htm			
Label and MSDS link: http://www.adapcoinc.com/product_adulticides.jsp			
	Naled	Dibrom concentrate	5481-480
Label link: http://www.stlucieco.gov/pdfs/Dibrome label.pdf			
MSDS link: http://www.stlucieco.gov/pdfs/Dibrome msds.pdf			
Pyrethrin			
	pyrethrins	Evergreen Crop Protection EC 60-6	1021-1770
		Pyrenone 25-5	432-1050
		Pyrenone crop spray	432-1033
		Pyrocide 7396	1021-1182
Label and MSDS link: http://www.adapcoinc.com/request msds.php			
Pyrethroids			
	resmethrin	Scourge insecticide 4%	432-716
Information Link: http://www.health.state.ny.us.nysdoh/westnile/education/2739.htm			
Label and MSDS link: http://www.adapcoinc.com/request msds.php			
	sumithrin	Anvil 10+ 10 ULV	1021-1688-8329
Information Link: http://www.atsdr.cdc.gov/consultations/west_nile_virus/phenothrin.html			
Label link: http://www.clarkemosquito.com/product_detail.cfm?productid=5&categoryid=23&parentlist=4,23			
MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=5&categoryid=23&parentlist=4,23			
	permethrin	Aqua-Reslin	432-763
		Permanone RTU	432-1182
		Biomist 4 + 12 ULV	8329-34
Label and MSDS link: http://www.adapcoinc.com/request msds.php			
Label and MSDS link: http://www.clarkemosquito.com/product_detail.cfm?productid=2&categoryid=23&parentlist=4,23			
	deltamethrin	Suspend SC	432-763
Label and MSDS link: http://www.backedbybayer.com/bayer/cropscience/backedbybayer.nsf/id/EN_Pest_Labels_MSDS			

Refer to Appendix 1 for explanation of pesticide formulation abbreviations.

Basic Toxicology

Most chemicals and substances have the potential to negatively affect some living organism if they are present in large enough quantities. For a chemical to have a toxic effect, the amount taken in must be enough to overcome the natural protective mechanisms of the organism. Toxicology is the study of the harmful effects of chemicals and substances to living organisms.

Definitions for toxicology

Toxicity: The inherent potential for a chemical or substance to harm living organisms.

Exposure: Coming into physical contact with a chemical or substance. Toxic effects can occur from contact with skin, through breathing, through oral ingestion, or through more than one route.

Dose: The amount of a chemical that gets to a location in an organism where it can cause some change.

Risk: The likelihood of negative health effects associated with some substance.

Relative Risk: Comparing the likelihood of negative health effects associated with different actions taken.

Mosquito control products and human health

Risks to people and domestic animals from mosquito control products are very low because people are exposed to small amounts of chemicals that are not very toxic.

The following was taken from the New York Health Department web site relative to the use of adulticides in New York but is equally applicable to California:

"The risk associated with the use of these products depends on the toxicity of the ingredients and the extent of exposure an individual has to them. The application rates for the active ingredients in the adulticide products are quite low, ranging from 0.0035 to 0.23 pounds per acre. As a result, exposure of the general public to adulticides is likely to be very low. ..."

Human health risks associated with larvicides are lower than those associated with adulticides. Larvicides not only are very low in toxicity to mammals, but also are applied to sites where the potential for human contact is negligible. (e.g., storm drains, sewage treatment plants, abandoned swimming pools etc.).

Bottom line – Relative risk

Reported West Nile virus infections in the United States between 1999 and the end of 2004 resulted in 666 human deaths and 8313* cases of neuro-invasive disease. Tens of thousands of birds and thousands of horses have also died or been euthanized as a result of WNV.

* Includes total human case count for 1999 through 2002. Data from 2003 and 2004 was separated into neuro-invasive disease versus milder flu-like illness. Prior to 2003 milder forms of the disease were not routinely diagnosed as WNV related illness. Case data is from the U. S. Center for Disease Control and Prevention and the United States Geological Survey available on their web sites.

WNV clearly poses risks to the health and welfare of humans and domestic and wild animals. Unnecessary exposure to pesticides should be avoided; however the demonstrated health risks from WNV are greater than potential risks associated with mosquito control activities. (5)

Toxicity of Mosquito Control Products

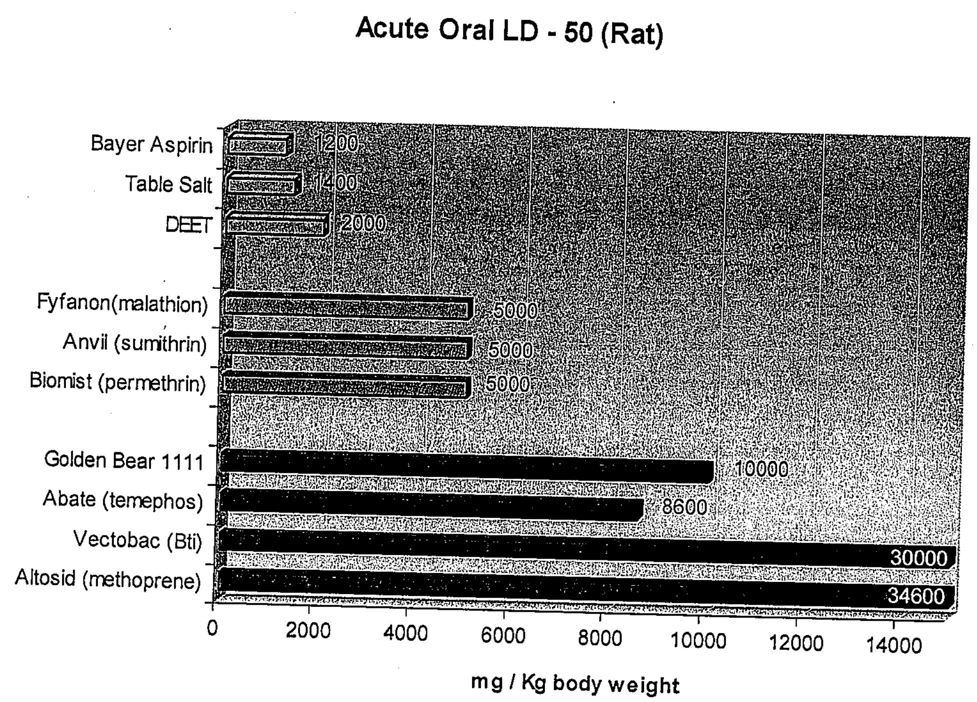
How toxic a substance is to a particular type of animal is often reported as a lethal dose to 50% of a test population (LD–50). Specifically what the LD–50 number indicates is how much of a given chemical it would take to have a 50% chance of killing an organism based on the body size of the organism. LD–50 is a measure of a dose that quickly kills an organism, it does not account for chronic (non-fatal) effects.

Human toxicity is looked at based on the fact that humans are similar in physical make up and function to other mammals. The following chart compares the mammalian oral LD–50 for two substances that humans readily consume to mosquito adulticides and larvicides.

A lower LD–50 means a substance is more toxic - it would take less of the substance to kill the organism ingesting it. What is demonstrated below is that products used to control mosquitoes are less toxic (even when ingested) than Bayer aspirin or table salt. Mosquito control products have much lower dermal (skin exposure) toxicity than oral toxicity.

<u>Chart 1: Relative LD50 Data for Mosquito Control Products</u>

* DEET is the active ingredient found in many insect repellents.



Note 1: shorter lines = lower LD – 50 = more toxic substance.

Additional Sources of Information

Pesticides - Additional information can be obtained from the Oregon State University web site: http://npic.orst.edu

Or from the EPA website: http://www.epa.gov/pesticides

Pesticide Poisoning - Detailed information about symptoms and treatment can be found in EPA publication: Recognition and Management of Pesticide Poisonings, 5th ed. available as a handbook or on Compact Disc. The information is also available on the EPA website:
http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm

Pesticide Labels and MSDS – available on many web sites and an internet search of any pesticide name or EPA registration number will give additional information
http://www.greenbook.net/

West Nile Virus - Additional information is available from the CDC web site:
http://www.cdc.gov/ncidod/dvbid/westnile/

Maps of WNV activity - Available from the United States Geological Survey: (USGS): http://westnilemaps.usgs.gov/

Insect Repellent - Information is available from the CDC web site:
http://www.cdc.gov/ncidod/dvbid/westnile/qa/insect_repellent.htm

DEET - Information is available from CDC web site:
http://www.epa.gov/pesticides/factsheets/chemicals/deet.htm

References

1. T. Jensen, Lampman, R., Slamecka, M.C., and Novak, R. J. 2000. Field efficacy of commercial antimosquito products in Illinois. *Journal of the Amer. Mosq. Cntrl. Assn.* 16(2); 148-152.

2. L. McWilliams. 2005. Variation in diet of the Mexican free-tailed bat (Tadarida brasiliensis mexicana). *Journal of Mammology.* 86(3): 599-605.

3. L. Podolsky. California myotis (*Myotus californicus*). *Animal Diversity Web.* University of Michigan Museum of Zoology.
   Web link:
   http://animaldiversity.ummz.umich.edu/site/accounts/information/Myotis_californicus.html

4. Ghost-faced Bat. Family Mormoopidae. (*Mormoops megalophylla*). *Nature.* Texas Parks and Wildlife
   Web link:
   http://www.tpwd.state.tx.us/nature/wild/vertebrate/mammals/bats/species/ghostfaced.htm

5. Center for Disease Control and Prevention. Human exposure to mosquito-control pesticides — Mississippi, North Carolina, and Virginia, 2002 and 2003. *MMWR Morb Mortal Wkly Rep* 2005, 54(21); 529-532.

Appendix 1

Definitions of pesticide formulation abbreviations

Abbreviation	What it means
CG	clay granule
WDG	water dispersible granule
WSP	water soluble packet
AS	aqueous solution
G	granule
HP-D	high potency dipteran active
MMF	mono-molecular film
W	wettable powder
ALL	Altosid liquid larvicide
SBG	single brood granule
XR-G	extended residual granule
BG	Biodac granule
ULV	ultra low volume
RTU	ready to use
SC	soluble concentrate

This document was prepared by the Vector-Borne Disease Section, California Department of Public Health, (916) 552-9730, August 2005. (Updated July, 2008)

State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME
Resource Management and Planning Division
Biogeographic Data Branch
California Natural Diversity Database

STATE AND FEDERALLY LISTED
ENDANGERED, THREATENED, AND RARE PLANTS OF CALIFORNIA

April 2011

Designations and Subtotals for each Designation:

	Designations:	Subtotals:
SE	State-listed endangered	134
ST	State-listed threatened	22
SR	State-listed rare	64
SC	State candidate for listing	0
FE	Federally listed endangered	139
FT	Federally listed threatened	47
FPE	Federally proposed endangered	0
FPT	Federally proposed threatened	0
	Both State and Federally listed	125

State listing is pursuant to §1904 (Native Plant Protection Act of 1977) and §2074.2 and §2075.5 (California Endangered Species Act of 1984) of the Fish and Game Code, relating to listing of Endangered, Threatened and Rare species of plants and animals. Federal listing is pursuant with the Federal Endangered Species Act of 1973, as amended. For information regarding plant conservation, contact the Habitat Conservation Planning Branch, 1416 Ninth Street, Sacramento, CA 95814, phone (916) 653-9767, or the nearest Department of Fish and Game office. For information on this list, contact CNDDB's Information Services at (916) 324-3812. Scientific and common names for State-listed plants are listed in Title 14, §670.2. Scientific or common names in parentheses are the most scientifically accepted nomenclature but have yet to be officially adopted into the California Code of Regulations, Title 14, Division 1, §670.2.

State Designated Plants

	Classification			
	State	**List Date**	**Federal**	**List Date**
Acanthomintha duttonii San Mateo thorn-mint	SE	Jul 1979	FE	Sep 18,1985
Acanthomintha ilicifolia San Diego thorn-mint	SE	Jan 1982	FT	Oct 13,1998
Agrostis blasdalei var. *marinensis* (=*Agrostis blasdalei*) Marin bent grass		Delisted April 2008.		
Allium munzii Munz's onion	ST	Jan 1990	FE	Oct 13,1998
Allium yosemitense Yosemite onion	SR	Jul 1982		

State Designated Plants

	Classification State	List Date	Federal	List Date
Alopecurus aequalis var. *sonomensis* Sonoma alopecurus			FE	Oct 22,1997
Ambrosia pumila San Diego ambrosia			FE	July 2, 2002
Amsinckia grandiflora large-flowered fiddleneck	SE	Apr 1982	FE	May 08,1985
Arabis hoffmannii Hoffmann's rock cress			FE	Jul 31,1997
Arabis macdonaldiana McDonald's rock cress	SE	Jul 1979	FE	Sep 28,1978
Arctostaphylos bakeri (=*A. b.* ssp. *bakeri* and *A. b.* ssp. *sublaevis*) Baker's manzanita	SR	Sep 1979		
Arctostaphylos confertiflora Santa Rosa Island manzanita			FE	Jul 31,1997
Arctostaphylos densiflora Vine Hill manzanita	SE	Aug 1981		
Arctostaphylos edmundsii var. *parvifolia* Hanging Gardens manzanita		Delisted April 2008		
Arctostaphylos glandulosa ssp. *crassifolia* Del Mar manzanita			FE	Oct 07,1996
Arctostaphylos hookeri ssp. *hearstiorum* Hearst's manzanita	SE	Sep 1979		
Arctostaphylos hookeri ssp. *ravenii* Presidio manzanita	SE	Nov 1978	FE	Oct 26,1979
Arctostaphylos imbricata San Bruno Mountain manzanita	SE	Sep 1979		
Arctostaphylos morroensis Morro manzanita			FT	Dec 15,1994
Arctostaphylos myrtifolia Ione manzanita			FT	May 26,1999
Arctostaphylos pacifica Pacific manzanita	SE	Sep 1979		
Arctostaphylos pallida pallid manzanita	SE	Nov 1979	FT	Apr 22,1998
Arenaria paludicola marsh sandwort	SE	Feb 1990	FE	Aug 03,1993
Arenaria ursina Big Bear Valley sandwort			FT	Sep 14,1998
Astragalus agnicidus Humboldt milk-vetch	SE	Apr 1982		
Astragalus albens Cushenbury milk-vetch			FE	Aug 24,1994

State Designated Plants

Classification

	State	List Date	Federal	List Date
Astragalus brauntonii Braunton's milk-vetch			FE	Jan 29,1997
Astragalus claranus (=*A. clarianus*) Clara Hunt's milk-vetch	ST	Jan 1990	FE	Oct 22,1997
Astragalus jaegerianus Lane Mountain milk-vetch			FE	Oct 06,1998
Astragalus johannis-howellii Long Valley milk-vetch	SR	Jul 1982		
Astragalus lentiginosus var. *coachellae* Coachella Valley milk-vetch			FE	Oct 06,1998
Astragalus lentiginosus var. *piscinensis* Fish Slough milk-vetch			FT	Oct 06,1998
Astragalus lentiginosus var. *sesquimetralis* Sodaville milk-vetch	SE	Sep 1979		
Astragalus magdalenae var. *peirsonii* Peirson's milk-vetch	SE	Nov 1979	FT	Oct 06,1998
Astragalus monoensis (=*A. monoensis* var. *monoensis*) Mono milk-vetch	SR	Jul 1982		
Astragalus pycnostachyus var. *lanosissimus* Ventura Marsh milk-vetch	SE	Apr 2000	FE	May 21,2001
Astragalus tener var. *titi* coastal dunes milk-vetch	SE	Feb 1982	FE	Aug 12,1998
Astragalus traskiae Trask's milk-vetch	SR	Nov 1979		
Astragalus tricarinatus triple-ribbed milk-vetch			FE	Oct 06,1998
Atriplex coronata var. *notatior* San Jacinto Valley crownscale			FE	Oct 13,1998
Atriplex tularensis Bakersfield smallscale	SE	Jan 1987		
Baccharis vanessae Encinitas baccharis	SE	Jan 1987	FT	Oct 07,1996
Bensoniella oregona bensoniella	SR	Jul 1982		
Berberis nevinii Nevin's barberry	SE	Jan 1987	FE	Oct 13,1998
Berberis pinnata ssp. *insularis* island barberry	SE	Nov 1979	FE	Jul 31,1997
Blennosperma bakeri Sonoma sunshine	SE	Feb 1992	FE	Dec 02,1991
Blennosperma nanum var. *robustum* Point Reyes blennosperma	SR	Nov 1978		
Bloomeria humilis dwarf goldenstar	SR	Nov 1978		
Brodiaea coronaria ssp. *rosea* Indian Valley brodiaea	SE	Sep 1979		

State Designated Plants

	Classification			
	State	**List Date**	**Federal**	**List Date**
Brodiaea filifolia thread-leaved brodiaea	SE	Jan 1982	FT	Oct 13,1998
Brodiaea insignis Kaweah brodiaea	SE	Nov 1979		
Brodiaea pallida Chinese Camp brodiaea	SE	Nov 1978	FT	Sep 14,1998
Calamagrostis foliosa leafy reed grass	SR	Nov 1979		
Calochortus dunnii Dunn's mariposa lily	SR	Nov 1979		
Calochortus persistens Siskiyou mariposa lily	SR	Jul 1982		
Calochortus tiburonensis Tiburon mariposa lily	ST	May 1987	FT	Feb 03,1995
Calyptridium pulchellum Mariposa pussypaws			FT	Sep 14,1998
Calystegia stebbinsii Stebbins's morning-glory	SE	Aug 1981	FE	Oct 18,1996
Camissonia benitensis San Benito evening-primrose			FT	Feb 12,1985
Carex albida white sedge	SE	Nov 1979	FE	Oct 22,1997
Carex tompkinsii Tompkins's sedge	SR	Nov 1979		
Carpenteria californica tree-anemone	ST	Jan 1990		
Castilleja affinis ssp. *neglecta* Tiburon Indian paintbrush	ST	Jan 1990	FE	Feb 03, 1995
Castilleja campestris ssp. *succulenta* succulent owl's-clover	SE	Sep 1979	FT	Mar 26,1997
Castilleja cinerea ash-gray Indian paintbrush			FT	Sep 14,1998
Castilleja gleasonii Mt. Gleason Indian paintbrush	SR	Jul 1982		
Castilleja grisea San Clemente Island Indian paintbrush	SE	Apr 1982	FE	Aug 11,1977

State Designated Plants

	Classification: State	List Date	Federal	List Date
Castilleja mollis soft-leaved Indian paintbrush			FE	Jul 31,1997
Castilleja uliginosa Pitkin Marsh Indian paintbrush	SE	Nov 1978		
Caulanthus californicus California jewel-flower	SE	Jan 1987	FE	Jul 19,1990
Caulanthus stenocarpus slender-pod jewel-flower		Delisted April 2008		
Ceanothus ferrisae coyote ceanothus			FE	Feb 03,1995
Ceanothus hearstiorum Hearst's ceanothus	SR	Aug 1981		
Ceanothus maritimus maritime ceanothus	SR	Nov 1978		
Ceanothus masonii Mason's ceanothus	SR	Nov 1978		
Ceanothus ophiochilus Vail Lake ceanothus	SE	Jan 1994	FT	Oct 13,1998
Ceanothus roderickii Pine Hill ceanothus	SR	Jul 1982	FE	Oct 18,1996
Cercocarpus traskiae Catalina Island mountain-mahogany	SE	Apr 1982	FE	Aug 08,1997
Chamaesyce hooveri Hoover's spurge			FT	Mar 26,1997
Chlorogalum purpureum var. *purpureum*[1] purple amole			FT	Mar 20,2000
Chlorogalum purpureum var. *reductum*[2] Camatta Canyon amole	SR	Nov 1978	FT	Mar 20,2000
Chorizanthe howellii Howell's spineflower	ST	Jan 1987	FE	Jun 22,1992
Chorizanthe orcuttiana Orcutt's spineflower	SE	Nov 1979	FE	Oct 07,1996

1 The U.S. Fish & Wildlife Service listed the entire species, *Chlorogalum purpureum.*

2 The U.S. Fish & Wildlife Service listed the entire species, *Chlorogalum purpureum.*

State Designated Plants

	Classification: State	List Date	Federal	List Date
Chorizanthe parryi var. *fernandina* San Fernando Valley spineflower	SE	Aug 2001		
Chorizanthe pungens var. *hartwegiana* Ben Lomond spineflower			FE	Feb 04,1994
Chorizanthe pungens var. *pungens* Monterey spineflower			FT	Feb 04,1994
Chorizanthe robusta (includes vars. *hartwegii* and *robusta*) robust spineflower			FE	Feb 04,1994
Chorizanthe valida Sonoma spineflower	SE	Jan 1990	FE	Jun 22,1992
Cirsium ciliolatum Ashland thistle	SE	Sep 1982		
Cirsium fontinale var. *fontinale* fountain thistle	SE	Jul 1979	FE	Feb 03,1995
Cirsium fontinale var. *obispoense* Chorro Creek bog thistle	SE	Jun 1993	FE	Dec 15,1994
Cirsium hydrophilum var. *hydrophilum* Suisun thistle			FE	Nov 20,1997
Cirsium loncholepis La Graciosa thistle	ST	Feb 1990	FE	Mar 20,2000
Cirsium rhothophilum surf thistle	ST	Feb 1990		
Clarkia franciscana Presidio clarkia	SE	Nov 1978	FE	Feb 03,1995
Clarkia imbricata Vine Hill clarkia	SE	Nov 1978	FE	Oct 22,1997
Clarkia lingulata Merced clarkia	SE	Jan 1989		
Clarkia speciosa ssp. *immaculata* Pismo clarkia	SR	Nov 1978	FE	Dec 15,1994
Clarkia springvillensis Springville clarkia	SE	Sep 1979	FT	Sep 14,1998
Cordylanthus maritimus ssp. *maritimus* salt marsh bird's-beak	SE	Jul 1979	FE	Sep 28,1978
Cordylanthus mollis ssp. *mollis* soft bird's-beak	SR	Jul 1979	FE	Nov 20,1997
Cordylanthus nidularius Mt. Diablo bird's-beak	SR	Nov 1978		
Cordylanthus palmatus palmate-bracted bird's-beak	SE	May 1984	FE	Jul 01, 1986
Cordylanthus rigidus ssp. *littoralis* seaside bird's-beak	SE	Jan 1982		

State Designated Plants

	Classification: State	List Date	Federal	List Date
Cordylanthus tenuis ssp. *capillaris* Pennell's bird's-beak	SR	Nov 1978	FE	Feb 03,1995
Croton wigginsii Wiggins' croton	SR	Jan 1982		
Cryptantha roosiorum bristlecone cryptantha	SR	Jul 1982		
Cupressus abramsiana (=Callitropsis abramsiana) Santa Cruz cypress	SE	Nov 1979	FE	Jan 08,1987
Cupressus goveniana ssp. *goveniana* (=*Callitropsis goveniana)* Gowen cypress			FT	Aug 12,1998
Dedeckera eurekensis July gold	SR	Nov 1978		
Deinandra arida (=*Hemizonia arida*) Red Rock tarplant	SR	Jul 1982		
Deinandra conjugens (=*Hemizonia conjugens*) Otay tarplant	SE	Nov 1979	FT	Oct 13,1998
Deinandra increscens ssp. *villosa*(=*Hemizonia increscens* ssp. *villosa*) Gaviota tarplant	SE	Jan 1990	FE	Mar 20,2000
Deinandra minthornii (= *Hemizonia minthornii*) Santa Susana tarplant	SR	Nov 1978		
Deinandra mohavensis (= *Hemizonia mohavensis*) Mojave tarplant	SE	Aug 1981		
Delphinium bakeri Baker's larkspur	SE	April 2007	FE	Jan 26,2000
Delphinium hesperium ssp. *cuyamacae* Cuyamaca larkspur	SR	Jul 1982		
Delphinium luteum yellow larkspur	SR	Sep 1979	FE	Jan 26,2000
Delphinium variegatum ssp. *kinkiense* San Clemente Island larkspur	SE	Sep 1979	FE	Aug 11,1977
Dichanthelium lanuginosum var. *thermale* Geysers dichanthelium	SE	Sep 1978		
Dieteria asteroides var. *lagunensis* Mount Laguna aster (= *Machaeranthera asteroides* var. *lagunensis*)	SR	Sep 1979		
Dithyrea maritima beach spectaclepod	ST	Feb 1990		
Dodecahema leptoceras slender-horned spineflower	SE	Jan 1982	FE	Sep 28,1987
Downingia concolor var. *brevior* Cuyamaca Lake downingia	SE	Feb 1982		

State Designated Plants

	Classification State	List Date	Federal	List Date
Dudleya abramsii ssp. *parva* (=*D. parva*) Conejo dudleya			FT	Jan 29,1997
Dudleya brevifolia (=*D. blochmaniae* ssp. *brevifolia*) short-leaved dudleya	SE	Jan 1982		
Dudleya cymosa ssp. *agourensis* [3] Santa Monica Mtns. dudleya			FT	Jan 29, 1997
Dudleya cymosa ssp. *marcescens* marcescent dudleya	SR	Nov 1978	FT	Jan 29,1997
Dudleya cymosa ssp. *ovatifolia* Santa Monica Mountains dudleya			FT	Jan 29,1997
Dudleya nesiotica Santa Cruz Island dudleya	SR	Nov 1979	FT	Jul 31,1997
Dudleya setchellii Santa Clara Valley dudleya			FE	Feb 03,1995
Dudleya stolonifera Laguna Beach dudleya	ST	Jan 1987	FT	Oct 13,1998
Dudleya traskiae Santa Barbara Island dudleya	SE	Nov 1979	FE	Apr 26,1978
Dudleya verityi Verity's dudleya			FT	Jan 29,1997
Enceliopsis nudicaulis var. *corrugata* Ash Meadows daisy			FT	May 20,1985
Eremalche kernensis Kern mallow			FE	Jul 19,1990
Eriastrum densifolium ssp. *sanctorum* Santa Ana River woollystar	SE	Jan 1987	FE	Sep 28,1987
Eriastrum hooveri Hoover's woolly-star			Delisted	Oct 7,2003
Eriastrum tracyi Tracy's eriastrum	SR	Jul 1982		
Erigeron parishii Parish's daisy			FT	Aug 24,1994
Eriodictyon altissimum Indian Knob mountainbalm	SE	Jul 1979	FE	Dec 15,1994
Eriodictyon capitatum Lompoc yerba santa	SR	Sep 1979	FE	Mar 20,2000

[3] The U.S. Fish & Wildlife Service has listed the more encompassing *Dudleya cymosa* ssp. *ovatifolia* from which ssp. *agourensis* was split.

State Designated Plants

	Classification			
	State	**List Date**	**Federal**	**List Date**
Eriogonum alpinum Trinity buckwheat	SE	Jul 1979		
Eriogonum apricum var. *apricum*[4] Ione buckwheat	SE	Aug 1981	FE	May 26,1999
Eriogonum apricum var. *prostratum*[5] Irish Hill buckwheat	SE	Jan 1987	FE	May 26,1999
Eriogonum butterworthianum Butterworth's buckwheat	SR	Nov 1979		
Eriogonum crocatum Conejo buckwheat	SR	Sep 1979		
Eriogonum giganteum var. *compactum* Santa Barbara Island buckwheat	SR	Nov 1979		
Eriogonum grande ssp. *timorum* (= Eriogonum grande var. timorum) San Nicolas Island buckwheat	SE	Nov 1979		
Eriogonum kelloggii Kellogg's buckwheat	SE	Apr 1982		
Eriogonum kennedyi var. *austromontanum* southern mountain buckwheat			FT	Sep 14,1978
Eriogonum ovalifolium var. *vineum* Cushenbury buckwheat			FE	Aug 24,1994
Eriogonum thornei (= *E. ericifolium* var. *thornei*) Thorne's buckwheat	SE	Nov 1979		
Eriogonum twisselmannii Twisselmann's buckwheat	SR	Jul 1982		
Eriophyllum congdonii Congdon's woolly sunflower	SR	Jul 1982		
Eriophyllum latilobum San Mateo woolly sunflower	SE	Jun 1992	FE	Feb 03,1995
Eryngium aristulatum var. *parishii* San Diego button-celery	SE	Jul 1979	FE	Aug 03,1993
Eryngium constancei Loch Lomond button-celery	SE	Jan 1987	FE	Dec 23,1986
Eryngium racemosum Delta button-celery	SE	Aug 1981		
Erysimum capitatum var. *angustatum* Contra Costa wallflower	SE	Nov 1978	FE	Apr 26,1978

4 The U.S. Fish & Wildlife Service has listed *Eriogonum apricum* as the species, which includes both rare varieties.

5 The U.S. Fish & Wildlife Service has listed *Eriogonum apricum* as the species, which includes both rare varieties.

State Designated Plants	**Classification**			
	State	**List Date**	**Federal**	**List Date**
Erysimum menziesii[6] Menzies' wallflower	SE	Sep 1984	FE	Jun 22,1992
Erysimum teretifolium Santa Cruz wallflower	SE	Aug 1981	FE	Feb 04,1994
Fremontodendron decumbens Pine Hill flannelbush	SR	Jul 1979	FE	Oct 18,1996
Fremontodendron mexicanum Mexican flannelbush	SR	Jul 1982	FE	Oct 13,1998
Fritillaria gentneri Gentner's fritillary			FE	Dec 10,1999
Fritillaria roderickii Roderick's fritillary	SE	Nov 1979		
Fritillaria striata striped adobe-lily	ST	Jan 1987		
Galium angustifolium ssp. *borregoense* Borrego bedstraw	SR	Sep 1979		
Galium buxifolium box bedstraw	SR	Nov 1979	FE	Jul 31,1997
Galium californicum ssp. *sierrae* El Dorado bedstraw	SR	Nov 1979	FE	Oct 18,1996
Galium catalinense ssp. *acrispum* San Clemente Island bedstraw	SE	Apr 1982		
Gilia tenuiflora ssp. arenaria sand gilia	ST	Jan 1987	FE	Jun 22,1992
Gilia tenuiflora ssp. hoffmannii Hoffmann's slender-flowered gilia			FE	Jul 31,1997
Gratiola heterosepala Boggs Lake hedge-hyssop	SE	Nov 1978		
Grindelia fraxino-pratensis Ash Meadows gumplant			FT	May 20,1985
Hazardia orcuttii Orcutt's hazardia	ST	Aug 2002		
Helianthemum greenei island rush-rose			FT	Jul 31,1997
Helianthus niveus ssp. *tephrodes* Algodones Dunes sunflower	SE	Nov 1979		
Hesperolinon congestum Marin western flax	ST	Jun 1992	FT	Feb 03,1995

6 The U.S. Fish & Wildlife Service separately listed all as endangered, *E. menziesii* ssp. *eurekense*, *E. menziesii* ssp. *menziesii*, and *E. menziesii* ssp. *yadonii*.

State Designated Plants

Classification

	State	List Date	Federal	List Date
Hesperolinon didymocarpum Lake County western flax	SE	Aug 1981		
Holmgrenanthe petrophila (= *Maurandya petrophila*) rock lady	SR	Jul 1982		
Holocarpha macradenia Santa Cruz tarplant	SE	Sep 1979	FT	Mar 20,2000
Howellia aquatilis water howellia			FT	Jul 14,1994
Ivesia callida Tahquitz ivesia	SR	Jul 1982		
Lasthenia burkei Burke's goldfields	SE	Sep 1979	FE	Dec 02,1991
Lasthenia conjugens Contra Costa goldfields			FE	Jun 18,1997
Layia carnosa beach layia	SE	Jan 1990	FE	Jun 22,1992
Lembertia congdonii (=*Monolopia congdonii*) San Joaquin woollythreads			FE	Jul 19,1990
Lesquerella kingii ssp. *bernardina* San Bernardino Mountains bladderpod			FE	Aug 24,1994
Lessingia germanorum San Francisco lessingia	SE	Jan 1990	FE	Jun 19,1997
Lewisia congdonii Congdon's lewisia	SR	Jul 1982		
Lilaeopsis masonii Mason's lilaeopsis	SR	Nov 1979		
Lilium occidentale western lily	SE	Jan 1982	FE	Aug 17,1994
Lilium pardalinum ssp. *pitkinense* Pitkin Marsh lily	SE	Nov 1978	FE	Oct 22,1997
Limnanthes bakeri Baker's meadowfoam	SR	Nov 1978		
Limnanthes douglasii var. *sulphurea* (=*Limnanthes douglasii ssp. sulphurea*) Point Reyes meadowfoam	SE	Apr 1982		
Limnanthes floccosa ssp. *californica* Butte County meadowfoam	SE	Feb 1982	FE	Jun 08,1992
Limnanthes gracilis var. *parishii* (=*Limnanthes gracilis ssp. parishii*) Parish's meadowfoam	SE	Jul 1979		
Limnanthes vinculans Sebastopol meadowfoam	SE	Nov 1979	FE	Dec 02,1991

State Designated Plants | **Classification**

	State	List Date	Federal	List Date
Lithophragma maximum San Clemente Island woodland star	SE	Feb 1982	FE	Aug 08,1997
Lotus argophyllus var. *adsurgens* San Clemente Island bird's-foot trefoil	SE	Nov 1979		
Lotus argophyllus var. *niveus* Santa Cruz Island bird's-foot trefoil	SE	Aug 1981		
Lotus dendroideus var. *traskiae* San Clemente Island lotus	SE	Apr 1982	FE	Aug 11,1977
Lupinus citrinus var. *deflexus* Mariposa lupine	ST	Jan 1990		
Lupinus milo-bakeri Milo Baker's lupine	ST	Jan 1987		
Lupinus nipomensis Nipomo Mesa lupine	SE	Jan 1987	FE	Mar 20,2000
Lupinus padre-crowleyi Father Crowley's lupine	SR	Aug 1981		
Lupinus tidestromii var. *tidestromii* (=*L. tidestromii*) Tidestrom's lupine	SE	Jan 1987	FE	Jun 22,1992
Machaeranthera lagunensis (see *Dieteria asteroides* var. *lagunensis*)				
Mahonia sonnei (= *Berberis sonnei*) Truckee barberry		Delisted April 2008	Delisted	Oct 1,2003
Malacothamnus clementinus San Clemente Island bush mallow	SE	Feb 1982	FE	Aug 11,1977
Malacothamnus fasciculatus var. *nesioticus* Santa Cruz Island bush mallow	SE	Nov 1979	FE	Jul 31,1997
Malacothrix indecora Santa Cruz Island malacothrix			FE	Jul 31,1997
Malacothrix squalida island malacothrix			FE	Jul 31,1997
Monardella linoides ssp. *viminea* (=*M. viminea*) willowy monardella	SE	Nov 1979	FE	Oct 13,1998
Nasturtium gambellii (= *Rorippa gambellii*) Gambel's water cress	ST	Feb 1990	FE	Aug 03,1993
Navarretia fossalis spreading navarretia			FT	Oct 13,1998
Navarretia leucocephala ssp. *pauciflora* few-flowered navarretia	ST	Jan 1990	FE	Jun 18,1997

State Designated Plants

Classification

	State	List Date	Federal	List Date
Navarretia leucocephala ssp. *plieantha* many-flowered navarretia	SE	Nov 1979	FE	Jun 18,1997
Nemacladus twisselmannii Twisselmann's nemacladus	SR	Jul 1982		
Neostapfia colusana Colusa grass	SE	Nov 1979	FT	Mar 26,1997
Nitrophila mohavensis Amargosa nitrophila	SE	Nov 1979	FE	May 20,1985
Nolina interrata Dehesa nolina	SE	Nov 1979		
Oenothera californica ssp. *eurekensis* Eureka Dunes evening-primrose	SR	Nov 1978	FE	Apr 26,1978
Oenothera deltoides ssp. *howellii* Antioch Dunes evening-primrose	SE	Nov 1978	FE	Apr 26,1978
Opuntia basilaris var. *treleasei* Bakersfield cactus	SE	Jan 1990	FE	Jul 19,1990
Orcuttia californica California Orcutt grass	SE	Sep 1979	FE	Aug 03,1993
Orcuttia inaequalis San Joaquin Valley Orcutt grass	SE	Sep 1979	FT	Mar 26,1997
Orcuttia pilosa hairy Orcutt grass	SE	Sep 1979	FE	Mar 26,1997
Orcuttia tenuis slender Orcutt grass	SE	Sep 1979	FT	Mar 26,1997
Orcuttia viscida Sacramento Orcutt grass	SE	Jul 1979	FE	Mar 26,1997
Ornithostaphylos oppositifolia Baja California birdbush	SE	Apr 2001		
Oxytheca parishii var. *goodmaniana* (=*Acanthoscyphus parishii* var. *goodmaniana* Cushenbury oxytheca			FE	Aug 24,1994
Packera ganderi (= *Senecio ganderi*) Gander's ragwort	SR	Jul 1982		
Packera layneae (= *Senecio layneae*) Layne's ragwort	SR	Nov 1979	FT	Oct 18,1996
Parvisedum leiocarpum (=*Sedella leiocarpa*) Lake County stonecrop	SE	Jan 1990	FE	Jun 18,1997
Pedicularis dudleyi Dudley's lousewort	SR	Sep 1979		
Pentachaeta bellidiflora white-rayed pentachaeta	SE	Jun 1992	FE	Feb 03,1995
Pentachaeta lyonii Lyon's pentachaeta	SE	Jan 1990	FE	Jan 29,1997
Phacelia insularis ssp. *insularis* northern Channel Islands phacelia			FE	Jul 31,1997

State Designated Plants **Classification**

	State	List Date	Federal	List Date
Phlox hirsuta Yreka phlox	SE	Jan 1987	FE	Feb 3,2000
Piperia yadonii Yadon's rein orchid			FE	Aug 12,1998
Plagiobothrys diffusus San Francisco popcorn-flower	SE	Sep 1979		
Plagiobothrys strictus Calistoga popcorn-flower	ST	Jan 1990	FE	Oct 22,1997
Pleuropogon hooverianus North Coast semaphore grass	ST	Dec 2002		
Poa atropurpurea San Bernardino blue grass			FE	Sep 14,1998
Poa napensis Napa blue grass	SE	Jul 1979	FE	Oct 22,1997
Pogogyne abramsii San Diego mesa mint	SE	Jul 1979	FE	Sep 28,1978
Pogogyne clareana Santa Lucia mint	SE	Nov 1979		
Pogogyne nudiuscula Otay Mesa mint	SE	Jan 1987	FE	Aug 03,1993
Polygonum hickmanii Scott's Valley polygonum	SE	May 2005	FE	Apr 8,2003
Potentilla hickmanii Hickman's cinquefoil	SE	Sep 1979	FE	Aug 12,1998
Pseudobahia bahiifolia Hartweg's golden sunburst	SE	Aug 1981	FE	Feb 06,1997
Pseudobahia peirsonii San Joaquin adobe sunburst	SE	Jan 1987	FT	Feb 06,1997
Rorippa subumbellata Tahoe yellow cress	SE	Apr 1982		
Rosa minutifolia small-leaved rose	SE	Oct 1989		
Sanicula maritima adobe sanicle	SR	Aug 1981		
Sanicula saxatilis rock sanicle	SR	Jul 1982		
Sedella leiocarpa (= *Parvisedum leiocarpum*) Lake County stonecrop	SE	Jan 1990	FE	Jun 18,1997
Senecio ganderi (see *Packera ganderi*)				
Senecio layneae (=*Packera layneae*)				
Sibara filifolia Santa Cruz Island rock cress			FE	Aug 08,1997
Sidalcea covillei Owens Valley checkerbloom	SE	Jul 1979		

State Designated Plants

Classification

	State	List Date	Federal	List Date
Sidalcea hickmanii ssp. *anomala* Cuesta Pass checkerbloom	SR	Nov 1979		
Sidalcea hickmanii ssp. *parishii* Parish's checkerbloom	SR	Nov 1979	Removed as FC, 2006 Fed. Register	
Sidalcea keckii Keck's checker-mallow			FE	Feb 16,2000
Sidalcea oregana ssp. *valida* Kenwood Marsh checkerbloom	SE	Jan 1982	FE	Oct 22,1997
Sidalcea pedata bird-foot checkerbloom	SE	Jan 1982	FE	Aug 31,1984
Sidalcea stipularis Scadden Flat checkerbloom	SE	Jan 1982		
Silene campanulata ssp. *campanulata* Red Mountain catchfly	SE	Apr 1982		
Streptanthus albidus ssp. *albidus* Metcalf Canyon jewel-flower			FE	Feb 03,1995
Streptanthus niger Tiburon jewel-flower	SE	Feb 1990	FE	Feb 03,1995
Suaeda californica California seablite			FE	Dec 15,1994
Swallenia alexandrae Eureka Valley dune grass	SR	Aug 1981	FE	Apr 26,1978
Taraxacum californicum California dandelion			FE	Sep 14,1998
Thelypodium stenopetalum slender-petaled thelypodium	SE	Feb 1982	FE	Aug 31,1984
Thermopsis macrophylla var. *angina* (=*T. macrophylla*) Santa Ynez false lupine	SR	Aug 1981		
Thlaspi californicum Kneeland Prairie penny-cress			FE	Feb 9,2000
Thysanocarpus conchuliferus Santa Cruz Island fringepod			FE	Jul 31,1997
Trichostema austromontanum ssp. *compactum* Hidden Lake bluecurls			FT	Sep 14,1998
Trifolium amoenum showy Indian clover			FE	Oct 22,1997
Trifolium polyodon Pacific Grove clover	SR	Sep 1979		
Trifolium trichocalyx Monterey clover	SE	Nov 1979	FE	Aug 12,1998
Tuctoria greenei Greene's tuctoria	SR	Sep 1979	FE	Mar 26,1997
Tuctoria mucronata Crampton's tuctoria	SE	Jul 1979	FE	Sep 28,1978
Verbena californica California vervain	ST	Aug 1994	FT	Sep 14,1998

State Designated Plants	**Classification**			
	State	**List Date**	**Federal**	**List Date**
Verbesina dissita Big-leaved crownbeard	ST	Jan 1990	FT	Oct 07,1996

FINAL

MITIGATED NEGATIVE DECLARATION

THE INTEGRATED MOSQUITO MANAGEMENT PROGRAM

OF THE NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

Napa County Mosquito Abatement District
P.O. Box 655
Napa, CA 94559
October 1999

INTEGRATED MOSQUITO MANAGEMENT PROGRAM

INTRODUCTION

This document is a Draft Mitigated Negative Declaration and Initial Study for the Integrated Mosquito Management Program of the Napa County Mosquito Abatement District (District), prepared by the District in accordance with Section 15162 of California Environmental Quality Act (CEQA) Guidelines. This document contains the following:

Draft Mitigated Negative Declaration. The Draft Mitigated Negative Declaration briefly summarizes and states the conclusions of the Initial Study (Part III), including potential impacts and mitigation measures to insure non-significance. Because the Project avoids significant impacts or includes measures that reduce potential impacts to levels of non-significance, the determination has been made that a Mitigated Negative Declaration is the appropriate document.

Initial Study. This portion of the document is organized with the following sections:

1. The Lead Agency's Determination, which is the statement of the overall significance of the Project's impacts and the identification of the appropriate environmental review document.

2. Environmental Checklist Form, which provides specific information about the Project's purpose and scope, the specific Project activities, actions taken by the District to keep potential environmental impacts of the Project at non-significant levels, and other required approvals.

3. Evaluation of Environmental Impacts, which contains the standard checklist where each environmental issue is defined, impacts are assessed, and determination is made of the level of significance of each potential impact. Explanations in support of the conclusions are also provided.

4. Detailed Technical Review of the Project, which contains narrative description of the Project Impact Area and Project activities, focusing on potential environmental impacts of Project activities and on the policies and practices adopted to ensure that impacts are not significant.

5. References cited or used in preparation of this Study.

6. Appendix. The District's Preliminary CEQA Review.

Comments regarding this report should be addressed to

Mr. Wesley A. Maffei
Manager
Napa County Mosquito Abatement District
P.O. Box 655
Napa, CA 94559

DRAFT MITIGATED NEGATIVE DECLARATION

Napa County Mosquito Abatement District
August 27, 1999

Project Title: INTEGRATED MOSQUITO MANAGEMENT PROGRAM

Project Proponent: NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

Project Location: The whole of Napa County. In addition, the District periodically cooperates with adjoining Mosquito & Vector Control Districts and/or County and State Health Departments on activities that cross normal District boundaries; in these situations, the District or Department with jurisdiction over the locations where specific activities are performed has primary responsibility for these activities.

Project Description: The Integrated Mosquito Management Program of the Napa County Mosquito Abatement District is a long-standing, ongoing program of surveillance and control of mosquitoes. The program consists of six types of activities: 1) **Surveillance** for mosquito populations, mosquito habitats, disease pathogens, and public distress associated with mosquitoes; this includes trapping and laboratory analysis of mosquitoes to evaluate populations and disease threats, direct visual inspection of known or suspected mosquito habitats, the use of all-terrain vehicles, maintenance of paths, and public surveys; 2) Public **Education** to encourage and assist reduction or prevention of mosquito habitats on private and public property; 3) Management of mosquito habitat, especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities, etc. ("**Physical Control**"); 4) Applications of herbicides and other forms of **Vegetation Management** to improve surveillance or reduce mosquito populations; 5) Applications of the "mosquito fish" *Gambusia affinis*, the bacterium *Bacillus sphaericus*, the fungus *Lagenidium giganteum*, and possibly other predators and pathogens of mosquitoes ("**Biological Control**"); and 6) Application of non-persistent selective insecticides to reduce populations of larval or adult mosquitoes ("**Chemical Control**").

General Plans: All Designations (Heavy Industry, Open Space, Parks, Residential, Commercial, Agricultural, etc.)

Zoning: All Zoning Districts

Potential Environmental Impacts and Mitigation: Because of the nature of the project activities, the District's Integrated Mosquito Management Program does not and could not cause significant impacts to aesthetics, agricultural resources, land use and planning, mineral resources, population and housing, public services, recreation, transportation and traffic, or utilities and service systems. In addition, district policies and the limited scale and frequency of project activities ensure that no significant impacts occur regarding air quality, cultural resources, geology and soil, hydrology and water quality, or noise.

The Project includes controls (District policies and practices) to minimize potential impacts to biological resources and hazards and hazardous materials, which could include:

1. Disturbance to natural communities or plants or animals, including special status species, associated with use of all-terrain vehicles, helicopters, and/or boats on and near wetlands;
2. Non-target pesticide impacts on plants or animals, including special status species;
3. Impacts to special status species by mosquito fish in the environment; and
4. Disturbance to and potential release of previously unknown sediment contaminants during physical control activities.

Established District policies require mosquito surveillance and the use of treatment criteria prior to chemical, biological, or physical control; monitoring and reporting of activities to appropriate agencies; and other measures to minimize potential environmental impacts. Additional mitigation measures to ensure that these potential impacts remain insignificant will include:

1. Maintenance of up-to-date maps and other information from the California Department of Fish and Game Natural Diversity Data Base and other reliable sources on the location of Special Status Species and designated Natural Communities in the Project Service Area;
2. Coordination of District activities with approved Habitat Conservation Plans and Endangered Species Recovery Plans;
3. Adoption of new policies as needed and provision of continuing training to field personnel to ensure minimization of specific mosquito control activities and/or the use of alternative mosquito control methods at times and in places where those specific mosquito control activities might otherwise significantly impact Special Status Species or designated Natural Communities; and
4. Review of agency lists for potential hazards (contaminated soils) prior to implementation of minor physical control projects in historically industrial zones; and additional, site-specific CEQA review prior to implementation of source reduction projects which might result in discharge of hazardous materials into the environment.

District Determination: In accordance with District policies regarding implementation of the California Environmental Quality Act (CEQA) and the CEQA Guidelines, the District conducted a Preliminary Review of its activities in early 1999 and concluded that all administrative, support, educational, and emergency activities were exempt from further CEQA review. Because some elements of the Integrated Mosquito Management Program are not clearly exempt from further CEQA review, the District has conducted an Initial Study to determine whether the District's Integrated Mosquito Management Program may have a significant effect on the environment. On the basis of that study the District hereby finds:

> *Although the on-going project could have a significant adverse effect on the environment, there is no significant adverse effect in this case because the mitigation measures described in the accompanying pages reduce impacts to insignificant levels or eliminate them. A Mitigated Negative Declaration is therefore the appropriate CEQA document for this Project.*

The environmental document that justifies the Mitigated Negative Declaration and provides the basis for this determination is the Initial Study, which is attached and hereby made part of this document.

PART III

CEQA INITIAL STUDY OF ENVIRONMENTAL IMPACTS

Napa County Mosquito Abatement District
August 30, 1999

Project Title: INTEGRATED MOSQUITO MANAGEMENT PROGRAM

SECTION 1. CEQA DETERMINATION

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:

The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

	Aesthetics		Agricultural Resources		Air Quality
	Biological Resources		Cultural Resources		Geology / Soils
	Hazards & Hazardous Materials		Hydrology / Water Quality		Land Use / Planning
	Mineral Resources		Noise		Population / Housing
	Public Services		Recreation		Transportation / Traffic
	Utilities / Service Systems		Mandatory Findings of Significance		

DETERMINATION. (To be completed by the Lead Agency.)

On the basis of this initial evaluation:

X **I find that although the proposed project could have a significant effect on the environment, there will not be a significant effect in this case because revisions in the project have been made by or agreed to by the project proponent. A MITIGATED NEGATIVE DECLARATION will be prepared.**

Wesley A. Maffei
Signature

31 Aug 1999
Date

Wesley A. Maffei, Manager
Printed Name

Napa County Mosquito Abatement District
For

SECTION 2. ENVIRONMENTAL CHECKLIST FORM

This document is an Initial Study of the potential environmental impacts of the Integrated Mosquito Management (IMM) Program of the Napa County Mosquito Abatement District (District). This Initial Study was prepared pursuant to the California Environmental Quality Act (CEQA) of 1970, as amended, and in accordance with the CEQA Guidelines. The primary purpose of the Initial Study is to determine and document whether the ongoing activities have a significant or potentially significant effect on the environment.

2.1 PROJECT TITLE:

THE INTEGRATED MOSQUITO MANAGEMENT PROGRAM OF THE NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

2.2 LEAD AGENCY NAME AND ADDRESS:

Napa County Mosquito Abatement District
P.O. Box 655
Napa, CA 94559

2.3 CONTACT PERSON AND PHONE NUMBER:

Wesley A. Maffei
Manager
(707) 258-6044

2.4 PROJECT LOCATION:

All areas contained within Napa County, California. In addition, the District can take action in bordering areas of Solano County, Sonoma County, Yolo County, or Lake County if needed to provide control of mosquitoes for residents of Napa County [Cal. Health & Safety Code Section 2270]. Areas actually or potentially impacted by the Project include:

1. The incorporated cities of American Canyon, Calistoga, Napa, St. Helena, and the Town of Yountville;
2. The unincorporated areas of Napa County; and
3. Other bordering areas in Solano, Sonoma, Yolo, or Lake Counties.

2.5 PROJECT SPONSOR'S NAME AND ADDRESS:

Napa County Mosquito Abatement District
P.O. Box 655
Concord, CA 95420

2.6 GENERAL PLAN DESIGNATION:

All general plan designations found within Napa County

2.7 ZONING:

All zoning designations found within Napa County

2.8 SURROUNDING LAND USES AND SETTING:

The Project Service Area, which is coterminous with Napa County, has a diverse set of land uses and environmental settings. The District divides the Service Area into six zones, corresponding roughly to the pattern of mosquito production found in each (see map at end of Section 2). Zone 1 is the southern area of the District (south of Highway 121) and serves the southern portion of the City of Napa, all of American Canyon, and the adjacent unincorporated areas. Land uses also include inactive salt ponds, state wildlife refuges, light industrial, and extensive agricultural production. All of the District's coastal marshland and some of its seasonal wetlands are within this zone. Zones 2 and 3 include the City of Napa north of Highway 121, the Town of Yountville, and adjacent unincorporated areas. Zones 4 and 5 serve the Cities of St. Helena and Calistoga as well as the unincorporated communities of Angwin, Oakville, Pope Valley, and Rutherford. Zones 2 through 5 have a wide range of climatic conditions, land uses, and habitats, including riparian areas, dense oak woodland, coniferous forests, open grassland, extensive agricultural production, seasonal wetlands, numerous wastewater ponds, etc.. Zone 6 serves the unincorporated areas in and around Lake Berryessa and is much warmer and dryer than the rest of the County.

Mosquito production is associated with wet areas of all types and sizes. This includes marshes, ponds, creeks, seasonal wetlands, wastewater ponds, storm-water detention basins, irrigated pastures, duck clubs, etc, as well as individual homes or commercial buildings. Because of the diversity of mosquito habitat, almost all land use categories in the District Service Areas may be affected by the Project.

2.9 OTHER PUBLIC AGENCIES WHOSE REVIEW/APPROVAL IS REQUIRED:

The District's IMM Program as a whole, including the registration and continuing education of state-certified field personnel, is reviewed and approved by the **California Department of Health Services**, through a formal Cooperative Agreement that is renewed annually.

For work on state lands and riparian zones, wetlands or other sensitive habitats, the District coordinates and reviews activities with the **California Department of Fish & Game** and the **California State Lands Commission** as Trustee Agencies.

For minor physical control activities, the District obtains five-year regional permits from the **U.S. Army Corps of Engineers** (with review by the **San Francisco Regional Water Quality Control Board** and/or the **U.S. Fish & Wildlife Service**, as appropriate), and from the **San Francisco Bay Conservation & Development Commission**.

For chemical control activities, the District reports to and is periodically reviewed by the **Napa County Agricultural Commissioner**.

2.10 DESCRIPTION OF PROJECT:

The Integrated Mosquito Control Program of the Napa County Mosquito Abatement District (the Project) that is evaluated in this Initial Study is an ongoing program of surveillance and control of mosquito vectors[1] of human disease and discomfort. The Program/Project essentially consists of six types of activities:

- **Surveillance** for mosquito populations, mosquito habitats, disease pathogens, and public distress associated with mosquitoes; this includes trapping and laboratory analysis of mosquitoes to evaluate populations and disease threats, direct visual inspection of known or suspected mosquito habitats, the use of all-terrain vehicles, maintenance of paths, and public surveys;
- Public **Education** to encourage and assist reduction or prevention of mosquito habitats on private and public property;
- Management of mosquito habitat, especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities, etc. ("**Physical Control**");

[1]The California State Health and Safety Code defines a "vector" as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal" (Section 2200(f)).

- Applications of herbicides and other forms of **Vegetation Management** to improve surveillance or reduce mosquito populations;
- Applications of the "mosquito fish" *Gambusia affinis,* the bacterium *Bacillus sphaericus*, the fungus *Lagenidium giganteum*; and possibly use of other predators or pathogens of mosquitoes (**"Biological Control"**); and
- Application of non-persistent selective insecticides to reduce populations of larval or adult mosquitoes (**"Chemical Control"**).

Descriptions of these activities, including their typical annual frequency and intensity, and general District policies and procedures to ensure that they result in no significant environmental impact, are provided below. Detailed technical descriptions of these activities, including an extensive literature review and material-specific or site-specific District policies and procedures, including application criteria, are discussed in detail in Section 4 of this Initial Study.

A. Purpose and Need

The California Health and Safety Code defines a vector as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal" (Section 2200(f)). The District undertakes activities through its Integrated Mosquito Management Program to control mosquitoes as vectors of disease and/or discomfort in the Service Area.

Certain species of mosquitoes found in Napa County can transmit malaria, St. Louis encephalitis, western equine encephalomyelitis, and potentially other encephalitis viruses. A few species of mosquitoes are also capable of transmitting dog heartworm. Although some species of mosquitoes have not been shown to transmit disease, most species can cause human discomfort when the female mosquito bites to obtain blood. Reactions range from irritation in the area of the bite to severe allergic reactions or secondary infections resulting from scratching the irritated area. Additionally, an abundance of mosquitoes can cause economic losses, and loss of use or enjoyment of recreational, agricultural, or industrial areas.

Mosquitoes are extremely mobile and cause the greatest hazard or discomfort away from their breeding site. Each mosquito species has a unique life cycle and most of them occupy different habitats. In order to effectively control all types mosquitoes in the District Service Area, an integrated mosquito management program must be employed. District policy is to identify those mosquito species and sources in the Service Area, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between mosquitoes and humans.

B. General Mosquito Management Strategy

As described in the Preliminary Review, the District's activities address mosquito management through a general strategy including identification of mosquito problems; responsive actions to control existing populations of mosquitoes, prevent new sources of mosquitoes from developing, and manage habitat to minimize mosquito production; education of land-owners and others on measures to minimize mosquito production or interaction with mosquitoes; and provision and administration of funding and institutional support necessary to accomplish these goals.

In order to accomplish effective and environmentally sound mosquito management, the manipulation and control of mosquitoes must be based on careful surveillance of their abundance, habitat (potential abundance), pathogen load, and/or potential contact with people; the establishment of treatment criteria (thresholds); and appropriate selection from a wide range of control methods. This dynamic combination of surveillance, treatment criteria, and selection between multiple control activities in coordinated program is generally known as Integrated Pest Management (IPM) (Glass 1975, Davis et al 1979, Borror et al 1981, Durso 1996, Robinson 1996).

The District's Mosquito Management Program, like any other IPM program, by definition involves procedures for minimizing potential environmental impacts. The District's Project employs IPM principles by first determining the species and abundance of mosquitoes through evaluation of public service requests and field surveys of immature and adult mosquito populations; and then, if the populations exceed predetermined criteria, using the most efficient, effective, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy. In some situations, water management or other physical control activities (historically known as "source reduction", "permanent control", or "long-term control"[2]) can be instituted to reduce mosquito breeding sites. The District also uses biological control such as the planting of mosquitofish in some settings. When these approaches are not effective or are otherwise inappropriate, then pesticides are used to treat specific mosquito-producing or mosquito-harboring areas or mosquito populations.

In order to maximize familiarity by the operational staff with specific mosquito sources in the Project area, the District is divided into zones (currently six). Each zone is assigned a full-time Mosquito Control Technician, and sometimes an Aide, whose responsibilities include minor physical control, inspection and treatment of known mosquito sources, finding and controlling new sources, and responding to service requests from the public.

Mosquito control activities are conducted at a wide variety of sites throughout the District's Project area. These sites can be roughly divided into those where activities may have an effect on the natural environment either directly or indirectly (through drainage), and sites where the potential environmental impacts are negligible ("Non-Environmental Sites". Examples of "Environmental Sites" in the Project area include tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, stormwater detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, irrigated pastures, or agricultural ditches. Examples of "Non-Environmental Sites" include animal troughs, artificial containers, tire piles, fountains, ornamental fish ponds, swimming pools, liquid waste detention ponds, and non-natural harborage (such as wood piles, residential and commercial landscape, trash receptacles, etc.).

The intensity of chemical, biological, or physical control activities in the District Service Area in general, or in any particular mosquito source, varies seasonally and from year to year because of weather conditions, size and distribution of mosquito populations, disease patterns, known or potential pesticide resistance, and in response to other variables. Therefore, the scopes of work discussed in the sections below are illustrative of typical District activities levels, but they are expected to show continuing variation in the future.

C. CEQA-Exempt District Activities

All District activities were evaluated in the District's CEQA Preliminary Review (Appendix A1), which was developed in the Spring of 1999. In the Preliminary Review, the District concluded that most activities conducted by the District are statutorily or categorically exempt from further CEQA review. It was also determined that some specific activities within the District's Integrated Mosquito Management Program might exceed the scope of the exemptions to CEQA, or might trigger one or more of the exceptions to the exemptions, primarily because of their potential impacts on endangered species or in critical wetland habitats. Therefore the District has undertaken this Initial Study. To ensure that no potentially significant cumulative effects are missed, the entire IMM Program is evaluated here, with the exception of the Education activities that are clearly exempt from further CEQA review, as described in the Preliminary Review. In addition, all administrative support activities are exempt and are not discussed further in this document.

In the event of emergency conditions (actual or imminent disease outbreak), District actions are also exempt from CEQA (see Preliminary Review), and are therefore not covered by this document. It should be noted, however, that reasonably foreseeable actions in the event of emergencies vary from the routine operational actions of the District only in scope or intensity, and as such are not expected to result in any significant environmental impact.

D. SURVEILLANCE

The District's responsibility to protect public health and welfare involves monitoring the abundance of mosquitoes, mosquito habitat, mosquito-borne pathogens, and interactions between mosquitoes and people over time and

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[2]In the 1940's to 60's, source reduction was sometimes called "permanent" or "long-term" control to contrast it with the clearly temporary ("short-term") results of chemical pesticides. Experience has showed that, while "long-term" may be an accurate description, the results of physical control are not permanent (see Section 4).

space. Collectively, these monitoring activities are termed Mosquito Surveillance. Mosquito surveillance provides the District with valuable information on what mosquito species are present or likely to occur, when they occur, where they occur, how many there are, and if they are carrying disease or otherwise affecting humans. Mosquito surveillance is critical to an Integrated Mosquito Management Program because the information it provides is evaluated against treatment criteria to decide when and where to institute mosquito control measures. Equally important is the use of mosquito surveillance in evaluating the efficacy, cost effectiveness, and environmental impacts of specific mosquito control actions.

The DISTRICT routinely uses a variety of traps for surveillance of adult mosquitoes, regular field investigation of known mosquito sources, flocks of sentinel chickens for arbovirus[3] testing, public service requests for adult mosquitoes; and low ground pressure all-terrain vehicles to access these sites.

The District's mosquito and disease surveillance activities are conducted in compliance with accepted Federal and State guidelines, and the reader is referred to the volumes by Moore et al. (1993), Durso (ed.). (1996), and Reisen et al. (1995) for further information on specific surveillance techniques. These guidelines recognize that local conditions vary, and are thus flexible in the selection and specific application of methods. Therefore, the District's specific activities and their potential environmental impacts are described below.

E. PHYSICAL CONTROL = HABITAT MODIFICATION

Dredging, placement of culverts or other engineering works, and other physical changes to the land can reduce mosquito production directly by improving water circulation or drainage, indirectly by improving habitat values for predators of larval mosquitoes, including fish and many invertebrates, or by otherwise reducing a site's habitat value for mosquito larvae. The DISTRICT performs these physical control activities in accord with all appropriate environmental regulations (wetland fill and dredge permits, endangered species review, water quality review, etc.), and in a manner that generally maintains or improves habitat values for desirable species. Major physical control activities or projects (beyond the scope of the District's five-year regional wetlands permits with the U.S. Army Corps of Engineers and the S.F. Bay Conservation and Development Commission) receive individual CEQA review. Minor physical control activities (covered by the regional wetlands permits) are covered under this document. These vary substantially from year to year, but typically consist of up to 2,000 feet of ditch maintenance. Under the regional permits, the District's work plans are reviewed annually by trustee and other responsible agencies prior to initiation of the planned work.

F. VEGETATION MANAGEMENT

The District periodically applies herbicides to reduce the mosquito habitat value of sites by improving water circulation or access by fish and other predators, or to allow access to standing water for inspections and treatment. Herbicides used by the District include Round Up and Rodeo, which are both based on the active ingredient Glyphosate, and Karmex, which is based on the active ingredient Diuron. Both Rodeo (labeled for aquatic applications) and Roundup (labeled for terrestrial applications) are used for spot control of actively growing vegetation. Karmex is used by the District in the fall as a preemergent herbicide. All herbicides are applied in strict conformance with label requirements.

Table 1 (page 9) shows the total amounts of herbicides used and the number of applications made by the District for the years 1995-1999.

G. BIOLOGICAL CONTROL

The DISTRICT uses the mosquitofish *Gambusia affinis* in some types of mosquito larval habitat to provide

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[3]Arbovirus is a conventional term used to refer to ARthropod-BOrne Viruses (Reisen et al 1995).

biological control of mosquitoes through direct predation of larvae. Stocking by DISTRICT personnel complies with strict guidelines designed to ensure that no significant impacts can occur to native species. These guidelines are discussed in Section 4 of this Initial Study. On average, the District releases about 60-80 pounds of mosquitofish annually, and distributes an additional 20 pounds to the public.

Other biological control methods available to the District include the application of the fungus *Lagenidium giganteum*, and the biological insecticide *Bacillus sphaericus* (B sphaericus). *Lagenidium giganteum* and *B. sphaericus* are not used operationally by the District at this time, but might be adopted in the future for specific applications. Because the potential environmental impacts of applying the *Bacillus* relate to potential disturbance associated with the mode of application, and the potential for non-target toxicity, these materials will be discussed below under Chemical Control.

H. CHEMICAL CONTROL = PESTICIDE APPLICATION

When field inspections indicate the presence of mosquito populations which meet District criteria for chemical control (including abundance, density, species composition, proximity to human settlements, water temperature, presence of predators, and others), District staff apply pesticides to the site in strict accordance with the pesticide label instructions. The total number of applications and weight or volumes of pesticides applied by the District in 1995-1999 are shown in Table 1 (page 9).

a. Mosquito Larvicides: Depending on time of year, water temperature, organic content, mosquito species present, larval density, and other variables, pesticide applications may be repeated at any site at recurrence intervals ranging from annually to weekly.

Larvicides routinely used by the DISTRICT include Bti (*Bacillus thuringiensis israelensis*), Methoprene (Altosid), and Golden Bear 1111.

Bti (*Bacillus thuringiensis israelensis*) is a bacterium that is ingested by larval mosquitoes and disrupts their gut lining, leading to death before pupation. Bti is applied by the District as a liquid or bonded to an inert substrate (sand or corn cob granules) to assist penetration of vegetation. Persistence is low in the environment, and efficacy depends on careful timing of application relative to the larval instar. Therefore, use of Bti requires frequent inspections of larval sources during periods of larval production, and may require frequent applications of material. Application can be by hand, ATV, or aircraft. The District used about 163 gallons of aqueous Bti solution and 157 pounds of technical powder in 1998, and unusually wet year with high demands for mosquito control.

Methoprene, or Altosid, is a synthetic juvenile hormone designed to disrupt the transformation of a juvenile mosquito into an adult. It is applied either in response to observed high populations of mosquito larvae at a site, or as a sustained-release product that can persist for up to about four months. Application can be by hand, ATV, or aircraft. The District applied about 22 pounds of Altosid Pellets and 26.5 gallons of Altosid Liquid Larvicide in the entire Service Area during 1998.

Golden Bear Oil 1111 is a petroleum distillate with low phytotoxicity and fast environmental breakdown, that forms a thin film on water and kills larvae through suffocation and/or direct toxicity. It is typically applied by hand, ATV, or truck at application rates of 3-5 gallons per acre. The District applied about 1,645 gallons of GB 1111 to the entire Service Area during 1998, and has not applied over 2,000 gallons during any calendar year.

Agnique is the trade name for a recently reissued surface film larvicide, comprised of ethoxylated alcohol, that kills mosquito larvae and pupae in much the same manner as Golden Bear 1111. The District may use Agnique as an alternative to Golden Bear 1111 in the future although costs, limits of application, and effective duration are issues of concern. 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.

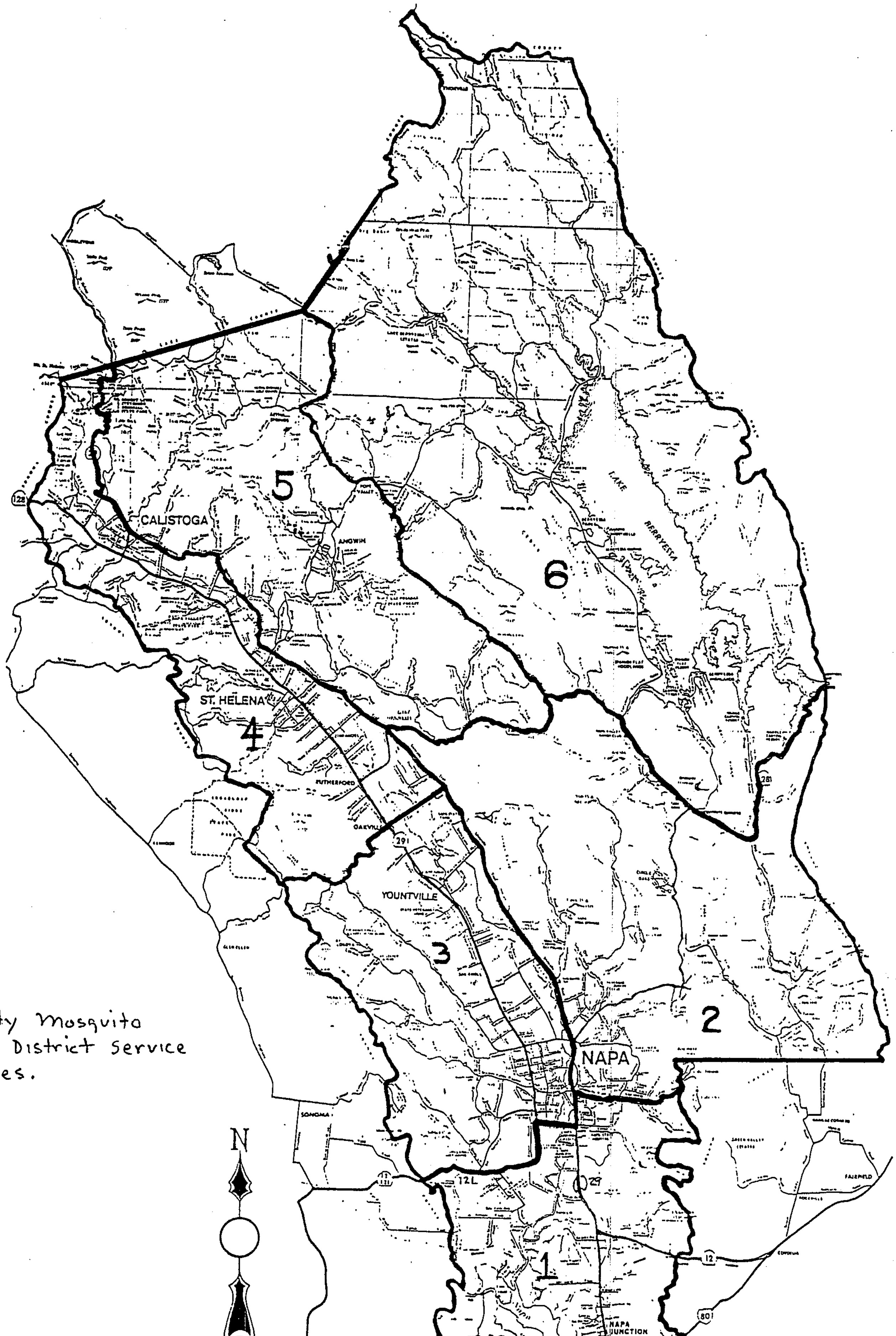
Finally, *Bacillus sphaericus* is a biological larvicide that the District may use in the future. The mode of action is similar to that of *Bti*, but *B. sphaericus* may be used more than *Bti* in some sites because of its higher effectiveness in water with higher organic content.

b. Mosquito Adulticides: In addition to chemical control of mosquito larvae, the DISTRICT also makes aerosol applications of pesticides for control of adult mosquitoes if specific criteria are met, including species composition, population density (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk (Section 4). As with larvicides, adulticides are applied in strict conformance with label requirements. Adulticides used by the District include Pyrethrins (Pyrocide® -- 23.8 gallons in 1998; Pyrenone Crop Spray® -- none applied in 1998) and the synthetic pyrethroids Resmethrin (Scourge® -- none in 1998) and Permethrin (none in 1998).

Table 1: Pesticide Use by Napa County Mosquito Abatement District, 1995-1999 (first value is number of applications of material by District staff during the year; second number is the total quantity of material applied by District staff during the year).

Pesticide (applications/units)	1995	1996	1997	1998*	1999*
Mosquito Larvicides					
Altosid					
Briquets (lbs)	0/0	0/0	0/0	0/0	0/0
Pellets (lbs)	2/8	2/8	2/12	12/21.95	18/5.44
Liquid (oz)	25/16.89	0/0	43/0.82	137/26.63	126/7.49
Bacillus thuringiensis H-14 (Bti)					
Teknar HPD (gal)	0/0	39/6.33	38/4.28	103/80.23	96/21.86
Vectobac 12AS (gal)	137/182.55	77/5.39	44/4.82	15/83.14	9/4.88
Vectobac Tech Powder (lbs)	417/223.9	380/219.88	377/172.43	310/157.71	154/99.67
Water Surface Films					
Golden Bear 1111 (gal)	340/571.25	282/647.75	230/714.5	407/1645.4	205/485
Agnique	0/0	0/0	0/0	0/0	0/0
Mosquito Adulticides					
Pyrethrins					
Pyrocide 7396 (gal)	105/18.68	127/17.73	93/15.32	131/23.81	135/21.92
Pyrenone (gal)	0/0	0/0	0/0	0/0	0/0
Resmethrin (Scourge) (gal)	0/0	0/0	0/0	0/0	0/0
Permethrin (Biomist) (gal)	0/0	0/0	0/0	0/0	0/0
Herbicides					
Glyphosate-based					
Rodeo (gal)	10/6	20/12	31/28.25	22/20.5	7/6.88
Roundup (gal)	49/34.2	44/30.38	70/44.88	27/22.63	44/37.56
Karmex DF (lbs)	82/1936	82/1588	94/1940	91/2200	0/0

Notes:
* 1998 was an exceptionally wet "El Niño" year
* 1999 data covers only January 1 – July 31



Napa County Mosquito
Abatement District Service
Area Zones.

SECTION 3. EVALUATION OF ENVIRONMENTAL IMPACTS

This section presents the detailed environmental checklist and a discussion of potential environmental impacts of the project and mitigation measures that have been incorporated into the project to reduce the impacts, if any, to a less-than-significant level. The checklist includes questions relating to 17 areas of concern, and following each subject category an explanation is provided to support the basis of the impact finding. In preparing this Section, the District has conformed with the CEQA Guidelines (Appendix G):

3.1 AESTHETICS.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect on a scenic vista?				X
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?				X
c) Substantially degrade the existing visual character or quality of the site and its surroundings?			X	
c) Create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?			X	

Explanation:

Setting

The Napa Valley has a very significant tourism industry, based on its attractive vineyards, riparian and other natural areas, hunting and fishing, and historic towns and structures. The aesthetic character of the area is critical to the economy and the quality of life, and protecting this character during government activities is a high priority for all government agencies, including the District.

Potential Environmental Impacts and Measures to Avoid Significance

Mosquito control activities will generally have no significant or long term effect on the appearance of wetlands or riparian zones. Inspection and control activities using wheeled vehicles on soft ground or in vegetated areas can temporarily knock down tall or stiff plants on the marshlands, but this is a short-term phenomena that is generally not visible except from a distance. In addition, the District typically uses ATV routes that minimize visual impacts. Physical control projects generally benefit the appearance of diked marshlands. With the changes in the hydrological regime, vegetation generally spreads into the barren areas. Overall, the cover and vigor of vegetation is expected to increase, and the area would appear greener. Bird use of source reduction sites should expand, especially during the dry season. These changes are expected to occur slowly over time, and are expected to enhance the views of the sites.

Adult mosquito traps contain light sources as an attractant to the mosquitoes. However, these lights are insignificant in relationship to existing light sources. Larger traps have a maximum light output of about 25 watts per trap, and are located in areas with 110v AC power and, thus, inevitably other lights. The smaller traps, which can be deployed at a distance from power lines, have batteries and bulbs equivalent to small flashlights.

3.2 AGRICULTURAL RESOURCES.

In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?				X
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?				X
c) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland to non-agricultural use?				X

Explanation:

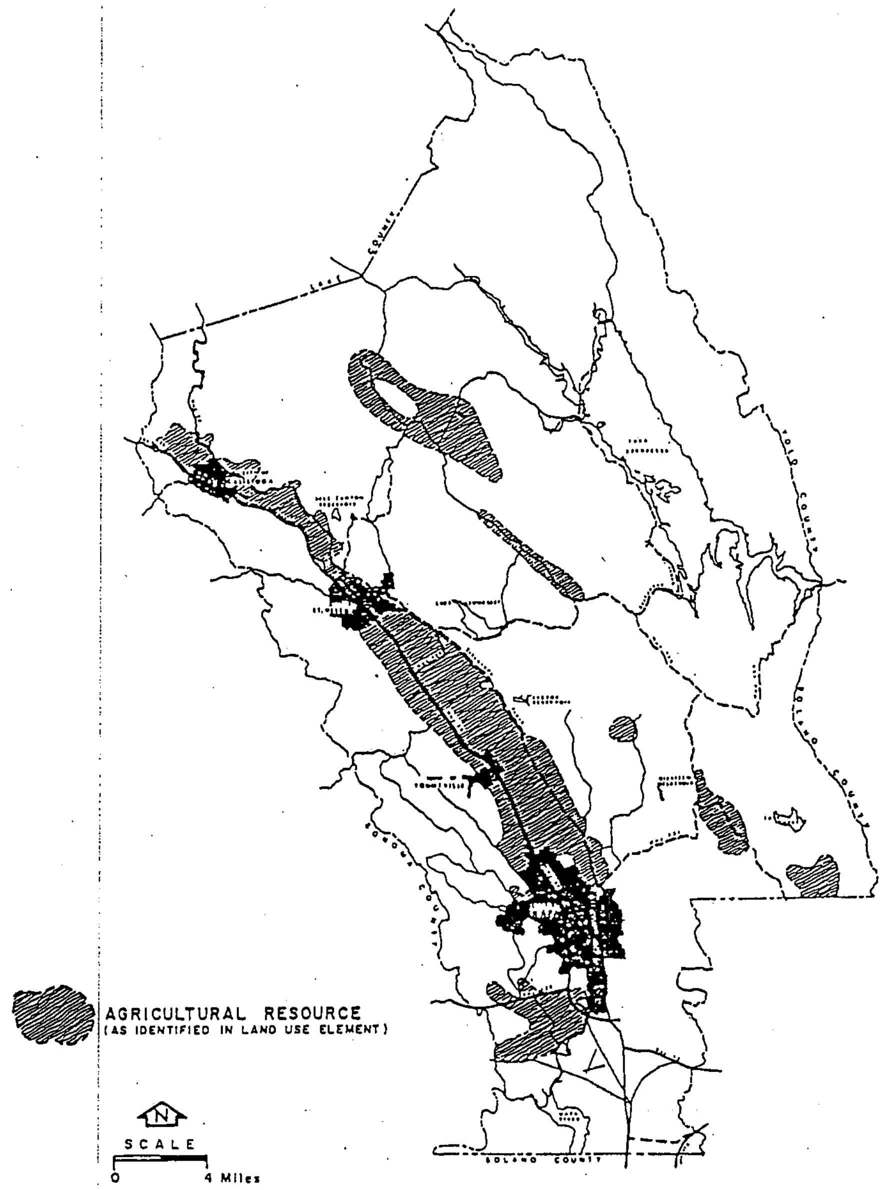
Setting

The District Service Area includes approximately 140,000 acres of agricultural lands, most of which is open range lands (see attached maps from Napa County General Plan). Of this total, about 36,000 acres are in cultivation each year, and about 500 acres are irrigated pastures (Napa County Ag. Commissioner, 8/27/99).

Potential Environmental Impacts and Measures to Avoid Significance

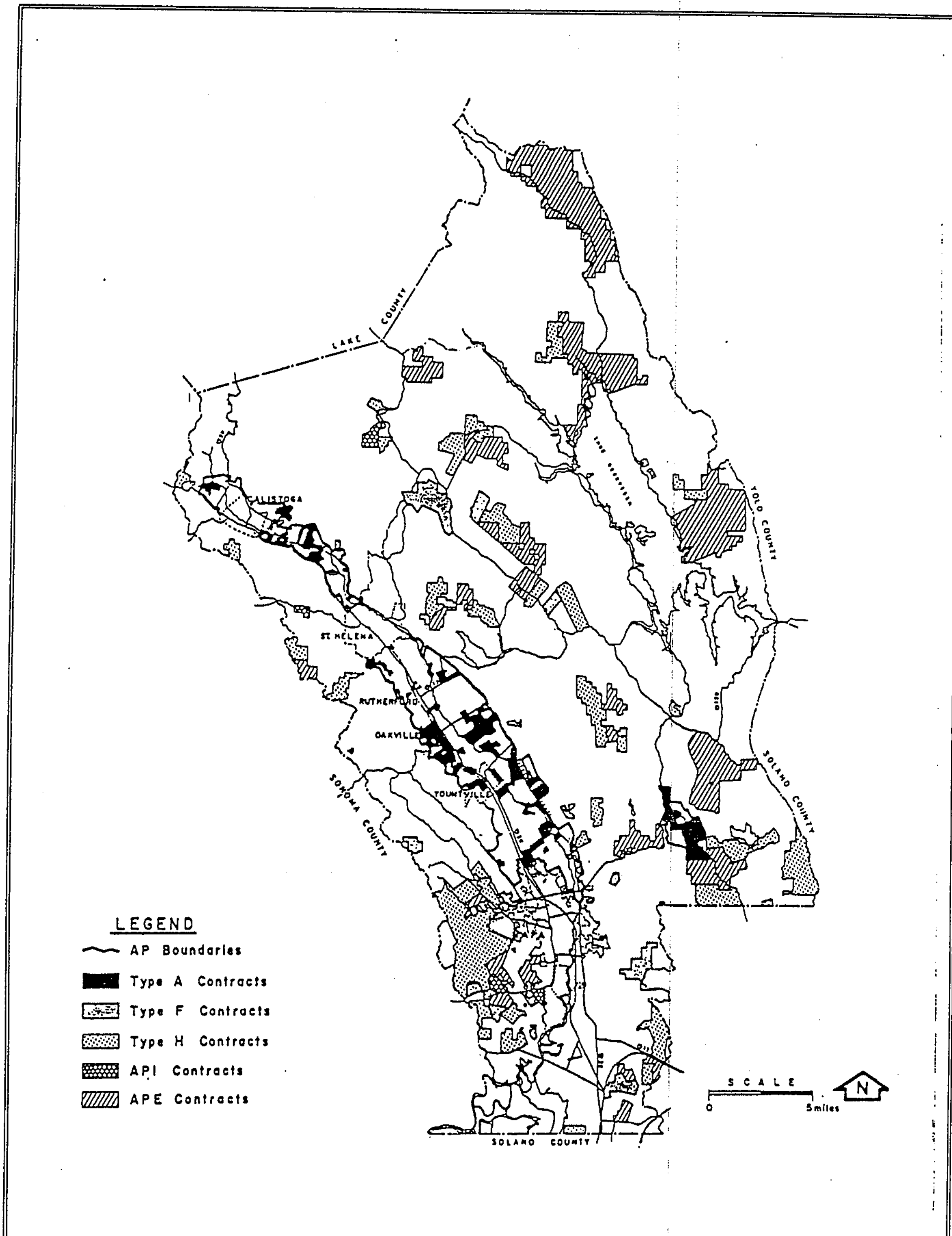
Mosquito control activities will not convert any agricultural lands to other uses, nor conflict with any Williamson Act contracts. Some District education or physical control activities could change the nature or timing of irrigation on crop lands or pastures, but these would not include conversions to non-agricultural uses. In some cases the District has consulted with land-owners who have converted agricultural or potential agricultural lands to duck clubs or other habitat conservation, but the District's role has been strictly to ensure that previously-planned conversion does not lead to increased mosquito production.

AGRICULTURAL LANDS



This map is a generalized representation of prime farmland; for more detailed information, consult the Napa County Soil Survey, published by U.S.D.A. Soil Conservation Service in 1978.

AGRICULTURAL PRESERVES



Source: Napa County Conservation, Development and Planning Department

3.3 AIR QUALITY.

Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Conflict with or obstruct implementation of the applicable air quality plan?			X	
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?			X	
c) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceedd quantitative thresholds for ozone precursors)?			X	
d) Expose sensitive receptors to substantial pollutant concentrations?			X	
e) Create objectionable odors affecting a substantial number of people?			X	

Explanation:

Setting

There are currently two pollutants for which the Air Basin that contains the Project Service Area has not attained both Federal and State criteria for ambient air quality: ozone (O_3), and particulate matter less than 10 micrometers in size (PM10) (BAAQMB, 6/25/99). Emissions of volatile organic compounds (VOC's), which are ozone precursors, are thus also considered an environmental problem in the Service Area.

In addition, it is recognized by the District that some individuals, institutions, and locations, including hospitals and schools, may be considered "sensitive receptors" with regards to air quality.

Potential Environmental Impacts and Measures to Avoid Significance - Chemical Control

Pesticide applications by the District do not significantly contribute to PM10, because most materials are applied directly to aquatic sources and aerosol applications use liquid droplets, not particulates, as carriers. Applications of GB-1111 and oil-based aerosols contribute insignificant quantities of VOC's. GB-1111, although an oil product, is listed as "non-volatile" on its Material Safety Data Sheet (MSDS -- see References). Aerosol pesticide applications in the District have not exceeded 25 gallons per year for all materials, which consist primarily of non-volatile ingredients. In addition, most of these materials are applied in rural or natural areas away from human settlement.

The District's Program/Project does not have a significant impact on sensitive receptors because of policies and practices to maintain a list of sensitive receptors and to minimize pesticide applications in their vicinity, to use the least toxic effective pesticide available in their vicinity, and to notify them prior to spraying.

Potential Environmental Impacts and Measures to Avoid Significance - Physical Control

Source reduction activities could generate small quantities of dust, which can add to PM10 loads. In practice, this is not a problem because of the saturated condition of the soils that are handled. In very dry diked marshes, ditching could cause dust problems if undertaken in late summer. However, the District's minor work regional permits require that work takes place from September through January, and allows only small projects. Therefore, net contribution to pollutant load is insignificant.

Increased emissions of odors by the source reduction activities following construction is very unlikely. Some wetland restoration projects in other areas have been accompanied by objectionable hydrogen sulfide odors. Based on a long history of variable flood regimes on the marshlands, with no odor complaints received by the District, it appears that the soils in this area are not prone to hydrogen sulfide production.

3.4 BIOLOGICAL RESOURCES.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service?		X		
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the California Department of Fish and Game or the U.S. Fish and Wildlife Service?			X	
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) Through direct removal, filling, hydrological interruption, or other means?		X		
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?			X	
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?				X
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?		X		

Explanation:

Setting

The Project impact area covers a wide range of natural habitats and highly developed areas, with an equally wide range of plant and animal communities from the heights of Atlas Peak and Mount Veeder to the extensive tidal marshlands associated with the Napa River and along the County's southern margin. Human activities in the Service Area, primarily during the last 150 years, have led to substantial changes in these habitats and in the populations of the organisms that inhabit them, so that many areas of the District Service Area exhibit some degree of human modification and impact.

Mosquito control activities are associated with wet areas of all types and sizes, and because of the diversity of mosquito habitat, mosquito control activities are conducted at a wide variety of different ecosystems and habitat types throughout the District's Project area. These sites can be roughly divided into those where activities may have an effect on the natural environment either directly or through drainage from an upstream site, and sites where the potential environmental impacts are negligible. Examples of "Environmental Sites" in the Project area include tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, stormwater detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, irrigated pastures, or agricultural ditches. Examples of "Non-Environmental Sites" include animal troughs, artificial containers, tire piles, fountains, ornamental fish ponds, swimming pools, liquid waste detention ponds, and non-natural harborage (such as wood piles, residential and commercial landscape, trash receptacles, etc.).

A. Impacts and Mitigation - Endangered and other Special Status Species

The California Department of Fish and Game's Natural Diversity Database (NDDB) lists 65 special status species[1] in Napa County (April 5, 1999; see Section 4). In almost all cases, the primary explanation for their status is loss of habitat. Because the District's activities do not involve changes in land use, and because proposed physical control activities in non-agricultural sites are reviewed annually by Trustee and other Responsible agencies, the District's activities do not contribute to this process. In the areas where the District's routine activities do overlap with specific habitat, District policies and practices ensure that no significant impacts can occur.

Of the thirteen species and subspecies listed as "Endangered" under either the Federal or State Endangered Species Acts (ESA), only nine occur in habitats where the District has any routine operations (Table 4.2.1). These include the marsh plant Soft Bird's-Beak (*Cordylanthus mollis ssp mollis*); the vernal pool plants Contra Costa Goldfields (*Lasthenia conjugens*), Sebastapol Meadowfoam (*Limnanthes vinculans*), and Few Flowered Navarettia (*Navarettia leucocephala* var. *pauciflora*); the spring and meadow plants Calistoga Popcorn Flower (*Plagiobothrys strictus*) and Napa Bluegrass (*Poa napensis*); the perennial-stream inhabiting California Freshwater Shrimp (*Syncaris pacifica*); the tidal marsh bird California Clapper Rail (*Rallus longirostris obsoletus*); and the marsh-inhabiting mammal Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*). The District takes extreme care to avoid disturbance to listed endangered species, as detailed below. Habitat descriptions and current maps of distribution and potential habitat of all endangered species in the Service Area are maintained by the District and incorporated into the operational guidelines of field personnel.

In addition to endangered species, Table 4.2.2 shows an additional six taxa, including one plant, one beetle, one frog, and three birds, that are listed as "Threatened" or "Rare" under either the Federal or California ESA, but that are not listed "Endangered" under either ESA. This listing indicates that the species or subspecies is vulnerable to decline to endangered levels, and habitat loss is listed as the primary threat for each of these species. Of these, only Mason's Lilaeopsis (*Lilaeopsis masonii*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Red-legged Frog (*Rana aurora draytonii*), and California Black Rail (*Laterallus jamaicensis coturniculus*) have habitat that might overlap with areas of routine District activity. The District takes care to avoid disturbance to listed threatened species, as detailed below, and is particularly careful to ensure no habitat loss for these taxa. Habitat descriptions and current maps of distribution of all threatened species in the Service Area are maintained by the District and incorporated into the operational guidelines of field personnel.

Table 4.2.3 lists an additional 17 vascular plants, 1 amphibian, 1 reptile, 3 birds, and 2 mammals that are considered "Species of Concern" under either the Federal or California ESA, but that are not listed as "Endangered" or "Threatened." Finally, the NDDB listing for Napa County (Table 4.2.4) notes 16 vascular plants and 6 birds that are not formally listed under the Federal or state ESA, but that are considered Special Status based either on a "species of concern" evaluation by the California Department of Fish & Game (CDFG) or by the California Native Plant Society (CNPS).

Although it has been suggested that other project elements (ATV use; Physical Control; Vegetation Management; Biological Control; and/or Chemical Control) may pose a threat to some endangered, threatened, rare,

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[1]Under the Federal and State Endangered Species Acts, the word "species" may also mean subspecies or other taxonomic groupings.

or other special status species in other areas, a thorough review of the IMM Program and the relevant scientific literature does not find substantial evidence to support these suggestions. Instead, the available credible information indicates that the Program/Project is very unlikely to have a significant impact on special status species or other biological resources within the Service Area. A detailed discussion and documentation to support these conclusions and the following observations is provided in the Project Technical Review (Section 4 of this Initial Study).

- The Project consists of a number of **ongoing activities**, each of which has been carried out by the District in the current Service Area for between 10 and 74 years without observed or demonstrated significant impacts on biological resources.
- Where adverse changes in biological resources have been observed in the Service Area or regionally, there is **no apparent relationship**, geographic or temporal, between District activities and these changes.
- There is **no substantial evidence of significant impacts** to biological resources caused by the specific project methods and materials, separately or cumulatively, at any level of application consistent with District policies and guidelines and Federal and State label requirements.
- The **scope** and **scale** of the District's activities are limited and insignificant in comparison to other similar activities in the Project Area, including agriculture and household pesticide use.
- The District **complies strictly with pesticide labels and wetlands permits** that are written to ensure that no significant impact to biological resources can occur.
- The District's activities are **highly selective in space and time**, based on a detailed list of potential mosquito sources, pre-control surveillance for mosquito abundance, and threshold criteria for control applications.
- The District's field technicians are **highly-trained** pesticide applicators, **certified by the California Department of Health Services** and required to complete frequent **continuing education** sessions sponsored by the District and by the Mosquito and Vector Control Association of California pursuant to State Regulations.
- The District's field activities are **routinely monitored** for safety, efficacy, and environmental impact by the District's Manager, by the Napa County Agricultural Commissioner, and by permit-issuing agencies.
- The District and the Mosquito & Vector Control Association of California routinely fund and collaborate with researchers from the University of California and other academic institutions on **research projects** to evaluate activities and to ensure that practices are used with the least potential impact on biological resources consistent with operational requirements.
- The District's activities are **consistent** with the Napa County General Plan Conservation Elements, and all known Habitat Conservation Plans, Endangered Species and Sensitive Habitat Recovery Plans, and City Plans in the Service Area.
- District staff routinely **coordinates and consults** with other responsible agencies, including the California Department of Health Services, the California Department of Fish and Game, the U.S. Fish and Wildlife Service, the San Francisco Bay Conservation and Development Commission, the California State Lands Commission, the San Francisco Regional Water Quality Control Board, the U.S. Army Corps of Engineers, the Napa County Resource Conservation District, and the Napa County Flood Control District to ensure that Project activities do not result in significant impacts to biological resources.

In addition to these general conclusions, the District makes the following specific findings.

1. ATV's

The District uses All-Terrain Vehicles (ATV's) on wetlands to facilitate surveillance, to deliver and apply chemical pesticides, and to perform some physical control activities. In each case, the potential impacts of the ATV's are similar, and consist of noise and other disturbance to nearby wildlife, trampling of vegetation and/or nests, and compaction of soils. After an exhaustive review of the literature (Section 4), the District concludes that the use of ATV's by the District does not and will not have a significant effect on the environment. Specifically, the District finds that 1) the low frequency of usage at any particular site reduces the disturbance and noise impacts to less than significance; 2) most vegetation types rebound rapidly from single passes by District ATV's; 3) all vegetation types regrow completely following ATV use by the District, with no evidence of long-term impact; 4)

District training and policies prevent significant risk of trampling of nesting or other wildlife; and 5) the low ground pressure of District ATV's precludes significant soil compaction or erosion.

2. Physical Control

The District's Physical Control activities can be subdivided by habitat type into a) agricultural channel maintenance; b) other drainage ditch maintenance; c) minor riparian zone work; and d) marshland tidal enhancement. Maintenance activities in agricultural channels and other drainage ditches are similar in nature to work routinely performed by farmers, municipalities, and others for the same purpose, and are of low frequency and intensity. Based on this comparison, and the lack of contrary evidence, we find that these activities do not have the potential for significant environmental impact. Physical control activities in riparian areas are discussed in Section 3.4B below.

The primary aim of tidal enhancement projects on marshlands is to restore and enhance water flows and wetland values that have deteriorated due to human activity, while protecting or enhancing existing functions and values. Since the various taxa that use the marshes vary in their habitat requirements, there is no single hydraulic or management regime which will optimize all of the possible species. However, the elevational range of marsh sites, combined with the small scale of physical control activities covered by this document, ensure that hydraulic changes are limited and that no specific habitat for special status species is lost or significantly degraded. In addition, the District's minor physical control activities on tidal and historically-tidal areas are governed by five-year regional permits obtained by the District from the U.S. Army Corps of Engineers (USACE) and the San Francisco Bay Conservation and Development Commission (BCDC). One condition of each of these permits is the provision by the District of annual work plans for agency review prior to implementation of the planned work. This ensures that Trustee and other Responsible agencies are given timely opportunities to review specific planned activities and, if needed, to modify the District's proposals.

The most significant legally-protected species on marsh activity sites are the Salt Marsh Harvest Mouse and the California Clapper Rail, which are closely associated with Pickleweed (*Salicornia virginica*) and Cordgrass (*Spartina foliosa*). Our observations and the literature (Section 4) indicate that our physical control activities on marshes are generally beneficial to these species and their associated plants, although increased tidal flushing following reintroduction of tides to subsided sites adjacent to brackish water may temporarily depress *Salicornia* extent. The District's minor physical control activities are generally beneficial to channel-dependent listed species like the California Clapper Rail (Habitat Goals Project 1999). The District has an active research and monitoring program to ensure that physical control projects minimize the need for repetitive maintenance and the immediate disturbance associated with construction activities.

3. Vegetation Management

The District finds no substantial evidence that our vegetation management program could have a significant environmental impact. The EIR prepared for Caltrans' much more extensive vegetation management program [see Section 4.5 and citation in Section 3.18] found no potential significant impact associated with the materials used by the District, even at Caltran's much higher cumulative use.

4. Biological Control

Some challenges have been made against the use of mosquitofish (*Gambusia affinis*) for the control of mosquitoes, primarily on the supposition that their omnivorous feeding habit poses a threat to the juvenile forms of the federally-threatened California Reg-Legged Frog (*Rana aurora draytonii*). After an extensive review of the literature and our own field experience (Section 4), the District finds that there is no substantial evidence supporting this claim. Specifically, we find that 1) the District maintains spatial and temporal separation between mosquitofish and immature Red-Legged Frogs, using the best available information on the location of the frogs; 2) the U.S. Fish and Wildlife Service acknowledges that they "cannot determine whether mosquitofish are harmful to California red-legged frogs." (USFWS 1996); 3) recent university research indicates that there is no direct (mortality) impacts of mosquitofish on Red-Legged Frogs in intense interactions in naturalistic settings, and that the only indirect impact seen in this research was a slight lowering of body weight at the transition from tadpole to adult, with no evidence that this had any biological significance (Lawlor 1999); 4) mosquitofish and red-legged frogs have been repetitively seen to coexist in natural settings outside of the District Service Area (USFWS 1996; Karl Malamud-Roam & Ron Keith, pers. comm. 1999); and 5) alternative and more plausible explanations exist to explain the observed historic decline in Red-legged frogs in the Service Area (USFWS 1996, Lawlor 1999).

5. Chemical Control

When mosquito numbers exceed District control thresholds and other control methods would be ineffective, contrary to permits or other environmental protections, or otherwise inappropriate, the District utilizes specific insecticides that are registered for use in California and that possess a current EPA label. As required by the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), each pesticide used by the District has been tested for acute and chronic effects using Good Lab Practices on an array of nontarget species and under laboratory and field conditions. These tests, as well as studies conducted by qualified researchers at universities and other research institutions, have produced a wealth of literature showing no long-term adverse effect to non-target biological resources when applied selectively and consistently with the labels. A detailed technical summary of the literature on pesticides used or contemplated by the District is presented in the Program Technical Review (Section 4 of this Initial Study).

In addition to general District policies and practices noted earlier, to protect listed insects and crustaceans the District does not routinely apply insecticides other than Bti or Methoprene to areas with known populations of these organisms. As discussed in Section 4, these materials have no detectible effect on listed stream or vernal pool fauna. Because of the hydrology and habitat types in these specific areas, the District finds it highly unlikely that we would use other insecticides in these areas except under emergency conditions, and would do so only in consultation with the appropriate agencies.

Two specific assertions of links between chemical pesticides used by the District and special status species will be addressed briefly here because of recent associated publicity, despite the lack the any substantial evidence to support them:

First, it has recently been suggested that Altosid (S-methoprene) may be associated with deformities in frogs that have been observed in a number of States. The District has performed an exhaustive review of the literature (see Section 4) and concludes that there is no substantial evidence to support this suggestion. Specifically, we find that 1) there is no evidence of a spatial or temporal relationship between Altosid use and amphibian deformities; 2) in particular, there is no evidence of frog deformities at all in the District's Service Area, and no significant evidence of frog deformities anywhere in California where methoprene is used; 3) well-documented alternative explanations for frog deformities, that are more consistent with the epidemiological patterns observed, have been reported; 4) the observations discussed to support the assertion have not been duplicated by any other researchers; 5) severe deficiencies in methodology and/or interpretation exist in the few reports that make this assertion; 6) consultations with Dr. Mark Jennings, and other eminent herpetologists demonstrate no professional agreement with the claims; and 7) recent exhaustive reviews of this literature by independent analysts in Minnesota and New Zealand unconditionally agree with the District's findings on this question.

Second, questions have been raised for a number of years about whether insecticides used against mosquitoes could cause indirect impacts on higher organisms through impacts on food chains, and specifically if larvicides could reduce the populations of *Chironomid* or other midges to a degree significant to waterfowl or wading birds. The District has performed an exhaustive review of the literature (see Section 4) and concludes that there is no substantial evidence to support this suggestion. Specifically, we find that 1) there is no evidence of a spatial or temporal relationship between larvicide use and population dynamics of waterfowl or wading birds; 2) Golden Bear 1111 has no effect on midge larvae (the species of concern in our area are primarily benthic); 3) Bti has no detectible effect on midge larvae when applied at label rates for mosquito control; 4) Methoprene, at label rates for mosquito control, can prevent adult emergence of midges but does not directly kill mosquito or midge larvae and therefore does not remove them from the food chain; 5) no bioaccumulation (food chain magnification) of larvicides in larva-eating animals has been demonstrated for larvicides used by the District; and 6) the District does not plan to use other larvicides in areas where midges might be a significant portion of the food chain, except under emergency conditions.

6. Mitigation Measures

Although the District does not find substantial evidence that the current Program could significantly impact special status species, the following additional mitigation measures will be adopted as a prudent action to ensure that impacts remain insignificant:

1. Maintenance of up-to-date maps and other information from the California Department of Fish and Game Natural Diversity Data Base and other reliable sources on the location of Special Status Species and designated Natural Communities in the Project Service Area;
2. Coordination of District activities with approved Habitat Conservation Plans and Species Recovery Plans; and
3. Adoption of new policies as needed and provision of continuing training to field personnel to ensure minimization of specific mosquito control activities and/or the use of alternative mosquito control methods at times and in places where those specific mosquito control activities might otherwise significantly impact Special Status Species or designated Natural Communities.

B. Impacts and Mitigation - Riparian and other Sensitive Habitats

District activities in sensitive habitats are essentially restricted to riparian corridors, which are addressed in this subsection, and to wetland areas, which are discussed in subsection 3.4(C) below. In riparian areas, the only District activities with any potential for environmental impacts are 1) minor physical control; 2) vegetation management for maintenance of access; 3) biological control (mosquitofish stocking); and 4) pesticide use. The only identified potential environmental impact of biological control in riparian zones is on sensitive species, which was discussed in A4 above (see also Section 4). Each of the other three is discussed individually below.

1. Physical Control & Vegetation Management

Physical control activities in riparian zones are regulated by Streambed Alteration Permits issued by the California Department of Fish and Game, as well as by Clean Water Act Section 404 permits issued by the U.S. Army Corps of Engineers, which are required for most activities in any jurisdictional wetlands. Vegetation Management activities in riparian zones consist essentially of brush clearing with hand tools to facilitate access for mosquito and mosquito habitat surveillance and control. In light of the precautionary measures imposed by the permit process and District policies and practices, the District does not find substantial evidence that either of these classes of activities could have a significant environmental impact.

2. Chemical Control

The potential environmental impacts associated with chemical control in riparian zones are discussed in A5.

C. Impacts and Mitigation - Wetland Habitats

District activities in non-riparian wetland habitats are addressed in this subsection. These primarily include tidal and diked marshlands (salt, brackish, and fresh), and vernal pools and other seasonal wetlands. In these areas, the only District activities with any potential environmental impacts are 1) ATV use; 2) minor physical control; 3) vegetation management for maintenance of access; 4) biological control (mosquitofish stocking); and 5) pesticide use. The only identified potential environmental impact of biological control in non-riparian zones is on sensitive species, which was discussed in A4 (see also Section 4). Each of the other four is discussed individually below.

1. ATV's

The District uses All-terrain vehicles (ATV's) on wetlands to facilitate surveillance, to deliver and apply chemical pesticides, and to perform some physical control activities. The general potential environmental impacts of ATV use were discussed in A1 above. In addition, vernal pools rarely reach District treatment criteria, and the District does not use ATV's or other vehicles in these areas except potentially under emergency conditions.

2. Physical Control and Vegetation Management

As is true in riparian zones (discussed in B1 above), physical control activities in wetlands require Clean Water Act Section 404 permits issued by the U.S. Army Corps of Engineers, and, in the coastal portions of the Service Area, a permit issued by the San Francisco Bay Conservation and Development Commission. Because of the stringent permit conditions imposed, we find no substantial evidence that significant environmental could result.

As in riparian zones, vegetation management in other wetlands is accomplished primarily to facilitate access for mosquito and mosquito habitat surveillance and control. In contrast to riparian areas, however, the District also makes use of chemical herbicides in agricultural drainage ditches and in some other settings to achieve this end.

3. Chemical Control

In addition to directly applying insecticides on wetlands for the control of larval mosquitoes, the District also sprays other pesticides for the control of adult mosquitoes in other areas, which might cause pesticide drift onto some wetlands. Based on the District's routine low application intensity, strict compliance with label criteria, and substantial research on non-target effects of the materials used operationally by the District, we find that no significant impact does or can generally result through this mechanism. District policies to ensure no significant environmental impacts will occur on the listed invertebrates in perennial streams and vernal pools are described in A5 above (see also Section 4).

D. Impacts and Mitigation - Migration Corridors and Nursery Sites

District activities have no known impact on any wildlife migration corridor, except as discussed in Section A.

E. Impacts and Mitigation - Local Policies and Ordinances

District activities have no apparent conflicts with any local environmental protection policies and ordinances.

Specifically, District activities are consistent with the Conservation Elements of the Napa County General Plan.

F. Impacts and Mitigation - Habitat Conservation Plans

A search of the USFWS website for "Habitat Conservation Plans/Incidental Take Permits" did not identify any federally-approved Habitat Conservation Plans in the District Service Area (6/3/99). A consultation with Dr. Peter Baye of the USFWS Division of Endangered Species indicated that there are currently no adopted Natural Community Conservation Plans for the Service Area (pers. comm. 8/30/99)

3.5 CULTURAL RESOURCES.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?			X	
b) Cause a substantial adverse change in the significance of an archaeological resource as defined in §15064.5?			X	
c) Directly of indirectly destroy a unique paleontological resource or site or unique geologic feature?				X
d) Disturb any human remains, including those interred outside of formal cemeteries?			X	

Explanation:

Setting

Napa County includes historical and archaeological resources, possibly including prehistoric human remains, in sites that date back thousands of years. Native American tribal groups that lived in the area prior to European contact were the Wappo, Lake Miwok, and Patwin (California Indian Library Collection 1999). Because the earliest human inhabitants of the area apparently spent much of their time near rivers and shores, most early sites have been buried as a result of extensive deposition of alluvium accompanied by a rise in sea level in the past 15,000 years (Atwater 1979, Moratto 1984), tectonic activity (Goman, 1996), and/or hydraulic mining debris (Gilbert, 1917). Thus, while a number of archaeological sites are known in the County (Pers. comm. Patricia Hornisher, Napa County Planning Dept, 8/31/99), it is possible that some of the coastal marshlands could cover archaeological resources.

During the Spanish and Mexican period of California history, much of the region was divided into ranchos, and many historical sites from this time remain (see attached list). Following integration into the United States socio-political sphere, the region experienced rapid growth and change, which has continued, at varying rates, until the present. Numerous historic resources from this time are also present (see attached list).

Potential Environmental Impacts and Measures to Ensure Insignificance

Mosquito control activities will not generally have any impact on historic resources, which are well known and routinely avoided. Minor physical control activities might involve modifications to older structures or inadvertent disturbance of archaeological sites, but this is very unlikely because these activities are essentially restricted to maintenance and minor modification of existing channels and water control structures.

The District will review potential minor physical control sites with the Napa County Planner prior to initiating these activities. In case of inadvertent disturbance of a potentially significant site, the District will promptly notify the State Historic Preservation Office and/or a qualified archaeologist and mitigation measures will be devised as appropriate. If human bones should be uncovered, work in the vicinity will stop and the Napa County Coroner will be called. If the coroner determines the remains to be human, he will contact the Native American Heritage Commission (NAHC). The NAHC will notify a local Native American descendent who will be allowed to inspect the find and provide recommendations for disposition.

Major physical control activities will have site-specific CEQA review prior to earthmoving. With the introduction of these measures, potential impacts are reduced to less than significant levels.

CERES

State Historical Landmarks

Napa County

California State Historical Landmarks in Napa County

Properties of historical importance in California are currently designated as significant resources in three state registration programs: State Historical Landmarks, Points of Historical Interest, and the California Register of Historic Places. Below is a list of the State Historical Landmarks for Napa County. This data is provided by the Office of Historic Preservation - California Department of Parks and Recreation and is also available in the California Historical Landmarks Book.

- **NO. 359 OLD BALE MILL** - This historic gristmill was erected by Dr. E. T. Bale, grantee of Carne Humana Rancho, in 1846. The mill, with surrounding land, was deeded to the Native Sons of the Golden West by Mrs. W. W. Lyman, and was restored through the efforts of the Native Son Parlors of Napa County.
Location: Bale Grist Mill State Historic Park, Hwy 29 (P.M. 32.1), 3369 N St. Helena Hwy, 3 mi NW of St. Helena
USGS Quadrangle Sheet Name: CALISTOGA

- **NO. 547 CHILES MILL** - Joseph Ballinger Chiles, who first came to California in 1841, erected the mill on Rancho Catacula 1845-56. The first American flour mill in Northern California, it was still in use in the 1880s. Chiles served as a vice president of the Society of California Pioneers, 1850-53.
Location: SW corner on hillside, Chiles and Pope Rd and Lower Chiles Valley Rd, 3.6 mi N on Hwy 128, Chiles Valley

- **NO. 562 LA CHRISTIANITA** - Near this spring, the first Christian baptism in Alta California was performed by Padre Francisco Gómez, a member of the Portolá Expedition, in 1769.
Location: Site and plaque in Camp Pendleton, Los Cristianitos Canyon, on Cristianitos Rd, 0.4 mi N. of intersection of San Mateo Rd, 3 mi E of I-5 at San Clemente, plaque in San Clemente Civic Center 100 Avenida Presidio, San Clemente
USGS Quadrangle Sheet Name: CALISTOGA

- **NO. 564 GEORGE YOUNT BLOCKHOUSE** - In this vicinity stood the log block-house constructed in 1836 by George Calvert Yount, pioneer settler in Napa County. Nearby was his adobe house, built in 1837, and across the bridge were his grist and saw mills, erected before 1845. Born in North Carolina in 1794, Yount was a trapper, rancher, and miller, he became grantee of the Rancho Caymus and La Jota. He died at Yountville in 1865.
Location: NE corner of Cook Rd and Yount Mill Rd, 1 mi N of Yountville

- **NO. 565 PETER LASSEN GRAVE** - In memory of Peter Lassen, the pioneer who was killed by

the Indians April 27, 1859, at 66 years of age.
Location: 2550 Wingfield Rd via Richmond Rd, 5 mi SE of Susanville

- **NO. 682 SITE OF YORK'S CABIN, CALISTOGA** - Among the first houses in this area was John York's log cabin, constructed in October 1845. Rebuilt as part of the home of the Kortum family, it was used as a residence until razed in 1930. Nearby was the cabin of David Hudson, also built in October 1845. Calistoga was named by Samuel Brannan.
Location: SW corner Hwy 29 (Foothill Blvd) and Lincoln Ave, Calistoga

- **NO. 683 SITE OF HUDSON CABIN, CALISTOGA** - David Hudson was one of the early pioneers who helped develop the upper portion of Napa Valley by purchasing land, clearing it, and planting crops and building homes. Hudson built his cabin in October 1845.
Location: NE corner of Hwy 29 (Foothill Blvd) and Lincoln Ave, Calistoga

- **NO. 684 SAM BRANNAN STORE, CALISTOGA** - Sam Brannan arrived in Napa Valley in the late 1850s and purchased a square mile of land at the foot of Mount St. Helena. This is the store he built, in which he made $50,000 in one year.
Location: NW corner of Wapoo Ave and Grant St, 203 Wapoo Ave, Calistoga

- **NO. 685 SAM BRANNAN COTTAGE, CALISTOGA** - Sam Brannan arrived in Napa Valley in the late 1850s with the dream of making it the 'Saratoga of California.' In 1866 cottages were built and palm trees planted in preparation for the grand opening of the resort. This is the only cottage still standing.
Location: 1311 Washington St, Calistoga

- **NO. 686 SITE OF KELSEY HOUSE, CALISTOGA** - Nancy Kelsey arrived in California in 1841 with the Bidwell-Bartleson party and settled with her family south of present-day Calistoga. Now the hearthstone is all that can be seen of the house. The property is owned by the Rockstrohs.
Location: 500 ft NW of intersection of State Hwy 29 and Diamond Mtn Rd, 1.1 mi S of Calistoga

- **NO. 687 NAPA VALLEY RAILROAD DEPOT, CALISTOGA** - The Napa Valley Railroad depot, now the Southern Pacific depot, was built in 1868. Its roundhouse across Lincoln Avenue is gone. On its first trip, this railroad brought people to Calistoga for the elaborate opening of Brannan's summer resort in October 1868.
Location: 1458 Lincoln Ave, Calistoga

- **NO. 693 GRAVE OF GEORGE C. YOUNT** - George Calvert Yount (1794-1865) was the first United States citizen to be ceded a Spanish land grant in Napa Valley (1836). Skilled hunter, frontiersman, craftsman, and farmer, he was the true embodiment of all the finest qualities of an advancing civilization blending with the existing primitive culture. Friend to all, this kindly host of Caymus Rancho encouraged sturdy American pioneers to establish ranches in this area, so it was well populated before the gold rush.
Location: George C. Yount Pioneer Cemetery, Lincoln and Jackson Sts, Yountville

- **NO. 710 ROBERT LOUIS STEVENSON STATE PARK** - In the spring of 1880, Robert Louis Stevenson brought his bride to Silverado. He and Fannie Osbourne Stevenson lived here from May 19 until July, while he gathered the notes for Silverado Squatters.
Location: Hwy 29 (P.M. 45.5), 75 mi NE of Calistoga

• **NO. 814 BERINGER BROTHERS WINERY** - Built by Frederick and Jacob Beringer, natives of Mainz, Germany, this winery has the unique distinction of never having ceased operations since its founding in 1876. Here, in the European tradition, were dug underground wine tunnels hundreds of feet in length. These maintain a constant temperature of 58 degrees, a factor considered necessary in the maturing and aging of fine wines.
Location: 2000 Main St, St. Helena

• **NO. 828 VETERANS HOME OF CALIFORNIA** - This home for California's aged and disabled veterans was established in 1884 by Mexican War veterans and members of the Grand Army of the Republic. In January 1897 the Veterans Home Association deeded the home and its 910 acres of land to the State, which has since maintained it.
Location: SW corner of California Dr and Hwy 29, Yountville

• **NO. 878 FIRST PRESBYTERIAN CHURCH BUILDING** - Designed by pioneer architects R. H. Daley and Theodore Eisen, this church is an outstanding example of late Victorian Gothic architectural styling. It is the best surviving example in this region of the early works associated with Eisen, who later became an important Southern California architect. The church has been in continuous use since its construction in 1874, longest pastorates were those of Richard Wylie and Erwin Bollinger.
Location: 1333-3rd St between Randolph and Franklin Sts, Napa

• **NO. 939 Twentieth Century Folk Art Environments (Thematic) -LITTO** - This is one of California's exceptional Twentieth Century Folk Art Environments. Over a period of 30 years, Emanuele 'Litto' Damonte (1896-1985), with the help of his neighbors, collected more than 2,000 hubcaps. All around Hubcap Ranch are constructions and arrangements of hubcaps, bottles, and pulltops which proclaim that 'Litto, the Pope Valley Hubcap King,' was here.
Location: 6654 Pope Valley Rd (P.M. 14.3), 2.1 mi NW of Pope Valley

See Also: Statewide Historical Landmarks listed by County

3.6 GEOLOGY AND SOILS.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				
i) Rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? *Refer to Division of Mines and Geology Special Publication 42.*			X	
ii) Strong seismic ground shaking?				X
iii) Seismic-rekated ground failure, including liquefaction?				X
iv) Landslides?				X
b) Result in substantial soil erosion or the loss of topsoill?			X	
c) Be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?			X	
d) Be located on expansive soils, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?				X

Explanation:

Setting

The Project Service Area is located in the San Francisco Bay Area, which is one of the most seismically active regions in the United States. Some regions in the Service Area, including some unstable geological units, are likely to be subject to strong ground shaking, liquifaction, landslides, and possibly ground rupture in the event of a proximal moderate to severe earthquake on any of a number of faults that run through the County (see attached maps from Napa County General Plan). However, it is unlikely that these events would affect the District's facilities, which consist of a 30' x 60' metal Butler type building and a 10' x 12' portable metal pesticide storage building.

The soils underlying many mosquito-producing sites within the District's Service Area are moist and prone to compaction or erosion under substantial dewatering and/or operations of vehicles with high ground pressure (over about three pounds per square inch = psi). Both peat and mineral soils underlying wetlands in the areas are prone to wind erosion if dewatered for long periods.

Potential Environmental Impacts and Measures to Ensure Insignificance - ATV's

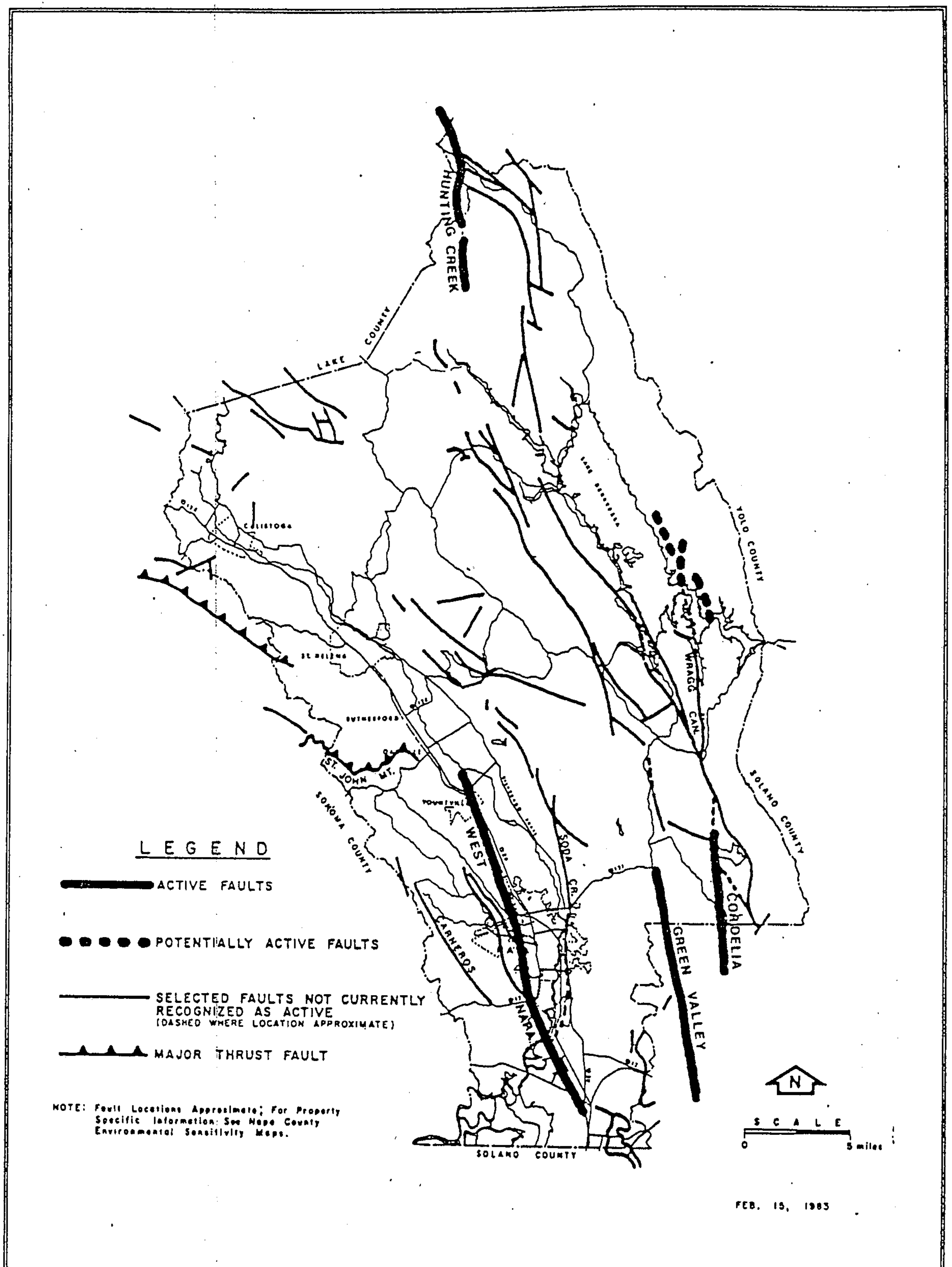
The use of all-terrain vehicles on marshes and other wetlands has been criticized on the grounds that they might compact soils or otherwise substantially alter the local geology. The District does not see substantial evidence that this could be a problem for our project for the following reasons: 1) the ATV's we use in natural settings have eight low pressure tires, wide soft treads, and a ground loading well under 2 psi; 2) the ATV's we use in agricultural settings have equivalent or lower total weight and ground loading than typical agricultural vehicles; 3) all of our field personnel that use ATV's are extensively trained on the use of ATV's; 4) over ten years experience with the same types of machinery have shown no evidence of long-term or significant impacts.

Potential Environmental Impacts and Measures to Ensure Insignificance - Physical Control

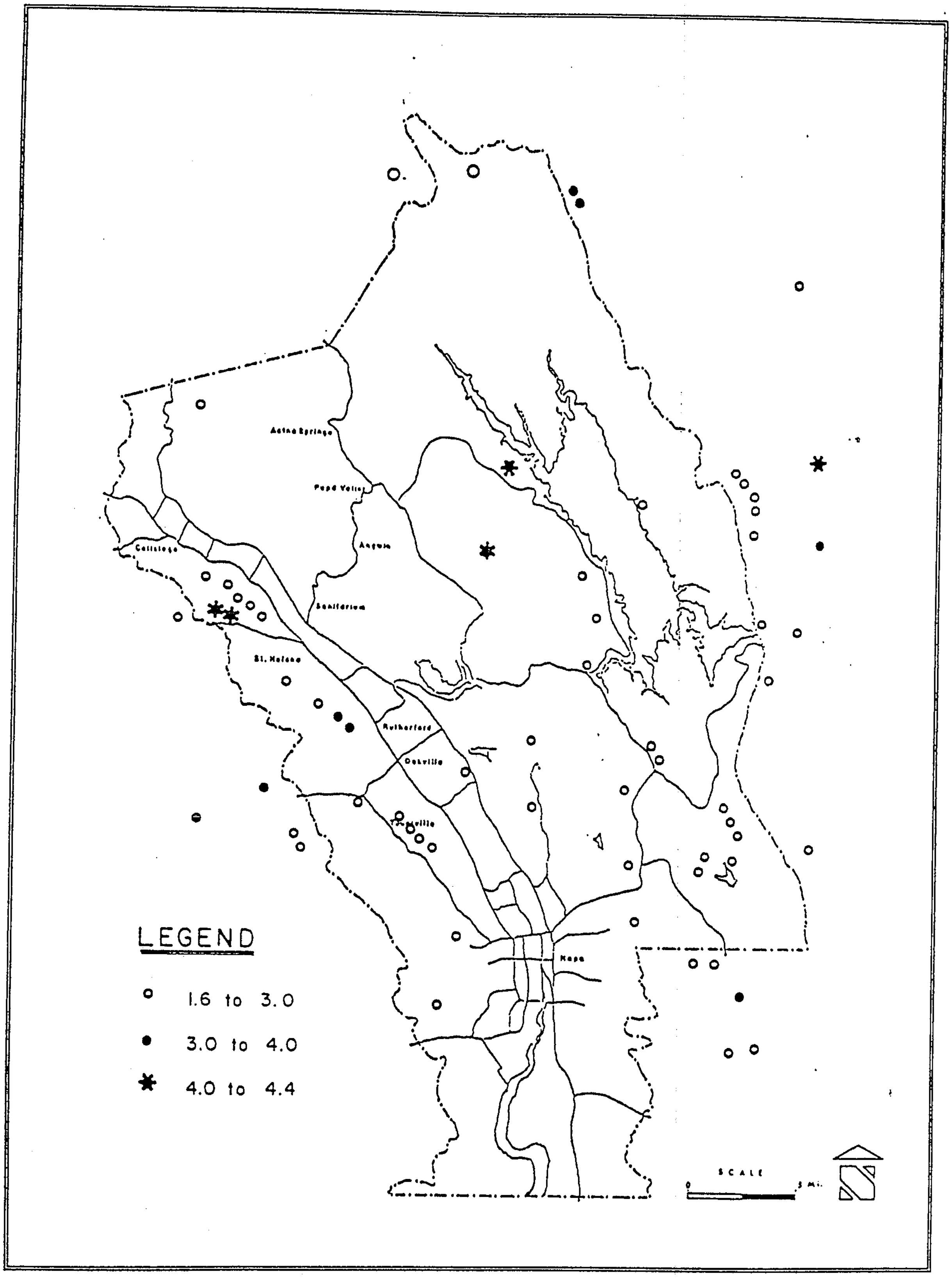
Artificial drainage of naturally-wet marshes can lead to warm weather drying, oxidation, wind erosion, and subsidence. Physical control activities by the District are designed to accelerate drainage only in built environments or in agricultural environments where soil irrigation and drainage is part of the ongoing agricultural practices. The District does not drain natural wetlands. On the contrary, physical control activities by the District are typically associated with improved soil water retention and reduced subsidence or erosion.

Other District activities have no impact on soils or geology.

FAULTS

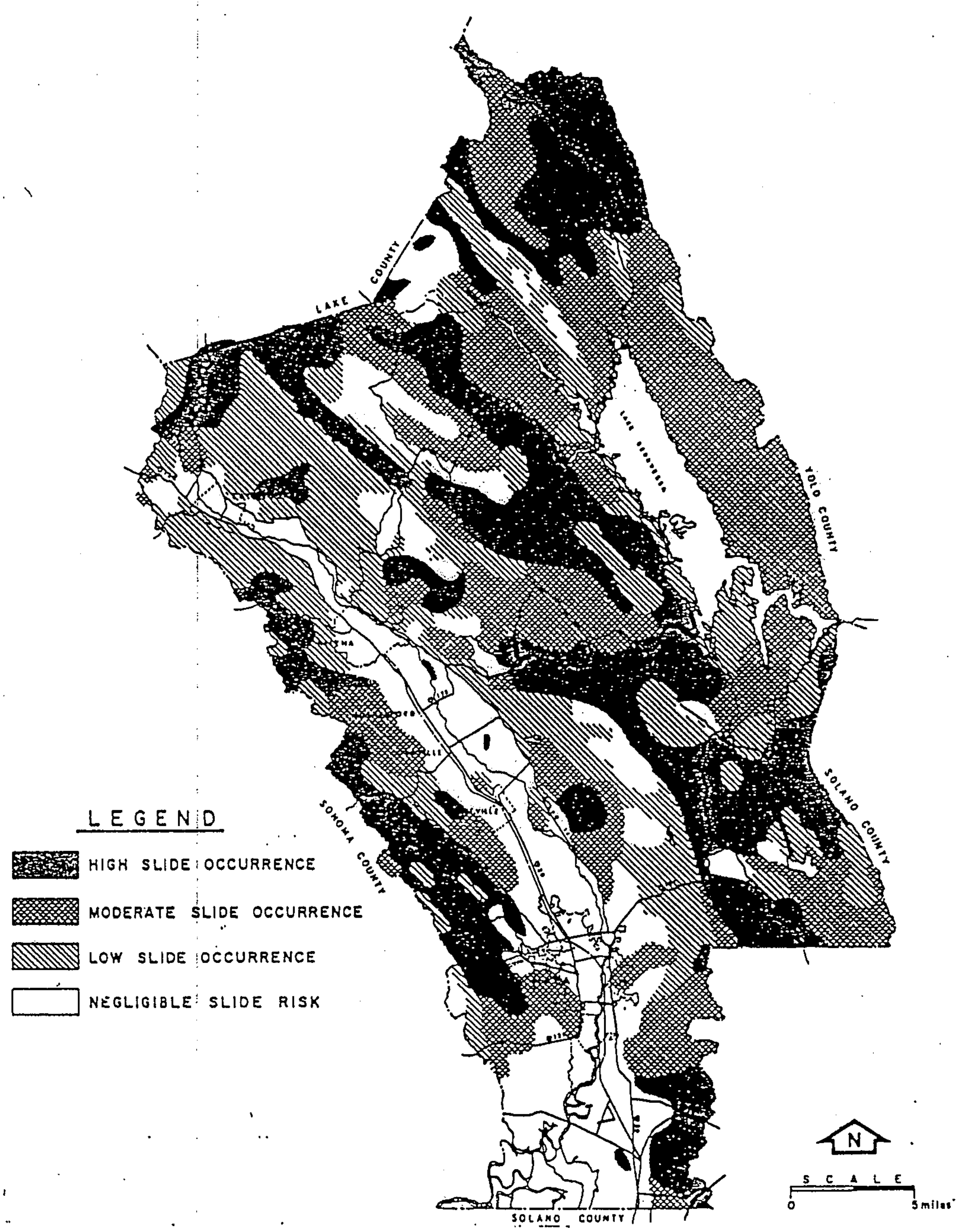


Source: C.D.M.G. Preliminary Special Studies Zone Maps, 1983;
U.S.G.S. Miscellaneous Field Studies Map MF-881, 1977;
U.S.G.S. Basic Data Contributions 54 and 56, 1973.



Source: U.C. Berkeley Seismographic Station

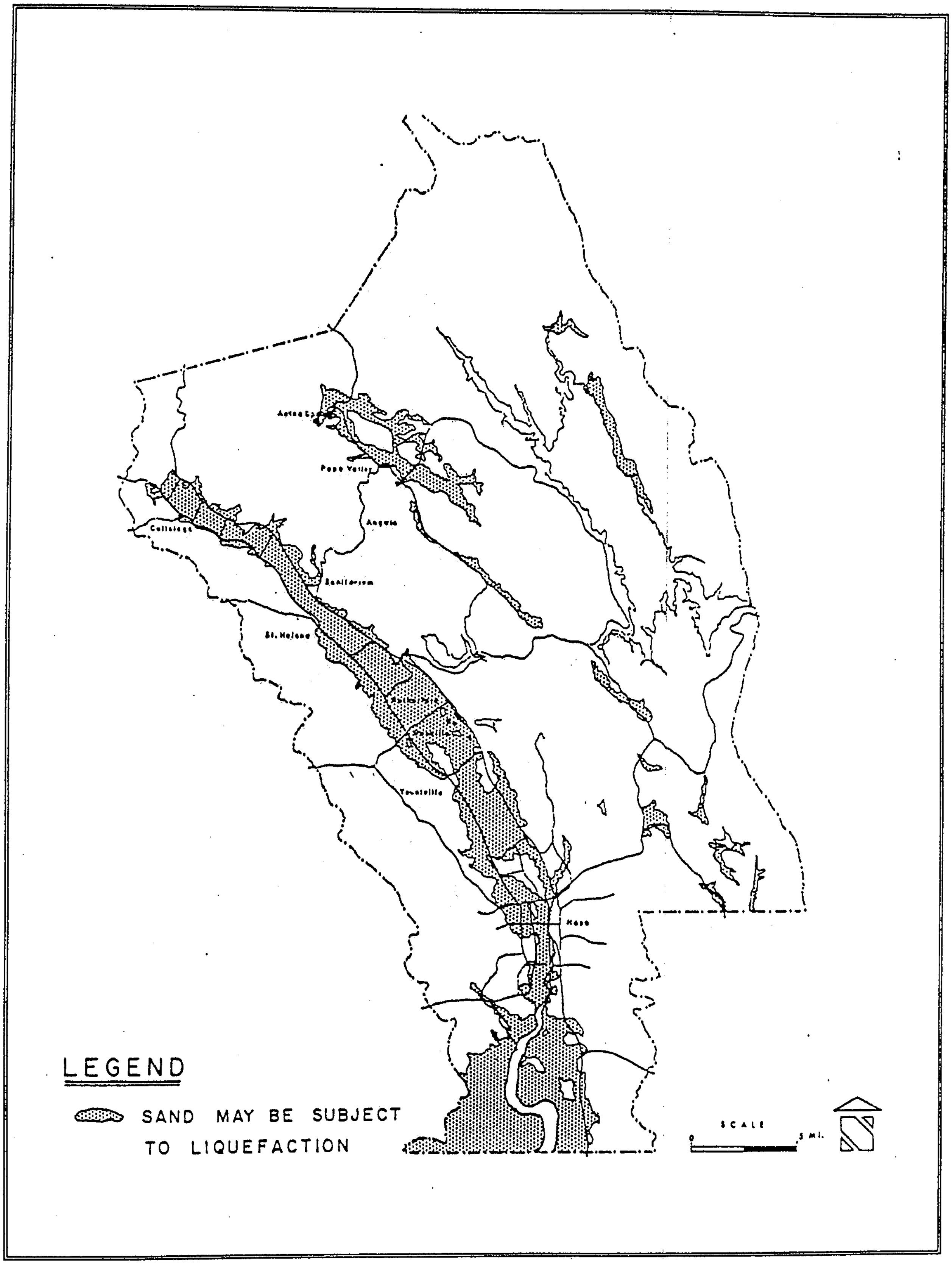
RELATIVE STABILITY OF UNDISTURBED SLOPES



NOTE: Map Generalized - Not Suitable For Evaluating Landslide Hazards On A Parcel Specific Basis; For The More Detailed Information Needed To Do This See Napa County Environmental Sensitivity maps.

SOURCE: Complied by Napa County Planning Department from maps prepared by the U.S. Geological Survey.

LIQUEFACTION POTENTIAL



Source: U.S.G.S. (1974) and C.D.M.G. (1963)

3.7 HAZARDS AND HAZARDOUS MATERIALS.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal or hazardous materials?			X	
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?			X	
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?			X	
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?		X		
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project result in a safety hazard for people residing or working in the project area?			X	
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?				X
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?				X
h) Expose people or structures to a significant risk of loss, injury or death involving wildland fires, including where wildland are adjacent to urbanized areas or where residences are intermixed with wildlands?			X	

Explanation:

Setting

The Project Service Area includes a large number of winery waste and sewage treatment ponds. Furthermore, there are some historical minor industrial sites within close proximity to the Napa River and some of its associated seasonal or tidal wetlands. The hazard status of these areas is not fully known to the District. Physical control activities in any of these areas might pose a threat of release of hazardous materials if prudent pre-project site evaluations are not undertaken.

There is a public airport within the District Service Area. Although not a site for extensive routine mosquito surveillance or control, the District could undertake pesticide applications within and around this site, due to the proximity to marsh and seasonal wetland habitats and to human settlements.

Most of the Project Service Area is vulnerable to wildland fires (see attached map from Napa County General Plan), including areas where District activities involve routine use of motorized vehicles or pesticide application equipment, or the transportation and application of GB-1111 (larvicidal oil).

Potential Environmental Impacts and Measures to Avoid Significance - Chemical Control and Vegetation Management

Minimizing the hazards of mosquito-borne disease depends on effective mosquito control, which can include the use of chemical insecticides and herbicides. Application of pesticides within label guidelines do not constitute a significant hazard to the public (Cal. Dept. of Pesticide Registration). All pesticides are classified as "hazardous materials" by the state of California, regardless of their acute toxicity. Therefore, routine District activities do pose a risk of release of hazardous materials through accidental releases, and this can occur within one-quarter mile of existing or proposed school sites. District policies and practices, however, ensure that these risks and impacts are not significant.

First, the pesticides used by the District are safe. The District does not use Category 1 or Category 2 pesticides (see Section 4). The pesticides that are routinely used by the District have very low acute toxicities, and very low chronic toxicity at the concentrations and volumes transported and applied by the District.

Second, the volumes of pesticides transported or used by the District are small. Bulk deliveries of pesticides to the District are very infrequent, and are always handled by haulers certified by DOT for the materials they are transporting. The District does not transport large volumes of pesticides in its own vehicles. The highest load capacity for a District vehicle is 99 gallons of either GB-1111 (light oil) or 99 gallons of aqueous solutions.

Third, all District vehicles that transport or apply pesticides are equipped with all equipment and supplies needed to contain the largest possible spill from that vehicle. All District vehicles are maintained in good condition by a full-time mechanic working in a fully-equipped shop.

Fourth, all District personnel that handle pesticides are registered by the California Dept. of Health Services as Pesticide Applicators, and are required to complete annual pesticide safety training, including pesticide spill drills, offered by the District.

Fifth, the District and its personnel are routinely inspected by the Napa County Agricultural Commissioner's office to verify that all equipment is calibrated and functioning properly and to assure adequate staff training and knowledge concerning the proper use and handling of all pesticides used by the District.

In addition, all District vehicles carry fire extinguishers and two-way radios which can be used to summon assistance in the unlikely event that any District action initiates a fire. Although GB1111 is a petrochemical product, its chemical and physical characteristics make it extremely unlikely to ignite during foreseeable circumstances (MSDS), and if it does ignite, the low volumes used in District equipment and the nature of the application sites reduces the possibility of a wildfire to insignificance.

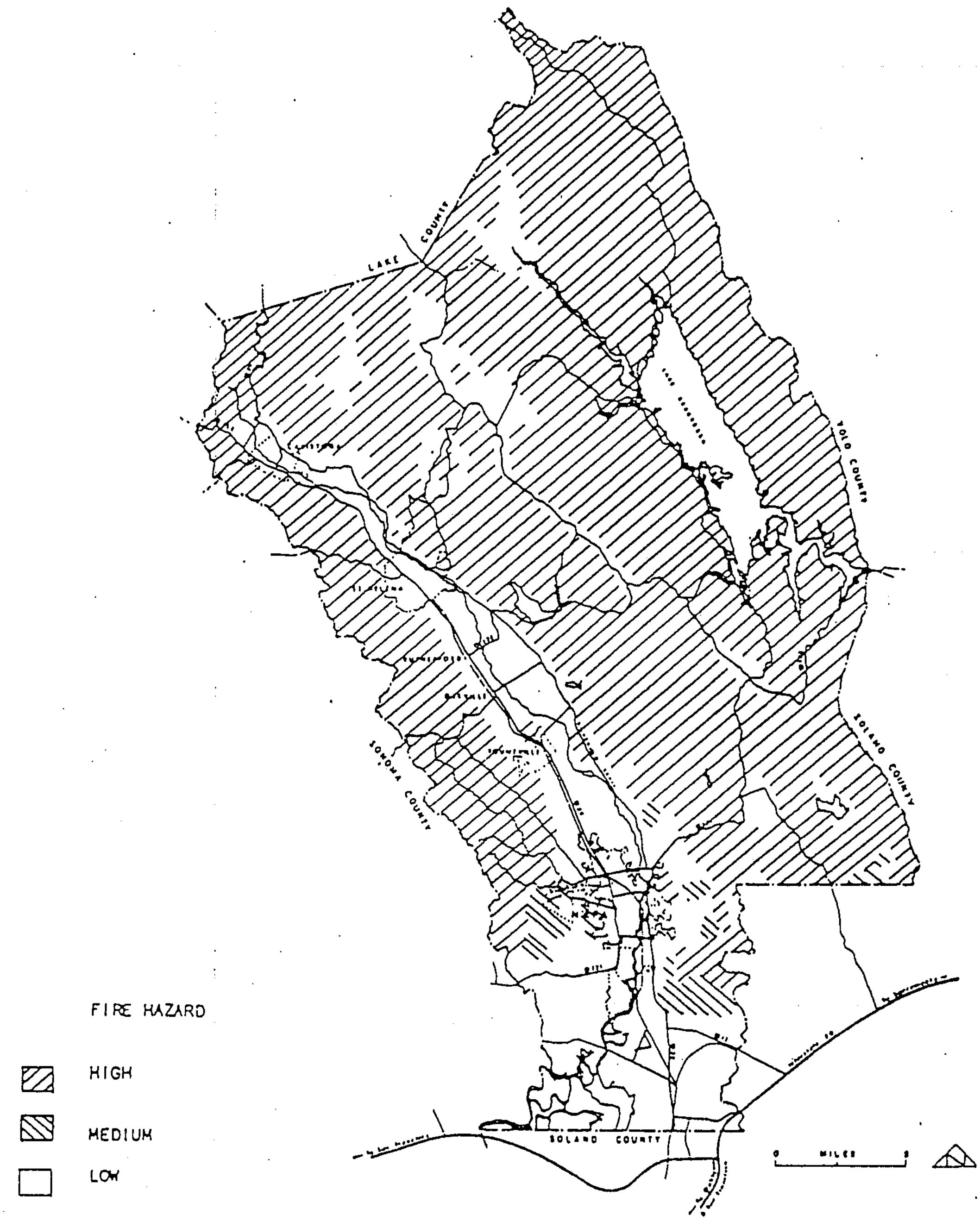
Potential Environmental Impacts and Mitigation - Physical Control

Excavation during minor physical control activities has the potential of uncovering previously-unknown buried hazardous materials. The risk of this is small because these activities typically take place in the footprint of existing levees, culverts, channels, or on sites that have never been an industrial site. However, in some circumstances, the land use history of an area where physical control is proposed is unclear. In addition, there is a possibility of exposure of contaminated soil from channel erosion after construction.

The USACE and BCDC regional permits that allow minor physical control work by the District require submission of annual work plans by the District and provide for wide agency review of these plans. As an additional prudent measure, the District will also conduct field visits, aerial photography evaluation, and agency record searches for evidence of contamination with hazardous materials, prior to initiating source reduction activities in any location where there is evidence of current or past industrial or heavy transportation activities in the area of influence of the proposed work.

WILDLAND FIRE HAZARD MAP

THIS MAP IS INTENDED TO PROVIDE A GENERALIZED PICTURE OF WILDLAND FIRE HAZARDS: FOR MORE DETAILED (PARCEL SPECIFIC) INFORMATION, THENAPA COUNTY ENVIRONMENTAL SENSITIVITY MAPS SHOULD BE CONSULTED.



Source: California Department of Forestry, Napa County Conservation, Development & Planning Department

3.8 HYDROLOGY AND WATER QUALITY.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Violate any water quality standards or waste discharge standards?			X	
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g. the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which a permit has been granted)?			X	
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?			X	
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?			X	
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?				X
f) Otherwise substantially degrade water quality?			X	
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?				X
h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?			X	
i) Expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of a failure of a levee or dam?			X	
j) Inundation by seiche, tsunami, or mudflow?				X

Explanation:

Setting

The District's activities largely take place in wetlands, including riparian zones, as described in Section 3.4 (Biological Resources). As noted in 3.7 (Hazards and Hazardous Materials) above, all physical control activities in jurisdictional wetlands are subject to annual review by a wide range of state and federal agencies, which helps the District identify and avoid potential impacts associated with water quality or quantity.

Potential Environmental Impacts and Measures to Avoid Significance - Water Quality

The only potential effects of Project activities on water quality would be seen in impacts on fish and wildlife (discussed under Biological Resources) or through accidental release of pesticides (discussed under Hazards & Hazardous Materials).

Potential Environmental Impacts and Measures to Avoid Significance - Groundwater

The Project does not involve consumptive use of groundwater. Some physical control activities might involve maintenance of existing drainage works in agricultural or other highly impacted sites. Near-surface groundwater could be slightly lowered in these settings, but only in a direction and scope similar to standard agricultural drainage practices on the same parcels. In physical control projects in natural areas, the consequences of District activities are generally a restoration of hydraulic actions to pre-European conditions. This is generally considered a desirable situation (Habitat Goals Project 1999), and where the impacts could significantly alter current habitat values, the District will conduct a separate CEQA review of the proposed activities.

Potential Environmental Impacts and Measures to Avoid Significance - Erosion and Siltation

Of the Project activities, only physical control and vegetation management have any potential to cause erosion or siltation, and the small scale of these activities, combined with the permit requirements associated with physical control, preclude significant impacts.

Potential Environmental Impacts and Measures to Avoid Significance - Flooding

Of the Project activities, only physical control and vegetation management have any potential to result in flooding, and the small scale of these activities, combined with the permit requirements associated with physical control, preclude significant impacts. Specifically, while water control structures are often built within the 100-year floodplain, the intent and functioning of these structures is to reduce flood risk, rather than to impede or detrimentally redirect flows. As above, the District will conduct a separate CEQA review of any proposed major new work.

3.9 LAND USE AND PLANNING

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Physically divide an established community?				X
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to, the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?			X	
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?			X	

Explanation:

Setting - Existing Environmental Practices, Plans, and Policies

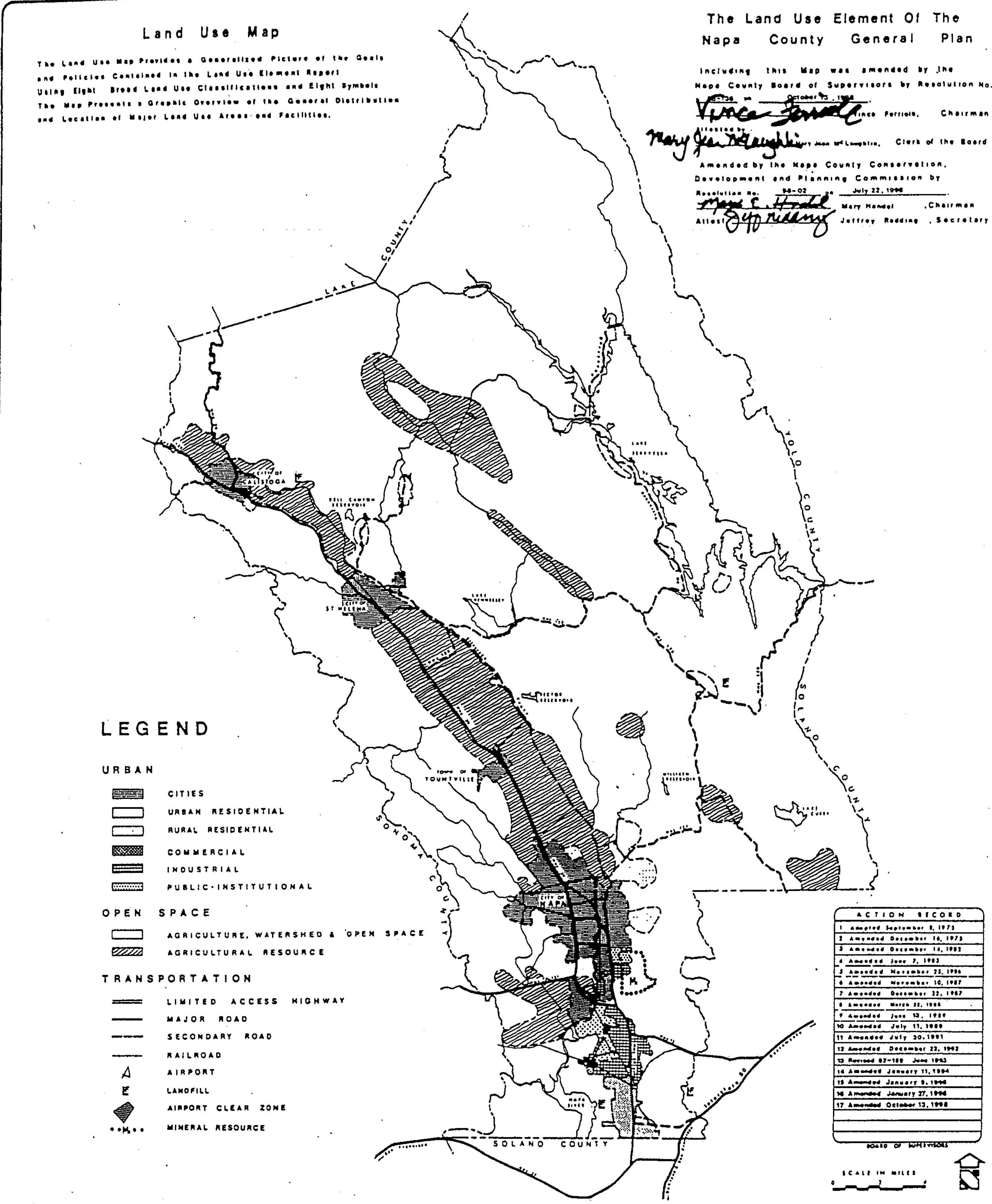
Because of the size and diversity of the District Service Area, there are a large number of existing environmental practices, plans, and policies, including those of Napa County (see attached map from Napa County General Plan) and the cities in the County. In addition, large institutional land-owners (e.g. the California Dept. of Fish & Game) have adopted land use plans and other environmental policies and practices.

Potential Environmental Impacts and Measures to Avoid Significance

All District activity types are compatible with the zoning, City and County general plan designations, and City and County general plan policies of the impact area. In addition, the County General Plan notes resource management, such as maintaining critical marsh and other endangered habitats, as one of the most appropriate uses in "Open Space" areas. Since the project involves maintenance and enhancement of wetlands, the project would be consistent with the policies contained in the County and City General Plans.

The activities proposed under the project do not directly result in any changes to land use on or off site. Implementation of the project activities is not expected to adversely affect adjacent uses or directly cause any changes to regional land use. Therefore, the project is compatible with existing land uses. The Project Elements, individually and collectively, appear to be consistent with all existing environmental policies and plans of relevance to the District's Service Area.

There are no approved Habitat Conservation Plans in the Service Area (USFWS 6/3/99; Peter Baye, pers. comm. 8/30/99).



NAPA COUNTY LAND USE PLAN 1998-2000

3.10 MINERAL RESOURCES.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the State?				X
c) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan?				X

Explanation:

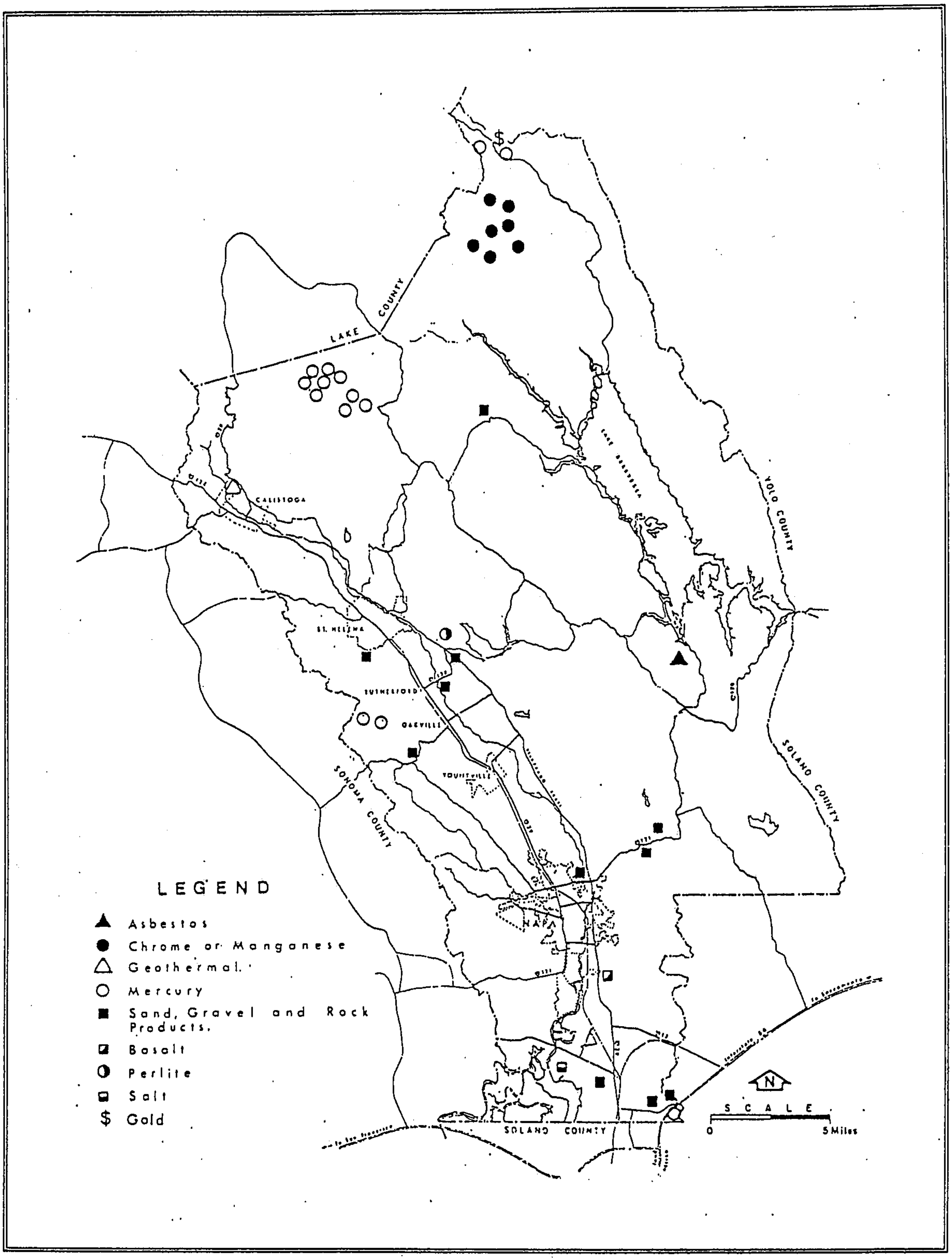
Setting

Mineral resources and mineral recovery operations are limited in Napa County (see attached map from Napa County General Plan). In the southern and central portions of the county, gravel and rock are extracted from river beds for general use. Other mineral resources include mercury, gold, chrome, and manganese (far northern reaches of the county), perlite (central region), asbestos (Lake Berryessa area), basalt (south county), salt (inactive; south county), and geothermal steam (Calistoga area).

Potential Environmental Impacts

Project operation does not involve any substantial mineral usage, nor does it interfere with any actual or proposed mineral extraction operations.

MINERAL DEPOSIT LANDS



3.11 NOISE.

Would the proposal result in:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exposure of persons to or generation of noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?				X
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?				X
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?				X
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?			X	
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?				X
f) For a project within the vicinity of a private airstrip, airport or public use airport, would the project expose people residing or working in the project area to excessive noise levels?				X

Explanation:

Setting

The District uses ATV's, boats, and aircraft, and performs or directs physical control with heavy equipment, in marshlands surrounded by various land uses, including light industry, transportation, sewer treatment, agriculture, other open space, and single family residential. Primary noise sources in the Service Area include vehicular traffic, train traffic, and operational and construction activities at industrial facilities. The residential areas are generally located at some distance from the marshlands. Potential noise impacts on nesting birds and other wildlife are discussed under Biological Resources.

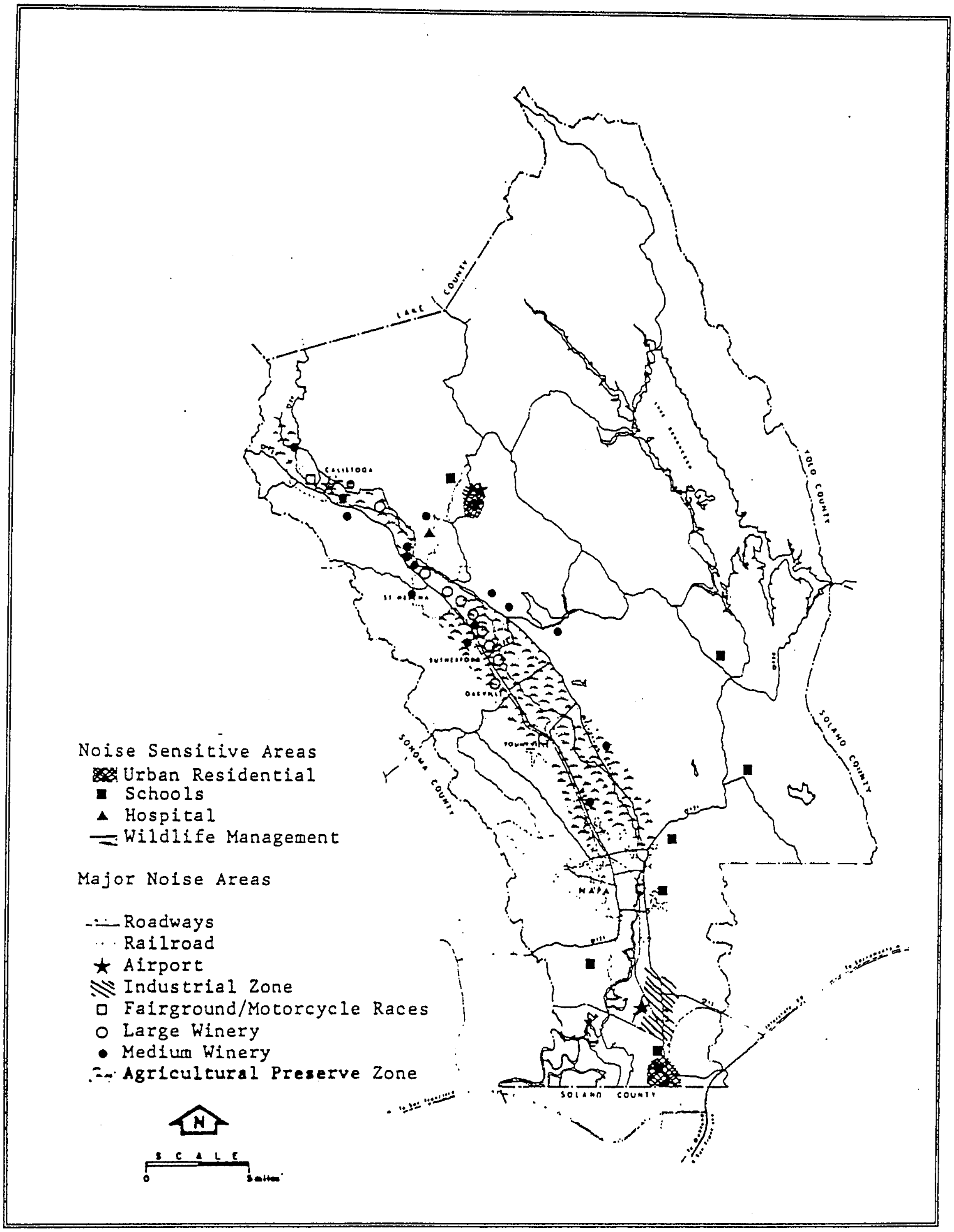
Potential Environmental Impacts and Measures to Avoid Significance - ATV's & Chemical Control

By Community Noise Equivalent Level criteria, there is no significant source of noise from the District's ATV's or other vehicles or ULV spray equipment to persons more than a few dozen feet from the vehicle. Because of the normal locations and times for operating these vehicles and equipment, and the very short time spent at any specific location, the risk of "unacceptable" noise is essentially nonexistent. Boat and aircraft use is infrequent and almost always near industrial areas, or open space at a distance from residential areas. Furthermore, aerial spray activities are coordinated with local and county emergency services, the county airport, and local communities (as needed) to minimize concerns with respect to low-flying aircraft. In summary, the District has been conducting these activities for over fifty years without receiving noise complaints.

Potential Environmental Impacts and Measures to Avoid Significance - Physical Control

Any noise associated with source reduction projects would occur during construction of levees, tide gates, and culverts, or during dredging. Since the closest residential receptors are generally at some distance from the marsh areas where source reduction activities are concentrated, the noise from the dredging should not be discernible from the background noise from road and industry. No significant impacts from noise during construction are therefore expected.

NOISE SENSITIVE AREAS/MAJOR NOISE AREAS: NAPA COUNTY UNINCORPORATED AREA



3.12 POPULATION AND HOUSING.

Would the proposal:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads and other infrastructure)?			X	
b) Displace substantial numbers of existing housing [units], necessitating the construction of replacement housing elsewhere?				X
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?				X

Explanation:

Setting

Single-family and other residential housing exists throughout Napa County, interspersed with industrial, commercial, and agricultural land uses. Prior to creation of the District, residential development in some areas of the County may have been slowed by high densities of mosquitoes. At this time, there are no areas in the District's Service Area where this is true.

Potential Environmental Impacts

No direct impacts on housing and population are anticipated from implementation of the Project. The Project does not create significant numbers of new jobs or directly induce any growth in the area; thus there would be no influx of workers. In addition, there would be no displacement of existing housing from the project, as Project implementation takes place on existing industrial, agricultural, and marsh lands.

While it could be argued that mosquito control activities by the District in the past removed a barrier to development, and therefore indirectly induced growth, the District now responds to the needs and desires of the existing population, and does not act anywhere within the Service Area with the intention of reducing mosquito populations to allow further development.

3.13 PUBLIC SERVICES.

a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives of any of the public services:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
Fire protection?				X
Police protection?				X
Schools?				X
Parks?				X
Other public facilities?				X

Explanation:

Setting

Public services including fire protection and emergency medical care are located in cities throughout the Project area. Police agencies with jurisdiction over some or all of the Project area include local Police Departments, the Napa County Sheriff, and the California Highway Patrol.

Maintenance requirements of some roads are relatively high, due in part to the current flood regimes.

Costs to Caltrans and the County during road flooding include barriers, pumps, sandbags, vehicles, and personnel.

Potential Environmental Impacts and Measures to Ensure Insignificance

The Project places no significant demands on city or county public services. During the short construction period associated with source reduction projects, there could be a small chance for a need for emergency medical or fire protection services. The only long-term demands foreseen for government services will be for operation and maintenance of the facilities built in this Project. Since local governmental entities have largely performed these functions in the past, little additional demand for services is likely. In addition, road maintenance and flood-related costs should drop following permitted drainage improvement projects.

3.14 RECREATION.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Would the project increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?				X
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities which might have an adverse physical effect on the environment?				X

Explanation:

Setting

The District Service Area includes significant recreational resources, including the Napa River and other areas adjacent to riparian zones or wetlands; and the wineries, historic cities, and other sites for outdoor tourism.

Potential Environmental Impacts

The project would not infringe on land upon which recreational uses could occur in the future. There would be no detrimental impact to recreational areas. By reducing mosquito abundance, the Program/Project substantially enhances outdoor recreational values and quality of life.

3.15 TRANSPORTATION / TRAFFIC.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections?			X	
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?				X
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?				X
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?				X
e) Result in inadequate emergency access?				X
f) Result in inadequate parking capacity?				X

Explanation:

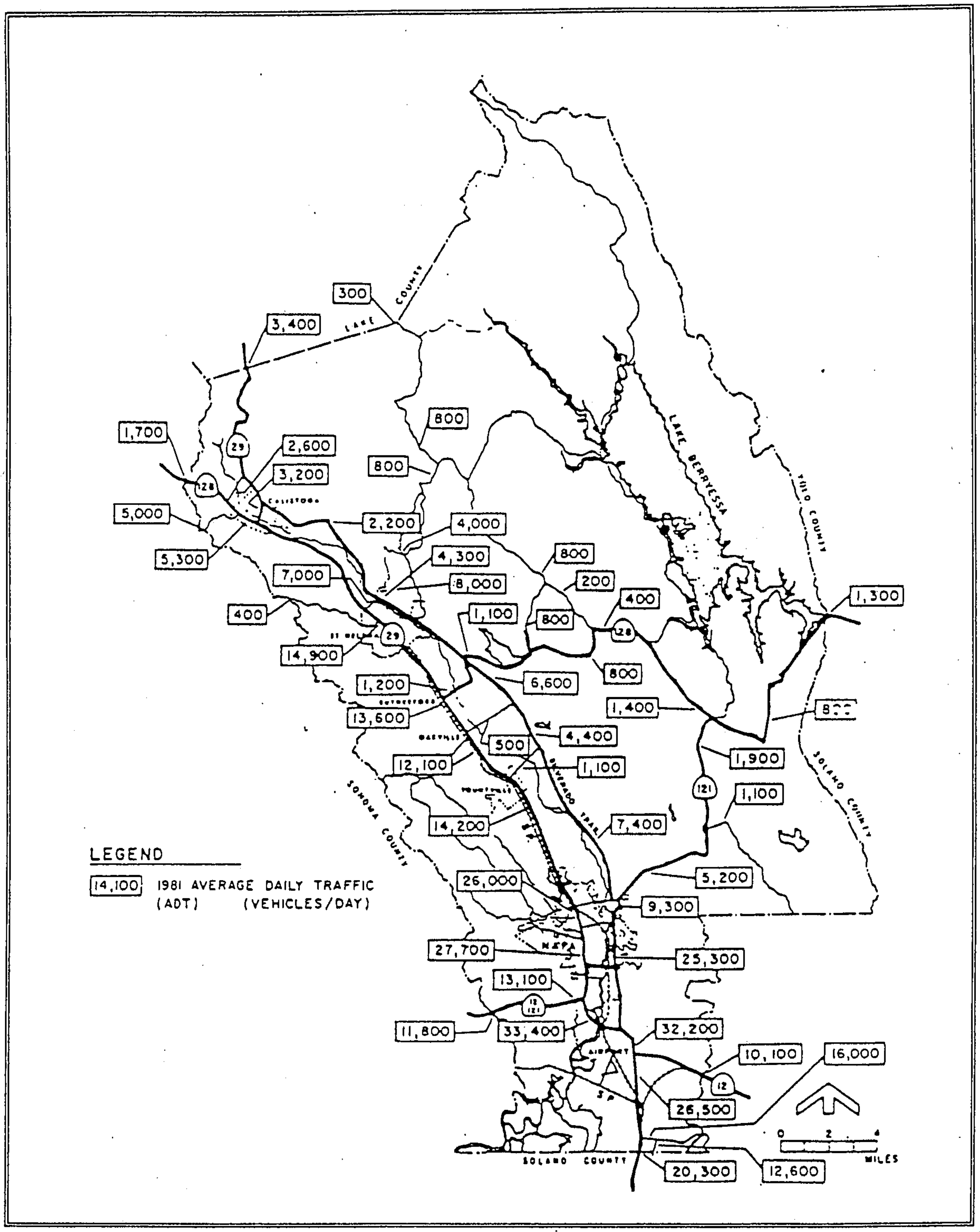
Setting

The Service Area includes a substantial commuting population and a very large tourism industry. Since 1994, 4.8 million tourists per year, many of them day visitors, have come to the Napa Valley area (Napa Valley Conference and Visitors Bureau 1998 Annual Report).

Potential Environmental Impacts and Measures to Avoid Significance

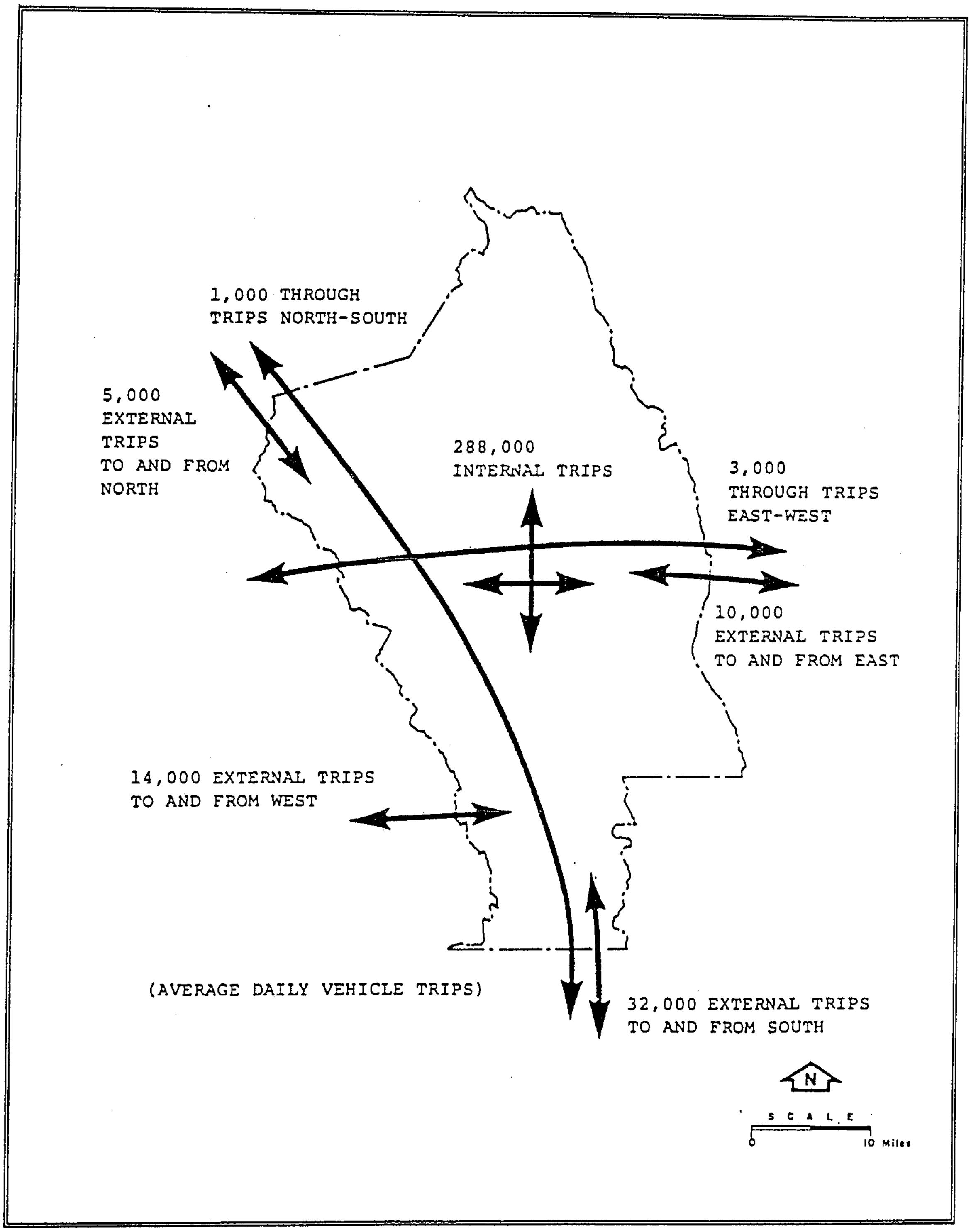
The small size of District staff and the small number of District vehicles (5) relative to the commuting, tourist, and business traffic in the Service Area (see attached maps from Napa County General Plan) means that District impacts to transportation and traffic are insignificant.

AVERAGE DAILY TRAFFIC, 1981



Source: CalTrans (1980 & 1981 Counts), Napa County Public Works Dept., Wilbur Smith & Associates, 1982

EXISTING VEHICLE TRIP DISTRIBUTION PATTERNS



Source: Wilbur Smith & Associates

3.16 UTILITIES AND SERVICE SYSTEMS.

Would the project:	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?				X
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects?				X
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities the construction of which could cause significant environmental effects?				X
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?				X
e) Result in a determination by the wastewater treatment provider which serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?				X
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?				X
g) Comply with federal, state, and local statutes and regulations related to solid waste?				X

Explanation:
Potential Environmental Impacts and Measures to Avoid Significance

Mosquito control activities discussed in this report would not result in any substantial usage of utilities or service systems. Thus, there would be no demand-related impacts.

Coordination of source reduction activities with pipeline and electric line owners and operators, and routine notification to Underground Service Alert, are requirements in all construction contracts and will ensure no impacts to existing utilities.

Regional storm water drainage will often be improved by source reduction projects, and flood risk to local homes and roads may be reduced (see Water and Hazards sections).

3.17 MANDATORY FINDINGS OF SIGNIFICANCE.

	Potentially Significant Impact	Potentially Significant Unless Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?			X	
b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)?			X	
c) Does the project have environmental effects which will cause substantial adverse effects on human beings, either directly or indirectly?			X	

Explanation:

The District's Integrated Mosquito Management Program includes established policies and practices, together with new mitigation measures identified in other Sections, that will ensure that potential impacts to plant and wildlife species and historic or prehistoric resources remain at a less-than-significant level. Construction contract documents for District activities include measures to ensure that potential exposure of workers or others to hazards is less-than-significant. The project would not adversely affect any long-term environmental goals; in fact, many District activities function to restore the ecological quality of existing marsh areas while also improving the human environment through mosquito control and flood risk reduction.

The project would not result in significant cumulative impacts because potential for significant project impacts is eliminated by the policies, practices, and mitigation measures that have been included in the project. The project would not adversely affect human beings, either directly or indirectly.

3.18 EARLIER ANALYSES.

The District refers in this Initial Study to earlier CEQA documents. Copies of all of these documents are on file with the District, and will be made available for public review upon request. A copy fee will be required for extensive requests.

1. Preliminary Review of Activities of the Napa County Mosquito Abatement District (May 1999; updated August 1999; attached as an Appendix).

2. Final Environmental Impact Report on Napa County General Plan Revision (1991)

3. Final Environmental Impact Report on Caltrans' Vegetation Control Program. May 1992. Prepared by Jones & Stokes Associates, Inc., State Clearinghouse No. 89092515. *especially* Appendix I: Risk Assessment for Herbicides Used or Proposed for Use by the California Department of Transportation for Vegetation Management. July 1991. Prepared by K.S. Crump Division, Clement International Corporation.

SECTION 4. DETAILED TECHNICAL REVIEW OF PROGRAM/PROJECT

4.1 INTRODUCTION

The Napa County Mosquito Abatement District's Integrated Mosquito Management Program (IMMP) that is evaluated in this document is an ongoing program of surveillance and control of mosquitoes of human disease and discomfort. This Program consists of a coordinated set of activities which are described and discussed in detail below. An extensive body of knowledge exists, both in the District and in the published literature, on the reasons for these activities and the specific implementation, mode of action, efficacy, cost-effectiveness, safety, and potential environmental impacts of each. Therefore, the reader is directed to the extensive attached bibliography, and especially to the publications of the District, the American Mosquito Control Association (AMCA), and the Mosquito & Vector Control Association of California (MVCAC), for general discussions of mosquito control or for detailed information on the rationale, modes of action, and specific application of each mosquito surveillance and control technique. This Technical Review, on the other hand, only briefly summarizes general information on mosquito control methods, and primarily focuses on the potential environmental impacts of those mosquito surveillance and control activities currently or potentially used by the District, and those aspects of the District's environmental setting, program, and policies that ensure that these potential environmental impacts are insignificant.

In the interest of precision and clarity, both the common and scientific names are presented initially for organisms discussed in this report. In subsequent references to a species or subspecies, the more well-known name will be used consistently. Lists of common and scientific names are compiled for mosquitoes in a table after Section 4.1, and for Special Status Species in a set of tables after Section 4.2.

A. Project/Program Rationale

The California Health and Safety Code defines a vector as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal" (Section 2200(f)). The District undertakes activities through its Integrated Mosquito Management Program to control mosquitoes as vectors of disease and/or discomfort in the Service Area.

Twenty species of mosquitoes reside within the wet areas of Napa County. The table following page 3 lists these species known to occur within the District's Service Area. The reader is referred to the publications by Bohart and Washino (1978) and Meyer and Durso (1993) for detailed information concerning the biology, ecology, and diseases vectored by these mosquitoes.

Certain species of mosquitoes found in Napa County can transmit malaria, St. Louis encephalitis, western equine encephalomyelitis, and potentially other encephalitis viruses. A few species of mosquitoes are also capable of transmitting dog heartworm. Although some species of mosquitoes have not been shown to transmit disease, most species can cause human discomfort when the female mosquito bites to obtain blood. Reactions range from irritation in the area of the bite to severe allergic reactions or secondary infections resulting from scratching the irritated area. Additionally, an abundance of mosquitoes can cause economic losses, and loss of use or enjoyment of recreational, agricultural, or industrial areas.

Mosquitoes are extremely mobile and cause the greatest hazard or discomfort away from their breeding site. Each mosquito species has a unique life cycle and most of them occupy different habitats. In order to effectively control the range of mosquitoes inhabiting the District Service Area, an integrated mosquito management program must be employed. District policy is to identify mosquito species and mosquito sources in the Service Area, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between mosquitoes and humans.

B. Project/Program Activities

The District's Integrated Mosquito Management Program consists of six general types of coordinated activities:

Surveillance for mosquito populations, mosquito habitats, disease pathogens, and public distress associated with mosquitoes. Mosquito surveillance activities include field counting, trapping, and laboratory analysis of mosquitoes, alternative hosts, and pathogens to evaluate populations and disease threats; field inspection of known or suspected mosquito habitats; maintenance of paths and the use of all-terrain vehicles to access mosquito habitat; analysis of public service requests and surveys; and other data collection methods.

Public Education to encourage and assist reduction and prevention of mosquito habitats on private and public property. While a critical element of our IMMP (see the attached Preliminary Review), public education activities are categorically exempt from CEQA review [CEQA Guidelines Sec. 15322] based on a finding by the State Secretary of Resources that these activities do not have a significant effect on the environment. Therefore, these activities will not be further reviewed in this document.

Physical Control. Management of mosquito habitat, especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities, etc., is known as "Physical Control". Activities designed to reduce mosquito populations through changes in the physical environment which reduce its habitat suitability for mosquitoes, or which improve habitat or mobility of natural predators of mosquitoes, are considered Physical Control; activities related to rearing or relocating these predators are discussed below as Biological Control. Activities which impact mosquito habitat through manipulation of vegetation is discussed below as Vegetation Management.

Vegetation Management. The District applies herbicides (chemical pesticides with specific toxicity to plants) and uses hand tools or other mechanical means of vegetation removal or thinning to improve surveillance or reduce mosquito habitats.

Biological Control. Application of the "mosquito fish" *Gambusia affinis*, the bacterium *Bacillus sphaericus* the fungus *Lagenidium giganteum*, or other predators or pathogens of mosquitoes is known as "Biological Control." *Gambusia affinis*, *Bacillus sphaericus*, and *Lagenidium giganteum* reproduce in natural settings, for at least some time, after release. *Bacillus thuringiensis israelensis* (Bti) materials applied by the District contain only spores made up of specific protein molecules produced by the Bti organism, and not live bacteria. Because the potential environmental impacts of *Bacillus sphaericus* or Bti application are generally similar to those of chemical pesticide applications, these materials are evaluated below under Chemical Control.

Chemical Control. In the context of the District's IMMP, "Chemical Control" is the application of non-persistent selective insecticides to directly reduce populations of larval or adult mosquitoes.

While these program/project elements together encompass the District's IMMP, it is important to note that the specific activities performed by District staff vary considerably from day to day, and from site to site, in response to mosquito species active, mosquito population size or density, mosquito population age structure, mosquito location, time of year, local climate and weather, potential for mosquito-borne disease, proximity to human populations, proximity to sensitive receptors, access by District staff to mosquito habitat, abundance of natural predators, availability and cost of control methods, effectiveness of previous control efforts at the site, potential for development of resistance in mosquito populations, land-owner policies or concerns, proximity to special status species, Endangered Species Recovery Plans, Habitat Conservation Plans, Natural Community Conservation Plans, and local community concerns. Therefore, the specific actions taken in response to current or potential mosquito activity in any specific place and time depends on factors of mosquito and pathogen biology, physical and biotic environment, human settlement patterns, local standards, available control methods, and institutional and legal constraints. While some consistent mosquito sources are exposed to repeated control activity, many areas with minor mosquito activity are not routinely treated, and most of the land within the District Service Area has never been directly treated for mosquitoes.

The District regularly reviews its IMMP to ensure that its practices are effective, economical, safe, environmentally sensitive, and responsive to the needs of the public. This means that new materials, methods, and treatment criteria are periodically incorporated by the District. Over the 74 year history of the District, these changes have generally reduced the potential environmental impacts of our activities through the introduction of more selective materials or through more subtle or sophisticated interactions with existing ecological and hydraulic processes. Therefore, although the District does not foresee adoption of any new general project elements beyond those listed above, it is likely that specific activities and policies discussed below will evolve, and it is certain that their intensity of application will continue to vary from site to site and from year to year. Where the modes of action and the intensity of proposed activities are similar to those in current use, the potential environmental impacts of the program as a whole should not increase as a result of these changes. Where substantially new materials, methods, or locations are proposed for routine operational use, the District will update this document.

C. General Mosquito Management Strategy

As described in the Preliminary Review, the District's activities address mosquito management through a general strategy including identification of mosquito problems; responsive actions to control existing populations of mosquitoes, prevent new sources of mosquitoes from developing, and manage habitat to minimize mosquito production; education of land-owners and others on measures to minimize mosquito production or interaction with mosquitoes; and provision and administration of funding and institutional support necessary to accomplish these goals.

In order to accomplish effective and environmentally sound mosquito management, the manipulation and control of mosquitoes must be based on careful surveillance of their abundance, habitat (potential abundance), pathogen load, and/or potential contact with people; the establishment of treatment criteria (thresholds); and appropriate selection from a wide range of control methods. This dynamic combination of surveillance, treatment criteria, and use of multiple control activities in a coordinated program is generally known as Integrated Pest Management (IPM) (Glass 1975, Davis et al 1979, Borror et al 1981, Durso 1996, Robinson 1996).

The District's Mosquito Management Program, like any other IPM program, by definition involves procedures for minimizing potential environmental impacts. The District's Project employs IPM principles by first determining the species and abundance of mosquitoes through evaluation of public service requests and field surveys of immature and adult mosquito populations; and then, if the populations exceed predetermined criteria, using the most efficient, effective, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy. In some situations, water management or other physical control activities can be instituted to reduce mosquito breeding sites. The District also uses biological control such as the planting of mosquitofish in some settings. When these approaches are not effective or are otherwise inappropriate, then pesticides are used to treat specific pest-producing or pest-harboring areas.

In order to maximize familiarity by the operational staff with specific mosquito sources in the Project area, the District is divided into zones (currently six). Each zone is assigned a full-time Mosquito Control Technician, and sometimes an Aide, whose responsibilities include minor physical control, inspection and treatment of known mosquito sources, finding and controlling new sources, and responding to service requests from the public.

Mosquito control activities are conducted at a wide variety of sites throughout the District's Project area. These sites can be roughly divided into those where activities may have an effect on the natural environment either directly or indirectly (through drainage), and sites where the potential environmental impacts are negligible ("Non-Environmental Sites"). Examples of "Environmental Sites" in the Project area include tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, stormwater detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, irrigated pastures, or agricultural ditches. Examples of "Non-Environmental Sites" include animal troughs, artificial containers, tire piles, fountains, ornamental fish ponds, swimming pools, liquid waste detention ponds, and non-natural harborage (such as covered wood piles, residential and commercial landscape, trash receptacles, etc.).

D. Emergency Activities

In the event of emergency conditions (actual or imminent disease outbreak), District actions temporarily vary from the routine operational actions of the District through increases in scope or intensity, and potentially through use of legal pesticides, in strict conformance with label requirements, that are not routinely used by the District. Because of their temporary nature and their essential similarity to routine activities, emergency activities are not expected to result in any significant environmental impact. In addition, the State has recognized that emergency conditions may require prompt action of a nature or intensity above typical levels as a means to protect public health, welfare, safety, or property, and has exempted these activities from requirements for further environmental review [CEQA Guidelines 15269, 15359].

Table 4.1.1: Mosquitoes of Napa County. The reader is referred to Bohart & Washino (1978) and Meyer & Durso (1993) for specific biological information on the mosquitoes listed in this table.

Scientific Name	Common Name
Genus *Aedes* ("*Ae.*")	
Aedes bicristatus	
Aedes dorsalis	Summer Salt Marsh Mosquito
Aedes nigromaculis	Irrigated Pasture Mosquito
Aedes sierrensis	Western Treehole Mosquito
Aedes squamiger	Winter Salt Marsh Mosquito
Aedes washinoi	Willow Pool Mosquito
Genus *Anopheles* ("*An.*")	
Anopheles franciscanus	
Anopheles freeborni	Western Malaria Mosquito
Anopheles occidentalis	
Anopheles punctipennis	Woodland Malaria Mosquito
Genus *Culex* ("*Cx.*")	
Culex apicalis	
Culex boharti	Bohart's Culex Mosquito
Culex erythrothorax	Tule or Cattail Mosquito
Culex pipiens	Little House Mosquito
Culex stigmatosoma	Banded Foul-Water Mosquito
Culex tarsalis	Encephalitis Mosquito
Culex thriambus	
Genus *Culiseta* ("*Cs.*")	
Culiseta incidens	Fish Pond Mosquito
Culiseta inornata	Winter Marsh Mosquito
Culiseta particeps	

Table 4.1.1.a: Supplemental Information on Mosquitoes of Napa County.

Scientific Name	Common Name	Habitat/Ecology	Hosts	Vector Potential/Diseases
Aedes bicristatus		One of the earliest appearing spring species. Larvae found in shallow margins of pools, ditches, etc. with heavy emergent vegetation.	Not very aggressive but will occasionally bite humans	Unknown
Aedes dorsalis	Summer Salt Marsh Mosquito	Larvae found in brackish and saline water (eg. intertidal marshes and margins of bays and lakes). Eight or more generations per year for tidal populations.	Bovine, equine and will readily bite humans	Calif. Encephalitis virus has been isolated from a Utah population.
Aedes nigromaculis	Irrigated Pasture Mosquito	Larvae form clumps along grassy margins. Associated with intermittently flooded pastures. Can have 10 or more generations per year.	Will readily bite humans and large domestic mammals.	Considered a potential threat for arbovirus transmission. Lab tests show this species can vector Western St. Louis and Japanese B encephalitis viruses.
Aedes sierrensis	Western Treehole Mosquito	Larvae found in treeholes and containers that have a lot of leafy sediment. Eggs hatch with initial fall rains and when dissolved oxygen is less than 0.25 ppm. Over winter as larvae with adults present from February – July.	Vicious biters of humans and other large mammals.	Primary vector of dog heartworm. Lab tests show this species capable of transmitting the Western equine encephalitis virus.
Aedes squamiger	Winter Salt Marsh Mosquito	Eggs hatch late fall and winter following high tides and heavy rains. Adults emerge end of February thru April and bite through early June. Univoltine.	Humans and ???	Unknown
Aedes washinoi	Washino's Willow Pool Mosquito	Larvae found in ditches, ponds, willow groves, berry vine filled depressions and densely shaded water sources.	Humans and ???	Unknown
Anopheles franciscanus		Larvae found in slow moving streams and pools of water containing rich growth of green algae and exposed to good sun. Over winter as adults.	Primarily mammals	Main Drain virus has been isolated from a San Diego population. Avian malaria was found in a Kern County population.
Anopheles freeborni	Western Malaria Mosquito	Larvae prefer clear, fresh seepage water in sunlit or partly shaded pools. Also found in rice fields and roadside ditches with grass. Over winter as adults.	Primarily mammals, will aggressively bite humans when encountered.	Most important vector of Vivax Malaria in California. Also a vector of Myxoma virus of rabbits. St. Louis encephalitis virus was isolated from a Sacramento population.
Anopheles occidentalis		Larvae found in ponds, creeks, streams, swamps, and seepages. Peak abundance in May and July. Over winter as both adults and larvae.	Rarely bites humans. Preference for bovine and equine blood.	
Anopheles punctipennis	Woodland Malaria Mosquito	Larvae mostly found in clear, shaded pools along creeks and streams in foothill areas.	Prefer large mammals	Has successfully transmitted Vivax Malaria. Has been reported as a vector of dog heartworm.

Supplemental Information on Mosquitoes of Napa County continued

Scientific Name	Common Name	Habitat/Ecology	Hosts	Vector Potential/Diseases
Culex apicalis		Larvae found in cut-off pools along woodland water courses and roadside ditches, Larvae present April thru December. Over winter as adults	Amphibians, reptiles and passerine birds.	Unknown – presumed none due to feeding preferences.
Culex boharti	Bohart's Culex Mosquito	Larvae found along the edges of slow moving streams or isolated pools of streams in open to partly shaded areas.	Amphibians	Unknown
Culex erythrothorax	Tule or Cattail Mosquito	Larvae found in tule swamps and ponds.	Primarily small mammals. Will bite humans if available	Western equine and St. louis encephalitis virus, and Turlock virus have been isolated from California populations. Calif. encephalitis virus has been isolated from Utah populations.
Culex pipiens	Little House Mosquito	Larvae prefer polluted or foul water high in organic content. Can occur in fresh water but not common. Found in artificial containers, storm drains, wastewater ponds, sumps, septic tanks, water under houses, etc.	Primarily birds. Will bite humans and pets if available.	Western equine and St. Louis encephalitis viruses are present in Calif. populations. Has also been known to vector Avian malaria.
Culex stigmatosoma	Banded Foul-Water Mosquito	Larvae found in both foul and slightly foul water from natural and artificial pools, storm drains, pastures, man-made containers, cess pools and wastewater ponds. Adults over winter in stumps and burrows.	Mammals and birds.	Western equine and St. Louis encephalitis viruses and Turlock virus have been isolated from Calif. populations. Is the primary vector of Avian malaria in Kern County.
Culex tarsalis	Encephalitis Mosquito	Larvae can be found in most fresh and brackish water sources. Can tolerate coastal marsh water with salinities up to 10 ppt. Not common in polluted water. Adults rest during the day in man-made shelters, animal burrows and treeholes.	Birds and mammals.	Primary vector of Western equine and St. Louis encephalitis viruses. Is also a vector of Avian malaria. Has been associated with Turlock, Hart Park and Lokern viruses.
Culex thriambus		Larvae are found in rock pools, isolated ponds and hoof prints along streams and creeks. Also in grassy roadside ditches.	Prefer passerine birds.	Unknown.
Culiseta incidens	Fish Pond Mosquito	Peak populations occur during the cooler months of the year. Larvae can be found in a wide range of fresh and brackish water habitats including isolated creek pools, artificial containers, fish ponds, abandoned swimming pools, water gardens, etc.	Domestic mammals and humans.	
Culiseta inorata	Winter Marsh Mosquito	Primarily a late fall through spring mosquito. Larvae found in a wide range of habitats including marshes, seepages, ditches, canals ponds, etc. Larvae can tolerate water with a salinity up to 26 ppt.	Prefer large domestic mammals. Will bite humans if available.	Have found Western equine enceph-alitis virus in Washington populations. Cache virus has been found in Utah and North Dakota populations.
Culiseta particeps		Larvae are found in small cut-off pools of streams and the shallow margins of *Typha* sp. Filled pools in wooded and semi-wooded habitats.	?	Unknown

4.2 PROGRAM/PROJECT SETTING

A. INTRODUCTION

The District's activities are conducted within a 797 square mile jurisdiction encompassing all areas contained within Napa County, California. Under Section 2270(a) of the Health and Safety Code, the District can also take limited action in bordering areas of Solano County, Sonoma County, Yolo County, or Lake County if needed to provide mosquito control for residents of Napa County. Therefore, areas actually or potentially impacted by District activities include

a. The incorporated cities of American Canyon, Calistoga, Napa, St. Helena, and the Town of Yountville;
b. The unincorporated areas of Napa County; and
c. Other bordering areas in Solano, Sonoma, Yolo, or Lake Counties.

The Project impact area covers a wide range of natural habitats and highly developed areas, with an equally wide range of plant and animal communities from the extensive tidal marshlands associated with the Napa River and along the County's south end to the heights of Atlas Peak and Mt. Veeder. Human activities in the Service Area, primarily during the last 150 years, have led to substantial changes in these habitats and in the populations of the organisms that inhabit them, so that many areas of the District Service Area exhibit some degree of human modification and impact (see County General Plan maps in Section 3).

Because of the diversity of mosquito habitat, mosquito control activities are conducted at a wide variety of different ecosystems and habitat types throughout the District's Project area. Mosquito control activities are associated with wet areas of all types and sizes. This includes marshes, ponds, creeks, seasonal wetlands, wastewater ponds, storm-water detention basins, irrigated pastures, duck clubs, etc, as well as individual homes or commercial buildings.

Mosquito control sites can be roughly divided into those where activities may have an effect on the natural environment either directly through on-site activities or indirectly through drainage to off-site areas, and sites where the potential environmental impacts are negligible. Examples of "Environmental Sites" in the Project area include Tidal Marshes, Duck Clubs, Other Diked Marshes, Lakes and Ponds, Rivers and Streams, Vernal Pools and other Seasonal Wetlands, Storm water Detention Basins, Flood Control Channels, Spreading Grounds, Street Drains and Gutters, Wash Drains, Irrigated Pastures, or Agricultural Ditches. Examples of "Non-Environmental Sites" include Animal Troughs, Artificial Containers, Tire Piles, Fountains, Ornamental Fish Ponds, Swimming Pools, Waste Detention Ponds, and Non-Natural Harborage (such as wood piles, residential and commercial landscape, trash receptacles, etc.).

B. WETLANDS AND OTHER SENSITIVE HABITATS

The District's Service Area includes extensive areas of wetlands and riparian corridors, and most of the District's mosquito control activities take place in these habitat types. The District maintains detailed maps and data bases of all areas where mosquito production takes place in the Service Areas (the "Source List"), and the location ("Source Number") is recorded for all chemical, biological, or physical control activities. Therefore, the District has a detailed long-term data base which allows evaluation of the intensity of control efforts, and their relationship to specific wetland or riparian sites. We have not observed degradation of these sites associated with our activities.

A number of specific habitat types that may be considered "sensitive" are found within the District Service Area. These include tidal marshes, extensive seasonal wetlands and grassland/meadow seeps, vernal pools, and numerous riparian corridors. These areas are well-known to District staff, and specific mosquito surveillance and control methods used in these areas are consistent with published management plans and District policies, defined throughout this report, to ensure their protection.

C. ENDANGERED AND OTHER SPECIAL STATUS SPECIES

The California Department of Fish and Game's Natural Diversity Database (NDDB) lists 65 special status species[1] in Napa County (April 5, 1999; see Section 3.4 and tables at the end of this Section). In almost all cases, the primary explanation for their status is loss of habitat. Because the District's activities do not involve changes in land use, and because proposed physical control activities in non-agricultural sites are reviewed annually by Trustee and other appropriate agencies, the District's activities do not contribute to this process. In those areas where the District's routine activities do overlap with specific habitat, District policies and practices ensure that no significant impacts can occur.

Of the thirteen species and subspecies listed as "Endangered" under either the Federal or State Endangered Species Acts (ESA), only nine occur in habitats where the District has any routine operations (Table 4.2.1). These include the marsh plant Soft Bird's-Beak (*Cordylanthus mollis ssp mollis*); the vernal pool plants Contra Costa Goldfields (*Lasthenia conjugens*), Sebastapol Meadowfoam (*Limnanthes vinculans*), and Few Flowered Navarettia (*Navarettia leucocephala* var. *pauciflora*); the spring and meadow plants Calistoga Popcorn Flower (*Plagiobothrys strictus*) and Napa Bluegrass (*Poa napensis*); the perennial-stream inhabiting California Freshwater Shrimp (*Syncaris pacifica*); the tidal marsh bird California Clapper Rail (*Rallus longirostris obsoletus*); and the marsh-inhabiting mammal Salt Marsh Harvest Mouse (*Reithrodontomys raviventris*). The District takes extreme care to avoid disturbance to listed endangered species, as detailed below. Habitat descriptions and current maps of distribution and potential habitat of all endangered species in the Service Area are maintained by the District and incorporated into the operational guidelines of field personnel.

In addition to endangered species, Table 4.2.2 shows an additional six taxa, including one plant, one beetle, one frog, and three birds, that are listed as "Threatened" or "Rare" under either the Federal or California ESA, but that are not listed "Endangered" under either ESA. This listing indicates that the species or subspecies is vulnerable to decline to endangered levels, and habitat loss is listed as the primary threat for each of these species. Of these, only Mason's Lilaeopsis (*Lilaeopsis masonii*), Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*), California Red-legged Frog (*Rana aurora draytonii*), and California Black Rail (*Laterallus jamaicensis coturniculus*) have habitat that might overlap with areas of routine District activity. The District takes care to avoid disturbance to listed threatened species, as detailed below, and is particularly careful to ensure no habitat loss for these taxa. Habitat descriptions and current maps of distribution of all threatened species in the Service Area are maintained by the District and incorporated into the operational guidelines of field personnel.

Table 4.2.3 lists an additional 17 vascular plants, 1 amphibian, 1 reptile, 3 birds, and 2 mammals that are considered "Species of Concern" under either the Federal or California ESA, but that are not listed as "Endangered" or "Threatened." Finally, the NDDB listing for Napa County (Table 4.2.4) notes 16 vascular plants and 6 birds that are not formally listed under the Federal or state ESA, but that are considered Special Status based either on a "species of concern" evaluation by the California Department of Fish & Game (CDFG) or by the California Native Plant Society (CNPS).

The listed species that are most likely to intersect with District activities are those in one of the following three habitat types: Tidal or Historically-Tidal Marshlands, Vernal Pools, or Riparian Zones and Springs.

A. Tidal & Historically-Tidal Marshlands

Special Status Species in the District's tidal and historically-tidal marshlands are the endangered Soft Bird's-Beak, California Clapper Rail, and Salt-Marsh Harvest Mouse; the threatened or rare California Black Rail and Mason's Lilaeopsis; and the unlisted Suisun Marsh Aster (*Aster lentus*), Delta Tule Pea (*Lathyrus jepsonii jepsonii*), and Marin Knotweed (*Polygonum marinense*). The District has extensive information on the distribution of these species and subspecies in the District Service Area.

B. Vernal Pools

Special Status Species in vernal pools in the District Service Area are the endangered Contra Costa Goldfields, Sebastopol Meadowfoam, and Few-Flowered Navarretia; and the unlisted Legenere (*Legenere limosa*), Dwarf

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[1]Under the Federal and California Endangered Species Acts, the word "species" may also mean subspecies or other taxonomic groupings.

Downingia (*Downingia pusilla*), Woolly Meadowfoam (*Limnanthes floccosa ssp. floccosa*), and Baker's Navarretia (*Navarettia leucocephala ssp. bakeri*). Additionally, District staff have located and identified a population of the fairy shrimp *Linderiella occidentalis* heretofore unknown in Napa County. The nature and location of vernal pools are well known to District personnel, and surveillance and control activities in these areas are infrequent and designed to prevent any damage to the hydrology, flora, or fauna of these sensitive areas.

C. Riparian Zones & Springs

Special Status Species in riparian zones (along streams) in the District Service Area are the endangered California Freshwater Shrimp); the threatened Valley Elderberry Longhorn Beetle and California Red Legged Frog; and the unlisted Marsh Checkerbloom (*Sidalcea oregona hydrophila*), Foothill Yellow-Legged Frog (*Rana boylii*), and Northwestern Pond Turtle (*Clemmy marmorata marmorata*). In addition, the endangered Calistoga Popcorn Flower and Napa Blue Grass are associated with springs in the Service Area. District activities in riparian areas or near streams are conducted almost exclusively on foot using hand tools or small volumes of highly-selective pesticides to minimize potential environmental impacts.

Table 4.2.1: Listed Endangered Species in Napa County

Compiled by Wes Maffei, NCMAD
from NDDB, April 5, 1999 Revision

Scientific Name	Common Name	Federal	California	Other	Notes
Vascular Plants					
Astragalus clarianus	Clara Hunt's Milk-Vetch	Endangered	Threatened	CNPS 1B	Valley grassland & foothill woodland
Castilleja affinis ssp neglecta	Tiburon Indian Paintbrush	Endangered	Threatened	CNPS 1B	Valley grassland; Serpentine substrate
Cordylanthus mollis ssp mollis	Soft Bird's-Beak	Endangered	Rare	CNPS 1B	**Brackish marshlands**
Lasthenia conjugens	Contra Costa Goldfields	Endangered		CNPS 1B	Valley grassland & **Vernal Pools**
Limnanthes vinculans	Sebastopol Meadowfoam	Endangered	Endangered	CNPS 1B	**Vernal Pools**, meadows, & seeps
Navarretia leucocephala ssp pauciflora	Few-Flowered Navarretia	Endangered	Threatened	CNPS 1B	**Vernal Pools**
Plagiobothrys strictus	Calistoga Popcorn-Flower	Endangered	Threatened	CNPS 1B	**Springs** & **Meadows**; Alkaline substrate
Poa napensis	Napa Blue Grass	Endangered	Endangered	CNPS 1B	**Springs** & **Meadows**; Alkaline substrate
Trifolium amoenum	Showy Indian Clover	Endangered		CNPS 1B	Valley grassland; Serpentine substrate
Invertebrates					
Syncaris pacifica	California Freshwater Shrimp	Endangered	Endangered		**Lowland perennial streams; Huichica Ck.**
Birds					
Haliaeetus leucocephalus	Bald Eagle	Threatened	Endangered		Nesting & wintering
Rallus longirostris obsoletus	California Clapper Rail	Endangered	Endangered		**Salty to brackish tidal marshes**
Mammals					
Reithrodontomys raviventris	Salt-Marsh Harvest Mouse	Endangered	Endangered		**Salty to brackish marshes; associated with pickleweed (*Salicornia virginica*)**

Table 4.2.2: Listed Threatened and Rare Species in Napa County
Compiled by Wes Maffei, NCMAD
from NDDB, April 5, 1999 Revision

Scientific Name	Common Name	Federal	California	Other	Notes
Vascular Plants					
Lilaeopsis masonii	Mason's Lilaeopsis	SC	Rare	CNPS 1B	**Open-water edge of brackish marshes**
Invertebrates					
Desmocerus californicus dimorphus	Valley Elderberry Longhorn Beetle	Threatened			Closely associated with Elderberry trees in **riparian areas**
Amphibians & Reptiles					
Rana aurora draytonii	California Red-Legged Frog	Threatened		CDFG SC	**Riparian & other wetlands.**
Birds					
Charadrius alexandrinus nivosus	Western Snowy Plover	Threatened		CDFG SC	Nesting habitat
Laterallus jamaicensis coturniculus	California Black Rail	SC	Threatened		**Marshes**
Strix occidentalis caurina	Northern Spotted Owl	Threatened		CDFG SC	Forests

Table 4.2.3: Other Listed Species of Concern in Napa County
Compiled by Wes Maffei, NCMAD
from NDDB, April 5, 1999 Revision

Scientific Name	Common Name	Federal	California	Other	Notes
Vascular Plants					
Aster lentus	Suisun Marsh Aster	SC		CNPS 1B	**Fresh water & brackish marshes**
Atriplex joaquiniana	San Joaquin Saltbush	SC		CNPS 1B	Shadscale scrub, valley grassland, meadows, & seeps; Alkaline soils
Calystegia collina ssp oxyphylla	Mt. St. Helena Morning Glory	SC		CNPS 4	Open grassy or rocky places or oak pine woods; Often serpentine
Ceanothus confusus	Rincon Ridge Ceanothus	SC		CNPS 1B	Dry, shrubby slopes
Ceanothus divergens	Calistoga Ceanothus	SC		CNPS 1B	Dry, shrubby, rocky, volcanic slopes
Ceanothus sonomensis	Sonoma Ceanothus	SC		CNPS 1B	Chaparral; Sand, serpentine, volcanic soils
Fritillaria pluriflora	Adobe Lily	SC		CNPS 1B	Adobe soils of interior foothills
Hesperolinon bicarpellatum	Two-Carpellate Western Flax	SC		CNPS 1B	Serpentine; Chaparral
Hesperolinon breweri	Brewer's Western Flax	SC		CNPS 1B	Chaparral or grassland; Sometimes serpentine
Hesperolinon drymarioides	Drymaria-Like Western Flax	SC		CNPS 1B	Serpentine; Chaparral or woodland
Juglans hindsii	N. California Black Walnut	SC		CNPS 1B	Canyons & valleys
Lathyrus jepsonii var jepsonii	Delta Tule Pea	SC		CNPS 1B	**Freshwater and brackish marshes**
Legenere limosa	Legenere	SC		CNPS 1B	**Wet areas; Vernal Pools**
Madia hallii	Hall's Madia	SC		CNPS 1B	Serpentine barrens in open chaparral
Polygonum marinenese	Marin Knotweed	SC		CNPS 3	**Coastal salt marshes**

Sidalcea hickmanii ssp viridis	Marin Checkerbloom	SC		CNPS 1B	Chaparral & open conifer forest; Sometimes on serpentine
Streptanthus brachiatus ssp brachiatus	Socrates Mine Jewel-Flower	SC		CNPS 1B	Serpentine barrens, open chaparral, or woodland
Reptiles and Amphibians					
Rana boylii	Foothill Yellow-Legged Frog	SC		CDFG SC	
Clemmys marmorata marmorata	Northwestern Pond Turtle	SC		CDFG SC	
Birds					
Agelaius tricolor	Tricolored Blackbird	SC		CDFG SC	**Marshes; Nesting colony**
Athene cunicularia	Burrowing Owl	SC		CDFG SC	Burrows
Gleothlypis trichas sinuosa	Saltmarsh Common Yellowthroat	SC		CDFG SC	**Salt marshes**
Mammals					
Corynorhinus townsendii townsendii	Townsend's Western Big-Eared Bat	SC		CDFG SC	
Sorex ornatus sinuosus	Suisun Shrew	SC		CDFG SC	**Salt to brackish marshes**

Table 4.2.4: Other Special Status Species in Napa County
Compiled by Wes Maffei, NCMAD
from NDDB, April 5, 1999 Revision

Scientific Name	Common Name	Federal	California	Other	Notes
Vascular Plants					
Astragalus rattanii var jepsonianus	Jepson's Milk-Vetch			CNPS 1B	Open grassy or gravelly areas; Often serpentine
Astragalus tener var tener	Alkali Milk-Vetch			CNPS 1B	Alkaline flats; Vernally moist meadows
Balsamorhiza macrolepis var macrolepis	Big-Scale Balsamroot			CNPS 1B	Open grassy slopes & valleys
Cryptantha clevelandii var dissita	Serpentine Cryptantha			CNPS 1B	Chaparral; Sometimes serpentine; Sandy/rocky soil
Downingia pusilla	Dwarf Downingia			CNPS 2	**Vernal Pools** & Roadside ditches
Erigeron angustatus	Narrow-Leaved Daisy			CNPS 1B	Serpentine areas
Hesperolinon sp nov "serpentinum"	Napa Western Flax			CNPS 1B	Serpentine; Chaparral
Layia septentriaonalis	Colusa Layia			CNPS 1B	Serpentine or sandy soils
Limnanthes floccosa ssp floccosa	Woolly Meadowfoam			CNPS 2	**Moist meadows & Vernal Pools**
Linanthus jepsonii	Jepson's Linanthus				
Lupinus sericatus	Cobb Mountain Lupine			CNPS 1B	Open wooded slopes
Navarretia leucocephala ssp bakeri	Baker's Navarretia			CNPS 1B	**Vernal Pools**
Navarretia rosulata	Marin County Navarretia			CNPS 1B	Rocky serpentine areas
Penstemon newberryi var sonomensis	Sonoma Beardtongue			CNPS 1B	Outcrops & peak areas

Sidalcea oregona ssp hydrophila	Marsh Checkerbloom			CNPS 1B	Wet soil of stream banks, meadows
Streptanthus morrisonii	Morrison's Jewelflower				Serpentine barrens; Chaparral
Birds					
Accipiter striatus	Sharp-Shinned Hawk		CDFG-SC		Nesting
Aquila chrysaetos	Golden Eagle		CDFG-SC		Nesting & Wintering
Cypseloides niger	Black Swift		CDFG-SC		Nesting
Elanus leucurus	White-Tailed Kite				Nesting
Falco mexicanus	Prairie Falcon		CDFG-SC		Nesting
Progne subis	Purple Martin		CDFG-SC		Nesting

California Department of Fish and Game
Natural Diversity Database

For information about these species or natural communities, or other species or natural communities, or for staff contacts, please see the NDDB website at http://www.dfg.ca.gov/whdab/cnddb.htm

IMPORTANT NOTICE:

This list of species was produced from data presently included in the California Natural Diversity Database (CNDDB). The CNDDB is a positive sighting data base, and our data sets can not be considered to be complete for every species in every county. Therefore, this list must not be considered to be a comprehensive list of all special status species in the county.

Special Status Plants, Animals and Natural Communities of

NAPA COUNTY

Scientific Name	Common Name	STATUS*: *(see footnotes) Federal	California	CDFG	CNPS
Vascular Plants					
Aster lentus	SUISUN MARSH ASTER	Species of concern	None		1B
Astragalus clarianus	CLARA HUNT'S MILK-VETCH	Endangered	Threatened		1B
Astragalus rattanii var jepsonianus	JEPSON'S MILK-VETCH	None	None		1B
Astragalus tener var tener	ALKALI MILK-VETCH	None	None		1B
Atriplex joaquiniana	SAN JOAQUIN SALTBUSH	Species of concern	None		1B
Balsamorhiza macrolepis var macrolepis	BIG-SCALE BALSAMROOT	None	None		1B
Calystegia collina ssp oxyphylla	MT. SAINT HELENA MORNING-GLORY	Species of concern	None		4
Castilleja affinis ssp neglecta	TIBURON INDIAN PAINTBRUSH	Endangered	Threatened		1B
Ceanothus confusus	RINCON RIDGE CEANOTHUS	Species of concern	None		1B
Ceanothus divergens	CALISTOGA CEANOTHUS	Species of concern	None		1B
Ceanothus sonomensis	SONOMA CEANOTHUS	Species of concern	None		1B
Cordylanthus mollis ssp mollis	SOFT BIRD'S-BEAK	Endangered	Rare		1B
Cryptantha clevelandii var dissita	SERPENTINE CRYPTANTHA	None	None		1B
Downingia pusilla	DWARF DOWNINGIA	None	None		2
Erigeron angustatus	NARROW-LEAVED DAISY	None	None		1B
Fritillaria pluriflora	ADOBE-LILY	Species of concern	None		1B
Hesperolinon bicarpellatum	TWO-CARPELLATE WESTERN FLAX	Species of concern	None		1B
Hesperolinon breweri	BREWER'S WESTERN FLAX	Species of concern	None		1B
Hesperolinon drymarioides	DRYMARIA-LIKE WESTERN FLAX	Species of concern	None		1B
Hesperolinon sp nov "serpentinum"	NAPA WESTERN FLAX	None	None		1B
Juglans hindsii	NORTHERN CALIFORNIA BLACK WALNUT	Species of concern	None		1B
Lasthenia conjugens	CONTRA COSTA GOLDFIELDS	Endangered	None		1B
Lathyrus jepsonii var jepsonii	DELTA TULE PEA	Species of concern	None		1B
Layia septentrionalis	COLUSA LAYIA	None	None		1B
Legenere limosa	LEGENERE	Species of concern	None		1B
Lilaeopsis masonii	MASON'S LILAEOPSIS	Species of concern	Rare		1B
Limnanthes floccosa ssp floccosa	WOOLLY MEADOWFOAM	None	None		2
Limnanthes vinculans	SEBASTOPOL MEADOWFOAM	Endangered	Endangered		1B
Linanthus jepsonii	JEPSON'S LINANTHUS	None	None		
Lupinus sericatus	COBB MOUNTAIN LUPINE	None	None		1B
Madia hallii	HALL'S MADIA	Species of concern	None		1B
Navarretia leucocephala ssp bakeri	BAKER'S NAVARRETIA	None	None		1B
Navarretia leucocephala ssp pauciflora	FEW-FLOWERED NAVARRETIA	Endangered	Threatened		1B
Navarretia rosulata	MARIN COUNTY NAVARRETIA	None	None		1B
Penstemon newberryi var sonomensis	SONOMA BEARDTONGUE	None	None		1B
Plagiobothrys strictus	CALISTOGA POPCORN-FLOWER	Endangered	Threatened		1B
Poa napensis	NAPA BLUE GRASS	Endangered	Endangered		1B
Polygonum marinense	MARIN KNOTWEED	Species of concern	None		3
Sidalcea hickmanii ssp viridis	MARIN CHECKERBLOOM	Species of concern	None		1B
Sidalcea oregana ssp hydrophila	MARSH CHECKERBLOOM	None	None		1B
Streptanthus brachiatus ssp brachiatus	SOCRATES MINE JEWEL-FLOWER	Species of concern	None		1B

Special Status Plants, Animals and Natural Communities of

NAPA COUNTY

Scientific Name	Common Name	STATUS*: *(see footnotes) Federal	California	CDFG	CNPS
Vascular Plants					
Streptanthus morrisonii	SEE INDIVIDUAL SUBSPECIES!	None	None		
Trifolium amoenum	SHOWY INDIAN CLOVER	Endangered	None		1B
Crustaceans					
Syncaris pacifica	CALIFORNIA FRESHWATER SHRIMP	Endangered	Endangered		
Beetles					
Desmocerus californicus dimorphus	VALLEY ELDERBERRY LONGHORN BEETLE	Threatened	None		
Amphibians					
Rana aurora draytonii	CALIFORNIA RED-LEGGED FROG	Threatened	None	SC	
Rana boylii	FOOTHILL YELLOW-LEGGED FROG	Species of concern	None	SC	
Reptiles					
Clemmys marmorata marmorata	NORTHWESTERN POND TURTLE	Species of concern	None	SC	
Birds					
Accipiter striatus (nesting)	SHARP-SHINNED HAWK	None	None	SC	
Agelaius tricolor (nesting colony)	TRICOLORED BLACKBIRD	Species of concern	None	SC	
Aquila chrysaetos (nesting and wintering)	GOLDEN EAGLE	None	None	SC	
Athene cunicularia (burrow sites)	BURROWING OWL	Species of concern	None	SC	
Charadrius alexandrinus nivosus (nesting)	WESTERN SNOWY PLOVER	Threatened	None	SC	
Cypseloides niger (nesting)	BLACK SWIFT	None	None	SC	
Elanus leucurus (nesting)	WHITE-TAILED KITE	None	None		
Falco mexicanus (nesting)	PRAIRIE FALCON	None	None	SC	
Geothlypis trichas sinuosa	SALTMARSH COMMON YELLOWTHROAT	Species of concern	None	SC	
Haliaeetus leucocephalus (nesting & wintering)	BALD EAGLE	Threatened	Endangered		
Laterallus jamaicensis coturniculus	CALIFORNIA BLACK RAIL	Species of concern	Threatened		
Progne subis (nesting)	PURPLE MARTIN	None	None	SC	
Rallus longirostris obsoletus	CALIFORNIA CLAPPER RAIL	Endangered	Endangered		
Strix occidentalis caurina	NORTHERN SPOTTED OWL	Threatened	None	SC	
Mammals					
Corynorhinus townsendii townsendii	TOWNSEND'S WESTERN BIG-EARED BAT	Species of concern	None	SC	
Reithrodontomys raviventris	SALT-MARSH HARVEST MOUSE	Endangered	Endangered		
Sorex ornatus sinuosus	SUISUN SHREW	Species of concern	None	SC	
Natural Communities					
Coastal and valley freshwater marsh	N.A.	None	None		
Coastal brackish marsh	N.A.	None	None		
Northern coastal salt marsh	N.A.	None	None		
Northern interior cypress forest	N.A.	None	None		
Northern vernal pool	N.A.	None	None		
Serpentine bunchgrass	N.A.	None	None		
Wildflower field	N.A.	None	None		

4.3 MOSQUITO AND DISEASE SURVEILLANCE ACTIVITIES

A. INTRODUCTION

The District's responsibility to protect public health and welfare involves monitoring the abundance of mosquitoes, mosquito habitat, mosquito-borne pathogens, and interactions between mosquitoes and people over time and space. Collectively, these monitoring activities are termed Mosquito Surveillance. Mosquito surveillance provides the District with valuable information on what mosquito species are present or likely to occur, when they occur, where they occur, how many there are, and if they are carrying disease or otherwise affecting humans. Mosquito surveillance is critical to an Integrated Mosquito Management Program because the information it provides is evaluated against treatment criteria to decide when and where to institute mosquito control measures. Equally important is the use of mosquito surveillance in evaluating the efficacy, cost effectiveness, and environmental impacts of specific mosquito control actions.

The District's mosquito and disease surveillance activities are conducted in compliance with accepted Federal and State guidelines, and the reader is referred to the volumes by the U.S. Public Health Service (Moore et al 1993), the Mosquito and Vector Control Association of California (Reisen et al 1995, Durso 1996), and by Service (1993) for further information on specific surveillance techniques. These guidelines recognize that local conditions vary, and are thus flexible in the selection and specific application of methods. Therefore, the District's specific activities and their potential environmental impacts are described below.

B. MOSQUITO SURVEILLANCE

Mosquitoes in nature are distributed within their environment in a pattern that maximizes their survival to guarantee reproductive success. Simply stated, this means that mosquitoes occur where they are likely to survive, mate, and produce young. One interesting aspect of mosquito biology is the fact that immature stages develop in water and later mature to a winged adult that is capable of both long and short range dispersal. This duality of their life history presents mosquito control agencies with unique circumstances that require separate surveillance strategies for the aquatic versus terrestrial life stages. Detailed descriptions of mosquito surveillance activities performed by the District can be found in the publications by Service (1993) and Durso (1996).

A. IMMATURE MOSQUITOES

Immature mosquito stages include eggs, four larval stages, and pupae. Mosquito control agencies routinely target the larval and pupal stages to preclude an emergence of adults. Operational evaluation of the presence and abundance of immature mosquitoes is limited to the larval and pupal stages, although the District may sample eggs for research reasons. Operationally, the abundance of the immatures in any identifiable "breeding" source is measured through direct sampling with a 250ml dipper, which provides relative local abundance as number of immatures per unit volume or area of the source. This method requires access by field personnel to within about three feet of larval sites at least every two weeks. The spatial patchiness of larvae requires access to multiple locations within each source, rather than to single "bell-weather" stations .

B. ADULT MOSQUITOES

Mosquito adults, primarily females, are sampled to determine the direct threat posed by their distribution, abundance, species mix, and pathogen status. Direct surveillance is typically accomplished using a variety of traps that are configured to attract mosquitoes to the trap where they are captured by suction and sequestered in an escape-proof net or glass enclosure. Other direct surveillance strategies, less commonly used by the District, include landing counts, and artificial resting units (Service 1993, Durso 1996).

Another important measure of adult mosquito abundance is the number and distribution of service requests from the public. While this number is obviously dependent on other factors beyond absolute mosquito abundance, including recent publicity about the district or about mosquito problems, it is an important indication of where and when the public desires action. In combination with identification of the species causing the disturbance, this can also be a powerful technique in identifying previously unknown mosquito sources, or known sources with resurgent mosquito production.

Host-seeking traps: Traps for host-seeking female mosquitoes include standard and modified (e.g. Fay; EVS = "Encephalitis Virus Surveillance") CDC-type portable light traps, which release carbon dioxide (dry ice and/or compressed gas) at a low rate (typically two pounds/night/trap) to attract female mosquitoes seeking blood meals. Essential trap components include a battery power source, a low ampere motor with suction-type fan housed in a durable plastic cylinder, carbon dioxide and light sources (typically 3-6 volts), and a collection container for holding captured adults. The number of females collected during each night of trap operation is expressed numerically as the number of females per trap night. Use of these traps requires direct access to the trap site by field personnel on two consecutive days, typically once per week.

Light traps: Light traps use a source of photo-attraction (typically a 25 watt incandescent bulb) to lure mosquitoes to the trap where they are pulled in by the suction provided by an electric motor/fan combination. Mosquitoes picked up by the suction are directed through a cone to a collection jar where they are killed by a household insecticide[2]. The standard trap of this type used by most mosquito control agencies is the New Jersey Light Trap. This trap is considerably larger and less portable than the host-seeking trap and requires a source of 110v AC to operate. Like the host-seeking trap, the number of females collected during each night of trap operation is expressed as the number of females per trap night. This surveillance methods requires one field visit per trap per week, and the District typically maintains about eighteen traps.

C. SURVEILLANCE FOR MOSQUITO-BORNE DISEASES

A. ARBOVIRAL DISEASES

The primary mosquito-borne human diseases for which routine surveillance occurs in the service area are known as "arboviruses" (ARthropod-BOrne viruses). The primary reservoir for the pathogens that cause these diseases are wild birds, and humans only become exposed as a consequence of an accidental exposure to the bite of infective mosquitoes. The two arboviruses of greatest public health concern in California are western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE). Clinical illness caused by WEE is predominately seen in young children while SLE tends to affect the elderly.

Detecting the presence of these mosquito-borne viruses in nature requires the application of a number of sophisticated methodologies, which are discussed in detail in the recent technical report by Reisen, et al. (1995). Two methods of encephalitis virus surveillance commonly used by mosquito control agencies in California involve 1) capturing and testing female mosquito mosquitoes for the presence of mosquito-borne encephalitis viruses and 2) periodically testing for the presence of encephalitis virus specific antibodies in the blood serum of either sentinel chickens or wild birds that are potentially exposed to infective mosquito bites.

Virus isolations from mosquito mosquitoes: Female mosquitoes to be tested for the presence of encephalitis viruses are usually captured by host-seeking traps. Collections are sorted by species and pooled in lots of 50. Pools are later tested to determine if virus is present and to what extent virus is disseminated (minimum infection rate) throughout the vector mosquito population.

Antibody conversion rates in sentinel birds: In addition to isolating viruses from mosquitoes captured in the wild, the presence of virus in the environment can also be detected by exposing animals that are not affected by infection, but develop neutralizing antibodies to the specific viral pathogen. A number of sentinel systems have been developed, and among those evaluated are domestic chickens in caged flocks consisting of 10-20 animals. Birds used as sentinels are treated humanely, and provided with ample shelter, water and feed. Wild birds can also be tested, and

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[2]A 1 inch piece of Shell No-Pest Strip© (Vapona) per trap, which is properly disposed of when no longer effective.

are banded and released into the wild after a small blood sample is taken. The collected blood samples (sera) are subsequently tested for the presence of virus specific antibody.

B. OTHER DISEASES

The presence and abundance of other diseases, including malaria and dog heartworm, are periodically monitored by the District.

More specifically, the District has in place a program to track both endemic (contracted from local mosquitoes) and imported malaria cases. Information received from County and State health departments alert the District of people diagnosed with malaria. The District then follows up with the patients to identify the source of infection (local or imported) and to ensure that treatment regimes are followed correctly and completely. Known breeding sites of the Woodland Malaria Mosquito (*Anopheles punctipennis*) within two miles of the patient's residence are resurveyed and, if needed, treated. This malaria surveillance program was established to prevent the malaria pathogen *Plasmodium vivax* from becoming established in Napa County *Anopeheles* populations. California's early history with extensive malaria morbidity and mortality, the presence of large populations of *An. punctipennis*, and the large and increasing human population in the County together justify this program.

In addition, dog heartworm is monitored through case reports submitted by veterinarians and by occasional testing of adult Western Treehole Mosquitoes (*Ae. sierrensis*) for the presence of the filarial worm *Dirofilaria immitis*.

D. CONCLUSIONS: POTENTIAL ENVIRONMENTAL IMPACTS OF SURVEILLANCE

The District's surveillance activities require access to mosquito habitat sites; the placement of mosquito traps, and sentinel birds in the field; the collection of mosquitoes in the field; and the direct or instrumental collection of physical data. Each of these activities poses a small potential for disturbance to natural or artificial environments.

The potential environmental impacts associated with the District's surveillance activities are insignificant. The State Secretary of Resources has determined that information collection and inspection activities do not generally have a significant impact on the environment [CEQA Guidelines Sections 15306 & 15309], and the available information on the District's surveillance activities are in agreement with this principle.

Surveillance Policy: District policy is to perform essential surveillance activities with the least negative impact on the environment. Technical staff use, whenever possible, pre-existing accesses such as roadways, open areas, walkways, and trails in a an effort to minimize off road travel. At times, vegetation management (e.g., pruning trees, clearing brush and weed removal) may become necessary where overgrowth impedes freedom of vehicle travel and staff movement on foot. All of these actions only result in a temporary/localized physical change to the environment with regeneration/regrowth occurring within a span of about one year.

District staff involved with performing surveillance duties are instructed to be respectful of the environment and associated wildlife and to limit their impact to only what is necessary to perform their assigned tasks. Wanton disregard and attendant abuses of the environment are not tolerated in the District's mosquito control surveillance operations. When off-road travel is necessary, District staff are instructed to avoid threatened and endangered plants and sensitive habitat areas and to minimize any environmental damage caused by off-road travel.

Non-invasive Sampling: Non-invasive sampling is considered a type of sampling that does not impact the environment directly. Low impact methods include the placement of host-seeking mosquito traps, light traps, artificial resting units (ARUs), and sentinel chicken flocks. In this situation, existing roads, trails, and clearings are usually utilized to accommodate this type of surveillance activity. Clearings are sometimes necessary for the placement of sentinel chicken coops and potentially Australian Crow traps and/or mist nets to sample resident and migratory wild birds.

Invasive Sampling: Invasive sampling is considered a type of sampling that may impact the environment directly. Where roads, trails, and clearings have to be created to gain access to facilitate surveillance, the consequences may require removal of vegetation and minor grading to establish roads, trails, and minimal clearings. These actions are necessary to establish sites where routine surveillance actions are necessary based upon established environmental risk factors associated with mosquito breeding and previous history of disease transmission. In any clearing or grading work, the District avoids threatened and endangered plants and habitat areas and minimizes the scope of the work to the smallest area feasible.

Obtaining samples of immature mosquitoes involves removal of some negligible quantities of water. This water may also include non-target organisms associated with the mosquito immatures. Technicians will either make a count of the immatures present or remove a small number for identification at the agency office laboratory, returning the contents of the dipper back into the source once the quantification and identification process is completed. Taking dipper samples also requires the technician to wade into the source and repetitively sample/dip along transects to assess the extent and magnitude of immature mosquito populations. Trampling of some vegetation can occur, but most sampling actions involve either walking the shore line or wading through open water gaps that border emergent vegetation (grasses, tules, cattails, etc.) where mosquito immatures are most likely to be sampled. Technicians are advised not to penetrate dense vegetation for reasons of safety and unnecessary environmental impact.

Special Use of Birds to Support EVS Activities: Placement of sentinel chickens is a necessary component of encephalitis virus surveillance (EVS). Therefore, their physical presence is required at sites where virus activity is to be monitored on a routine basis. Sentinel chickens are sequestered in a coop structure (usually 4'x4'x6' or larger) covered with 1" welded wire to exclude access by resident wildlife with perhaps the exception of mice and other small rodents. Feed and water is housed within the coop enclosure. Manure is removed as needed to reduce fly production. A wire skirting is placed around the base of the coop to prevent wildlife from directly contacting the feces and foraging on the residual feed (various commercially available chicken feeds).

Transportation and Access Requirements: Normal surveillance necessitates the use of access roads, trails, and clearings to facilitate sampling. Roads allow vehicles to transport needed staff and equipment to specific sites deemed critical. As indicated above, this action may necessitate the periodic removal of some marginal vegetation and weed control on the median between the wheel ruts of established dirt/gravel roads. Access trails (2-3 feet in width) to the margins of wetlands, ponds, streams, and rivers are maintained by periodic vegetation removal via simple pruning or trimming if necessary. Weeds/grasses choking trails also can be removed by spot application of herbicides. These vegetation control methods are discussed in more detail in sub-section 4.5 below.

All Terrain Vehicles (ATVs): The District sometimes relies upon the use of all terrain vehicles to facilitate access into areas that are not otherwise accessible by conventional transportation means or by foot. Some situations where flooding and wetlands preclude access by 4-wheel drive vehicles or reasonable walking distance in waders/boots do require the use of an approved ATV. District staff do not use ATV's where environmental conditions (e.g., impenetrable vegetation/terrain, endangered/threatened plants) can result in causing an accident, personal injury or significant environmental damage.

4.4 PHYSICAL CONTROL = MOSQUITO HABITAT MANAGEMENT

A. INTRODUCTION

The population of any mosquito species in an area, and hence its potential ability to spread human disease and discomfort, is limited by the capacity of the environment to produce, feed, harbor, and allow dispersal of the species. As for any animal, the "carrying capacity" and "immigration potential" of an area for mosquito species are complex variables which are often summarized with the phrase "habitat" (Collins & Resh 1989).

Managing mosquito habitat to reduce mosquito production or migration, either directly or through public education, is often the most cost-effective and environmentally-benign element of an integrated mosquito management program. This approach to the control of mosquitoes and other pests is often called "physical control" to distinguish it from those mosquito management activities that directly rely on application of chemical pesticides (chemical control) or the introduction or relocation of living agents (biological control). Other terms that have been used for mosquito habitat management include "source reduction", which emphasizes the significance of reducing the habitat value of an area for mosquitoes, or "permanent control", to contrast with the temporary effectiveness of pesticide applications[3]. Mosquito habitat management is important because its use can virtually eliminate the need for pesticide use in and adjacent to the affected habitat, and in some situations can virtually eliminate mosquito production from specific areas for long periods of time, freeing staff for other work and reducing the potential disturbances associated with frequent biological or chemical control activities. It is important to note that, regardless of the terminology, the intent is to reduce the abundance of mosquitoes produced or sheltered by an area while protecting or enhancing the habitat values of the area for desirable species. In many cases, physical control activities involve restoration and enhancement of natural ecological functioning, including production and dispersal of special status species and/or predators of mosquitoes.

Dredging, placement of culverts or other engineering works, and other physical changes to the land can reduce mosquito production by improving water movement or the District's capacity for active management of water. In natural settings, these activities are generally used to enhance water circulation, which directly reduces mosquito production while at the same time improving habitat values for many predators or parasites of larval mosquitoes, such as fish and many invertebrates. The biology of mosquito predators, parasites, and predators is discussed in the Section on Biological Control. In artificial or highly managed settings, physical control can include improved drainage as well, to reduce the duration of standing water below the time needed for the development of immature mosquitoes. The District performs these physical control activities in accord with all appropriate environmental regulations (wetland fill and dredge permits, endangered species review, water quality review, etc.), and in a manner that generally maintains or improves habitat values for desirable species.

Physical control of mosquitoes can be as simple as properly discarding old containers that hold water capable of producing mosquitoes such as the *Ae. sierrensis* or the Fish Pond Mosquito *(Cs. incidens)* or as complex as implementing Open Marsh Water Management (OMWM) or Rotational Impoundment Management (RIM) in historically-tidal marshlands. OMWM and RIM are source reduction strategies that control salt marsh mosquitoes (e.g. the Winter Salt Marsh Mosquito *(Ae. squamiger)* or the Summer Salt Marsh Mosquito *(Ae. dorsalis)*) at the same time that significant habitat restoration is occurring.

B. MOSQUITO HABITATS CONDUCIVE TO PHYSICAL CONTROL

Mosquitoes grow in a wide range of habitat types in the District's Service Area, and environmentally-beneficial or benign physical control methods have been developed for most of these habitat types, including both natural and artificial or highly-modified settings. However, each habitat type also includes some specific examples in which their site characteristics may preclude effective or acceptable physical control. Therefore, the descriptions below are generic, and site-specific evaluation is important before initiating source reduction.

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[3]In the 1940's to 60's, source reduction was sometimes called "permanent" or "long-term" control to contrast it with the clearly temporary ("short-term") results of chemical pesticides. Experience has showed that, while "long-term" may be an accurate description, the results of physical control are not permanent.

Freshwater Lakes, Ponds And Retention Areas: The District Service Area includes a number of areas, generally man-made, that are permanently ponded with fresh water. Examples include the margins of reservoirs with shallow water and emergent vegetation, artificial ponds for holding drinking water for livestock and retention ponds created for holding of rainwater. Some retention ponds have been constructed within freeway interchanges and others have been built in cities and towns to provide wildlife habitat and flood protection. Natural lakes are usually not a mosquito problem because most of the water is deep, and there may be little emergent vegetation.

There are a number of species of mosquitoes that exploit these types of habitat. In the District Service Area, the Encephalitis Mosquito (*Cx. tarsalis)*, the Banded Foul-Water Mosquito *(Cx. stigmatosoma)*, the Winter Marsh Mosquito *(Cs inornata), Cs. incidens*, and the Willow Pool Mosquito (*Ae. washinoi*) are found in ponded freshwater.

Seasonal (Rainwater) Wetlands and Vernal Pools: The Service Area's Mediterranean climate results in large numbers of seasonally-flooded areas which may produce large numbers of mosquitoes during part of the year. Vernal pools are a specific type of seasonally-flooded wetland, distinguished by a subsurface hardpan and often an assemblage of protected plants and invertebrates. Mosquitoes produced in these types of rainwater sources include *Cx. tarsalis*, *Cs. inornata*, and *Ae. washinoii.*

Peripheral areas of tidal and historically tidal marshes can produce mosquitoes in response to seasonal rains, as well as following unusually high tides. Depending on the salinity and timing of flooding, mosquitoes found in these settings can include the *Culiseta* and *Culex* species mentioned above as well as *Ae. squamiger* or *Ae. dorsalis*.

Salt and Brackish Marshes: The tidal marshlands of the District Service Area vary in their salinity, their tidal regimes, and their engineering history, and the mosquito fauna they support is consequently varied. Prior to the creation of dikes and levees, the upper sections of some marshes produced enormous *Aedes* broods following the higher high tides associated with full or new moons ("spring tides"), because natural predators of mosquitoes could not survive the dry periods between these high tides. Extensive diking and drainage exacerbated this situation in many areas by prolonging the duration and intensity of the dry periods, while still allowing periodic inundation. The high mosquito populations made human habitation difficult in many areas, and the District was originally founded to address mosquitoes from the marshlands along the lower Napa River. In the District Service Area, several past physical control efforts greatly reduced salt-marsh mosquito production in these marshes through enhancing the frequency and duration of tidal inundation, or through other water management strategies.

In the District's Service Area, *Ae. squamiger* and *Ae. dorsalis* are the primary salt marsh mosquitoes. *Ae. squamiger* is a winter breeder and has a single generation per year. *Ae. dorsalis* adults occur in the spring and summer, and may have several generations per year. Adults of both species of mosquito frequently travel long distances from their larval habitats to find a blood meal.

Marshes and Duck Clubs: A number of marshes of varying salinity are managed to provide aquatic habitats for wildlife, especially water fowl, in Napa County. Some of these marshes are drained and re-filled periodically to enhance the primary productivity of the habitat, and under certain circumstances, this can result in large populations of mosquitoes.

The major waterfowl management areas in the District Service Area include private duck clubs (Detjen, Zanders, Giovannoni) and the California Department of Fish & Game's Huichica Creek Unit, Napa River Unit, Coon Island Unit, American Canyon Unit, and Fagen Marsh Ecological Reserve.

Ae. dorsalis, Ae. squamiger, Cx. tarsalis, and *Cs. inornata* are the most common species found in these habitats. Depending upon the management practices for the marsh or swamp, floodwater *Aedes* such as *Ae. dorsalis* can become a serious problem, especially in those cases where marshes are periodically drained and re-flooded.

Riparian Zones: Riparian zones, consisting primarily of riparian forests and willow groves associated with intermittent creeks, are those areas that border the edges of seasonal and year round streams and rivers. The variability of light, moisture and the amounts and types of lush vegetation result in a complex, biologically diverse habitat that has many microhabitats and species. This complex biological system also supports a number of mosquito species, five of which are pests or vectors of the diseases malaria or dog heartworm. These mosquitoes include *An. punctipennis*, *Ae. sierrensis*, *Ae. washinoi*, *Cs. incidens*, and *Cs. particeps* (this species has no common name).

Tree holes: Tree holes are rot cavities formed in the bases of branches or in those parts of trees where branches have broken off or have been improperly trimmed. Some species of trees, such as oaks, sycamores, elms, cottonwoods and eucalyptus are prone to having one or more tree holes. *Ae. sierrensis* is the mosquito species frequently breeding in this habitat and is the primary vector of dog heartworm disease.

Wastewater treatment facilities: Aquatic sites in this category include a wide variety of ponds, ditches and other structures designed to handle wastewater of some kind. Included are sewage treatment ponds, ponds managed for denitrification, dairy drains and storm sewers.

Mosquito species usually found in these types of sources are the Little House Mosquito (*Cx. pipiens*), *Cx. stigmatosoma*, and to a lesser degree, *Cx. tarsalis*, the Tule (or Cattail) Mosquito *(Cx. erythrothorax)*, and flood-water *Aedes* species. Human activities are responsible for establishing the vast majority of the aquatic habitats used by *Cx. pipiens*. A much wider range of larval habitats, including both artificial and natural aquatic systems, is used by *Cx. tarsalis*. In large wastewater ponds, immature *Cx. pipiens* and *Cx. stigmatosoma* are generally most abundant near the inflow area where the nutrient loads are normally the highest.

Cx. tarsalis is like *Cx. stigmatosoma* in terms of its range of larval habitats, but its seasonal pattern of abundance is similar to that found in *Cx. pipiens*. *Cx. tarsalis* inhabits not only semipermanent ponds but also more ephemeral habitats, such as temporary pools in spray-irrigation fields. *Cx. erythrothorax* is the most pestiferous wastewater *Culex* species because it feeds mainly on mammals, while females of the other species are either general or primarily avian feeders. However, *Cx. tarsalis* is the species with the greatest impact because it is the dominant *Culex* in California during the summer and fall, occurs in wastewater systems that vary over a wide range of nutrient loads, and is the primary vector of St. Louis encephalitis (SLE) and western equine encephalomyelitis (WEE) viruses.

Aedes. - Unlike *Culex,* whose eggs hatch within a few days after being laid in rafts on the water surface, *Aedes* lay their eggs individually on moist substrate with hatching occurring only after the eggs have been flooded. Consequently, *Aedes* are seldom found in wastewater systems where there is little or no variation in surface water levels. However, poorly designed, improperly operated, or inadequately maintained systems often lead to conditions that are ideal for an invasion by floodwater mosquitoes. Poorly drained spray-irrigation fields often become water logged, especially during the rainy season. Land application of wastewater may also increase the salt content of the soils. Under these conditions, inland sites may become suitable aquatic habitats for the salt marsh mosquito *Ae. dorsalis*.

Irrigated Agriculture: There are several species of mosquitoes that can breed in water that stands only 1 to 2 weeks. Such habitats include irrigation tail water as well as standing water in irrigated pastures. Many mosquito species are found in these sources. Pastures and other agricultural lands are enormous mosquito producers, frequently generating huge broods of *Aedes*, *Culex* and *Culiseta* mosquitoes.

Cx. tarsalis, Cx. pipiens, Cx. stigmatosoma, the Irrigated Pasture Mosquito *(Ae. nigromaculis)*, and *Cs. inornata* are just some of the species that may breed in irrigated agricultural areas.

Artificial Containers: Containers such as flowerpots, cans, barrels, buckets, fountains, cemetery urns, and tires are excellent habitats for several species of mosquitoes. Abandoned or poorly maintained swimming pools, hot tubs, and spas also fall into this category. Typically problems with container-breeding mosquitoes occurs during and just after the wetter parts of the year.

The container-inhabiting mosquito of particular concern in California is *Cs. incidens*. Other mosquito species found in containers include *Cx. pipiens, Cx. stigmatosoma, Cx. tarsalis, Cs. inornata* and *Ae. sierrensis*. Artificial containers also have the potential to serve as a breeding source or means for introducing exotic mosquitoes such as *Ae. aegypti* and *Ae. albopictus*. These exotic species, important vectors of yellow fever and Dengue fever, have become well established in the southeastern United States and have been difficult to control because of their propensity for common use of artificial containers.

C. METHODS FOR PHYSICAL CONTROL OF MOSQUITOES IN NON-TIDAL HABITATS

Physical control of mosquitoes requires modifying the environment so that it provides less habitat value for mosquitoes while maintaining or improving habitat for desirable species. Generally, this involves improving the circulation of water in areas where temporary expanses of shallow standing water allow mosquitoes to flourish, and where thick vegetation, periodic drying, or poor water quality preclude significant predator pressure. While physical control of mosquitoes can represent a "win-win" strategy in many sites, it is not appropriate everywhere, and is seen as one element of the District's IMM Program. In this subsection, physical control of mosquitoes in non-tidal environments is discussed briefly. For a more thorough review, please see *Guidelines for the Ecological Control of Mosquitoes in Non-tidal Wetlands of the San Francisco Bay Area* (Collins & Resh 1989). Physical control of mosquitoes in tidal and historically tidal marshlands is discussed in Sub-Section 4.4D, but much of the following discussion is also relevant for duck clubs on historically-tidal marshlands.

Physical control of mosquitoes in nontidal habitats typically involves improving the habitat value or dispersal potential of the site for mosquito predators; reducing the habitat value for mosquitoes through vegetation management, increased circulation, steepening banks, or changes in water quality; or by reducing the duration of standing water in areas that produce mosquitoes by filling small areas or improving drainage.

Filling or draining artificially ponded areas (low spots in flood-irrigated fields, etc.) can be cost-effective and environmentally-acceptable, but are not appropriate strategies in natural areas (however small), large permanent water bodies, or in areas set aside for storm water or wastewater retention. In such situations, the other options are more appropriate. At this time, the District is rarely involved in new drainage projects. However, the District does maintain or assist with the maintenance of some existing drainage systems. This maintenance can include upkeep of gates and other water control structures, excavating accumulated spoil materials, and vegetation management such as cutting, mowing, clearing debris, and/or herbiciding overgrown vegetation (see Section 4.5).

Ditches are a traditional technique for mosquito control, and they function in a number of ways. In addition to providing drainage if they lead from high to low ground, ditches can serve as a larvivorous fish reservoir. As rainfall increases, larvivorous fish move outward to adjacent areas to prey on immature mosquitoes, and as water levels decrease, larvivorous fish retreat to water in the ditches. Also, sills or weirs constructed in ditches can intentionally decrease water flow, decrease emergent aquatic weeds, prevent depletion of the water table, and allow larvivorous fish year-round refuge.

Over the past several decades, urban development has occurred in areas where mosquito control drainage ditches have existed as the primary drainage systems. In many cases, maintenance responsibility for mosquito control projects has been taken over by city and county public works departments and integrated into their comprehensive storm water management programs.

<u>Aquatic Plant Management And The Effects On Mosquito Populations:</u> Certain mosquito species use various aquatic plants such as bulrush or cattails as a primary habitat for egg deposition and larval development. Because aquatic plants can, at times, produce heavily vegetated stands, the use of conventional mosquito management techniques, such as biological and chemical control, may be ineffective. Therefore, management of the vegetation (mosquito habitat) may be the only means of reducing populations of mosquitoes that rely on aquatic plants. At times, this is accomplished directly through the use of herbicides or mechanical removal; these methods and their environmental consequences will be discussed later and in Section 4.5. At other times, vegetation change is accomplished indirectly through water management; these consequences of physical control will be discussed in this Section (4.4).

<u>Freshwater Swamps and Marshes:</u> Environmental laws greatly restrict habitat manipulations in these areas (which can produce *Aedes*, *Anopheles, Culex*, and *Culiseta* species) without extensive site-specific review by permit agencies. Where maintenance of existing ditches and other channels is allowed under Nation-wide and Regional permits from the U. S. Army Corps of Engineers (USACE) and/or Stream-bed Alteration Permits from the California Department of Fish and Game, these activities could be conducted by the District under this Review. Otherwise, the District would undertake separate CEQA assessment on a case by case basis.

<u>Riparian Zones:</u> Control measures will vary depending on the density of the human population, proximity of sensitive species, the vector potential of the mosquito causing the complaint, and access to the larval breeding or adult resting habitat. Minor physical control activities with insignificant environmental impacts can be accomplished using hand tools to connect small ponded areas to the channel along the edge of streams with highly variable flows. Generally, thick brush and complex micro-topography preclude extensive physical control in these areas, and biological or chemical control is generally more effective.

<u>Tree holes:</u> Control measures are very limited here due to the large numbers of tree holes in most impacted areas, difficulties in access, concerns for staff safety, and in some cases the age and size of the tree (heritage trees). The control methods utilized are also dependant on the location and numbers of people and pets affected by the mosquitoes produced from this habitat. Current control measures include public education, filling of some holes with sand or other inert materials to displace larval habitat, or chemical control (larvicides or aerosols).

Irrigated Agricultural Fields: Proper water management, land preparation, and adequate drainage are the most effective means of physically controlling mosquitoes in these types of sources. The District provides technical assistance to landowners that are interested in reducing mosquitoes by developing drainage systems on certain lands. Additionally, several state and federal programs provide both financial and technical assistance in developing efficient irrigation and drainage facilities for private land. These programs not only improve the value of the property, but assist in controlling mosquito development.

Wastewater Treatment Facilities: In many parts of California, clean freshwater for domestic, agricultural, or industrial uses is becoming a critical resource. Wastewater recycling and reuse help to conserve and replenish freshwater supplies. Concern for water quality conditions in lakes, rivers, and marine areas has resulted in the enactment of new state laws that will greatly limit future disposal of wastewater into these aquatic systems. To adjust to these changing conditions, many communities must implement wastewater reuse and recycling programs. Mosquito problems are frequently associated with some of the conventional wastewater treatment operations, and the expanded use of wastewater recycling and reuse may inadvertently create even more mosquito habitats.

Pond management options which are effective in controlling mosquitoes include timed periodic draining, providing deep water sanctuary for larvivorous fish, minimizing emergent and standing vegetation, and maintaining steep banks. The District routinely advises property owners on the best management practices for ponds to reduce mosquito development. In addition, the District provides localized vegetation management on most ponds to discourage mosquito oviposition sites.

Septic Systems: Many households in California, especially in rural areas, use on-site treatment systems, such as septic tanks and associated drain fields. With proper soil porosity, sufficient lateral fields, and low human congestion, these systems are safe and efficient. The wastewater in a properly located and maintained septic tank system will percolate into the subsoil without causing surface water accumulation that may induce mosquito production. Yet, when these systems are placed in locations with inappropriate soil conditions, wastewater will flow laterally, often into nearby swales and ditches. Physical control measures include repair and rebuilding of systems, and ditch maintenance in areas where lateral flow occurs.

Municipal Treatment Facilities: In California, municipal treatment facilities may be associated with mosquito problems. These can stem from operation of both small (package plants) and large facilities. Package plants may result in mosquito production in holding ponds because they are poorly maintained or operated beyond their capacity. Larger plants may use various methods to improve water quality conditions beyond the levels obtained in secondary treatment process. These methods include spray irrigation, rapid-dry ponds, aquatic plant/wastewater systems, and the use of natural or modified wetlands. Physical control methods include vegetation management, pond maintenance, structure repair, and improvement of pond substrates.

Spray-Irrigation Systems: Secondarily treated wastewater is used to irrigate golf courses, road medians, pastures, sod fields, citrus groves, and other types of crops. During the rainy season, these spray fields may become waterlogged, particularly those in low-lying areas with high water tables or in poorly drained soils. Under these conditions, the continued application of spray irrigation will result in the accumulation of surface water, thus providing aquatic habitats for a variety of mosquito species. Physical control methods are employed by landowners, and include proper grading of irrigated lands, and better water management.

Wastewater/Aquatic Plant Systems: At some sewage treatment facilities in California, certain species of aquatic plants (e.g., water hyacinths) have been added to human-made ponds containing secondarily treated wastewater for nutrient removal and biomass production. Mosquito problems can be produced in this type of system if the inflow has received inadequate secondary treatment. Effective nutrient removal requires periodic harvesting of a portion of the standing crop.

Storm Water and Wastewater Management: The management of Storm water and wastewater is very important, and when done without sound engineering, poor construction or improper maintenance, can result in considerable mosquito problems. Because of recent restrictions on the flow of storm waters into natural waterways, the question of design of Storm water retention facilities has become a critical issue. Physical control measures may be required, but proper design of facilities will be the most important factor.

Currently there is a wide range of mosquitoes produced in these facilities including floodwater *Aedes* species in intermittently wet facilities and *Culex* and *Anopheles* species associated with permanent or semi-permanent wet facilities. The *Aedes* species are the most pestiferous, and may serve as vectors of viruses that infect humans.

Mosquito production can be engineered out of Storm water and wastewater facilities but not always easily. Permanent water ponds can be kept clean of weeds with a water quality that is also sufficient to support mosquito-eating fish. Dry facilities can be designed to dry down in three days to prevent floodwater mosquito production, but some standing water beyond the three-day period may occur due to intermittent rainfall common during the rainy season.

Agricultural and Industrial Wastewater: Many commercial operations have on-site treatment facilities for decreasing nutrient loads from their wastewater, and generally, they use techniques similar to those applied to domestic wastewater. The quantity of wastewater produced at some commercial locations, such as those associated with wine making, may be highly variable during the year. Therefore, the amount of surface water in the holding ponds or spray fields used in the wastewater treatment may fluctuate considerably, thereby contributing to the production of mosquitoes. Wastewater from feed lots and dairy barns is often placed in holding or settling ponds without any prior treatment. Several mosquito species of the genus *Culex* can become extremely abundant in these ponds, especially in the absence of aquatic plant control.

Artificial Container Habitats: A container-breeding mosquito problem can be solved by properly disposing of such materials, covering them or tipping them over to ensure that they do not collect water. The District has an extensive program that addresses urban container breeding mosquito problems through house-to-house surveillance and formalized education programs.

Tires: Waste tires have been legally and illegally accumulating in California for the past several decades. The legal accumulations usually take the shape of a somewhat organized pile containing up to several million tires. Illegally dumped tires may be scattered about singly or exist in piles containing up to 40 to 50 thousand tires. Unfortunately, most of the problem tires are not in large piles, but scattered about, making removal difficult and, at best, labor intensive.

The design of tires makes them ideal breeding sites for several species of mosquitoes, of which, some are very important vectors of disease. Until the mid-1980s, waste tires were considered more of a nuisance and environmental threat than the possible foci of mosquito-borne disease epidemics. This changed in 1985 when a substantial breeding population of *Ae. albopictus* was discovered in Houston, Texas. It is probable that this population arrived from Japan as eggs deposited inside used tires.

Thus far, *Ae. albopictus* has not become established in California, and the dry summers here appear not to be favorable to their establishment. However, their introduction poses a serious threat, and California mosquitoes such as *Cx. pipiens* and Cs. *incidens* do breed in tires. It should be noted that in 1987, *Ae. albopictus* was found in imported used tires in Oakland, California. Early detection and an aggressive, long-term surveillance and control program prevented this mosquito from becoming established.

For management of used tires, the California Integrated Waste Management Board oversees storage sites with more than 500 tires. That agency also has developed regulations regarding the storage of waste tires with regards to mosquito control. These regulations include the provision of the local mosquito control agency being involved with the permit process required to store used tires.

D. METHODS FOR PHYSICAL CONTROL OF MOSQUITOES IN TIDAL HABITATS

Physical control of mosquitoes on tidal or historically-tidal marshlands has been a major activity of the District since its inception in 1925. While marsh filling or diking for mosquito control were common in other areas, the District relied primarily on ditching, either for improved drainage on sites diked by others, or for enhanced tidal circulation on undiked sites. Today, both of these activities are still permissible, but the great majority of District activity in these areas focuses on increasing tidal circulation as a means of directly reducing habitat suitability for mosquitoes and as a means of improving production or access for predators of mosquitoes.

Extensive evaluation of the physical control methods described below indicates that they have no significant detrimental impact of the environment when performed under District and permitting agency guidelines, and on the contrary are generally beneficial to a wide range of desirable species including special status species (Balling et al 1979, Resh and Balling 1979, Balling et al 1980, Barnby and Resh 1980, Resh et al 1980, Rosenberg et al 1981, Balling and Resh 1982, Balling and Resh 1983, Resh and Balling 1983, Barnby et al 1985, Collins and Resh 1985; Collins et al 1986, Balling and Resh 1991, Batzer and Resh 1992, Kramer et al 1992, Batzer et al 1993, Kramer et al 1995, Batzer et al 1997). The District has funded or participated in some of this research and has incorporated the significant findings into its source reduction policies.

Circulation Ditches and Open Marsh Water Management: Ditching can be used in both salt marsh or freshwater locations to control mosquitoes by: 1) enhancing drainage thus eliminating mosquito-producing sites, or, 2) allowing larvivorous fish access to mosquito breeding locations (this can be enhanced through the creation of permanent water bodies which act as predatory fish reservoirs). A ditching network frequently connects shallow ditches to permanent water habitats, whether they be ponds or canals. Where it is impossible or impractical to connect to major waterways, a permanent pond is constructed deep enough to hold water throughout the year to harbor fish, and radial ditches connect the mosquito-producing locations to the ponds.

Speed Scavel: Many marshes in the San Francisco Estuary have small ditches that are, or have been, created with a small plow known as a speed scavel. This device is usually pulled by a small tractor or a vehicle known as a Thiokol or snow cat. The ditches formed by the speed scavel are up to 18 inches wide and 18 inches deep and are another means by which water circulation can be enhanced within a tidal or muted tidal system. Small dredge spoils are created along the sides of the ditch which requires District staff to then broadcast these materials by hand to minimize the potential for creating areas where unwanted, exotic vegetation can grow within the marsh. This technique has been used successfully for many years by the District and other mosquito and vector control districts throughout the state.

Rotary Ditching: Over the past 20 years, rotary ditching has been implemented on both the east and west coasts of the U.S. Rotary ditching involves the construction of shallow ditches usually 4 feet wide and 2-3 feet deep, using high-speed rotary equipment which broadcasts spoil evenly over the marsh surface. Rotary ditching generally is considered more environmentally acceptable than deep ditching because spoil material from these shallow ditches is evenly distributed in a very thin layer over the marsh surface. Consequently, the problem of the accumulation of overburden, with the subsequent invasion of exotic vegetation, is eliminated. Impacts to vegetation are usually limited to the ditch itself, as the tractor will climb over the vegetation allowing it to spring back, causing little damage. Marsh ditching seems to affect the vegetation as only a top-dressing of dirt might affect a lawn. Experience repeatedly has demonstrated that a properly designed rotary ditching system can greatly decrease the need for larvicide applications on the affected marsh. Rotary ditching can be cost effective and of lower management intensity when used in areas where it can be physically installed.

Rotary ditchers broadcast the spoil indiscriminately and can throw debris great distances. Therefore, great care is necessary when working in congested areas. In loose soils, the size and shape of the finished ditch will not be maintained due to erosion from water movement through the ditch. Because of the fixed geometry of the ditcher side slopes, the chosen depth at any point along a channel determines the width at that point; therefore, a shallow ditch is also relatively narrow.

As with other ditching programs, some concerns have been raised about the possible marsh hydrological changes (i.e., dewatering of marsh ponds or pans) that may occur from the installation of rotary ditches. This dewatering concern has been typically addressed through the installation of ditch sills, the tops of which are usually set at mean high water. The installation of sills can result in water being retained in the ditch and on the marsh surface; however, this is not always the case with some dewatering of the marsh still occurring. Also, more frequent flooding of the marsh can alter soil salinity, with possible impacts to the benthic invertebrate or plant communities. Because these marshes typically evolved with high channel densities and high flood frequencies, this represents a relatively minor transition between natural successional stages at the site.

Basic limitations on the use of rotary ditching revolve around the size of the ditch needed, soil types, access, adjacent terrain, vegetation present, and the potential for buried contaminants or historic or archaeological sites. Areas with sandy loose soil are not good ditching candidates. Ditch cleaning or new construction is possible in areas of limited woody vegetation if planned carefully. Experience has shown that poorly engineered ditches can produce more mosquitoes than preconstruction areas, as is true for any physical control project. Because they distribute material evenly over the marsh surface, rotary ditches do not result in the formation of spoil piles. Therefore, rotary ditching receives serious consideration for any mosquito control ditch-construction project. Environmental regulatory agencies generally will consider rotary ditching of impoundments because it usually will reduce pesticide use and will allow the maintenance of an impoundment in a free tidally exchanging condition for a longer period of the year. In some cases, it allows the impoundment to be opened permanently. Rotary ditching projects are usually undertaken by mosquito control offices and require permits from the USACE along with other local and regional approval.

Impoundments: The principle of impounding water for mosquito control is simple; keeping a sheet of water across a salt-marsh substrate prevents *Aedes* mosquitoes from ovipositing on these otherwise attractive soils. On impounded marsh, mosquito and biting midge control is effectively achieved with a minimum of pesticide use. While common in Florida, impounding water specifically for mosquito or biting midge control has not been used extensively along the California coast. However, impounding water for other purposes, including waterfowl habitat and salt production, is very common in the San Francisco Bay Area, and can have the same results, depending on the timing, depth, duration, and frequency of flooding, as well as the characteristics of the soil and vegetation.

Duck Ponds and Mosquito Production: For close to 100 years, duck clubs have existed around the San Francisco Estuary to provide enhanced habitat for waterfowl and to allow hunting by club members. Cooperative management of these areas to limit mosquito production while enhancing waterfowl production has been a goal of Mosquito and Vector Control Districts for many years, and there is an extensive body of theoretical and practical knowledge on how to achieve this end.

Most of the duck clubs are in Solano County, and while mosquitoes produced in them can affect people in Napa County, mosquito control on Solano County clubs is outside the jurisdiction of this District.

Rotational Impoundment Management: RIM is a formal strategy of impoundment management that achieves multipurpose management by allowing the impoundment to: 1) control salt-marsh mosquito production from the marsh through means other than insecticides; 2) promote survival and re-vegetation by maintaining open periods and sufficiently low water levels during the summer flooding period, and 3) allow marine life to use the previously unavailable impounded high marsh.

E. CONCLUSIONS: POTENTIAL ENVIRONMENTAL IMPACTS

The District makes a distinction between "Minor" and "Major" physical control activities, based on the 5-year regional wetlands permits issued to the District by the USACE and the San Francisco Bay Conservation and Development Commission (BCDC). Those mosquito source reduction activities which require individual permits from the Corps and BCDC because of their scope or nature are considered "Major" and all activities that do not require individual permits are considered "Minor".

The potential environmental impacts of the District's Minor physical control activities are not significant. The State Secretary of Resources has determined that most of these activities do not generally cause significant environmental impact [CEQA Guidelines Sections 15301 & 15304]. Section 15301 uses this determination to exempt from CEQA review the operation, maintenance and minor alteration of existing drainage or other facilities involving negligible or no expansion of use. Examples cited in the Guidelines include the maintenance of stream channels and debris clearing to protect fish. Section 15304 exempts the minor alteration of land, water and vegetation that do not involve the removal of mature, scenic trees. Examples cited in the Guidelines include minor trenching where the surface is restored and maintenance dredging where the spoil is deposited in an authorized spoil area.

Consistent with the scope of the exemptions, and as applied to mosquito control activities, minor trenching and ditching means the following: digging, excavating and expanding ditches, drains and trenches in situations where all of the following conditions are satisfied: the capacity of the new or expanded facility is only negligible or insignificant; the surface area is restored; the spoil, if any, is deposited in an authorized area; and the work does not impact any mature trees, threatened or endangered plant or animal species, or sensitive habitat areas.

More extensive ditching may still fall under the regional USACE and BCDC permits, and based on the literature cited above and the protections (including annual review of plans) built into these permit processes, we do not find that our work can have a significant environmental impact. Projects too extensive to fall under the regional permits, as noted above, will need to be analyzed on a case-by-case basis with project-specific initial studies or other required environmental documents. Major physical control projects potentially involve substantial environmental change, and are subject to individual review under CEQA by the District.

4.5 VEGETATION MANAGEMENT

A. INTRODUCTION

Species composition and density of vegetation are basic elements of the habitat value of any area for mosquitoes, for predators of these mosquitoes, and for protected flora and fauna. District staff periodically undertakes vegetation management activities, or encourages and teaches others how to do so on their property, as a tool to reduce the habitat value of sites for mosquitoes or to aid production or dispersal of mosquito predators, as well as to allow access by District staff to mosquito habitat for surveillance and other control activities. These activities can include physical manipulation using small hand tools such as machetes and pruners, weed removal with mechanized equipment, water management (e.g. periodically drying and then reflooding ponded areas), and/or chemical control (herbicides). Care and timing are critical with water management so as to not encourage unnecessary mosquito breeding due to fluctuating water levels. Chemical control of vegetation uses the herbicides Round Up and Rodeo, which are both based on the active ingredient Glyphosate, and Karmex, a preemergent herbicide based on the active ingredient diuron. All herbicides are applied in strict conformance with label requirements and District policies.

B. PHYSICAL CONTROL OF VEGETATION

Tools ranging from shovels, pruners, chain saws, and "weed-whackers" on up to heavy equipment, can all be used at times to clear plant matter that either prevent access to mosquito breeding sites or that prevent good water management practices which would minimize mosquito populations. Generally, however, District "brushing" activities rely almost entirely on hand tools. Surveys for special status plants, coordination with the landowner, and acquisition of necessary permits are completed before any work is undertaken. Trimmed vegetation is either removed and disposed of properly from the site or broadcast in such a way as to minimize visual degradation of the habitat. Trimming is also kept to a minimum to reduce the possibility of the invasion of exotic species of plants and animals. Follow up surveys are also conducted to verify that the work undertaken was effective and that the physical manipulation of the vegetation did not result in any unintended overall habitat degradation. To date, no complaints have been received and no habitat degradation has been noted following physical manipulation of vegetation within a mosquito breeding habitat.

In addition, the use of water management to control vegetation is in some ways an extension of physical control, in that water control structures created as part of a physical control project may be used to directly manipulate hydroperiod (flood frequency, duration, and depth) as a tool for vegetation management. In addition, where potential evapotranspiration rates are high, this water management can also become a mechanism for salinity management, and indirectly, vegetation management through another path.

C. HERBICIDES

The District's restricted use of herbicides to principally man-made sites precludes the risk of damage to, or loss of, sensitive wetland habitats or special status organisms. Surveys are conducted to ensure that risk from application of these chemicals will not impact any sensitive habitats, special status species or food crops. Furthermore, care is taken to make sure that potential drift is eliminated by using these chemicals only during periods when there is no wind. Application is also timed to maximize effectiveness and reduce the need for additional applications. The following information on toxicity and environmental effects is taken from Caltrans' EIR for herbicide use (1991).

D. GLYPHOSATE-BASED HERBICIDES

The herbicides Roundup and Rodeo are both based on the active ingredient Glyphosate. These are selective materials with very low animal toxicity (see Table after this Section), and they are applied in strict conformance with label requirements. The District applied 22.63 gallons of Round Up, which is labeled for terrestrial application, and 26.5 gallons of Rodeo, which is chemically similar to Round Up but labeled for aquatic application, in 1998.

1. IDENTIFICATION AND USE

Glyphosate, N-(phosphonomethyl)glycine, is a nonselective, nonresidual, postemergence herbicide used for the control of weeds and brush (Shipp et al., 1986; USDA, 1984). Glyphosate is effective against deep-rooted perennial species and against annual and biennial species of grasses, sedges and broadleaf weeds (EPA, 1986). It acts in plants by inhibiting amino acid synthesis. Its physical form is colorless crystals. The two most widely used formulations are Roundup (41% of the isopropylamine salt of glyphosate with surfactants) and Rodeo (53% of the isopropylamine salt of glyphosate without surfactants). Roundup and Rodeo are occasionally used to control growth of poison oak and black berry vines that would otherwise prevent access to mosquito breeding habitats, and to control weed growth on the levees and access roads associated with winery waste and wastewater treatment ponds.

2. FATE AND TRANSPORT IN THE ENVIRONMENT

The persistence of glyphosate in the environment is very low and in soil is dependent on absorption to soil particles, runoff, and microbial transformation. Complete microbial transformation does occur rapidly in soil and water (hydrolysis half-life 35 days). Depending on soil type, a half-life of 3-130 days has been calculated. The lower number is for silty, clay loam and the upper for a sandy loam with little organic matter (USDA, 1984) Glyphosate in soil is resistant to chemical degradation and phototransformation (Shipp et al., 1986). The vapor pressure of glyphosate is negligible, indicating that glyphosate would not volatilize (Hartley and Kidd, 1987).

In aquatic systems, glyphosate absorbs strongly to organic and mineral matter where it is degraded primarily by microorganisms (Shipp et al., 1986). Its estimated half-life in natural waters is 7-10 weeks (Ghassemi et al, 1981). Glyphosate is relatively nonmobile in the environment due to its rapid and strong absorption to soil particles. The extent of absorption onto soil appears to be related to the clay content of soil and the cation-exchange capacity of the soil (Glass, 1987). Absorption is greater in soils saturated with aluminum and iron compared with soils saturated with sodium and calcium. At low application rates, pH does not affect glyphosate binding to soil, while at high application rates glyphosate binding decreases with increasing soil pH (Shipp et al., 1986). The K_{oc} for glyphosate is calculated to be 25.4 ml/gm (Lyman et al, 1982), indicating that glyphosate would be expected to migrate with infiltrating groundwater. However, studies of glyphosate in the environment indicate that is not the case. Glyphosate was not detected in groundwater in California (CDFA, 1989). Data indicate that it is relatively nonleachable and has a low tendency for transport in runoff (Shipp et al., 1986).

Glyphosate has virtually no tendency to bioaccumulate in animals (Ghassemi et al., 1981). The Unites States Department of Agriculture (1984) reports a default BCF of 1 as a conservative indicator of bioconcentration and suggests glyphosate has a low tendency for bioaccumulation.

3. POTENTIAL FOR HUMAN AND OTHER MAMMALIAN TOXICITY

Ingestion of Roundup by humans has been reported to result in irritation of the mouth, nausea, intestinal discomfort, vomiting and diarrhea. Ingestion of large quantities has been reported to result in hypotension and pulmonary edema (Monsanto, 1989). Dose levels at which these effects were observed were not reported nor is it clear to what extent the surfactant component contributed to these effects. Dermal exposure to a 6.4% aqueous solution of roundup by volume on human skin did not result in primary irritation or in dermal sensitization.

The acute oral, inhalation and dermal toxicity of glyphosate is low. The acute oral LD_{50} of glyphosate and Roundup in rats ranged from 4,300 - 5,600 mg/kg and in rabbits has been reported at 3,800 mg/kg. A four hour LC_{50} of 25 mg Roundup/l of air has been reported in rats. In another inhalation study, no evidence of toxicity was observed in rats exposed to 4.89 mg Roundup/l of air. Percutaneous absorption studies indicate that glyphosate is not readily absorbed through the skin. No signs of toxicity have been observed in rabbits following dermal exposure to 5,000 mg/kg of glyphosate or Roundup. Therefore, the acute dermal LD_{50} in rabbits is greater than 5,000 mg/kg for both chemicals. The LD_{50} for dermal exposure to Roundup in rats exceeds 17,600 mg/kg. Glyphosate is nonirritating to the skin, but moderate skin irritation, attributed to the presence of surfactants, has been reported in laboratory animals after exposure to Roundup. The transient ocular irritation has been reported in rabbits exposed to glyphosate and Roundup in standard eye irritation tests (Shipp et al., 1986). No signs of allergic contact dermatitis or dermal sensitization has been reported in guinea pigs exposed to glyphosate.

No treatment-related alterations in clinical chemistry parameters or pathological changes in organs have been observed in rats or mice exposed orally to glyphosate either subchronically or chronically. Adverse effects have been limited to depressed body weight or altered organ weights. In male rats, no toxicity occurred at 135 mg glyphosate/kg/day, but an increase in the absolute and relative lung weight was reported at 340 mg glyphosate/kg/day. In mice, there were no signs of toxicity reported at 2,305 mg glyphosate/kg/day, but a reduction in body weight gain did occur at 12,225 mg glyphosate/kg/day. Minor nasal irritation has been the only effect observed following subchronic inhalation exposure of rats to 0.36 mg of an aqueous solution of Roundup (41% glyphosate/l of air) (Shipp et al., 1986).

No treatment-related toxicity has been observed following chronic exposure to glyphosate at doses up to 5,874 mg/kg/day in mice or 31 mg/kg.day in rats (Shipp et al., 1986). An apparent decrease in the absolute and relative pituitary weight has been observed in dogs administered 100 mg glyphosate/kg/day for one year (EPA, 1986).

No adverse effects on reproductive capability have been observed in rats fed 30 mg glyphosate/kg/day in a three generation reproduction study. Focal renal tubular dilation was reported in third generation male rats exposed to 30 mg glyphosate/kg/day in this study with no effects observed in 10 mg glyphosate/kg/day. There was no evidence of a teratogenic effect in rats or rabbits exposed to 3,500 or 350 mg glyphosate/kg/day, respectively (Shipp et al., 1986).

Glyphosate has been evaluated for genotoxic activity in a variety of in vivo and in vitro systems. No evidence of genotoxicity has been reported (Shipp et al., 1986).

No significant differences in the total number of tumor-bearing animals or the total number of animals with malignant tumors were found in a 26-month feeding study in rats at doses up to 31 mg glyphosate/kg/day. In a 24-month study in mice at a dose of 3,900 mg glyphosate/kg/day, an increase in the incidence of renal tubular adenomas compared to historical controls was reported in male mice; however, they were not considered to be treatment-related (Shipp et al., 1986). An independent panel reviewed the pathology and concurred that the tumors were not treatment-related and EPA revised the cancer classification from C to D.

The Table at the end of this Section lists the known organismal toxicity studies for glyphosate.

E. DIURON (KARMEX)

1. IDENTIFICATION AND USE

The herbicide 3-(3,4-dichlorophenyl)1,1-dimethylurea, a substituted urea commonly known as Diuron, Trade name Karmex, is a systemic herbicide which inhibits photosynthesis. Its physical form is colorless crystals and it is used for a variety of annual and perennial broadleaf and grassy weeds on both crop and non-crop sites (EPA, 1983, WSSA, 1983). Diuron is applied by this District in the fall and winter for weed control on waste water pond levees and access roads for sewage treatment facilities and wineries.

2. FATE AND TRANSPORT IN THE ENVIRONMENT

Diuron is relatively stable and does not readily undergo phototransformation or volatilization (soil half-life 150-200 days). Therefore, losses by these two mechanisms is probably insignificant. Loss of Diuron from surface soil is minimal (Newton and Dost, 1984) unless diuron is exposed on the soil surface for several days or weeks under hot, dry conditions (WSSA, 1983). Transformation of Diuron in soil is through progressive demethylation followed by hydrolysis (EPA, 1982). This process appears to occur via microbes and is subject to the metabolic rates induced by the soil environment. Microbial transformation is faster with moderate temperatures, higher organic content in soil, and adequate moisture (EPA, 1982).

Diuron is expected to tightly bind to soil resulting in relatively low mobility, and penetration of diuron into surface soil would be very shallow (Newton and Dost, 1984). The K_{oc} for Diuron was calculated to be 560 ml/gm, indicating that diuron would have a moderate tendency to absorb to soil and not migrate to ground water (Lyman et al., 1982). However, diuron has been detected in ground water in California at concentrations ranging from 0.10 to 3 /l (CDFA, 1989).

In surface water, diuron is relatively immobile due to limited solubility (42 mg/l at 25°C) and absorption to sediment. Because of this low mobility, surface deposits of diuron are not an important source of water contamination due to runoff (Newton and Dost, 1984). In aqueous solutions, diuron is relatively stable to hydrolysis at pH values commonly found in natural surface waters (EPA, 1982).

Diuron may have a slight potential for bioaccumulation in animals; however, the extent of bioaccumulation has not been established (EPA, 1982). No measured steady-state bioconcentration factor (BCF) is available for Diuron. An empirical regression equation may be used to estimate the BCF for aquatic species. Based on the solubility of diuron, the BCF is estimated to be 75 (Kenaga and Goring, 1978), indicating a low tendency for bioconcentration.

3. POTENTIAL FOR HUMAN AND OTHER MAMMALIAN TOXICITY

No studies on human toxicity following diuron exposure have been found.

The acute toxicity of diuron in laboratory animals by the oral, dermal, or inhalation routes is low. The acute oral LD_{50} in rats ranges from 3,400 to >10,000 mg diuron/kg. In rabbits, the acute dermal LD_{50} is greater than 2,500 mg/kg, and the 1-hour LC_{50} is less than 200 mg/l in rats. Diuron is nonirritating or produced only slight irritation to the skin and eyes in rabbits and skin sensitization tests in guinea pigs were negative.

No data on neurotoxicty was located in the literature.

Diuron is not teratogenic in laboratory animals, but can produce fetotoxicity at high dosages. In a developmental study in rats given diuron during gestation, no teratogenic effects were observed at doses up to 500 mg/kg, however, fetotoxicity, manifested by wavy ribs and other bone variants, occurred at 125 mg/kg, the lowest dose tested. No adverse reproductive effects, fetotoxicity, or teratogenicity were reported in a three-generation reproduction study in rats administered 6.25 mg/kg/day.

Diuron has not been shown to be genotoxic. Results were negative for diuron tested in forward gene mutation assays, *Salmonella typhimurium* assays (with and without metabolic activation), and in tests for unscheduled DNA synthesis. However, the principle metabolite of diuron, 3,4-dichloroaniline, was mutagenic in the fungus, *Aspergillus nidulans* (EPA, 1982).

Results of a two year study in which rats were fed diuron were negative for carcinogenic effects.

A lifetime Health Advisory for exposure to diuron in drinking water of 14 g/l has been proposed by the EPA (Hileman, 1990).

The Table at the end of this Section lists the known organismal toxicity studies for diuron.

<u>F.</u> <u>CONCLUSIONS: POTENTIAL ENVIRONMENTAL IMPACTS</u>

The low inherent toxicity of glyposate- and diuron-based herbicides, the low volumes of these materials applied by the District, and the District's policies of avoiding natural sites with these materials together ensure that no significant environmental impacts results from the District's use of Diuron.

Toxicity of Glyphosate to Selected Test Organisms

Organism	Effect	Dose (mg/kg)	Comments	Source
Bobwhite Quail	LD_{50}	>2,000		USDA, 1988
Bobwhite Quail	8-day LD_{50}	>928	Dose estimated from concentration in food (4,460 ppm)	USDA, 1984
Japanese Quail	5-day LD_{50}	625	Dose estimated from 5,000 ppm in food; no fatalities	USDI, 1986
Mallard	8-day LD_{50}	>928	Dose estimated from concemtrations in food (4,460 ppm)	USDA, 1984
Chicken	NOEL	15,000	Adult hen; dosed twice daily with 1,250 mg/kg, 3 consecutive days; no effects observed	USDA, 1984
Goat	LD_{50}	4,860	Roundup	USDA, 1988

Organism	Effect	Conc. (mg/l)	Comments	Source
Rainbow Trout fingerling (0.5 g)	96-hr LC_{50}	10-97	Static tests; range of hardness of 5.3-86 mg/l $CaCO_3$, and pH 6.3 to 8.2, respectively; technical	Wan et al, 1989
Rainbow Trout	96-hr LC_{50}	48	Roundup	USDA, 1984
fingerling (0.5 g)	96-hr LC_{50}	14-33	Static tests; range of hardness of 5.3-86 mg/l $CaCO_3$, and pH 6.3 to 8.2, respectively; Roundup	Wan et al, 1989
fingerling (1 g)	96-hr LC_{50}	1.3	Roundup	USDA, 1988
fingerling (2 g)	96-hr LC_{50}	8.3	Static test; Roundup	USDA, 1984 &1988
Trout	96-hr LC_{50}	>1,000	Rodeo	USDA, 1988
	96-hr LC_{50}	680-1,000	Combined with surfactant; Rodeo	USDA, 1988
Bluegill	96-hr LC_{50}	140	Technical	USDA, 1988
	96-hr LC_{50}	24	Flow through test; technical	USDA, 1988
	96-hr LC_{50}	78	Flow through test; technical	USDA, 1988
	96-hr LC_{50}	5	Static test; Roundup	USDA, 1984
	96-hr LC_{50}	14	Roundup	USDA, 1984
	96-hr LC_{50}	>1,000	Rodeo	USDA, 1988
Fathead Minnow	96-hr LC_{50}	97	Static Test; technical	USDA 1984 & 1988
	MATC	>25.7	No adverse effects on survival, growth, or reproduction; 255 days exposure; technical	USDA, 1988
	96-hr LC_{50}	2.3	Static test; Roundup	USDA, 1984 & 1988
Channel Catfish	96-hr LC_{50}	130	Technical	USDA, 1988
fingerling (2.2 g)	96-hr LC_{50}	13	Static test; Roundup	USDA, 1984 & 1988
Swim-up Fry	96-hr LC_{50}	3.3	Roundup	USDA, 1988

Toxicity of Glyphosate to Selected Test Organisms (cont'd)

Organism	Effect	Conc. (mg/l)	Comments	Source
Carp	96-hr LC_{50}	115	Technical	USDA, 1988
	96-hr LC_{50}	>10,000	Rodeo	USDA, 1988
Grass Carp	96-hr LC_{50}	15	Roundup	USDA, 1988
Chinook Salmon	96-hr LC_{50}	20	Roundup	USDA, 1988
	96-hr LC_{50}	750-1,440	Rodeo	USDA, 1988
Coho Salmon	96-hr LC_{50}	22	Roundup	USDA, 1988
	96-hr LC_{50}	600-1,000	Rodeo	USDA, 1988
Cladoceran (*Daphnia* sp.)	48-hr LC_{50}	780	Technical	USDA, 1988
Cladoceran (*Daphnia magna*)	48-he EC_{50}	3	First instar, Roundup	USDA, 1988; USDI, 1986
	48-hr LC_{50}	930	Rodeo	USDA, 1988
	NOEL	50	21-day exposure; reduced reproduction at 96 mg/l; technical	USDA, 1988
Grass Shrimp	96-hr LC_{50}	281	Technical	USDA, 1984
Fiddler Crab	96-hr LC_{50}	934	Technical	USDA, 1984
Midge Larvae (*Chironomus plumosus*)	48-hr EC_{50}	55	Third instar; static test; technical	USDA, 1984; USDI, 1986
	48-hr EC_{50}	18	Static test; Roundup	USDA, 1984 & 1988
	------	2	Significant increase in stream drift; Roundup	USDA, 1984 & 1988
Amphipod (*Gammarus pseudolimnaeus*)	96-hr LC_{50}	43	Roundup	USDA, 1988
Crayfish	96-hr LC_{50}	>1,000	Roundup	USDA, 1988
Copepod (*Nitocera spinipes*)	96-hr LC_{50}	22	Roundup	USDA, 1984 & 1988

Note: LC_{50} = concentration lethal to 50% of the test organisms
EC_{50} = concentration resulting in a specific effect in 50% of the test organisms
MATC = maximum acceptable toxicant concentration derived from chronic study
NOEL = no observed effect level

Toxicity of Diuron to Selected Test Organisms

Organism	Effect	Dose (mg/kg)	Comments	Source
Mallard	LD_{50}	>2,000	Single dose	USDA, 1986
Mallard	8-day LD_{50}	>200	Ducklings; dose estimated from >1,000 ppm in food	USDA, 1986
Bobwhite Quail	8-day LD_{50}	>346	Dose estimated from 1,730 ppm in food	USDA, 1986
Japanese Quail	8-day LD_{50}	>625	Dose estimated from 5,000 ppm in food	USDA, 1986
Pheasant	8-day LD_{50}	>625	Dose estimated from 5,000 ppm in food	USDA, 1986
Chicken	10-day LOEL	10	Decreased weight gain resulted after 10 daily doses; all chickens died after 9 doses of 250 mg/kg	USDA, 1986

Organism	Effect	Conc. (mg/l)	Comments	Source
Rainbow Trout	96-hr LC_{50}	5.3	Static test	Mayer & Ellersieck, 1986
Bluegill Sunfish	96-hr LC_{50}	2.8	Static test	Mayer & Ellersieck, 1986
Guppy	96-hr LC_{50}	25		Hartley & Kidd, 1987
Lake Trout	96-hr LC_{50}	1.1	Static test	Mayer & Ellersieck, 1986
Cutthroat Trout	96-hr LC_{50}	0.71	Static test	Mayer & Ellersieck, 1986
Coho Salmon	LC_{50}	<2.4	Static test	Mayer & Ellersieck, 1986
Striped Mullet	LC_{50}	6.3		Kenaga, 1979
Amphipod (*Gammarus fasciatus*)	96-hr LC_{50}	0.16	Mature; static test	Mayer & Ellersieck, 1986
Cladoceran (*Daphnia magna*)	LC_{50}	47		Kenaga, 1979
Cladoceran (*Daphnia pulex*)	48-hr EC_{50}	1.4	First intar; static test	Mayer & Ellersieck, 1986
Cladoceran (*Simocephalus serrulatus*)	48-hr EC_{50}	2	First instar; static test	Mayer & Ellersieck, 1986
Brown Shrimp	EC_{50}	>1		Kenaga, 1979
Sowbug (*Asellus brevicaudus*)	96-hr LC_{50}	15.5	Mature; static test	Mayer & Ellersieck, 1986
Stonefly (*Pteronarcys californica*)	96-hr LC_{50}	1.2	Second year class; static test	Mayer & Ellersieck, 1986
Eastern Oyster	96-hr LOEL	1.8	50% decrease in shell growth	USDA, 1986

Note: LC_{50} = concentration lethal to 50% of the test organisms.
EC_{50} = concentration resulting in a specific effect in 50% of the test organisms (usually immobilization in cladocerans)
LOEL = lowest observed effect level

4.6 BIOLOGICAL CONTROL OF MOSQUITOES.

A. INTRODUCTION

Biological control of mosquitoes and other pests is the intentional introduction or redistribution of pathogens, parasites or predators to reduce the size of target mosquito populations. In this report, and generally in the literature, it is distinguished from habitat manipulations that do not involve direct movement of living organisms, even though these "physical control" activities may ultimately depend on the action of parasites or predators for their success. Biological control of mosquito larvae is one of the principal components of the District's Integrated Mosquito Management program. The District does not use biological control against adult mosquitoes at this time.

Intentional biological control of mosquitoes is a relatively recent development and can largely be traced to observations and ecological studies of fish predation on mosquito larvae beginning early in this century (Smith 1904). Early investigations studied the potential effects of indigenous, and later introduced, fish on mosquito larvae. Results of such studies have been adopted in developing strategies to use mosquito predators in providing economical and sustained levels of control. As resistance to pesticides and environmental concerns associated with their use became more prevalent after the mid-1960's, biological control of larval mosquitoes became used more often as a method of protecting the public from mosquitoes and the diseases they transmit. However, reliable biological control of adult mosquitoes has not been demonstrated, and is not currently pursued by the District. It should also be noted that biological control methods also have potential environmental impacts, and their proper use is as one component of an integrated management program based on surveillance, treatment criteria, and selection of the most appropriate control method at the time and place that mosquito control is required.

Predation of mosquito larvae by the mosquitofish *Gambusia affinis* is significant in many types of mosquito habitat in the District Service Area, and the District intentionally releases mosquitofish into some of these sites. Stocking by DISTRICT personnel complies with strict guidelines designed to ensure that no significant impacts can occur to native species. These guidelines are discussed below. In 1998, District staff stocked about 60 pounds of mosquitofish and distributed about an additional 20 pounds of fish to the public.

Other biological control methods available to the District include the application of the fungus *Lagenidium giganteum* ("*Lagenidium*"), and the "biological insecticide" *Bacillus sphaericus* ("*B. sphaericus*"). Although neither *Lagenidium* and *B. sphaericus* are routinely used by the District at this time, either might be adopted in the future for specific applications. In addition, protein spores from the bacteria *Bacillus thuringiensis israelensis* (Bti) are used by the District as a "biological insecticide," but because no live organisms are used, the District does not consider this Biological Control. Because the potential environmental impacts of applying either type of *Bacillus* are associated with the potential disturbance associated with the mode of application and the potential for non-target toxicity, these materials will also be discussed in the Chemical Control section of this document.

B. BIOLOGICAL CONTROL AGENTS

Biological control agents of mosquitoes include a wide variety of pathogens, parasites and predators. As a rule, mosquito pathogens and parasites are usually highly specific to their mosquito host, whereas predators are more general in their feeding habits and opportunistically feed on mosquitoes.

Mosquito Pathogens: Mosquito pathogens include an assortment of viruses and bacteria. They are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae.

Examples of viruses that can infect mosquitoes are mosquito iridoviruses, densonucleosis viruses, nuclear polyhedrosis viruses, cytoplasmic polyhedrosis viruses and entomopoxviruses. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* and several strains of *Bacillus thuringiensis israelensis*. These two bacteria produce proteins that are toxic to mosquito larvae. Both are produced commercially as mosquito larvicides.

Mosquito Parasites: The life cycles of mosquito parasites are biologically more complex than those of mosquito pathogens and involve intermediate hosts or organisms other than mosquitoes. Mosquito parasites are ingested by the feeding larva or actively penetrate the larval cuticle to gain access to the host interior. Once inside the host, parasites consume the internal organs and food reserves until the parasite's developmental process is complete. The host is killed when the parasite reaches maturity and leaves the host (*Romanomermis culicivorax)* or reproduces (*Lagenidium giganteum)*. Once free of the host, the parasite can remain dormant in the environment until it can begin its developmental cycle in another suitable host.

Examples of mosquito parasites are the fungi *Coelomomyces spp., Lagenidium giganteum, Culicinomyces clavosporus* and *Metarhizium anisopliae*; the protozoa *Nosema algerae, Hazardia milleri, Vavraia culicis, Helicosporidium spp., Amblyospora californica, Lambornella clarki* and *Tetrahymena spp.*; and the nematode *Romanomermis culicivorax.*

Mosquito Predators: Mosquito predators are represented by highly complex organisms, such as insects, fish, birds and bats, that consume larval or adult mosquitoes as prey. Predators are opportunistic in their feeding habits and typically forage on a variety of prey types. This allows the predators to build and maintain populations at levels sufficient to control mosquitoes, even when mosquitoes are scarce.

Examples of mosquito predators include representatives from a wide variety of taxa: coelenterates (*Hydra* spp.); platyhelminths (*Dugesia dorotocephala, Mesostoma lingua,* and *Planaria* spp.); insects (Anisoptera, Zygoptera, Belostomidae, Geridae, Notonectidae, Veliidae, Dytiscidae and Hydrophilidae); arachnids (*Pardosa* spp.); fish (*Gambusia affinis, Gasterosteus aculeatus, Poecillia reticula*); bats; and birds (anseriformes, apodiformes, charadriiformes and passeriformes). Because of their abundance and easy identification, Notonectids and Dytiscids are routinely monitored by District staff. Where these invertebrate predators of mosquito larvae are abundant, chemical control is rarely used (see Treatment Criteria in Section 4.7).

Environmental Relationships in Biological Control: The effectiveness of a mosquito biological control agent lies in its ability to reduce mosquito numbers as quickly as possible. An ideal biological agent 1) feeds preferentially on mosquitoes, 2) exhibits an extremely efficient hunting or parasitizing strategy, and 3) reproduces quickly. These traits determine suitability for practical application. New mosquito sources initially have few predators and other competing aquatic organisms. Mosquito control personnel use this knowledge to develop a control strategy that involves integrated pest management techniques.

Since mosquitoes are capable of colonizing sources within days of flooding, initial control efforts attempt to suppress the first generations of mosquitoes until natural predators or competitors can control them. Initial treatment includes the selective use of pesticides and appropriate environmental manipulation, such as vegetation and water quality management. Once biological control is established in a "managed" source, periodic inspections at timely intervals are adequate to monitor changes in larval abundance. Periodically, the source may require treatments with pesticides when 1) predators are not effective, 2) aquatic and shoreline vegetation provides too much shelter, 3) the water level changes, or 4) water quality does not support predators.

Conservation and Application of Predators: The ability of predators to control mosquitoes, is related to four factors: 1) whether mosquitoes are preferred prey, 2) whether the hunting strategy of the predator maximizes contact with mosquitoes, 3) whether the predator consumes large numbers of mosquitoes, and 4) whether the predator is present in sufficient numbers to control mosquitoes. Predator effectiveness is enhanced when proper conditions are present.

Within a typical aquatic environment that produces mosquitoes, predators are distributed among different substrates. For example the surface of the pond supports water striders, planaria and spiders. Below the water surface, backswimmers, predaceous diving beetles and water scavenger beetles live and feed. If the pond contains vegetation, then the plant surfaces (periphyton) will support *Hydra*, damselfly and dragonfly nymphs, and giant water bug nymphs and adults. The benthos supports dragonfly and damselfly nymphs that feed on organisms associated with silts and organic detritus. Together, the different predators form a spatial network that accounts for predation throughout the pond. Ideally an adequate variety of vegetation should be present to maintain sufficient levels of predator diversity. Greater potential for an acceptable level of mosquito control exists when more predators are present. Care should be taken so that mosquitoes do not have an advantage when too much or too little vegetation is removed.

Most of the currently registered mosquito larvicides minimally impact predators. Making applications at the lower end of the label rate can further minimize any undesirable impacts from these larvicides. The overall objective of using predators is to reduce the frequency of pesticide applications. This minimizes environmental impact and delays the development of mosquito resistance to pesticides.

Predation on mosquitoes is a natural process that will occur without human intervention. However, the level of mosquito control by natural predators can be increased by the conservation of predators in the environment and by augmentation of the predator population through stocking and habitat enhancement.

C. PRACTICAL APPLICATIONS OF BIOLOGICAL CONTROL AGENTS

A wide range of organisms have been evaluated for their effectiveness as biological control agents against mosquito larvae, but only a relatively small number are currently in use in California. There have been a number of reasons for this, including 1) difficulties in mass production, 2) failure to produce a consistent level of larval control, 3) expense, and 4) restricted application because of environmental concerns. Most agents, particularly predators and parasites, have only demonstrated acceptable control in conjunction with mosquitofish and larvicides. Currently, the only biological control agents in use or consideration by the District are *Bacillus thuringiensis israelensis*, *Bacillus sphaericus*, *Lagenidium giganteum* and the mosquitofish *Gambusia affinis*. Mosquitofish will be discussed in the next subsection.

Microbial Agents and Mosquito Control: Commercial formulations of *Bacillus sphaericus* and *Bacillus thuringiensis israelensis* are extensively used as mosquito larvicides. Both are highly selective for mosquitoes and are innocuous to associated non-target organisms and predators. *Bacillus thuringiensis israelensis* is also toxic to black flies, a pest and disease vector.

Bacillus thuringiensis israelensis and *Bacillus sphaericus* are often considered chemical control measures because they are available in commercial formulations that consist of granular, powdered or liquid concentrates. The use of these two microbials is discussed further under Chemical Control (Section 4.7).

Lagenidium giganteum and Mosquito Control: *Lagenidium giganteum* is a fungal parasite of mosquito larvae. Motile zoospores enter mosquito larvae either when ingested or by penetrating the cuticle. The fungus grows rapidly throughout the host body cavity and once the host dies, zoospores are released that can infect other larvae.

Lagenidium giganteum is a highly specific parasite of mosquito larvae. Other organisms are not susceptible and there is no mammalian toxicity. However, use of *L. giganteum* is limited because of environmental requirements for growth and development of the fungus.

Lagenidium giganteum is available commercially as an aqueous suspension. It contains 40% (wt./wt.) *L. giganteum* (California strain) mycelium (10^{10} CFU or Colony Forming Units, a concentration measure by cell counts per liter) and 60% inert ingredients. *Lagenidium giganteum* may be applied from ground or air. Label rates range from 9 to 180 fluid ounces per acre. Most treatments will require 20 to 80 fl. oz./acre, a common rate is 25 fl. oz./acre. Zoospores form within 16 hours after application and mortality occurs within 24 to 48 hours.

D. MOSQUITOFISH AND MOSQUITO CONTROL

Gambusia affinis is the most commonly used biological control agent for mosquitoes in the world. Careful use of this fish can provide safe, effective, and persistent suppression of a variety of mosquito species in many types of mosquito sources. As with all safe and effective control agents, the use of mosquitofish requires a good knowledge of operational techniques and ecological implications, careful evaluation of stocking sites, use of appropriate stocking methods, and regular monitoring of stocked fish. For general information on the biology of mosquitofish and their application in mosquito control programs, the reader is referred to Downs (1991) and Swanson et al (1996).

Aquatic Habitats: Mosquitofish have been used to control mosquitoes in a wide variety of mosquito sources. These sources include both artificial and natural water bodies: dairy, industrial and municipal wastewater ponds; flood control basins and underground storm drains; neglected swimming pools, ornamental ponds and water troughs; irrigation and roadside ditches; seasonally flooded agricultural lands, rice fields, duck clubs and wildlife refuges; and such wetlands areas as marshes, sloughs, swamps and river seepage.

The number and density of mosquitofish needed to achieve acceptable control of larval mosquitoes varies considerably with the mosquito species, water temperature, etc.. In situations where large populations of mosquitoes are hatching in a short amount of time, a relatively high density of mosquitofish is required. In general, suitable habitats promote reproduction and growth rather than just sustaining the stocked mosquitofish population. Sources where conditions do not favor population growth may not be suitable for mosquitofish use, or may require stocking at substantially higher rates.

The principal habitat characteristic that affects the successful use of mosquitofish is its relative stability. Mosquitofish usually are not effective in intermittently flooded areas unless a refuge impoundment is provided. Because of this, mosquitofish are more effective against mosquitoes breeding in permanent and semi-permanent water (e.g. *Culex* spp., *Anopheles* spp., and *Culesita* spp.) than against floodwater mosquitoes (primarily *Aedes* spp.).

Mosquitofish are best suited for use in shallow, standing water and are particularly useful in large sources where the repeated use of chemical control is expensive, prohibited, or impractical.

Availability of food, other than mosquito larvae, and shelter are also important factors affecting the suitability of a site. Mosquitofish survival, growth, and reproduction are highly dependent on diet and feeding rates. Shelter to protect the young from cannibalistic adults is essential for population growth. Vegetation, or other shelter, may also reduce predation on adult mosquitofish by birds, larger fishes, and other predators.

Habitats in which the water quality conditions, particularly temperature, dissolved oxygen, pH, and pollutants, exceed the tolerance limits of mosquitofish are not suitable sites for biocontrol. In sources with poor but sublethal water quality, feeding, reproductive activity and consequently mosquito control, may be adversely affected. Use of mosquitofish is sometimes possible in suboptimal environments that inhibit reproduction, but special stocking and monitoring methods may be required.

The presence of piscivorous fishes or other predators in the source habitat may rule out stocking with mosquitofish. High densities of invertebrate and vertebrate predators, such as notonectids and young game fish, which prey on small mosquitofish can prevent mosquitofish population growth.

<u>Stocking Methods:</u> Stocking methods can have significant effects on the degree of mosquito control achieved. In most cases, the objective is to release the minimum number of fish at the time when conditions within the source promote rapid population growth and at locations which facilitate dispersal throughout the source. The most appropriate methods depend on the type and location of the mosquito source, season, and the degree and duration of control desired.

<u>Stocking Rate:</u> Mosquitofish generally are released at densities lower than those necessary for mosquito control with the expectation that reproduction and recruitment will greatly increase the fish population within a few weeks. The best stocking rate depends primarily on the type of mosquito source, season, and mosquito control objective, for example immediate control vs. control later in the season. Understocking can result in inadequate mosquito control whereas overstocking may result in excellent control, but is wasteful of the usually limited fish supply.

In general, for early season stocking of mosquito sources that contain healthy populations of food organisms and adequate vegetation to provide shelter for the small mosquitofish, 0.2-0.5 lb./acre is appropriate. Higher stocking rates are necessary in a variety of circumstances, including 1) late season stocking and/or short flooded season, for example, wild rice fields or duck club ponds. In these situations, mosquitofish population growth is reduced as a result of a shorter breeding season and declining thermal and photoperiodic stimuli for breeding; 2) poor quality environments which depress or inhibit reproduction and/or feeding, for example, habitats characterized by low temperature, low light, or high levels of chemical or organic pollution; 3) sources in which immediate mosquito control is desired; and 4) sources which harbor high densities of mosquito larvae, for example, agricultural drainage ditches.

<u>Stocking Date:</u> Date of release of mosquitofish into a mosquito source affects biocontrol efficacy primarily through its influence on mosquitofish population growth. The age of the source can also affect population growth since both food and shelter may be sparse in new habitats. In mosquito sources stocked late in the season, population growth is reduced because of the shortened breeding season and declining reproductive stimuli. Stocking date necessarily varies with type of mosquito source but, in general, mosquitofish are released one to three weeks post-flooding. Mosquito sources that require late season stocking, such as duck club ponds are usually stocked with higher numbers of fish or treated with supplemental larvicides.

Stocking Location: A sufficient number of mosquitofish must be stocked where mosquito larvae are present. Although mosquitofish can swim through dense vegetation, dispersal throughout a large habitat takes time and is slowed by the presence of additional barriers such as dikes or complicated shorelines.

The size and complexity of a source are important considerations when determining the number and locations of release sites. In large, complicated habitats, such as rice fields or wetlands, mosquitofish are typically be released at several locations. For small area sources, all fish may be released at a single site.

Water flow may also be a consideration. In general, mosquitofish are stocked at the upstream end of the source since fish tend to move downstream from the release site.

Handling, Release and Monitoring: Most mosquitofish are released by hand; however, mosquitofish can also be dropped from airplanes and helicopters, when stocking large area sources such as rice fields. Regardless of the release method, care is taken to minimize stress. Abrupt changes in water temperature are avoided, and fish are usually transported in water at a temperature similar to that at the end source. Mosquitofish are not stocked during extremely hot weather or when water temperatures approach the upper tolerance limits of the fish (>35°C or 95°F).

After stocking, mosquitofish populations are monitored regularly to assess fish density, population growth, and biocontrol efficacy. A low number of fish may necessitate restocking or alternative mosquito control efforts.

The minnow trap is the most commonly used tool for assessing mosquitofish populations and, when used properly, it is effective and reliable. A minnow trap consists of a fine mesh cage with one or two inset funnel-shaped openings oriented with the narrow ends pointed into the cage. Fish enter the trap easily; the outer opening is wide and directs the fish into the cage. Once inside, the only exit is the narrow opening and few fish escape. Minnow traps are set so that a portion of the trap is above the anticipated maximum water level. This insures that surface feeding mosquitofish are captured and allows captured fish access to the surface for survival during episodes of low dissolved oxygen (e.g., pre-dawn hours). Minnow traps can be constructed using readily available material or purchased from many commercial aquaculture suppliers.

The number of fish captured in a trap provides a good estimate of the total number of fish in the habitat. Frequency of monitoring is optional but, for reliability between samples, minnow traps are usually deployed for equal amounts of time. The District generally leaves traps in place for 24 hours.

Use of Mosquitofish by the Public: Mosquitofish are made available to the public for backyard water gardens and ornamental fish ponds. Fish can be picked up Monday through Friday during normal office hours. All citizens that pick up fish are informed of the restrictions for use of mosquitofish and of the California Fish and Game regulations pertaining to the placement of non-native fishes into creeks, lakes or other natural water bodies of the state. The public is also informed on how to properly care for and maintain the mosquitofish that they are given.

E. ENVIRONMENTAL CONSIDERATIONS OF MOSQUITOFISH USE

Many species of larvivorous fish have been evaluated as agents to control mosquitoes, including various species of atherinids, centrarchids, cichlids, cyprinids, cyprinodontids, gasterosteids, and other poeciliids. However, mosquitofish are considered best suited from both biological and operational perspectives.

Advantages of Mosquitofish for Biological Control: Mosquitofish possess characteristics which make them efficient predators of mosquito larvae. They thrive in shallow, calm, vegetated waters, which is the same environment where many mosquitoes prefer to lay eggs, and can tolerate wide ranges of water temperature and quality. Mosquitofish are surface-oriented predators where mosquito larvae are an accessible prey. The small size of the fish enable them to penetrate moderately vegetated and shallow areas within the mosquito source. Mosquitofish are live-bearers that grow rapidly, mature at a young age, and reproduce quickly. This allows the fish to establish a high population in the source shortly after stocking. In many sources, seasonal peaks in mosquitofish activity and population growth coincide with mosquito reproduction times. Because of their omnivorous feeding habits, mosquitofish can thrive in habitats where mosquitoes occur intermittently.

Mosquitofish are hardy and easy to handle, transport, and stock. As a result of extensive research and practical experimentation in California, mosquitofish can be reliably cultured in large numbers. Problems still exist in some areas with winter survival rates and inadequate supplies of fish in the spring. Because the fish reproduce where they are stocked, long-term control can be achieved by stocking relatively few fish, often in a single application. Compared to pesticides, which require repeated applications, mosquitofish can provide inexpensive and safe long-term control, sometimes within days after application. Although not all introductions are successful, mosquitofish are an effective biological control component of an integrated mosquito management program.

Limitations to Use of Mosquitofish for Biological Control: Not all types of mosquito sources are suitable for stocking with mosquitofish and mosquitofish are not effective in all situations. Since mosquitofish usually are not stocked in numbers sufficient to cause an immediate effect, they do not control mosquitoes as quickly as pesticides do. In some areas, federal, state, or local agency permission is required to stock mosquitofish.

Mosquitofish and Non-mosquito Prey: Mosquitofish, despite their name, cannot survive solely on a diet of mosquito larvae (Reddy & Pandian 1972). Laboratory and field research have shown that mosquitofish also will eat a wide variety of food, including zooplankton, copepods, cladocerans, and immature stages of many insects, including midges, water beetles, damselflies, and mayflies (Washino & Hokama 1967, Ahmed et al 1970, Reed & Hoy 1970, Miura et al 1979, Farley 1980, Walters & Legner 1980, Bence 1988, Walton & Mulla 1991, Lawlor et al 1999). Hess & Tarzwell (1942) concluded that mosquitofish were true opportunistic feeders, so that the simple availability of prey was the key criteria in prey selection by mosquitofish. As such, the selection of food items by mosquitofish apparently shifts away from specific prey as its abundance drops. The District has been unable to find any substantial evidence of extirpation of any taxa by mosquitofish in creeks or other open or complex natural sites.

Within their generally wide diet, mosquitofish do have some clear feeding preferences, including food at the water surface, prey size ranging from large zooplankton to very small fish or invertebrates, and prey that is not highly mobile (Swanson et al 1996). While mosquitofish can modify food chains in small experimental pools, and can have significant impacts on endemic fish in these settings (Swanson et al 1996, USFWS 1996), there has been no published information on significant effects on reducing food resources for higher predators, reducing other mosquito predators, or reducing Special Status Species in the District Service Area. Because questions have been raised on this last point with regards to the California Red-legged Frog, this species is discussed in additional depth below.

Mosquitofish and Red-Legged Frogs: Some challenges have been made against the use of mosquitofish for the control of mosquitoes, based on the concern that the omnivorous feeding habit of mosquitofish poses a threat to the juvenile forms of the federally-threatened California Red-legged Frog. The District does not find substantial evidence to support this claim, either in the literature or from our own field experience. Specifically, the U.S. Fish and Wildlife Service (USFWS), after originally issuing statements asserting that mosquitofish have played a role in the historic reduction of red-legged frogs, acknowledged in their final Listing document for the species that they have no evidence for a link between mosquitofish and the decline of Red-Legged Frogs:

> "The Service is aware of several sites where mosquitofish and California red-legged frogs are currently coexisting. This evidence suggests that the relationship between mosquitofish and California red-legged frogs is complex. Additional research clearly is needed to more fully understand how these two species interact. The final rule has been revised to reflect current knowledge on this issue. The Service cannot determine whether mosquitofish are harmful to California red-legged frogs." (USFWS Federal Register 5/23/96)

Subsequently, research at the University of California at Davis, partially funded by the USFWS, showed no direct (mortality) impacts of mosquitofish on Red-Legged Frogs in intense interactions in naturalistic settings; the only indirect impact seen in this research was a slight lowering of body weight at the transition from tadpole to adult, with no evidence that this has any biological significance (Lawlor et al, 1999). In addition, as noted by the USFWS, mosquitofish and red-legged frogs have been frequently observed by qualified researchers to coexist in natural settings, similar to those in the District Service Area (field notes by Karl Malamud-Roam, Terry Strange, Chris Miller, Wes Maffei, Ron Keith, and others). Finally, alternative and more plausible explanations, including hunting, habitat destruction, and the introduced Bullfrog (*Rana catesbeiana*), apparently explain the observed historic decline in Red-legged frogs in the Service Area (USFWS 1996, Lawlor et al 1999).

Project Controls to Limit Environmental Impacts to Non-Significance: District activities are undertaken in coordination with other agencies involved in management of natural resources and the environment, and are carried out pursuant to a framework of federal and state regulation. The following specific observations support our conclusion that existing District controls are effective to avoid significant environmental impact:

- The District has used mosquitofish in the current Service Area for over fifty years without any apparent relationship, geographic or temporal, between our activities and observed environmental changes;
- The District's use of mosquitofish is highly selective in space and time, based on a detailed list of potential mosquito sources, pre-control surveillance for mosquito abundance, and threshold criteria for control applications;
- In particular, District policies explicitly prohibit release of mosquitofish into known Red-legged Frog sites, as mapped by the California Department of Fish and Game's Natural Diversity Database, Habitat Conservation Plans, and other reliable sources;
- The District's field technicians are highly-trained, certified by the California Department of Health Services, and are required to complete frequent continuing education sessions sponsored by the State, the District, or the Mosquito & Vector Control Association of California;
- The District's field activities are routinely monitored for safety, efficacy, and environmental impact by the District's Manager, by the Napa County Agricultural Commissioner, and by permit-issuing agencies;
- The District's activities are consistent with the Conservation Policies of the Napa County General Plan and identified Habitat Conservation Plans, Endangered Species and Sensitive Habitat Recovery Plans, and City Plans in the Service Area; and
- District staff routinely coordinates and consults with other responsible agencies, including the California Department of Health Services, the California Department of Fish and Game, the U.S. Fish and Wildlife Service, BCDC, the California State Lands Commission, the San Francisco Regional Water Quality Control Board, USACE, the Napa County Resource Conservation District, and the Napa County Flood Control District to ensure that Project activities do not result in significant impacts to biological resources.

F. CONCLUSIONS

The District has found biological control in the form of mosquitofish release and redistribution to be an environmentally-acceptable mosquito control technique in many settings. Particularly in altered or artificial aquatic habitats, the use of mosquitofish as a component of an integrated mosquito management program may be environmentally preferable to no action, the exclusive use of pesticides, or drainage (World Health Organization, 1982). In addition, the increasingly limited availability of registered pesticides and increasing insect resistance to pesticides increases the need for alternatives including biological control. As agents for biological control of mosquitoes, mosquitofish deserve consideration, and, in many specific situations, are the best choice.

Though mosquitofish are not native to California, they are now ubiquitous throughout most of the state's waterways and tributaries. In much of the state's wetland areas, mosquitofish are now part of the natural ecosystem. Also, much of the aquatic habitat that is highly productive for mosquitoes is disrupted habitat, with flora and fauna that are predominately non-native species. In these areas, stocking of mosquitofish will have minimal impact on non-target species.

Many precautions are taken to minimize the environmental impact in habitats where mosquitofish are introduced. Mosquitofish are introduced into wetland communities that are biologically complex. The impact on habitats that contain native fishes are especially considered and weighed prior to introduction. Mosquitofish are stocked only in careful compliance with federal and state endangered species acts, so as to avoid the potential to harass and impact threatened and endangered fish, amphibians, insects and other wildlife. The considered use of mosquitofish by the District ensures the protection of the environment by augmenting the natural process of predation on mosquito larvae through the use of a natural predator, the mosquitofish.

While the District has not yet adopted other biological control agents for operational use, tests with *Bacillus sphaericus* and *Lagenidium giganteum* indicate that they may be appropriate and environmentally-acceptable mosquito control agents in the District Service Area in the near future.

Mosquitofish Stocking Guide Chart

CONDITION	SOURCE†								
	Lake or Pond	Creek	Horse Trough or Wine Barrel	Swimming Pool or Ornamental Pond	Irrigation Ditch*	Marsh	Catchment Basins	Flood Control Canal	Duck C[illegible] Pond[illegible]
Threatened or Endangered Species Present	DS	DS	NA	NA	DS	DS	DS	DS	DS
Threatened or Endangered Species Absent	S	S	S	S	S	S	S	S	S
Water Temperature Below 55°F	DS	DS	DS	DS	DS	DS	DS	DS	DS
Water Temperature Above 55°F	S	S	S	S	S	S	S	S	S
Salinity Below 15ppt	S	S	S	S	S	S	S	S	S
Salinity Above 15ppt	NA	NA	NA	NA	NA	DS	NA	NA	DS
Distance to Populated Area Less Than 10 miles	S	S	S	S	S	S	S	S	S
Distance to Populated Area Greater Than 10 miles	DS	DS	DS	DS	DS	DS	DS	DS	DS
Water Velocity High	NA	DS	NA	NA	DS	NA	DS	DS	NA
Water Velocity Low	S	S	S	S	S	S	S	S	S

† Consult staff if status of threatened or endangered species is unknown or if there is the potential for fish migrate to other sources.

* Usually have mosquitofish.

‡Sources with predatory fish may need to be stocked yearly.

DS= Don't Stock Mosquitofish **S=Stock Mosquitofish** **NA= Not Applicable**

Home/cem/wp/MFSChart

4.7 CHEMICAL CONTROL

A. Introduction

Control of mosquitoes with pesticides ("Chemical Control") is an essential portion of the District's Integrated Mosquito Management Program. When mosquito abundance exceeds District thresholds, and physical or biological control would be ineffective, inefficient, or otherwise inappropriate, selective pesticides to control larval mosquitoes (larvicides) and/or adult mosquitoes (adulticides) are used.

District staff have discretion to select from and apply a range of pesticides when field inspections indicate the presence of mosquito populations which meet District chemical control criteria and guidelines. Depending on the mosquito, these criteria and guidelines evaluate mosquito species composition, density, extent, and age (larval instar) structure; proximity to human settlements, including sensitive receptors; weather (water temperature, wind, evaporation rate, air temperature inversion); abundance of predators of mosquitoes; regional or local pathogen (disease organism) activity; vegetation; previous control efficacy history at the specific site; and/or potential for development of resistance (see District Guidelines following this Section; also Durso 1996, Lawlor 1997, etc.). Pesticide use by the District thus varies spatially and temporally in response to a large number of variables. The total number of applications and quantities of pesticides applied by the District from 1995 through July 1999 are shown in the following table.

Table 4.7.1: Pesticide Use by Napa County Mosquito Abatement District, 1995-1999 (first value is number of applications of material by District staff during the year; second number is the total quantity of material applied by District staff during the year). 1999 data are through July 31. Note that 1998 was an extraordinarily wet year, with very high mosquito production.

Pesticide (applications/units)	1995	1996	1997	1998	1999
Mosquito Larvicides					
Altosid					
Briquets (lbs)	0/0	0/0	0/0	0/0	0/0
Pellets (lbs)	2/8	2/8	2/12	12/21.95	18/5.44
Liquid ~~(oz)~~ (gal)	25/16.89	0/0	43/0.82	137/26.63	126/7.49
Bacillus thuringiensis H-14 (Bti)					
Teknar HPD (gal)	0/0	39/6.33	38/4.28	103/80.23	96/21.86
Vectobac 12AS (gal)	137/182.55	71/5.39	44/4.87	15/83.14	9/4.88
Vectobac Tech Powder (lbs)	417/223.9	380/219.88	377/172.43	310/157.71	154/99.67
Water Surface Films					
Golden Bear 1111 (gal)	340/571.25	282/647.75	230/714.5	407/1645.4	205/485
Agnique	0/0	0/0	0/0	0/0	0/0
Mosquito Adulticides					
Pyrethrins					
Pyrocide 7396 (gal)	105/18.68	127/17.73	93/15.32	131/23.81	135/21.92
Pyrenone (gal)	0/0	0/0	0/0	0/0	0/0
Resmethrin (Scourge) (gal)	0/0	0/0	0/0	0/0	0/0
Permethrin (Biomist) (gal)	0/0	0/0	0/0	0/0	0/0

Herbicides					
Glyphosate-based Rodeo (gal) Roundup (gal)	10/6 49/34.2	20/12 44/30.38	31/28.25 70/44.88	22/20.5 27/22.63	7/6.88 44/37.56
Karmex DF (lbs)	82/1936	82/1588	94/1940	91/2200	0/0

In addition to the pesticides used routinely by the District, which are all discussed in detail in this Section, there are a large number of other materials, especially organophosphate (OP) larvicides (see below), labeled and registered for use against mosquitoes in California. The District does not use, nor does it plan to use, organophosphate pesticides. Therefore, although these materials are available for use, they will not be discussed in this report. Further information on any California registered pesticide is available from the California Department of Pesticide Registration (DPR 1999).

B. POTENTIAL ENVIRONMENTAL IMPACTS OF CHEMICAL CONTROL

Any chemical control of mosquitoes or any other pests presents a number of potential environmental impacts, the significance of which can vary substantially. These potential environmental impacts can be conveniently divided into those associated with the pesticide itself, including its inert ingredients and breakdown products, and those associated with its mode of application (noise and other disturbance effects). In addition, potential pesticide impacts are often divided into those which might affect people directly (safety, residue, chronic toxicity), and those affecting other non-target organisms (especially Endangered and other Special Status Species). This sub-section will present generic issues and information on the potential environmental impacts associated with the mosquito control pesticides and pesticide application methods used or under consideration by the District, and the general policies and practices of the District to ensure that these impacts are not significant. Further information, specific to each material or application method, follows in the next sub-sections.

The pesticides used by the District are selective, non-persistent, and safe to the operator and other persons. Only pesticides registered by the United States Environmental Protection Agency and California Environmental Protection Agency are used by the District. Pesticide application is always done in strict accordance with the pesticide label instructions (labels and Material Safety Data Sheets = MSDS for all pesticides used by the District are available from the District or from the California Department of Pesticide Registration). The District's strict compliance with pesticide labels and MSDS's, together with other measures described below, ensure that the pesticides available for mosquito control, when applied in accordance with legal requirements, are safe and cause little or no environmental impact.

1. SAFETY

Pesticides, by their nature, are toxic to some organisms. Their toxicity, however, varies considerably between different species, and to a lesser extent between individuals of the same species, when exposed to identical dosages. The safety of pesticides to humans is primarily assessed through measurements of acute (single-dose) toxicity in other animals, which is summarized using "signal words" on the pesticide label or the "LD-50" values on the MSDS (high values indicate low toxicity; see Durso 1996). The following is an explanation of these signal words. Please note that the District does not use pesticides with a "Warning" or "Danger" label except under emergency conditions.

CAUTION. This word signals that the product is slightly toxic ("Category 3 or 4"). An ounce to more than a pint taken by mouth could kill the average adult. Any product which is slightly toxic orally, dermally, or through inhalation or causes slight eye and skin irritation will be labeled "CAUTION".

WARNING. This word signals that the product is moderately toxic ("Category 2"). As little as a teaspoonful to a tablespoonful by mouth could kill the average sized adult. Any product which is moderately toxic orally, dermally, or through inhalation or causes moderate eye and skin irritation will be labeled "warning".

DANGER. This word signals that the pesticide is highly toxic ("Category 1"). A taste to a teaspoonful taken by mouth could kill an average sized adult. Any product which is highly toxic orally, dermally, or through inhalation or causes severe eye and skin burning will be labeled "DANGER".

Pesticide safety is also evaluated in terms of Chronic Toxicity, or the response of organisms to repeated exposures to the material being tested. The California Department of Pesticide Registration (DPR) requires extensive testing for toxicity as a condition for allowing registration of pesticides in California, and as of July 1999 did not report any studies showing evidence of chronic toxicity associated with any of the pesticides used by the District when used at or near label rates (DPR 1999). DPR has reported "possible adverse" effects associated with repeated exposures at extremely high dosages (exceeding legally allowed label rates and District operations by a factor of 100 or more) of Permethrin, Pyrethrins, Resmethrin, Piperonyl Butoxide, Glyphosate, and Diuron (DPR 1999). District policies and practices, which are discussed in more detail below, ensure that the conditions encountered during these tests cannot occur during District operations.

Finally, standard toxicology measurements show average risk to the population as a whole. Therefore, a substantial margin of safety is incorporated in label instructions and District application policies and practices to protect children, persons with compromised health, and other "sensitive receptors."

Protection of public health and safety and other environmental values is ensured during pesticide applications by rigorous measures, including applicator registration and testing by the California Department of Health Services, ongoing training provided by the District and the Mosquito & Vector Control Association of California, routine equipment calibration, and regular inspections by the Napa County Agricultural Commissioner.

2. NON-TARGET EFFECTS

In addition to potential toxicity to humans, pesticides are evaluated for their potential effects on other non-target organisms. The District uses selective materials with little or no impact on other mammals, birds, and most other vertebrates. Some labeled mosquito control pesticides can have non-target effects on other invertebrates or fish, amphibians, and other aquatic organisms. The Environmental Hazards section on labels of pesticides used for mosquito control instruct applicators about how to avoid and minimize these non-target impacts, and the District rigorously follows these instructions. For example, some adulticide labels instruct the applicator to avoid direct application over water or drift into sensitive areas (i.e., wetlands) due to a potential toxicity of these compounds to fish and invertebrates. Although there is some variation in the habitats to be avoided, they usually include lakes, streams and marshes. The District strictly follows label instructions and carefully monitors environmental and meteorological conditions to maximize effectiveness while avoiding and minimizing non-target exposure and environmental effects.

An additional type of non-target effect that has been reported in the past is the disruption of food chains through the loss of wide ranges of insects or other prey organisms. With the pesticides currently used by the District, their selective toxicity and lack of bioaccumulation generally protect food chains from significant impact. However, some recent questions have been raised about the potential impacts of these more selective materials on midges, which are physiologically similar to mosquitoes and important in the food supply for some waterfowl and wading birds. The District has performed an exhaustive review of the scientific literature and concludes that there is no substantial evidence to support this suggestion. Specifically, 1) there is no evidence of a spatial or temporal relationship between larvicide use and population dynamics of waterfowl or wading birds (Scientific Peer Review Panel 1996); 2) Golden Bear 1111 has no effect on benthic midge larvae, which do not breath at the water surface; 3) Bti has no detectible effect on midge larvae when applied at the maximum allowable label rates for mosquito control; 4) Methoprene, at label rates for mosquito control, can prevent adult emergence of some species of midges but does not directly kill mosquito or midge larvae and therefore does not remove them from the food chain; 5) no bioaccumulation (food chain magnification) of larvicides in larva-eating animals has been demonstrated for larvicides used by the District; and 6) the District does not use, and does not plan to use, other larvicides in areas where midges might be a significant portion of the food chain, except under emergency conditions.

3. INERT INGREDIENTS, SYNERGISM, AND ENVIRONMENTAL FATE

Ideally, the safety and environmental effects of pesticides are evaluated not only in terms of the active ingredient(s) of the pesticide, but also with relation to their inert ingredients and the chemicals that are produced as the pesticide is broken down in the environment (environmental fate), and with all possible combinations of other environmental compounds (synergisms). In the past, some persistent mosquito control pesticides (eg.DDT) both accumulated in animal tissues and were concentrated up food chains (bioaccumulation), and also created breakdown products that themselves posed environmental risks (eg. DDE from DDT). As a practical matter, it has been impossible for DPR or any other institution to test every possible chemical interaction and breakdown product. However, pesticides are tested as mixtures, together with their inert compounds, prior to their registration by USEPA or DPR, and extensive information has been collected on their total toxicity, bioaccumulation, and environmental fate. Neither EPA, DPR, nor other researchers have found significant environmental effects associated with the inert ingredients, synergisms, or breakdown products associated with materials used by the District. In addition, these materials do not bioaccumulate (see specific material descriptions later in this Section).

4. RESISTANCE AND LOSS OF EFFECTIVENESS

A number of examples of pesticide resistance have been published over the years, and one of the concerns with the development of resistance is the observed tendency of applicators to increase application frequency and/or intensity as pesticide effectiveness drops. The District has not experienced control failures due to resistance while using the current array of pesticides. However, to help guard against the development of resistance, and the monetary or environmental costs that can result, the District makes use of a number of pesticides with different modes of action, closely monitors research on resistance, and is committed to revising application practices if needed to avoid resistance.

5. DISTURBANCE ASSOCIATED WITH APPLICATION METHODS

In order to minimize potential non-target effects, modern pesticides are not only selective, but are also labeled for application directly to the mosquito population or habitat. Therefore, a means of applying the pesticide to the environment is needed and, for remote or large sites, a means of transportation. While small mosquito sources are routinely treated by hand with a backpack tank or other small container/sprayer, the District also uses trucks, hose reels, ATV's, and/or aircraft as needed for pesticide application. The noise and physical disturbance associated with these vehicles can cause disturbance to wildlife or nearby people, and the District plans its applications to minimize application frequency and disturbance intensity. At times, the desire for pesticides with low environmental persistence must be balanced with the desire to minimize application frequency, and some specific materials (eg. Altosid pellets, see below) are specifically designed for a long-term slow release of non-persistent pesticides.

6. DISTRICT POLICIES AND PRACTICES TO PROTECT THE ENVIRONMENT

In addition to the environmental protection measures and procedures inherent in the District's IMM program as discussed earlier (especially application thresholds and other criteria), there are other practices inherent in the District's chemical control program that protect the environment:

1. There are numerous federal and state laws and regulations that strictly control and regulate the storage, transport, handling, use and disposal of the pesticides in order to protect against surface and groundwater contamination and other impacts to the environment and public health. (E.g., Federal Insecticide, Fungicide and Rodenticide Act; Cal. Food & Agric. Code divisions 6 & 7; Cal. Code of Regs., title 3, division 6.) The District and its staff consistently comply with these laws and regulations and are routinely inspected by the county agricultural department for compliance.
2. The District only uses pesticides registered by the U.S. Environmental Protection Agency and California Department of Pesticide Regulation. The District then strictly complies with the pesticide label restrictions and requirements concerning the storage, transport, handling, use and disposal of the pesticides.
3. Consistent with the District's integrated mosquito management principles, when using pesticides, the District selects the least hazardous material that will meet its goals. The District does not use Category 1 pesticides, and only uses Category 2 pesticides in emergency conditions.
4. The District regularly calibrates the output of all of its pesticide application equipment.
5. The District and its employees are regulated by the State Department of Health Services (DHS). Mosquito control activities are coordinated with DHS pursuant to an annual Cooperative Agreement, under which the District commits to comply with certain standards concerning mosquito control and pesticide use. State law and the Cooperative Agreement require District mosquito control employees to be certified by DHS as a mosquito control technician. This certification helps to ensure that the employees are adequately trained regarding safe and proper mosquito control techniques, including the handling and use of pesticides and compliance with laws and regulations relating to mosquito control and environmental protection. The District also works in close coordination with the county agricultural commissioner, including periodic reporting of its activities.

C. Chemical Control of Mosquito Larvae

1. INTRODUCTION

Larviciding is a general term for the application of non-living natural materials or synthetic chemical products to aquatic habitats to kill mosquito larvae or pupae or to otherwise prevent emergence of adult mosquitoes. Materials designed to function in this way are known as larvicides, and they can be applied in a wide variety of formulations using a broad range of application technologies. Larviciding was developed early this century for the control of malaria and yellow fever mosquitoes, and still represents the most extensive set of District chemical control activities.

The District uses larvicides to treat a wide variety of aquatic habitats and communities, ranging from small domestic containers to larger agricultural and marshland areas. Frequently, the aquatic habitats targeted for larviciding are temporary or semi-permanent, since permanent aquatic sources usually contain natural mosquito predators such as fish and do not require further treatment, unless vegetation is so dense that it prevents natural predation. Temporary sites such as tidal marshes, flooded agricultural areas, or the margins of creeks produce prolific numbers of flood-water mosquitoes. While flood water mosquitoes develop during the first weeks after flooding, it often takes at least two to three weeks for the first macro invertebrate predators of mosquitoes to become established, and therefore biological or chemical control can be needed.

Where chemical control is appropriate, the major advantage of larviciding is the very small amount of larval habitat compared to adult mosquito habitat, and consequently the small acreage requiring treatment. Typically, the District applies larvicides to about one percent of the total District Service Area in any year.

There are times when larviciding is inappropriate (Durso 1996). Effective larviciding results are not always easy to achieve, and is critically dependent on timing when using nonpersistent pesticides. The size, location, or topography of the mosquito source area may make timely larviciding impossible. Spatial accuracy of the larvicide application is also extremely important. Congregated larvae may be easy targets, but missing a relatively small area containing them is also easy and leads to the emergence of many adults. Finally, larvicide labels allow a range of legal application dose rates; the selected rate must be sufficiently high to control the targeted mosquito species and sufficiently low to avoid or minimize non-target effects, especially where Special Status Species are present.

Natural fauna inhabiting larvicide application sites in addition to mosquitoes may include amphibians, fish, other vertebrates, and invertebrates, particularly insects and crustaceans, but larviciding causes little impact to these species. Temporarily flooded sites that meet District criteria to larvicide are generally very low in diversity of non-mosquito animal species at those times, due to the time needed for most non-mosquito species to locate and colonize these sites after flooding (Collins & Resh 1989). Also, because the District applies larvicides in limited areas at any time, most of the non-target species that do exploit temporary aquatic habitats are capable of quickly recovering from localized population declines via re-colonization from untreated proximal areas (Lawlor et al 1997).

Impacts of larviciding on flora are insignificant because the materials have no toxicity to plants, because the application methods involve very little disturbance to plants or soil, and because there are a small number of Special Status plants within potential District treatment areas, and District staff is trained to avoid them.

Larvicides routinely used by the DISTRICT include Golden Bear Oil 1111, Methoprene (Altosid), and Bti (*Bacillus thuringiensis israelensis*). Depending on water temperature, organic content, mosquito larval density, and other variables, pesticide applications may be repeated at any site at frequencies ranging from annually (synchronous cold water species) to weekly (irrigated pastures in hot weather, etc.).

Commercially available and experimental larvicides used by the District are discussed below. The presentation begins with the Insect Growth Regulator S-Methoprene, and then follows with Water Surface Films (GB1111 and Agnique), and concludes with Ingested Bacterial Larvicides (Bti and *Bacillus sphaericus*). A discussion of application methods, which are essentially common to all these materials, follows.

2. INSECT ENDOCRINE AGENTS = INSECT GROWTH REGULATORS (IGR's)

S-METHOPRENE. s-Methoprene (known simply as Methoprene or as its trade name, Altosid) is a synthetic analogue (mimic) of a naturally occurring insect hormone called Juvenile Hormone (JH). JH is found during aquatic life stages of the mosquito and in other insects, but is most prevalent during the early instars. As mosquito larvae mature, the level of JH steadily declines until the 4^{th} instar molt, when levels are very low. This is considered to be a sensitive period when all the physical features of the adult begin to develop. s-Methoprene in the aquatic habitat can be absorbed on contact and the insect's hormone system then becomes unbalanced. When this happens during the sensitive period, the imbalance interferes with 4th instar larval development. One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. Based on its mode of action, s-Methoprene is considered an insect growth regulator (IGR). This material has no effect on mosquito pupae and must be contacted by larvae to be effective.

Methoprene is applied either in response to observed high populations of mosquito larvae at a site, or as a sustained-release product that can persist for four months or longer. Application can be by hand, ATV, or aircraft. The District applied about 22 pounds of Altosid Pellets and 26.6 gallons of Altosid Liquid Larvicide in the entire Service Area during 1998.

FORMULATIONS AND DOSAGES. s-Methoprene is a very short lived material in nature, with a half-life of about two days in water, two days in plants, and ten days in soil (Wright 1976 in Glare & O'Callaghan 1999, La Clair et al 1998). The manufacturer has developed a number of formulations to maintain an effective level of the active material in the mosquito habitat (0.5-3.0 parts per **billion** = ppb[4]; (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 include Altosid Liquid Larvicide (A.L.L.) and Altosid Liquid Larvicide Concentrate, Altosid Briquets, Altosid XR Briquets, and Altosid Pellets. Altosid labels contain the signal word "CAUTION".

ALTOSID LIQUID LARVICIDE (A.L.L.) & A.L.L. CONCENTRATE. These two micro-encapsulated 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 were the first solid methoprene product marketed for mosquito control, beginning in 1978. 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.

Applications are usually made at the beginning of the mosquito season, and under normal weather conditions, repeat treatments occur at approximately 30 day intervals. The recommended application rate is 1 Briquet per 100 sq. ft. in non-flowing or low-flowing water up to 2 feet deep. Small sites with any mosquito genera may be treated with this formulation. Typical treatment sites include storm drains, catch basins, roadside ditches, ornamental ponds and fountains, cesspools and septic tanks, waste treatment and settlement ponds, transformer vaults, abandoned swimming pools, and construction and other man-made depressions.

ALTOSID XR BRIQUETS. This formulation consists of 2.1% (wt./wt.) s-methoprene (.00145 lb. AI/briquet) embedded in hard dental plaster (calcium sulfate) and charcoal. Despite containing only 3 times the AI as the "30-day briquet", the comparatively harder plaster and larger size of the XR Briquet change the erosion rate allowing sustained s-methoprene release for up to 150 days in normal weather. The recommended application rate is 1 to 2

[4]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.

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, small pastures, meadows, freshwater swamps and marshes, woodland pools, flood plains and dredge spoil sites.

ALTOSID PELLETS. Altosid Pellets were approved for use in April 1990. They 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 was approved for use in 1997. This product contains 1.5% (wt./wt.) s-methoprene. Granules are designed to slowly release s-methoprene as they erode. Under normal weather conditions, control can be achieved for up to 21 days. Label application rates range from 5 lbs. to 20.0 lbs. per acre, depending on the target species and/or habitat. The species are the same as listed for the briquet formulations. Listed target sites include meadows, rice fields, freshwater swamps and marshes, salt and tidal marshes, woodland pools, tires and other artificial water holding containers, dredge spoil sites, waste treatment ponds, ditches, and other natural and man-made depressions.

ENVIRONMENTAL IMPACTS: Methoprene is a material with very high specificity in its mode of action. Exhaustive reviews of the published literature on this material attest to its lack of adverse environmental impact (Mian & Mulla 1982, Scientific Peer Review Panel 1996, Glare & O'Callaghan 1999, Office of the Minnesota Legislative Auditor 1999). The table following the Methoprene discussion is a list of organisms impacted by S-Methoprene in studies reviewed by Glare & O'Callaghan (1999).

Wright (1976) reviewed the toxicology data collected for Methoprene registration and found no clinical signs of toxicosis in swine, sheep, hamsters, rats, dogs, rabbits, guinea pigs and cattle. Additionally, teratological (birth defect) studies in swine, sheep, hamsters, rats and rabbits showed no observable effects. Hester et al. (1980) found non-target organisms did not exhibit any adverse effects when exposed to treatments of sand granule and liquid formulations of methoprene up to a maximum of three and seven weeks, respectively. The acute, short-term toxicity of ZR-515 (methoprene) was also tested on 35 aquatic organisms including Protozoa, Platyhelminths, Rotatoria, Annelida, Arthropoda, Mollusca, Chordata and Thallophyta, and LC50 values of 0.9 to 5.0 ppm were calculated (250 to 1000 times label rates) (Miura and Takahashi 1973). Dosages used for larval mosquito control produced no adverse effect on the organisms tested, except for some sensitivity in larvae of some aquatic Diptera (Chironomidae, Ephydridae, and Psychodidae).

Bircher and Ruber (1988) assessed the toxicity of methoprene to all life cycle stages of the salt marsh copepod (*Apocyclops spartinus*) at concentrations ranging from 0.1 to 10.0 ppm. In general the copepods were resistant to concentrations of methoprene used to control mosquitoes, but early nauplii did show some mortalities to methoprene concentrations near the lower margins of mosquito susceptibility. Christiansen et al. (1977) showed a reduction in survival of larvae of the mud-crab *Rhithropanopeus harrisii* (Gould) under a range of salinity and temperature conditions, when exposed to 0.01, 0.1 and 1.0 ppm methoprene. McKenney and Mathews (1988) reported that larval survival, growth and energy metabolism of an estuarine shrimp *Palaemonetes pugio* were altered by exposure to low ug/l concentrations of an insect growth regulator (the juvenile hormone analogue, methoprene).

Finally, an extensive early study of technical (powdered) methoprene on a Louisiana coastal marsh (Breaud et al 1977) showed reductions in populations of adult and young scud (*Hyalella azteca*), adult and young opossum shrimp (*Taphromysis louisianae*), adult and young freshwater prawns (*Palaemonetes paludosus*), immature mayflies

(*Callibaetis* sp.), larval dance flies (*Notophila* sp.), larval midges (*Chironomidae*), adult and young fresh water snails (*Physa* sp.), immature damselflies and dragonflies (*Enallagma, Anax*, and *Belonia* spp.), adult burrowing water beetles (*Suphisellus* sp. and *Hydrocanthus* sp.), adult water scavenger beetles (*Berosus infuscatus*), and immature water scavenger beetles (*Berosus* spp.). On the other hand, populations **increased** for immature water boatmen (*Trichocorixa louisianae*), larval moth flies (*Psychoda* sp.), adult and young crawfish (*Procambarus clarki* and *Cambarellus* sp.), and adult predaceous diving beetles (*Liodessus affinis*) after the methoprene applications. Finally, no statistically significant (P>0.05) difference was seen between the test and control populations of 28 other aquatic organisms. Interpretation of this study is difficult in part because of the mixed nature of the results, which largely indicate the complexity of ecosystem dynamics in marshlands. Also, the application rate (28gm AI/ha technical powder) was at least twice the highest label rate allowed today, and was effectively much higher when the encapsulation and other coatings on modern formulations is considered.

After examining these and other studies, District staff and the recent reviewers listed above have concluded that 1) applications of methoprene (especially technical powder) at rates significantly higher than allowed by the label can adversely impact a number of aquatic animals; 2) animal species are not extirpated (locally eliminated) by repeated methoprene use except at application rates far higher than District practices; 3) emergence of adults of some fly species (specifically, some types of midges) can be temporarily reduced at application rates similar to District practices; 4) larval flies affected by methoprene are not killed at label application rates, but are prevented from becoming adults; 5) for species that are affected by methoprene, recolonization and reestablishment of populations from neighboring sites is fast once intense control was relaxed, 6) the patchy distribution of mosquito larvaes leads to maintenance of untreated refugia for non-targets, speeding recolonization, and 7) no bioaccumulation of methoprene has been seen in animals that have eaten mosquito or midge larvae treated with methoprene.

Finally, it has recently been suggested that methoprene may be associated with deformities in frogs that have been observed in a number of States (Frognet 1999). The District finds no substantial evidence to support this suggestion, and recent exhaustive reviews of this literature by independent analysts in Minnesota and New Zealand also find no evidence to support this claim (Glare & O'Callaghan, 1999; Minnesota State Auditor's Office, 1999). First, there is no evidence of a spatial or temporal relationship between Altosid use and amphibian deformities and, in particular, there is no evidence of frog deformities at all in the District's Service Area, and no significant evidence of frog deformities anywhere in California where methoprene use occurs (Fenn 1999). Second, well-documented alternative explanations for frog deformities, including infection with Trematodes, that are more consistent with the epidemiological patterns observed, have been reported (Sessions 1999). Third, the observations discussed to support the assertion have not been duplicated by any other researchers (Ankley et al 1998, Glare & O'Callaghan 1999). Fourth, consultations with Dr. Mark Jennings (May 1999) and other eminent herpetologists find no professional agreement with the claims of methoprene and frog deformities. Finally, severe deficiencies in methodology and/or interpretation exist in the few reports that make this assertion, including La Clair's failure to compensate for natural degradation of methoprene in the environment (La Clair 1998) and Sparling's failure to evaluate parasitism (Sparling 1998).

Published reports of concentrations of methoprene (ppm) required to inhibit 50% of adult emergence (IC_{50}) or cause 50% mortality (LC_{50}).

Target	Stage[1]	Mortality measure (ppm) LC_{50}	Mortality measure (ppm) $IC/EI/EC_{50}$ [2]	Formulation	Reference
Diptera: Culicidae					
Aedes aegypti		0.0221		Altosid	Zebitz 1986
Ae. aegypti		0.000077			Spencer and Olson 1979
Ae. aegypti	4th	0.0008-0.015			Pridantseva *et al.* 1978
Ae. aegypti	4th	0.013		Altosid SR-10	Pridantseva and Volkova 1976
Ae. aegypti	4th		0.00038		Buei *et al.* 1975
Ae. aegypti	3rd	0.000397		Altosid ALL	Ritchie *et al.* 1997
Ae. albopictus		0.0009			Baruah and Das 1996
Ae. albopictus	4th		0.00062		Buei *et al.* 1975
Ae. albopictus	1st		0.0120	Altosid 10F	Toma *et al.* 1990
	4th		0.0009		
Ae. albopictus	4th		0.0017	Poultex 5E	Farghal *et al.* 1988
Ae. daitensis	1st		0.0743	Altosid 10F	Toma *et al.* 1990
Ae. detritus		0.0009		Altosid SR-10	Majori *et al.* 1977
Ae. epactius		0.000002			Spencer and Olson 1979
Ae. funereus	3rd	0.000072		Altosid ALL	Ritchie *et al.* 1997
Ae. notoscriptus	3rd	0.000359		Altosid ALL	Ritchie *et al.* 1997
Ae. riversi	1st		0.0176	Altosid 10F	Toma *et al.* 1990
Ae. iriomotensis	1st		0.0017	Altosid 10F	Toma *et al.* 1990
	4th		0.00006		
Ae. sollicitans	4th	0.000005		95.4% a.i	Khoo and Sutherland 1985
Ae. sollicitans		0.00015			Spencer and Olson 1979
Ae. togoi		0.0024		Altosid	Zebitz 1986
Ae. togoi	4th		0.00085		Buei *et al.* 1975
Ae. triseriatus	4th	0.000135		Altosid SR-10	Wells *et al.* 1975
		0.000093		Altosid 10-F	
Ae. triseriatus	4th	0.000176		technical 95.4% a.i-	Khoo and Sutherland 1985
Ae. vigilax		0.000022		Altosid ALL	Ritchie *et al.* 1997
Armigeres subalbatus	4th		0.15		Buei *et al.* 1975
Ar. subalbatus	1st		14.9352	Altosid 10F	Toma *et al.* 1990
Ar. subalbatus	4th		1.2819		
Anopheles dirus	4th	0.00010-0.00017		Altosid sustained-release	Sithiprasasna *et al.* 1996
An. farauti	3rd	0.000057		Altosid ALL	Ritchie *et al.* 1997
An. sundaicus	4th	0.00009			Imai *et al.* 1987
Culex annulirostris	3rd	0.000089		Altosid ALL	Ritchie *et al.* 1997
Cx. fuscanus	1st		0.0976	Altosid 10F	Toma *et al.* 1990
	4th		0.0009		
Cx. infantulus	4th		0.00073		Buei *et al.* 1975
Cx. orientalis	4th		0.0010		Buei *et al.* 1975
Cx. pipiens pallens	3rd		0.03		Noguchi and Ohtaki 1974
	4th		0.02		
	pharate pup.		0.0006		
	pupae		1.0		
Cx. pipiens pallens	3rd		0.028		Buei *et al.* 1975
	4th		0.00037		
Cx. quinquefasciatus		0.0011			Baruah and Das 1996
Cx. quinquefasciatus	1st		0.0374	Altosid 10F	Toma *et al.* 1990

	4th		0.0013		
Cx. quinquefasciatus (Cuba)	4th	0.005			Navarro-Ortega *et al.* 1991
Cx. quinquefasciatus (France)		0.0006			
Cx. quinquefasciatus	4th		0.00076	Poultex 5E	Farghal *et al.* 1988
Cx. sitiens	3rd	0.001124		Altosid ALL	Ritchie *et al.* 1997
Cx. tritaeniorhynchus	1st		0.0466	Altosid 10F	Toma *et al.* 1990
Cx. tritaeniorhynchus	4th		0.0012	Altosid 10F	Toma *et al.* 1990
Cx. tritaeniorhynchus summorosus	4th		0.00065		Buei *et al.* 1975
Cx. univittatus	eggs	1.1276		Altosid	Abdel-Aal 1995
Psorophora columbiae		0.000052			Spencer and Olson 1979
Diptera: Ceratopogonidae					
Culicoides circumscriptus			0.0094	slow release	Takahashi *et al.* 1985
Diptera: Chironomidae					
Chironomus yoshimatsui	last instar		0.0025 0.00065	Altosid 10 F/ slow release	Kamei *et al.* 1982
C. yoshimatsui[3]	field		0.0044	Altosid 10 F	Kamei *et al.* 1982
Diptera: Muscidae					
Musca domestica			50.3		Das and Vasuki 1992
			0.4 -15		Danish Pest Infestation Laboratory 1974
Diptera: Psychodidae					
Psychoda alternata			0.0014 0.0023	Altosid 10F/ slow release	Kamei *et al.* 1993
Diptera: Tephritidae					
Ceratitis capitata	eggs		1028	Altosid SR10	Farghal *et al.* 1983
	larvae		350		
	prepupae		0.63		
	pupae		1.80		
Coleoptera: Chrysomelidae					
Dicladispa armigera	larvae	1.26			Hazarika and Baishya 1997
	pupae	1.13			
D. armigera	eggs	0.92			Hazarika and Baishya 1996
	adults				
Coleoptera: Coccinellidae					
Epilachna chrysomelina	eggs	6.4	1.6		Kinawy and Hussein 1987
Coleoptera: Tenebrionidae					
Tenebrio molitor			0.026	Altosid	Solomon and Metcalf 1974
Hemiptera: Lygaeidae					
Oncopeltus fasciatus			5.0	Altosid	Solomon and Metcalf 1974
Lepidoptera: Nocutidae					
Spodoptera litura	last-instar		68.077		Mane and Subrahmanyam 1996
Lepidoptera: Tortricidae					
Cydia molesta	eggs	0.000055			MacFarlane and Jameson 1974
Siphonaptera: Pulicidae					
Xenopsylla cheopis		0.00011			Chamberlain *et al.* 1988
Ctenocephalides felis	cocoon formation: larval-adult:		0.014 0.00032		Kobayashi *et al.* 1994
Acari: Pyroglyphidae					
Dermatophagoides farinae	tritonymphs		0.0028		Saleh *et al.* 1976

[1] No. of instar
[2] IC_{50}, EI_{50} and EC_{50} = 50% inhibition of emergence
[3] In the field, 2 h exposure.

Toxicological properties of methoprene (from Wright 1976).

Property	Dose for effect
Acute oral toxicity - rat	34,600 mg/kg
Acute oral toxicity - dog	LD_{50}=5000-10000 mg/kg
Subacute oral studies (90 days, rate and dog)	No effects with 5000 ppm
Primary skin and eye irritation	Non irritating
Acute dermal toxicity (rabbit)	Dermal LD_{50}=3000-10000 mg/kg
Acute aerosol inhalation (rat)	No effects at 2000 ppm
Three generation reproduction study (rat)	No effects at 2500 ppm
Teratology studies (rat, rabbit)	No effects at 1000 mg/kg
Dominant lethal mutagenicity	No effects at 2000 mg/kg
Static fish toxicity studies	
Bluegill	LD_{50} =4.62 ppm
Channel catfish	LD_{50} >100 ppm
Coho salmon	LD_{50} =32 ppm
Trout	LD_{50} =106 ppm
Crustacean toxicity studies	
Crayfish	LD_{50} =100 ppm
Fresh water shrimp	LD_{50} =100 ppm
White shrimp	LD_{50} =100 ppm
Pink shrimp	LD_{50} ±100 ppm
Subacute oral feeding studies	
Mallard duck	LD_{50} >10,000 ppm
Bobwaite quail	LD_{50} >10,000 ppm
Chickens	LD_{50} >4640 ppm
Reproduction studies (bobwhite quail and mallard duck)	No effects at 30 ppm
Mammalian hormone bioassay (mouse and rat)	No estrogenic, androgenic, anabolic or glucocorticoid activity

Environmental properties of methoprene (From Wright 1976)

Property	
Persistence in soil (1 lb/acre, 1.12 kg/ha)	Halflife < 10 days
Movement in soil	Remains in top few inches of soil
Persistence in water in field	Halflife < 2 days
Persistence in plants (1 lb/acre, 1.12 kg/ha)	
Alfalfa	Halflife < 2 days
Rice	Halflife < 1 day
Uptake by plants	Wheat did not take up residues from treated soil
Fate in food chain	Does not accumulate in food chain
Fate in animals (mice, rats, guinea pigs, steers or cows)	Rapidly metabolised and eliminated
Fate in fish (natural field conditions)	No accumulation
Effects on non-target insects	No deleterious effects on non-target species

3. WATER SURFACE FILMS

INTRODUCTION. Water Surface Film larvicides spread across water surfaces and disrupt larval respiration, killing mosquitoes and some other classes of air-breathing aquatic insects. Water surface film larvicides used by the District include specially refined petroleum distillates (Golden Bear 1111) and ethoxylated Isostearyl Alcohols (Agnique). In addition to being safe and selective agents effective for the control of younger larval instars, these are the only currently registered larvicides used by the District that are effective against mosquito pupae. Therefore, when timely larval control is not possible or not successful, pupal control can usually be achieved using these products.

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

GB-1111 provides effective control on a wide range of mosquito species. Applied to breeding areas, GB-1111 is an effective material against any mosquito larvae and pupae obtaining atmospheric oxygen at the water surface. It can even be effective in treating adult mosquitoes as they emerge. Where pupal density is high, or where warm water indicates that this will occur soon, GB-1111 is used unless other materials are required by site-specific protocols or other application criteria. Low dosages (1 gallon per acre) of oil work slowly, especially in cold water, and can take 4 to 7 days to give a complete kill. Higher dosage rates are sometimes used (up to 5 gallons per acre) to lower the kill time. It is typically applied by hand, ATV, or truck and aerial application is possible for large areas, but is not routine. The District applied about 1,645 gallons of GB 1111 to the entire Service Area during 1998, and has not applied over 2,000 gallons during any calendar year.

POTENTIAL ENVIRONMENTAL IMPACTS OF GB-1111. Little information has been published on the potential environmental impacts of this pesticide. GB-1111 was reregistered as a mosquito larvicide by the California Department of Pesticide Registration on April 20, 1999 (DPR 1999), and subsequent consultations with the Registration Specialist for this material at DPR indicate that the Department did not find evidence that GB-1111 has any potential significant environmental impacts when applied under label requirements and District application protocols (Duane Schnabel, DPR, pers. comm. May, 1999).

Four studies by Tietze et al (1991, 1992, 1993, 1994) tested three species of fish (Inland Silversides, Mosquitofish, and Sheepshead Minnows) and a range of microorganisms and concluded that this larvicide is not toxic to the tested organisms at label application rates. Mulla and Darwazeh (1981) experimented with GB-1111 in small experimental ponds and found that benthic invertebrates were unaffected while populations of surface breathing insects were temporarily reduced following application of this larvicide. Lawlor (UC Davis, in prep., pers. comm 8/25/99) has recently completed a significant independent study of non-target effects of GB-1111, with financial assistance from USFWS, on the tidal marshes of Newark, CA, and observed the following effects: 1) surface breathing insect populations were reduced at the time of treatment; 2) this effect did not persist beyond a few days (= no residual pesticide effects); 3) those potentially affected animals with high mobility left the site, while some of those that could not leave died (especially water boatmen (Corixidae)); 4) overall populations of invertebrate species were not affected, apparently because of recolonization from neighboring untreated sites.

AGNIQUE: Agnique is the trade name for a recently reissued surface film larvicide, comprised of ethoxylated alcohol. To date, the District has not used Agnique, but may do so in the future. 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.

POTENTIAL ENVIRONMENTAL IMPACTS OF AGNIQUE. A number of efficacy and nontarget studies had been conducted on this material when it was registered under the name Aerosurf. The pesticide was reregistered in California in July 1999 and consultations with DPR indicate that the Department did not find evidence that Agnique has any potential significant environmental impacts when applied under label requirements and District application protocols (Duane Schnabel, DPR, pers. comm. May, 1999). Minor proprietary changes in preparation did not apparently change any of the material's potential environmental impacts, and therefore the earlier literature is referenced.

Most published studies conducted with this larvicide tested application rates of 3 to 100 times the maximum label rate. At these rates, no observable effect on mortality or development was noted in tests on green tree frogs, seven species of fresh and salt water fish, two species of shrimp, five species of water beetle, or one species each of fairy shrimp, crayfish, snail, polychaete worm, mayfly naiad, copepod, ostracod, or midge. In addition, no effect was seen on five species of plants. As with GB-1111, air (surface) breathing insects were temporarily adversely impacted. Waterboatmen, backswimmers, and one species of water beetle exhibited increased mortality at application rates above label limits. In addition, a clam shrimp, a crab, an amphipod, and one species of isopod exhibited minor to significant increases in mortality at levels several times the highest application rate allowed by the label. For more information, please see the accompanying table. It should be noted that the greater persistence of this material (up to two weeks) relative to GB-1111 can reduce the need for repeated applications, but might also increase the duration of suppression of other air-breathing insects. Because District larvicide protocols require application of larvicides only in areas with mosquito larvae, and because larval distribution is highly patchy (Service 1993), recolonization of impacted non-targets from unsprayed areas should still occur promptly.

Isostearyl Alcohol Ethoxylate
Monomolecular Surface Film
Non-target Effects

Species		Effects	Reference
Hyla cinerea (Hylidae)	Fresh-water green tree frog	6 month study; >10 x application rate: normal progression from tadpole to adult	Webber & Cochran
Hypostomus plecostomus Loricaariidae	Fresh water fish	6 month study; >10 x application rate: normal development	Webber & Cochran
Gambusia affinis Baird and Girard (Poeciliidae)	Fresh water mosquito fish	6 month study, >10 x application rate: normal development	Webber & Cochran
Fundulus confluentus Goode and Bean	Salt water fish	7 day study, >10 x application rate: normal development	Webber & Cochran
Fundulus grandis Baird and Girard	Salt water fish	7 day study, >10 x application rate: normal development	Webber & Cochran
Cyprinodon variegatus Lacepede (Cyprindodontidae)	Salt water fish	7 day study, >10 x application rate: normal development	Webber & Cochran
Poecilia latipinna Lesveur (Poeciliidae)	Salt water fish	7 day study, >10 x application rate: normal development	Webber & Cochran
Dormitator maculatus Bloch (Eleotridae)	Salt water fish	7 day study, >10 x application rate: normal development	Webber & Cochran
Fundulus similus (Baird and Girard)	Longnose killifish	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Palaemonetes pugio Holthius	Grass shrimp	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Palaemonetes paludosus (Gibbs)	Freshwater shrimp	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Uca spp.	Fiddler crab	96 hour static acute toxicity testing, 100x application rate: 3.3% mortality	Hester, Olson & Dukes
Procambarus spp.	Crayfish	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Gammarus spp.	Freshwaater amphipod	96 hour static acute toxicity testing, 100x application rate: 1.9% mortality	Hester, Olson & Dukes
Asellus spp.	Freshwater isopod	96 hour static acute toxicity testing, 100x application rate: 0.5% mortality	Hester, Olson & Dukes
Streptocephalus seali Ryder	Fairy shrimp	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Physa spp.	Snail	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes
Laeonereis culveri (Webster)	Polychaete	96 hour static acute toxicity testing, 100x application rate: 0% mortality	Hester, Olson & Dukes

Isostearyl Alcohol Ethoxylate
Monomolecular Surface Film
Non-target Effects

Callibaetis pacificus (Seeman)	Mayfly naiads	Field testing, 0.5 – 1.0 gallon/acre: no effects	Mulla, Darwazeh, Luna, 1983
Berosus metalliceps Sharp (Dytiscidae)	Diving beetle adults	Field testing, 0.5 – 1.0 gallon/acre: no effects	Mulla, Darwazeh, Luna, 1983
Copepods, Ostracods		Field testing, 0.5 – 1.0 gallon/acre: no effects	Mulla, Darwazeh, Luna, 1983
Chironomids	Midges, adults	Field testing, 0.5 – 1.0 gallon/acre: dead adults on water surface	Mulla, Darwazeh, Luna, 1983
Eulimnadia sp. Conchostraca: Limnadiidae	Clam shrimp	Field testing, 3 – 10x application rate: high mortality rates on day one post-treatment; complete recovery of population by day 3	Takahashi, Wilder, Miura, 1984
Corisella spp. Hemiptera: Corixidae	Corixids	Field testing, 3 – 10x application rate: high mortality rates on day one post-treatment; complete recovery of population by day 3	Takahashi, Wilder, Miura, 1984
Notonecta unifasciata	Nonectids	Field testing, 3 – 10x application rate: Low to moderate mortality rate on day one post-treatment; complete recovery of population by day 3	Takahashi, Wilder, Miura, 1984
Tropisternus spp.	Beetle adults	Field testing, 3 – 10x application rate: 36% mortality observed on day one post-treatment only at 10x application rate; complete recovery of population by day 3	Takahashi, Wilder, Miura, 1984
Tropisternus spp.	Beetle larvae	Field testing, 3 – 10x application rate: no effect observed	Takahashi, Wilder, Miura, 1984
Enorchrus sp.		Field testing, 3 – 10x application rate: no effect observed	Takahashi, Wilder, Miura, 1984
Laccophilus spp.		Field testing, 3 – 10x application rate: no effect observed	Takahashi, Wilder, Miura, 1984
Hygrotus sp.		Field testing, 3 – 10x application rate: no effect observed	Takahashi, Wilder, Miura, 1984

Isostearyl Alcohol Ethoxylate
Monomolecular Surface Film
Non-target Effects

Chironomids	Midges, larvae	Field testing, 3 – 10x application rate: no effect observed	Takahashi, Wilder, Miura, 1984
Avicenna germinan (Linn.)	Black mangrove	Field testing, 1 gallon/acre application rate: no effect observed	Hester, Dukes, Levy, Ruff, Hallmon, Olson, Shaffer
Batis maritima (Linn.)	Saltwort	Field testing, 1 gallon/acre application rate: no effect observed	Hester, Dukes, Levy, Ruff, Hallmon, Olson, Shaffer
Spartina laterniflora Loisel	Cordgrass	Field testing, 1 gallon/acre application rate: no effect observed	Hester, Dukes, Levy, Ruff, Hallmon, Olson, Shaffer
Sagittaria sp.	Arrowhead	Field testing, 1 gallon/acre application rate: no effect observed	Hester, Dukes, Levy, Ruff, Hallmon, Olson, Shaffer
Oryza sativa Linn. Var. mars	Rice	Field testing, 1 gallon/acre application rate: no effect observed	Hester, Dukes, Levy, Ruff, Hallmon, Olson, Shaffer

4. BACTERIAL (INGESTION) LARVICIDES

INTRODUCTION. The District uses two types of ingested toxins whose active ingredients are manufactured by bacteria. These control agents are often designated as Bacterial Larvicides. Their mode of action requires that they be ingested to be effective, which can make them more difficult to use than the contact toxins and water surface films. Bacteria are single-celled parasitic or saprophytic micro-organisms that exhibit both plant and animal properties, and range from harmless and beneficial to intensely virulent and lethal. A beneficial form, *Bacillus thuringiensis* (Bt), is the most widely used (especially in agriculture) microbial pesticide in the world. It was originally isolated from natural Lepidopteran (butterfly and moth) die-offs in Germany and Japan. Various Bt products have been available since the 1950's, and in 1976, Dr. Joel Margalit and Mr. Leonard Goldberg isolated from a stagnant riverbed pool in Israel, a subspecies of *B. thuringiensis* that had excellent mosquito larvicide activities. It was named *B.t.* variety *israelensis* (B.t.i.) and later designated *Bacillus thuringiensis* Serotype H-14. Either of these two designations may be found on the labels of many bacterial mosquito larvicide formulations used today. Another species of bacteria, *B. sphaericus*, also exhibits mosquito larvicidal properties.

BTI (*Bacillus thuringiensis* var. *israelensis*). B.t.i. organisms produce, when environmental conditions are favorable, five different microscopic protein pro-toxins packaged inside one larger protein container or crystal. The crystal is commonly referred to as delta (d-) endotoxin. If the d-endotoxin is ingested by a mosquito larva, these five proteins are released in the alkaline environment of the insect larval gut. The five proteins are converted into five different toxins if specific enzymes also are present in the gut. Once converted, these toxins destroy the gut wall, which leads to paralysis and death of the larvae. B.t.i. is toxic to larval stages of all genera of mosquitoes and to black flies (Simuliidae).

B.t.i. is grown commercially in large fermentation vats using sophisticated techniques to control environmental variables such as temperature, moisture, oxygen, pH and nutrients. The process is similar to the production of beer, except that B.t.i. bacteria are grown on high protein substrates such as fish meal or soy flour and the spore and delta endotoxin are the end products. At the end of the fermentation process, B.t.i. bacteria exhaust the nutrients in the fermentation machine, producing spores before they lyse and break apart. Coincidental with sporulation, the delta endotoxin is produced. The spores and delta endotoxins are then concentrated via centrifugation and microfiltration of the slurry. It can then be dried for processing and packaging as a solid formulation or further processed as a liquid formulation. Since some fermentation medium (e.g. fish meal) is always present in liquid formulations, they generally smell somewhat like the medium.

There are five basic B.t.i. 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. B.t.i. granules, pellets, and briquets are formulated from B.t.i. primary powders and an inert carrier. B.t.i. labels contain the signal word "CAUTION".

The amount of toxins contained within B.t.i. products are reported indirectly as the result of at least two different bioassays and are difficult to equate to one another. Prepared volumes of toxins are applied to living mosquito larvae and the resulting mortality produces through formulae numerical measures known as International Toxic Units (ITU's) and *Ae. aegypti* International Toxic Units (AA-ITU's). These measures are only roughly related to observed efficacy in the field, and are therefore inappropriate to consolidate and report on like other toxicants (active ingredients).

Bti is applied by the District as a liquid or sometimes bonded to an inert substrate (sand or 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 due to sensitivity to UV light. Kills are usually observed within 48 hours of toxin ingestion. As a practical matter, apparent failures are usually followed with oil treatments.

Timing of application is extremely important in operational use of bacterial toxins. Optimal benefits are obtained when treating 2nd or 3rd instar larvae. Treatments at other development stages may provide poor control. Since fourth instar mosquito larvae quit feeding prior to becoming pupae, it is necessary to apply B.t.i. prior to this point in their development. Although the details are poorly understood, evidence suggests that larvae also undergo a period of reduced feeding or inactivity prior to molting from 1ST to 2ND, 2ND to 3RD, and 3RD to 4TH instars. If we apply B.t.i at these points in their development, the toxic crystals may settle out of the water column before the larvae resume feeding, and with synchronous broods of mosquitoes, complete control failures may result. With asynchronous broods, efficacy may also be reduced. Therefore a disadvantage of using B.t.i. is the limited application window available.

BTI LIQUIDS. Currently, three commercial brands of B.t.i. 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 B.t.i. formulations discussed below.

B.t.i. liquid may also be combined with the Altosid Liquid Larvicide discussed earlier. This mixture is known as Duplex. Because B.t.i. 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 B.t.i. with methoprene (which is most effective when larvae are the oldest and largest or when you have various, asynchronous stages of one or more species) allows a District to use less of each product than they normally would if they would use one or the other. Financially, most savings are realized for treatments of mosquitoes with long larval development periods, asynchronous broods or areas with multiple species of mosquitoes.

BTI POWDERS. Aquabac Primary Powder, Vectobac TP and Bactimos WP brands of B.t.i. powders are available. The Vectobac TP label recommends using a calculated 3.2 to 6.4 oz (by weight)/acre in clean water, and up to 12.8 oz/acre in dirty water situations. The Bactimos WP label correspondingly recommends using 2 to 6 oz/acre and up to 12 oz/acre. Aquabac Primary Powder currently is labeled for manufacturing use only. However, the label is currently being amended by the EPA to allow end user applications in quantities similar to those of the other powder formulations. The District used approximately 158 pounds of Vectobac TP in 1998.

BTI SAND GRANULES. Labeling is available for both Vectobac and Bactimos B.t.i. powders to guide end users in making their own "On Site Sand Granules", and commercial formulations are also available. Sand formulations require coating the particles with an oil, such as GB-1111, and then applying dry B.t.i. powder which will stick to the oil. Because most target mosquito species graze at the water surface or within the water column, and not at the bottom, it is desirable to stick the powder to the sand in a way that B.t.i. is released upon contact with the water, and is thus available for the larvae. The District prepares its own Bti sand granules, in accordance with the label instructions, using Vectobac Technical Powder and GB1111. This is the primary Bti formulation used by the District, and the Bti used to prepare sand granules was included in the District's use of Bti Powders described in the previous paragraph.

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

ENVIRONMENTAL IMPACTS OF BTI. Products containing Bti are ideally suited for use in integrated mosquito management programs because the active ingredient has a highly specific mode of action and is therefore extremely selective. Bti does not interrupt activities of most beneficial insects and predators. Bti controls all larval instars provided they have not quit feeding, and can be used in almost any aquatic habitat with no restrictions. It may be applied to irrigation water and any other water sites except treated finished drinking water. Bti is fast acting and its efficacy can be evaluated almost immediately. It can kill larvae within 1 hour after ingestion, and since each instar must eat in order for the larvae to grow, that means Bti usually kills mosquito larvae within 48 hours of application. Bti leaves no residues, and it is quickly biodegraded. Resistance is unlikely to develop simultaneously to the five different toxins derived from the Bti delta-endotoxin since they have five different modes of action. This suggests that this mosquito larvicide will continue to be effective for many years.

Bti labels carry the CAUTION signal word, suggesting the material may be harmful if inhaled or absorbed through the skin. However, the 4-hr Inhalation LC 50 in rats is calculated to be greater than 2.1 mg/liter (actual) of air, the maximum attainable concentration. The acute Dermal LD 50 in rabbits is greater than 2,000 mg/kg body weight and is considered to be non-irritating to the eye or skin. That is equivalent to a 220 lb. individual spilling more than a half gallon of Bti liquid directly onto his/her skin or eyes and not washing it off. Toxicology profiles also suggest that the inert ingredients (not the Bti) in liquid formulations, may cause minor eye irritation in humans. The acute Oral LD 50 in rats is greater than 5,000 mg/kg body weight (similar to an individual drinking over 5 quarts) suggesting the material is practically non-toxic in single doses. Common table salt has an LD 50 of 4,000 mg/kg of body weight.

Bti applied at label rates has virtually no adverse effects on applicators, livestock, or wildlife including beneficial insects, annelid worms, flatworms, crustaceans, mollusks, fish, amphibians, reptiles, birds or mammals (deBarjac et al 1980, Garcia et al 1981, Gharib and Hilsenhoff 1988, Holck and Meek 1987, Knepper and Walker 1989, Leclair et al 1988, Marten et al 1993, Merritt et al 1989, Molloy et al 1992, Miura et al 1980, Mulla et al 1983, Mulla et al 1982, Purcell 1981, Reish et al 1985, Shadduck 1980, Siegel et al 1987, Tietze et al 1993,1992,1991, Tozer and Garcia 1990). However, non-target activity on larvae of insect species normally associated with mosquito larvae in aquatic habitats has been observed. There have been reported impacts in larvae belonging to the midge families Chironomidae, Ceratopogonidae, and Dixidae (Anderson et al 1996, Molloy 1992, Mulla et al 1990, Rodcharoen et al 1991, Tozer and Garcia 1990). These non-target insect species, taxonomically closely related to mosquitoes and black flies, apparently contain the necessary gut pH and enzymes to activate delta-endotoxins. However, the concentration of Bti required to cause these effects is 10 to 1,000 times higher than maximum allowed label rates.

Bacterial spores of Bti are uniquely toxic to nematoceran Diptera (mosquitoes, midges, blackflies, psychodids and ceratopogonids) (Lacey and Mulla 1990). That result was reported after reviewing Bti studies conducted using a variety of Bti formulations and under a variety of test conditions. Lacey and Mulla (1990) concluded that Bti was a highly selective larvicide that produced minimal adverse impact on the environment. Garcia et al. (1981) tested a total of 23 species of aquatic organisms other than mosquito larvae using various formulations of Bti in his laboratory. No mortality was observed for these species with the exception of *Chironomus maturus* which showed a degree of susceptibility similar to that of mosquito larvae. Miura et al. (1980) found Bti at rates used for mosquito control to be very safe to organisms associated with mosquito breeding habitats. A total of 28 species or species groups were treated with the bacterium under simulated or field conditions, with no adverse effects observed, except for chironomid larvae, which were slightly affected. However, the effect was so light that the population in the field continuously increased after the treatment. Miura et al. (1981) found Bti and *Bacillus sphaericus*, when applied at rates used for mosquito control, very safe to organisms associated with mosquito breeding habitats, including natural enemies of mosquito larvae. When various aquatic organisms were exposed to the bacteria under laboratory, simulated or field conditions, no adverse effect was noted on the organisms with the exceptions of chironomid and psychodid larvae. Chironomid larvae were slightly affected by Bti treatment at a rate used for mosquito control but pyschodid larvae were only affected at the higher concentration (50ppm).

After testing mice, rats and rabbits, Siegal et al. (1987) concluded that Bti was not a virulent mammalian pathogen and that it could be used safely in environments where human exposure was likely to occur. Key and Scott (1992) conducted laboratory studies with Bti and *Bacillus sphaericus* against the grass shrimp *Palaemonetes pugio* and the mummichog *Fundulus heteroclitus*. Their study indicated that both Bti and *B. sphaericus* larvicides have large margins of safety. In a study by Aly and Mulla (1987), aquatic mosquito predators were fed with *Cx. quinquefasciatus* Say fourth-instar larvae intoxicated with either Bti or *Bacillus sphaericus* preparations. Although the mosquito larvae contained large amounts of the bacterial preparations in their gut, no effect upon longevity or ability to molt was observed in the backswimmer *Notonecta undulata*, in naiads of the dragonfly *Tarnetrum corruptum*, or in naiads of the damselfly *Enallagma civile*. Equally, the reproduction of *N. undulata* and the predation rate and ability to emerge normally in *T. corruptum* and *E. civile* were not affected by ingestion of large amounts of bacterial toxins.

At extremely high doses, negative effects of Bti were obtained when solubilized parasporal crystalline proteins were injected into the intra-abdominal space of Japanese quail (Kallapur et al., 1992). Exposure of brook trout *Salvelinus fontinalis* fry to 4500 and 6000 mg/liter Teknar for 45 min resulted in 20 and 86.4% mortality, respectively (Fortin et al., 1986). Again, it should be noted that the rates tested were more than 50X the allowed label rate for mosquito control.

Organisms not susceptible to *Bacillus thuringiensis israelensis*

Higher order	Genus and species	Common name	Reference
ACARI	*Hydrachnella* sp.		Becker and Margalit 1993
	Hydracarina sp.	mite	Beck 1982
	Hydrachna sp.	mite	
AMPHIBIANS	*Hylo regilla*	tree frog tadpole	Abbott Laboratories; Garcia *et al.* 1980
	Bufo sp.	toad tadpole	
	Bufo bufo		Becker and Margalit 1993
	Bufo viridis		
	Bufo calamita		
	Taricha torosa	California newt	Abbott Laboratories; Garcia *et al.* 1980
	Rana temporaria		Paulov 1985a & b
	Triturus alpestris		Becker and Margalit 1993
	Triturus vulgaris		
	Triturus cristatus		
	Bombina variegata		
	Rana esculenta		
FISH	*Gambusia affinis*	mosquito fish	Abbott Laboratories; Garcia *et al.* 1980
	Lucania parva	rainwater killifish	
	Gasterosteus wheatlandi	twospine stickleback	
	Lepomis macrochirus	bluegill	Christensen 1990a
	Salvelinus fontinalis	brook trout	Wipfli *et al.* 1994
	Salmo trutta	brown trout	
	Oncorhynchus mykiss	rainbow trout	Wipfli *et al.* 1994; Christensen 1990b
	Pseudomugil signifer	Pacific blue-eye fish	Brown *et al.* 1998
	Poecilia reticulata	larvivorous fish	Mittal *et al.* 1994
	Tilapia nilotica		Lebrun and Vlayen 1981
	Esox lucius		Becker and Margalit 1993
	Cyprinus carpio		
	Perca fluviatilis		
	Ambloplites rupestris	rock bass	Merritt *et al.* 1989
	Epiplatys sp.	killifish	Beck 1982
	Cyprinoidei	goldfish	
	Cyprinodon variegatus	sheephead minnow	Christensen 1990c
CRUSTACEANS	*Orconectes limosus*	crayfish	Becker and Margalit 1993
	Amphipoda		
	Gammaridae sp.	scuds	Abbott Laboratories; Garcia *et al.* 1980
	Hyalella azetaca	sideswimmer	Abbott Laboratories; Garcia *et al.* 1980
	Gammarus duebeni	Salt-marsh	Roberts 1995
	Gammarus pulex	crustaceans	Becker and Margalit 1993
	Hyallela azteca		Gharib and Hilsenhoff 1988
	Palaemonidae		
	Leander tenuicornis		Brown *et al.* 1996
	Palaemonetes varians		Roberts 1995
	Decapoda		
	Hemigrapsus sp.	purple shore crab	Abbott Laboratories; Garcia *et al.* 1980
	Anostraca		
	Artemia salina	fairy shrimp	Abbott Laboratories; Garcia *et al.* 1980
	Conchostracans		
	Eulimnadia texana	clam shrimp	Mulla 1990
	Cladocera		
	Simocephalus vetulus	water flea	Abbott Laboratories; Garcia *et al.* 1980
	Daphnia		Ali 1981
	Daphnia magna		Lebrun and Vlayen 1981
	Daphnia pulex		Becker and Margalit 1993
	Moina rectirostris		Mulla 1990

	Moina macrocopa		Beck 1982
	Chirocephalus grubei	anostacan snail	Becker and Margalit 1993
	Ostracoda		
	Ostracoda		Becker and Margalit 1993; Ali 1981
	Cypridae sp.	seed shrimp	Abbott Laboratories; Garcia *et al.* 1980
	Copepoda		
	Macrocyclops sp.	copepods	Abbott Laboratories; Garcia *et al.* 1980
	Macrocyclops albidus	Larvivorous	Marten *et al.* 1993
	Mesocyclops longisetus	copepods	
	M. ruttneri		
	Acanthocyclops vernalis		
	Cyclops spp.		Ali 1981; Beck 1982
	Cyclops strenuus		Becker and Margalit 1993
	Isopoda	marine sow bug	Abbott Laboratories; Garcia *et al.* 1980; Knepper and Walker 1989
	Asellus aquaticus		Becker and Margalit 1993
INSECTS	Ephemeroptera		
	Baetis sp.		Ali 1981
	Callibaetis sp.	mayfly nymphs	Abbott Laboratories; Garcia *et al.* 1980
	Callibaetis pacificus		Mulla 1990
	Stenonema		Merrit *et al.* 1989
	Cloeon dipterum		Becker and Margalit 1993
	Leptoplebia sp.		Beck 1982
	Caenis lactea		
	Ephemera danica		
	Odonata		
	Ischnura sp.	damselfly nymphs	Abbott Laboratories; Garcia *et al.* 1980
	Anax sp.		
	Erythemis simplicicollis		Painter *et al.* 1996
	Tarnetrum corruptum		Aly and Mulla 1987
	Enallagma civile		
	Ischnura elegans		Becker and Margalit 1993
	Symetrium striolatum		
	Orthetrum brunneum		
	Cordulia sp.	dragonfly nymph	Beck 1982
	Hemiptera		
	Trichocorixa reticulata	water boatmen	Abbott Laboratories; Garcia *et al.*, 1980
	Hesperocorixa leavigata		
	Trichocorixa		
	Corixidae		
	Bueona scimitra	backswimmer	Abbott Laboratories; Garcia *et al.* 1980
	Notonecta kirby	backswimmer	Abbott Laboratories; Garcia *et al.* 1980
	Notonecta undulata	backswimmers	Aly and Mulla 1987
	Notonecta glauca		Beck 1982; Olejnicek and Maryskova 1986
	Buenoa antigone		Quiroz-Martinez *et al.* 1996
	Pleidae	pygmy backswimmer	Abbott Laboratories; Garcia *et al.* 1980
	Micronecta meridionalis		Becker and Margalit 1993
	Sigara striata	water bug	Beck 1982; Becker and Margalit 1993
	Sigara lateralis		
	Ranatra sp.		Beck 1982
	Ilyocoris cimicoides		Becker and Margalit 1993
	Anisops varia		
	Heteroptera		
	Plea leachi		Becker and Margalit 1993

Coleoptera		
Tropisternus salsamentus	scavenger and predaceous water beetle	Abbott Laboratories; Garcia *et al.* 1980
Peltodytes edentulus,		Gharib and Hilsenhoff 1988
Haliplus immaculicollis		
Hydroporus undulatus		
Laccophilus maculosus		
Tropisternus sp.		Abbott Laboratories; Garcia *et al.* 1980
Dytiscidae		Abbott Laboratories; Garcia *et al.* 1980
Hyphydrus ovatus		Becker and Margalit 1993
Guignotus pusillus		
Coelambus impressopunctatus		
Hygrotus inaequalis		
Hydroporus palustris		
Ilybius fuliginosus		
Rhantus pulverosus		
Rhantus consputus		
Hydrobius fuscipes		
Anacaena globulus		
Hydrophilus caraboides		
Berosus signaticollis		
Bombyx mori		Nataraju *et al.* 1993
Baeosus sp.	beetles	Beck 1982
Coelambus sp.		
Gyrinidae sp.		
Laccophilus sp.		
Trichoptera		
Mystacides alafunbriata	caddisfly larvae	Abbott Laboratories; Garcia *et al.* 1980
Several species	caddisfly nymphs	Abbott Laboratories; Garcia *et al.* 1980
Limnephilus flavicornis (F.),	caddisfly	Lebrun and Vlayen 1981
Limnophilus sp.		Becker and Margalit 1993
Phryganea sp.		
Diptera		
Ephydra riparia complex	brinefly larvae	Abbott Laboratories; Garcia *et al.* 1980
Dicraneta sp.	cranefly larvae	
Chelifera sp.	dancefly larvae	
Musca domestica	housefly	Vankova 1981; Larget *et al.* 1981
Procladius freemani	tanypodine midges	Mulla *et al.* 1990
P. sublettei		
Tanypus sp.		
Chanoborus sp.	gnat	Beck 1982
Drosophila melanogaster	fruit fly	
Erioischia brassicae	cabbage maggot	
Toxorhynchites splendens	predatory mosquito	
Culicoides sp.	predatory midge	
Chironomus plumosus	midge	
Chironomid larvae		
Lucilia cuprina		Akhurst *et al.* 1997
Plecoptera		
Several species	stonefly nymphs	Garcia *et al.* 1980; Kreig *et al.* 1980
Hymenoptera		
Apis mellifera	honey bee	Abbott Laboratories; Garcia *et al.* 1980
Trichogramma evanescens	egg parasite	Beck 1982

FLATWORMS	**Tubellaria**		
	Dugesia dorotocephala	flatworm	Abbott Laboratories; Garcia *et al.* 1980
	Dugesia tigrina		Becker and Margalit 1993
	Bothromesostoma personatum		
	Platyhelminthes		
	Dugesia tigrina	planarian flatworm	Beck 1982
EARTHWORMS	**Nadididae**	earthworms	Abbott Laboratories; Garcia *et al.* 1980
	Lumbricidae		
	Tubifex sp.		Becker and Margalit 1993
	Helobdella stagnalis	Leech	
	Oligochaeta	roundworm	Beck 1982
NEMATODA	*Neoaplectana carpocapsae*	entomopathogenic	Poinar *et al.* 1990
	Heterorhabditis heliothidis	nematodes	
MOLLUSCS	Gastropoda		Abbott Laboratories; Garcia *et al.* 1980
	Physa sp.	freshwater snail	
	Pelecypoda sp.	mussels	
	Taphius glabratus	snail	Larget *et al.* 1981
	Physa acuta		Becker and Margalit 1993
	Anisus leucostomus		
	Bathyomphalus contortus		
	Hippeutis complanatus		
	Pisidium sp.		
	Aplexa hypnorum	moss bladder snail	Beck 1982; Becker and Margalit 1993
	Galba palustris	marsh snail	
	Bithynia tentaculata	snail	Beck 1982
	Planorbis planorbis	snail	
	Radix sp.	ear pond snail	Beck 1982
	Vivparus contectus	snail	
	Ostrea edulis	oyster	
	Mytilus edulis	blue mussel	
Cnidaria			
	Hydra sp.		Becker and Margalit 1993
Rotatoria			
	Brachionus calyciflorus	zooplankton	Becker and Margalit 1993

Abbott Laboratories: from 1993 publicity on VectoBac®.

BACILLUS SPHAERICUS. *Bacillus sphaericus* is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments. This bacterium is also grown in fermentation vats and formulated for application using processes similar to that of Bti. Some strains produce a protein endotoxin at the time of sporulation. This endotoxin destroys the insect's gut in a way similar to Bti and the toxin is only active against the feeding larval stages and must be partially digested before it becomes activated. The District does not use *Bacillus sphaericus* presently, but may apply it in some circumstances in the future.

At present, the molecular action of *B. sphaericus* is now well understood. Isolation and identification of the primary toxin responsible for larval activity has demonstrated that it is a protein with a molecular weight of 43 to 55 kD. A standard bioassay similar to that used for Bti has been developed to determine preparation potencies. The bioassay utilizes *Culex quinquefasciatus* 3rd to 4th instar larvae.

B. sphaericus adversely affects larval mosquitoes but, in contrast to Bti, is virtually non-toxic to Black Flies (Simulidae). *Culex* species are the most sensitive to *Bacillus sphaericus*, followed by *Anopheles* and some *Aedes* species. In California, *Culex* spp. and *Anopheles* spp. may be effectively controlled. Several species of *Aedes* have shown little or no susceptibility, and salt marsh *Aedes* species are not susceptible. *B. sphaericus* differs from Bti in being able to control mosquito larvae in highly organic aquatic environments, including sewage waste lagoons, animal waste ponds, and septic ditches. Also in contrast to Bti, field evaluations of VectoLex-CG (a commercial formulation of *B. sphaericus*) have shown environmental persistence for 2-4 weeks, and the ability to recycle (grow and reproduce). Persistence varies with a number of environmental parameters, and is low in saline or highly-organic environments.

VECTOLEX CG. VectoLex-CG is the trade name for Abbott Laboratories' granular formulation of *B. sphaericus* (strain 2362). The product has a potency of 50 BSITU/mg (*Bacillus sphaericus* International Units/mg) and is formulated on a 10/14 mesh ground corn cob carrier. The VectoLex-CG label carries the "CAUTION" hazard classification. VectoLex-CG is intended for use in mosquito breading sites that are polluted or highly organic in nature, such as dairy waste lagoons, sewage lagoons, septic ditches, tires, and storm sewer catch basins. VectoLex-CG is designed to be applied by ground (by hand or truck-mounted blower) or aerially at rates of 5-10 lb./acre. Best results are obtained when applications are made to larvae in the 1st to 3rd instars. Use of the highest rate is recommended for dense larval populations. Larval mortality may be observed as soon as a few hours after ingestion but typically takes as long as 2-3 days, depending upon dosage and ambient temperature.

ENVIRONMENTAL IMPACTS OF BACILLUS SPHAERICUS. *B. sphaericus* has been extensively tested and has had no adverse effects on mammals or other non-target organisms. *B. sphaericus* technical material was not infective or pathogenic when administered as a single oral, intravenous or intratracheal dose to rats (Shadduck et al, 1980; Siegel and Shadduck, 1990). No mortalities or treatment-related evidence of toxicological effects were observed. The acute oral and dermal LD 50 values are greater than 5000 mg/kg and greater than 2000 mg/kg, respectively. The technical material is only moderately irritating to the skin and eye. Oral exposure of *B. sphaericus* is practically nontoxic to mallard ducks. No mortalities or signs of toxicity occurred following a 9000 mg/kg oral treatment. Birds fed diets containing 20% w/w of the technical material experienced no apparent pathogenic or toxic effects during a 30-day treatment period. Mallards given an intraperitoneal injection of *B. sphaericus* demonstrated toxicologic effects including hypoactivity, tremors, ataxia and emaciation. The LD 50 value was greater than 1.5 mg/kg.

Acute aquatic fresh water organism toxicity tests were conducted on bluegill sunfish, rainbow trout and daphnids. The 96 hour LC 50 and NOEC (No Observable Effect Concentration) value for bluegill sunfish and rainbow trout was greater than 15.5 mg/liter; the 48 hour EC 50 and NOEC value for daphnids was greater than 15.5 mg/liter. Acute aquatic saltwater organism toxicity tests were conducted on sheepshead minnows, shrimp and oysters. The 96 hour LC 50 value for both sheepshead minnows and shrimp was 71 mg/liter, while the NOEC value was 22 mg/liter for sheepshead minnows and 50 mg/liter for shrimp. The 96-hour EC 50 value for oysters was 42 mg/liter with a NOEC of 15 mg/liter. The LC 50 and NOEC value for immature mayflies was 15.5 mg/liter. Honeybees exposed to 10E4-10E8 spores/ml for up to 28 days demonstrated no significant decrease in survival when compared to controls. Additional studies on various microorganisms and invertebrates, specifically cladocerans, copepods, ostracods, mayflies, chironomid midges, water beetles, backswimmers, water boatmen, giant water bugs, and crawfish, have shown no adverse effects or negative impacts (Holck and Meek 1987, Miura et al 1981, Mulla et al 1984, Rodcharoen et al 1991, Walton and Mulla 1991, Key and Scott 1992, Tietze et al 1993). Furthermore, Ali (1991) states that although *B. sphaericus* is known to be highly toxic to mosquito larvae, *B. sphaericus* does not offer any potential for midge control. Acute toxicity of *B. sphaericus* to non-target plants was also evaluated in green algae. The 120-hour EC 50 and NOEC values exceed 212 mg/liter.

5. LARVICIDING TECHNIQUES AND EQUIPMENT

Because of the wide range of mosquito sources in the Service Area, and the variety of pesticide formulations described above, the District uses a variety of techniques and equipment to apply larvicides, including hand held sprayers and spreaders, truck- or ATV-mounted spray rigs, and helicopters or other aircraft. For a brief description of these application methods, see Durso (1996). District criteria for selecting application methods are attached.

Ground Application Equipment. The District uses conventional pick-up trucks, ARGO and Polaris All Terrain Vehicle's (ATV's) as larvicide vehicles. A chemical container tank, high pressure, low volume electric or gas pump, and spray nozzle are mounted in the back of the truck bed, with a switch and extension hose allowing the driver to operate the equipment and apply the larvicide from the truck's cab. The ATV's have a chemical container mounted on the vehicle, a 12 volt electric pump supplying high pressure low volume flow, and booms and/or hoses and spray tips allowing for application while steering the vehicle. ATV's are ideal for treating areas such as agricultural fields, pastures, and other off-road sites. Additional training in ATV safety and handling is provided to employees before operating these machines.

Additional equipment used in ground applications include hand held sprayers and backpack blowers. Hand held sprayers (hand cans) are standard one or two gallon garden style pump-up sprayers used to treat small isolated areas. Backpack sprayers are gas powered blowers with a chemical tank and calibrated proportioning slot. Generally a pellet or small granular material is applied with a backpack sprayer or "belly grinder" machine designed to distribute pellets or granules.

There are several advantages of using ground application equipment, both when on foot and when conveyed by vehicles. Ground larviciding allows applications while in close proximity to the actual treatment area, and consequently treatments to only those micro habitats where larvae are actually present. This also reduces both the unnecessary pesticide load on the environment and the financial cost of the amount of material used and its application. Both the initial and the maintenance costs of ground equipment is generally less than those for aerial equipment. Ground larviciding applications are less affected by weather conditions than are aerial applications.

However, ground larviciding is impractical for large or densely wooded areas. There is also a greater risk of chemical exposure to applicators than there is during aerial larviciding operations. Damage may occur from the use of a ground vehicle in some areas. Ruts and vegetation damage may occur, although both these conditions are reversible and generally short-lived. Technicians are trained to recognize sensitive areas and to use good judgement to avoid significant impacts.

Aerial Application Equipment. When large areas are simultaneously producing mosquito larvae at densities exceeding District treatment thresholds, then the District may use helicopters or other aircraft to apply any of the larvicides discussed above. The District contracts with independent flying services to perform aerial applications, with guidance to the target site provided by District staff. Aerial application of larvicides is a relatively infrequent activity for the District, typically occurring only a few times each year, with each application covering up to a few hundred acres. However, larval production can vary substantially and the District is capable of undertaking more frequent or extensive operations.

There are three advantages to using fixed or rotary wing (helicopter) aerial larvicide application equipment compared to ground application. First, it can be more economical for large target areas with extensive mosquito production. Second, by covering large areas quickly, it can free District staff to conduct other needed surveillance or control. Third, it can be more practical for remote or inaccessible areas, such as islands and large marshes, than ground larviciding. However, there is a greater risk of drift with aerial applications, especially with liquid or ULV (Ultra Low Volume) aerial larviciding, and consequently there is more potential risk of non-target exposure. In addition, accuracy in hitting the target area temporarily requires additional manpower for flagging or expensive electronic guidance systems, which can increase costs. Finally, in addition to the timing constraints inherent in most larvicide use, the potential application window can be very narrow for aerial activities due to weather conditions.

6. MANAGING LARVICIDE RESISTANCE.

Selecting the proper class of larvicide and the formulation are both important in pesticide resistance management. For example, use of sub-lethal dosages (below the lower end of the label recommended application rates) may encourage resistance. Insects with inherent tolerances for weakly applied pesticides may survive to produce tolerant offspring. Also, use of extended-release formulations beyond their recommended use period may encourage resistance by exposing mosquitoes to sub-lethal concentrations of active ingredients.

7. LARVICIDES AND OTHER CONTROL OPTIONS.

Currently used mosquito larvicides, when applied properly, are efficacious and environmentally safe. These agents have been successfully integrated into the District's programs. Historically, Mosquito and Vector Control Districts have usually viewed larviciding as less effective or less economical than physical control, water management, or biological control; and as more effective than adulticiding. However, this view developed long ago when the values of wetlands were not as widely recognized as they are today, and when relative control costs were different. To some extent, this philosophy has been evolving in recent decades as more selective larvicides have become available, and as physical and biological control have become more constrained by regulatory requirements. While it can be hard to compare the relative environmental impacts of different control strategies, it is now increasingly common to primarily use selective larvicides in relatively undisturbed sites, and to emphasize physical control and biological control primarily in man-made or disturbed areas.

Compared to adulticides, larvicides are generally more selective and pose less risk for drift. Larvicides are usually applied directly into natural and man-made aquatic habitats as liquid or solid formulations, and aerial drift is negligible. Drift in water can result from flushing or rainwater runoff, but under these conditions, rapid environmental breakdown and dilution reduce pesticide concentration and consequently minimizes exposure to non-target organisms.

D. Chemical Control of Adult Mosquitoes

1. INTRODUCTION

When physical, biological, and chemical control of larval mosquitoes fails or is otherwise insufficient, the District periodically uses insecticides to directly reduce populations of adult mosquitoes (adulticiding). When adult mosquito populations exceed District thresholds (see flow chart at the end of this Section), District staff use ULV (Ultra Low Volume) sprayers to generate aerosol mists of very small insecticide droplets, which are allowed to intentionally drift into and across areas harboring the target species. Insecticides for control of adult mosquitoes are known as adulticides, and the District can select from a variety of materials registered for this purpose. District staff can also choose from a variety of adulticide application equipment, ranging from hand-held to vehicle-mounted to aerial spray rigs. Please note the distinction between "aerosol" pesticide applications, which describe all District adulticiding activity, and "aerial" pesticide applications, which refer to any application of pesticides from aircraft, regardless of the target.

The effectiveness and efficiency of adulticiding depends on a number of related factors. First, the mosquito species to be treated must be susceptible to the insecticide applied. Some California mosquitoes are resistant or more tolerant to some adulticides thus affecting the selection of chemical. Second, insecticide applications must be made during periods of adult mosquito activity, which varies between species. Some species of mosquitoes are diurnal (biting in the daytime), others are crepuscular (biting at dawn or dusk), and still others are nocturnal (biting at night). Aerosol applications should be made when the target mosquitoes are flying and are maximally exposed to the aerosol mist. District criteria emphasize adulticiding as a technique to reduce populations of *Cx. tarsalis* (the primary vector of encephalitis) and *Ae. sierrensis* (the primary vector of dog heartworm), which are primarily crepuscular species. Therefore, District adulticiding activity primarily takes place at dawn and dusk.

In addition, technical considerations can influence adulticide effectiveness. First, the application must generate a pesticide concentration in the air that is lethal to the target insect. Second, since the aerosol mist must move from the sprayer to the target mosquitoes; the size of the pesticide droplets is critical to ensure proper movement without rapid evaporation, settling to the ground, or drift away from the target site. Studies have shown that droplets within the 8-15 micron diameter range are most effective in controlling adult mosquitoes (Mount 1998). Third, whether the treatment is ground or aerially applied, sufficient insecticide must be distributed to cover the target site with an effective dose. Densely vegetated habitats may require a higher application rate than open areas to allow the wind to sufficiently carry droplets through the foliage.

Finally, environmental conditions may also affect the results of adulticiding. Wind determines how the ULV droplets will be moved from the sprayer to and within the treatment area. Conditions of no wind will result in the material not moving from the application point. High wind can inhibit mosquito activity and will quickly disperse the insecticide too widely to be effective. Light wind conditions (1-10 mph) are the most desirable both because mosquitoes are most likely to be active and because the aerosol is most likely to maintain the proper concentration as it moves through the target area. Also, ULV applications are generally avoided during hot daylight hours because thermal conditions will cause small droplets to rise, moving them away from mosquito habitats and flight zones. Preferred conditions include the presence of a thermal inversion near the ground, which can trap the aerosol in a mist in the lower ten or twenty feet of the atmosphere, maintaining the proper control dose with minimal material use. Ideal conditions of wind and temperature are generally found around sunrise or sunset, and adulticiding is usually conducted during these times. This practice minimizes exposure of non-target diurnal species such as bees or butterflies. Control of adults of some mosquito species may require modifications of this schedule to accommodate the species flight activity pattern.

District criteria on the use of ULV treatments are attached, and address mosquito species composition and abundance, pathogen (disease organism) presence, proximity of mosquitoes to human populations, presence of an open (no people) target area, and weather conditions (see attached pages). As with larvicides, adulticides are applied in strict conformance with label requirements.

The adulticide routinely used by the District is Pyrethrum (= Pyrethrins; MGK Pyrocide® -- about 23.8 gallons applied in 1998). The synthetic pyrethroids Resmethrin and Permethrin have not been used by the District in the last five years, but might be used under some circumstances.

2. PYRETHRINS AND PYRETHROIDS

INTRODUCTION Pyrethrin (pyrethrum) is a natural insecticide extracted from certain varieties of the flower *Chrysanthemum cinerariaefolium* and consists of six active ingredients collectively known as pyrethrins (Worthing & Hance 1991). This material provides effective control of adult mosquitoes and other insect pests at very low dosage and has little residual activity (persistence) due to its sensitivity to sunlight. The flowers are grown commercially in parts of Africa and Asia. Synthetic analogues of the natural pyrethrins reached commercial success in the 1950's. Like the natural pyrethrins, 'first generation' synthetic pyrethroids such as phenothrin and tetramethrin, are relatively unstable when exposed to light. During the 1960's-1970's, great progress was made in synthetic light-stable pyrethroids. These photostable pyrethroids represent the 'second generation' of these compounds. However, the low persistence of natural pyrethrum means that it is often required in agricultural areas, despite its significantly higher cost.

Pyrethrins and pyrethroids exhibit rapid knockdown and kill of adult mosquitoes, characteristics that are considered a major benefit of their use. The mode of action of these compounds relates to their ability to affect sodium channel function in the insects' neural membranes. Their toxicity in insects is markedly increased by the addition of synergists (primarily piperonyl butoxide) which inhibit detoxification of the pyrethrins in insects. There is no evidence that these synergists increase toxicity in mammals.

Pyrethrins and synthetic pyrethroids are not cholinesterase inhibitors, are non-corrosive and will not damage painted surfaces. They are less irritating than other mosquito adulticides and have a less offensive odor. In comparison to other adulticides, pyrethroids may be effectively applied at much lower rates of active ingredient per acre.

NATURAL PYRETHRINS: MGK Pyrocide and Pyrenone Crop Spray are California-registered natural pyrethrin formulations, with labels containing a CAUTION statement. MGK Pyrocide contains 5% pyrethrin and 25% piperonyl butoxide, while Pyrenone Crop Spray contains 6% pyrethrins and 60% piperonyl butoxide. MGK Pyrocide is applied as a ULV spray with a dosage per acre of typically 0.87 oz/acre (equivalent to 0.0027lbs of pyrethrins and 0.0135 pounds of piperonyl butoxide per acre). The Pyrenone label is less restrictive, but District protocols result in similar doses of active ingredient and synergist.

RESMETHRIN. Resmethrin is a 1st generation synthetic pyrethroid and is the active ingredient in Scourge. Resmethrin provides rapid knockdown and quick kill of all species of adult mosquitoes, and is also effective against many other flying or crawling insects, although it is slower acting than natural pyrethrins. Resmethrin exhibits very low mammalian toxicity, degrades very rapidly in sunlight and provides little or no residual activity. Resmethrin products are available in several concentrations that range from 1.5% to 40% and may or may not contain piperonyl butoxide.

Scourge contains 4.14% Resmethrin, 12.54% piperonyl butoxide, 5% aromatic petroleum solvent (a mixture of hydrocarbons) and other inert ingredients. Scourge is labeled with the signal word "Caution", and has a maximum rate of application of 0.007 lbs per acre of the active ingredient.

PERMETHRIN. Permethrin is a second-generation synthetic pyrethroid with a broad spectrum of activity against all mosquito species. It exhibits fast action, low volatility, good photostability, low solubility in water, no odor, and low mammalian toxicity. Its photostability means that permethrin provides some residual activity when applied directly to surfaces. It is formulated as the active ingredient in products such as Permanone and Biomist. Permethrin is a general use pesticide with labels that may contain either the signal word WARNING (Category 2) or CAUTION (Category 3) depending on the particular product. The District does not use Category 2 pesticides except in emergency circumstances. Permethrin products are available in various concentrations, from 1.5% to 57% and may or may not be synergized with piperonyl butoxide. Synergized permethrin products may contain piperonyl butoxide in various ratios by weight but the maximum rate of application is 0.007 lbs. per acre of the active ingredient.

3. ADULTICIDING TECHNIQUES AND EQUIPMENT

The District applies adulticides, when needed, primarily from truck mounted ULV aerosol equipment, and occasionally from hand-held or ATV-mounted ULV equipment. Adulticide application from the air is possible, but would be used by the District only in emergency conditions. Therefore, aerial aerosol applications are not evaluated in this review.

ULV aerosol machines ("cold foggers") use a forced air blower to generate a fine mist of technical (pure) or highly concentrated insecticide. ULV machines come in a wide variety of sizes, and 8-12 horsepower blowers are most common. Unlike earlier "thermal foggers", ULV sprayers use no oil diluent, and their name is derived from the very low volumes of total material sprayed per acre treated. In mosquito control ground adulticiding operations, application rates rarely exceed 1 oz./acre of particles, each with diameters from 8-15 microns.

The sprayers today use several techniques to meet these requirements. Air blast sprayers, which use either high volume/low pressure vortical nozzles or high pressure air-shear nozzles to break the liquid into very small droplets, are most common. Other forms of atomization equipment include centrifugal energy nozzles (rotary atomizers) which form droplets when the liquid is thrown from the surface of a high speed spinning porous sleeve or disc, ultrasonic equipment which vibrates and throws the droplets off, and electrostatic systems which repel the droplets.

The insecticide metering equipment available on these machines ranges from a simple glass flow-meter and a pressurized tank or electric pump on fixed flow machines to computer controlled, speed correlated, event recording and programmable flow management systems. The fixed flow units are designed to be operated with the vehicle traveling at a constant speed. Most of these use 12 volt laboratory type pumps which are quite accurate.

Ground adulticiding equipment is normally mounted on some type of vehicle, but the District also has smaller units that can be carried by hand or on a person's back for small area treatments. Pickup trucks are the most common conveyance for ULV sprayers, but the District also can use ATV's. With the 8-12 hp midsize sprayers described above, a vehicle speed of about 10mph typically generates an acceptable dose rate.

4. POTENTIAL ENVIRONMENTAL IMPACTS OF ADULTICIDING

Adulticiding poses a number of potential environmental impacts associated with non-target toxicity, pesticide drift, and with disturbance associated with the applications. The mode of action of pyrethrins and pyrethroids means that these pesticides have a wider spectrum of potential non-target toxicity than the larvicides discussed before (Worthing & Hance 1991). In addition, the need for the aerosol mist to drift through the mosquito harborage (target area) generates some risk that materials will spread beyond the intended target area. However, selective use of these materials, based on the District's rigorous criteria for selecting and applying these materials and strict adherence to label requirements, limits their potential environmental impacts to insignificant levels.

Pyrethrins and pyrethroids are highly toxic to most insects, moderately toxic to many fish and some birds, and much less toxic to other organisms (Mallis 1990, Worthing & Hance 1991). Worthing & Hance (1991) report acute oral LD50 values of pyrethrin of about 150 ug/bee in honey bees, 584-9000 mg/kg for rats, and >10,000 mg/kg for mallard ducks[5]. Percutaneous LD50 values for pyrethrin include >1,500 mg/kg for rats and >5,000 mg/kg for rabbits. Toxicity values for Resmethrin in rats include oral LD50 >2,500 mg/kg and percutaneous LD50 >3,000 mg/kg. For Permethrin, typical oral LD50 values are 430-4,000 mg/kg in rats, 40-2690 mg/kg in mice, >3,000 mg/kg in chickens, and >13,500 mg/kg in Japanese quail. In addition, DPR has reported "possible adverse" chronic toxicity effects associated with repeated exposures at extremely high dosages (exceeding legally allowed label rates and District operations by a factor of 100 or more) of Permethrin, Pyrethrins, Resmethrin, and Piperonyl Butoxide (DPR 1999).

Translating these values to a risk assessment of field applications can be difficult because of the complex distributions of both target and non-target species in natural settings. While it is clear that these materials can cause significant immediate mortality in some desired insects, recent studies by UC Davis and USFWS researchers have demonstrated rapid (24 - 48 hour)rebound of impacted insect populations following ULV activities with pyrethroids and malathion in the Central Valley (Lawlor et al, 1997). In general, mosquito distribution is patchy, so adulticide application is discontinuous; this allows non-target organisms both to migrate to untreated areas to escape toxins and/or to recolonize the treated area from nearby untreated areas.

Toxicity in fish is measured as LC50, or the concentration of toxicant in the water that is fatal to 50% of the sample by the end of a fixed time period (often 96 hours). Worthing & Hance (1991) report 96 hour LC50 values for coho salmon and channel catfish exposed to pyrethrum of 39 mg/L and 114 mg/L respectively. It is not easy to relate these values to the volumes of active ingredient that might drift from a treatment area and settle on water, but the risk has been judged high enough that the pesticide labels for these materials warn not to apply them to lakes, streams, or ponds, or when drift from the application might settle on these areas. However, direct deleterious effects have not been documented for non-targets in aquatic habitats as a result of deposition of currently employed adulticides, probably due to a small mass depositing per unit area and dilution factors such as tidal flushing and water depth (Lawlor et al, 1997).

In addition to label restrictions over drift onto sensitive environmental sites, there are operational limitations on these materials based on the need to minimize potential impacts on some classes of sensitive agricultural resources -- in particular, organic farms and honey bees and bee hives. Excessive drift onto organic farms can disrupt agricultural activities and/or lead to loss of organic registration for the farmer. Drift onto honey bees or hives with active bees can kill the bees and destroy the hive. In either case, inadvertent non-target impacts can lead to significant public outcry or financial claims against the District. For all these reasons, these types of impacts are not acceptable to the District.

5. MEASURES TO MINIMIZE ENVIRONMENTAL IMPACTS OF ADULTICIDING

The most important measure to minimize the potential environmental impacts of adulticiding is spatial and temporal separation of aerosol applications from sensitive species or habitats. In general, this is accomplished by strict compliance with label requirements and District criteria. For example, the Environmental Hazards section on labels of pesticides used as mosquito adulticides instruct applicators to avoid direct application over water or drift into sensitive areas due to a potentially high toxicity of these compounds to fish and invertebrates. Although there is some variation in the habitats to be avoided, they usually include lakes, streams and marshes. Also, District staff always evaluate the wind speed and direction and the potential for a thermal inversion prior to initiating aerosol activities.

Specific measures include the District's emphasis on *Cx. tarsalis* in its adulticide criteria. The District typically applies aerosol adulticides at dawn or dusk because that is when this target species is active. Fortuitously, this is also when temperature inversions and light wind generally make drift easiest to predict and manage, and also when many non-target insects (bees, butterflys) are not active. In addition, District policies and protocols do not allow non-emergency adulticiding in residential areas without proper notification and consent of the affected residents, or over open water.

The District takes measures to avoid impacts to organic farmers, bee keepers, and other sensitive receptors. Organic farmlands are located and plotted by the district. Adulticiding operations are performed in a manner that avoids drift over organic farms. The District strives to identify and communicate with bee keepers, to avoid exposing their colonies to adulticiding activities undertaken by District staff. Avoiding bee hives has been a primary concern of District operations. Location of hives are identified on maps and technicians are instructed to avoid applying pesticide in a manner that would drift over these areas.

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[5]When an LD50 is reported as greater than a large number, it means that fewer than half of the test animals died at the highest concentration tested.

In addition, the District maintains a list of sensitive receptors, and has established a policy to notify these receptors prior to aerosol applications and/or to avoid aerosol applications which might drift onto them, except under emergency conditions. Finally, conducting ULV operations in the early morning and late evenings, increases the efficacy of the control operation and minimizes exposure to people and their pets.

As described for larviciding, spray equipment is calibrated regularly, and at least once a year. Measurements for output and droplet sizes of the pesticides being used are confirmed to maximize efficiency and minimize potential adverse impacts.

All personnel who apply pesticides receive retraining at least once a year. This training consists of an annual review concerning all aspects of the pesticides the applicator will be handling that year. All applicators are certified by the Department of Health Services on the safe and proper use of pesticides. Applicators must also undergo a minimum of 20 hours of formal continuing education every two years to maintain their state certification.

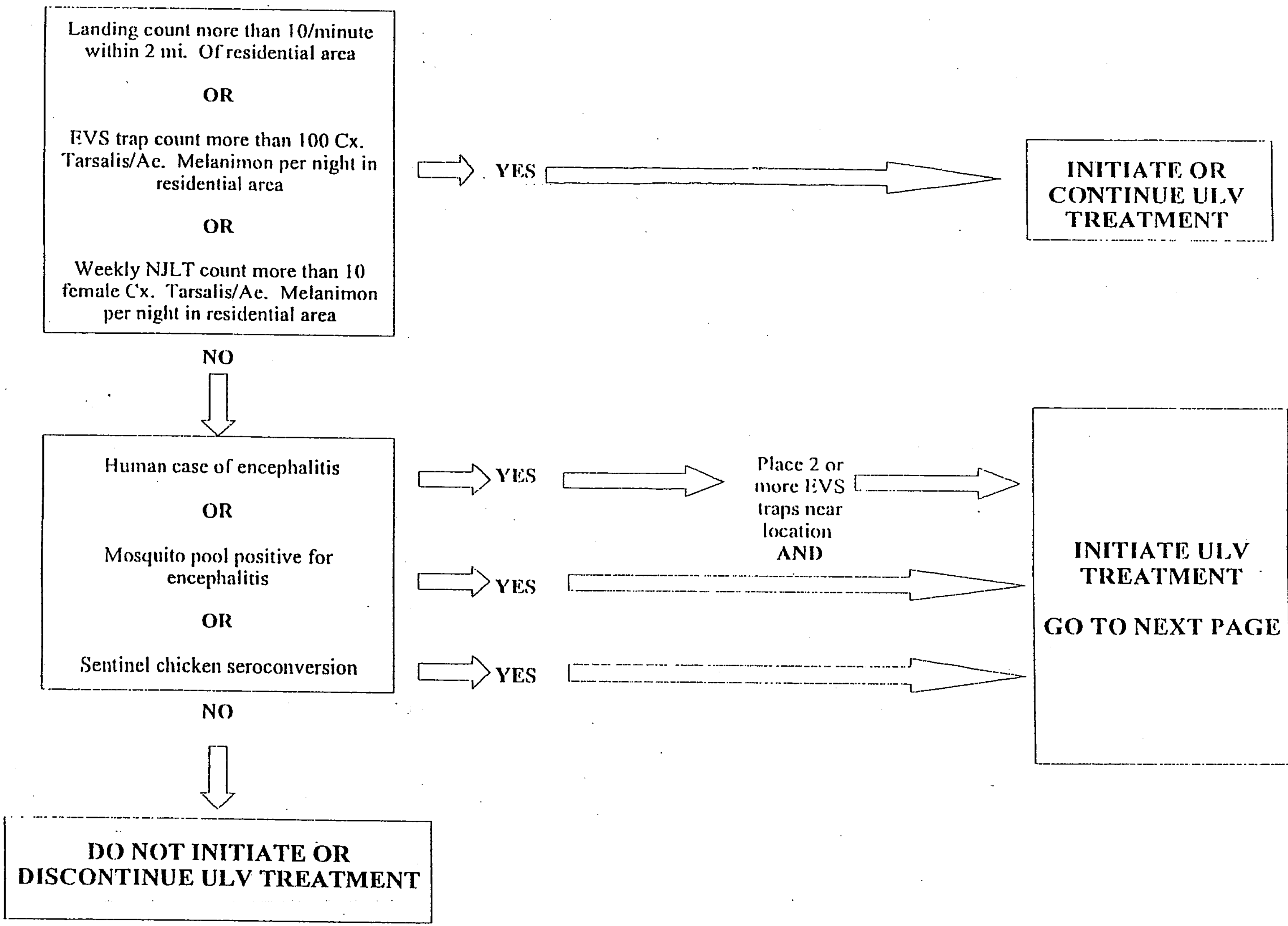
E. CONCLUSIONS: APPROPRIATE USE OF CHEMICAL CONTROL

The use of pesticides is an effective and environmentally sensitive part of the District's Program to manage mosquito populations in the District. The use of larvicides limits the proliferation of mosquito larvae in aquatic sources, while adulticiding reduces harmful levels of adult mosquitoes. In concert with public education and physical and biological control, this combination of control methods maintains and protects the human environment so that it is safer, healthier and more comfortable, while recognizing and protecting habitat values for other desired species.

The District's use of IPM principles ensures that pesticides are not used more frequently or more extensively than needed. For example, in 1998 the District treated only 5,405 acres directly for mosquitoes and an additional 294 acres with herbicides to reduce mosquito production. The total District Service Area is over 509,440 acres, with mosquito production and adult mosquito harborage found in discrete areas throughout this acreage. Thus, less than 0.06% of the total Service Area was treated with herbicides and less than 1.1% was treated with mosquito larvicides and adulticides during this time.

The District contains many sources that produce significant mosquito populations near populated areas. Without ongoing and effective mosquito control, the resulting mosquito activity would significantly and adversely effect the human environment. The District's program will never eradicate all mosquitoes. Rather, it is a resource maintenance program aimed at striking a balance to allow comfortable and healthful human existence within the natural environment, while protecting and maintaining the environment.

ULV TREATMENT CRITERIA p.1



ULV TREATMENT CRITERIA p.2

Encephalitis detected (from p.1)
ULV initiated

Landing count more than 10/minute

OR

Any EVS trap count more than 100 Cx. Tarsalis/Ae. Melanimon per night

OR

Any weekly NJLT count more than 10 female Cx. Tarsalis/Ae. Melanimon per night

Yes → **CONTINUE ULV TREATMENT**

NO → **DISCONTINUE ULV TREATMENT**

SECTION 5. REFERENCES

notes: 1) CEQA Environmental Documents are described under subsection 3.18 of this Initial Study

2) Each of the General References listed immediately below has an extensive bibliography justifying the general conclusions. To avoid unnecessary repetition, we refer the reader to them for additional literature on mosquito control and its potential environmental impacts.

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APPENDIX

CEQA PRELIMINARY REVIEW OF DISTRICT ACTIVITIES

NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

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May 31, 1999

EXECUTIVE SUMMARY

The California Environmental Quality Act (CEQA) was adopted by the California Legislature in 1970. It requires state and local agencies to estimate and evaluate the environmental implications of their actions, and to avoid or reduce the significant environmental impacts of their decisions when feasible.

CEQA generally requires state and local agencies to prepare an environmental document (either an Environmental Impact Report (EIR) or a Negative Declaration) assessing the potential environmental impacts of discretionary projects that may affect the environment, and to adopt mitigation measures for "potentially significant impacts". CEQA exempts from these requirements certain activities that are not considered "Projects", projects declared exempt from CEQA by the Legislature, and other classes of projects that the State Secretary for Resources has determined do not have a significant effect on the environment.

However, the Act also specifies that the categorical exemptions may not be used where activities "may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies", where "the cumulative impact of successive projects of the same type in the same place, over time, is significant", or "where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances."

Napa County Mosquito Abatement District's (District) Mosquito Control Program/Project employs IPM (Integrated Pest Management) principles to effectively protect the public from mosquitoes and mosquito-borne disease while protecting the environment. The District first determines the species and abundance of mosquitoes through evaluation of public service requests and field surveys of immature and adult mosquito populations; and then, if the populations exceed predetermined criteria, uses the most efficient, effective,, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy. In some situations, water management or other physical control activities are instituted to reduce mosquito production. The District uses biological control such as the planting of mosquito fish in some settings. When these approaches are not effective or are otherwise inappropriate, then pesticides are used to treat specific mosquito-producing or mosquito-harboring areas.

The District previously concluded that its mosquito control activities were exempt from CEQA, and declared a policy of issuing CEQA environmental documents in those cases where specific activities were not exempt.

Based upon the currently available evidence, as demonstrated in this document and in the cited references, the District now concludes that most District activities are still exempt from CEQA. However, some specific activities within the District's Project might exceed the scope of these exemptions to CEQA, or might trigger one or more of the exceptions to the exemptions, primarily because of regulatory questions about our potential impacts on endangered species or on critical wetland habitats. Therefore, The District will undertake an Initial Study, as described in the CEQA Guidelines, of our Mosquito Surveillance and Control Project.

Major physical control projects, and other activities as required, will continue to be assessed under individual CEQA documents.

I. PURPOSE OF PRELIMINARY REVIEW

The purpose of this preliminary review is to evaluate whether Napa County Mosquito Abatement District's ("District") mosquito control activities require environmental evaluation and/or mitigation under the California Environmental Quality Act ("CEQA"). This review is prepared under CEQA Guidelines sections 15060 and 15061 to evaluate the application of CEQA and the CEQA exemptions to the District's Mosquito Surveillance and Control Program/Project.

The District was formed in 1925 to control mosquitoes throughout Napa County. The District's Program/Project to control mosquitoes consists of continual surveillance and monitoring of mosquito populations and of human contact with mosquitoes to ascertain the threat of disease transmission and public nuisance; and the use of safe, environmentally sensitive, integrated mosquito management and control methods (discussed in more detail within this document) to protect the public from this threat. Control of mosquitoes has thus been an ongoing and longstanding Project of the District.

The purpose of this report is to evaluate whether the District's Integrated Mosquito Management Program is in accord with the California Legislature's current policy for environmental quality. Specifically, this report will:

1. Summarize the District's powers and the current and potential activities that together comprise the District's Program/Project;

2. Determine whether activities within the District's Project fall within one or more of the statutory or categorical exemptions to CEQA;

3. If an activity is categorically exempt, determine if one of the exceptions to the use of categorical exemptions set forth in State CEQA Guidelines section 15300.2 applies to the exemption; and

4. Identify the manner in which the District will comply with CEQA for its Project.

A. The California Environmental Quality Act (CEQA)

The California Environmental Quality Act was adopted by the California Legislature in 1970. According to the CEQA Deskbook, "The California Environmental Quality Act is California's most important environmental law. It requires state and local agencies to estimate and evaluate the environmental implications of their actions. Furthermore, it aims to prevent environmental effects an agencies actions by requiring them, when feasible, to avoid or reduce the significant environmental impacts of their decisions." (Bass, et al., 1996). Specifically, in the introduction to CEQA (California Public Resources Code section 21000), the Legislature finds and declares as follows (emphasis added):

(a) The maintenance of a quality environment for the people of this state now and in the future is a matter of statewide concern.

(b) It is necessary to provide a high-quality environment that at all times is healthful and pleasing to the senses and intellect of man..

(c) There is a need to understand the relationship between the maintenance of high-quality ecological systems and the general welfare of the people of the state, **including their enjoyment of the natural resources of the state.**

(d) The capacity of the environment is limited, and it is the intent of the Legislature that the government of the state take immediate steps **to identify any critical thresholds for the health and safety of the people of the state and take all coordinated actions necessary to prevent such thresholds being reached.**

(e) Every citizen has a responsibility to contribute to the preservation and enhancement of the environment.

(f) The interrelationship of policies and practices in the management of natural resources and waste disposal requires systematic and concerted efforts by public and private interests to enhance environmental quality and to control environmental pollution.

(g) It is the intent of the Legislature that all agencies of the state government which regulate activities of private individuals, corporations, and public agencies which are found to affect the quality of the environment, shall regulate such activities so that major consideration is given to preventing environmental damage, while **providing a decent home and satisfying living environment for every Californian.**

Therefore, in Section 21001 (CEQA), the Legislature further finds and declares that it is the policy of the state to:

(a) Develop and maintain a high-quality environment now and in the future, and take all action necessary to protect, rehabilitate, and enhance the environmental quality of the state.

(b) Take all action necessary to provide the people of this state with clean air and water, enjoyment of aesthetic, natural, scenic, and historic environmental qualities, and freedom from excessive noise.

(c) Prevent the elimination of fish or wildlife species due to man's activities, insure that fish and wildlife populations do not drop below self perpetuating levels, and preserve for future generations representations of all plant and animal communities and examples of the major periods of California history.

(d) Ensure that the long-term protection of the environment, consistent with the provision of a decent home and suitable living environment for every Californian, shall be the guiding criterion in public decisions.

(e) Create and maintain conditions under which man and nature can exist in productive harmony to fulfill the social and economic requirements of present and future generations.

(f) Require governmental agencies at all levels to develop standards and procedures necessary to protect environmental quality.

(g) Require governmental agencies at all levels to consider qualitative factors as well as economic and technical factors and long-term benefits and costs, in addition to short-term benefits and costs and to consider alternatives to proposed actions affecting the environment.

Pursuant to Public Resources Code section 21083, guidelines for the implementation of CEQA have been developed as regulations contained in the California Code of Regulations, Title 14. These regulations are known as the State CEQA Guidelines. The State CEQA Guidelines state that the basic purposes of CEQA are to: (1) inform governmental decision makers and the public about the potential significant environmental effects of a proposed project; (2) identify ways that the environmental damage can be avoided or significantly reduced; (3) prevent significant, avoidable damage to the environment by requiring changes in the projects through the use of alternative or mitigation measures; and (4) disclose to the public why a project is approved if significant environmental effects are involved (California Code of Regulations, Title 14, section 15002).

1. Definitions

The State CEQA Guidelines define "environment" as the physical conditions which exist within the area which will be affected by the proposed project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance, including both natural and man-made conditions (Guidelines Sec. 15360). This means that protecting the public from disease-carrying and noxious pests is a form of environmental protection.

A "project" is an activity subject to CEQA (Guidelines Sec. 15002(d)). More broadly, a project is defined as "the whole of an action, which has the potential for resulting in a physical change in the environment, directly or ultimately" (section 15378). This definition means that an agency cannot "segment" or "piecemeal" a project into small parts if the effect is to avoid full disclosure of environmental impacts. Specifically, it is forbidden to chop a project into small segments to avoid preparing an Environmental Impact Report (EIR), if one would otherwise be required (Bozung v. Local Agency Formation Commission (1975) 13 Cal.3d 263). In addition, related activities must be evaluated in the same CEQA document when either 1) one action is a reasonably foreseeable consequence of the other action; or 2) the actions are integral parts of the same project (Bass, et al., 1996).

A "significant effect on the environment" means a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance (section 15382). Though perhaps contrary to common usage, this definition means that substantial beneficial changes in the environment are not considered "significant" by CEQA, and do not require avoidance or mitigation to comply with the Act.

"Regulatory Agency" is not defined in either the CEQA statutes or Guidelines. Under the California Health and Safety Code, Sec. 2200 et seq., the District clearly has broad powers to promulgate and enforce standards for the management of water and potential mosquito habitat by landowners, and as such might be considered a Regulatory Agency under CEQA.

According to the CEQA Guidelines (Guideline Appendix G), a project will normally have a significant effect on the environment if it will (emphasis added):

(a) Conflict with adopted environmental plans and goals of the community where it is located;
(b) Have a substantial, demonstrable negative aesthetic effect;
(c) Substantially affect a rare or endangered species of animal or plant or the habitat of the species;
(d) Interfere substantially with the movement of any resident or migratory fish or wildlife species;
(e) Breach published national, state, or local standards relating to solid waste or litter control;
(f) Substantially degrade water quality;
(g) Contaminate a public water supply;
(h) Substantially degrade or deplete ground water resources;
(I) Interfere substantially with ground water recharge;
(j) Disrupt or adversely affect a prehistoric or historic archaeological site or a property of historic or cultural significance to a community or ethnic or social group; or a paleontological site except as part of a scientific study;
(k) Induce substantial growth or concentration of population;
(l) Cause an increase in traffic which is substantial in relation to the existing traffic load and capacity of the street system;
(m) Displace a large number of people;
(n) Encourage activities which result in the use of large amounts of fuel, water, or energy;
(o) Use fuel, water, or energy in a wasteful manner;
(p) Increase substantially the ambient noise levels for adjoining areas;
(q) Cause substantial flooding, erosion or siltation;
(r) Expose people or structures to major geologic hazards;
(s) Extend a sewer trunk line with capacity to serve new development;
(t) Substantially diminish habitat for fish, wildlife or plants;
(u) Disrupt or divide the physical arrangement of an established community;
(v) **Create a potential public health hazard** or involve the use, production or disposal of materials which pose a hazard to people or animal or plant populations in the area affected;
(w) Conflict with established recreational, educational, religious or scientific uses of the area;
(x) Violate any ambient air quality standard, contribute substantially to an existing or projected air quality violation, or expose sensitive receptors to substantial pollutant concentration.
(y) Convert prime agricultural land to non-agricultural use or impair the agricultural productivity of prime agricultural land; or
(z) Interfere with emergency response plans or emergency evacuation plans.

B. Exemptions to CEQA

CEQA generally requires state and local agencies to prepare an environmental document (either an environmental impact report (EIR) or negative declaration) assessing the potential environmental impacts of discretionary projects that may effect the environment, and to mitigate "potentially significant impacts". CEQA exempts from this requirement certain activities that are not considered "Projects", projects declared exempt by the Legislature ("statutory exemptions"; listed at CEQA Guidelines sections 15260-15282), and other classes of projects that the State Secretary for Resources has determined do not have a significant effect on the environment ("categorical exemptions"; listed at CEQA Guidelines sections 15301-15329). The District previously concluded that its mosquito control activities were generally exempt from CEQA, and declared a policy of issuing CEQA environmental documents in those cases where specific activities were not exempt. (See District Board of Trustees Resolutions No. 196, etc., Appendix C)

1. Statutory Exemptions

Statutory exemptions from CEQA, granted by the legislature, which may apply to actions of the District include "non-projects", ongoing projects, feasibility and planning studies, ministerial projects, emergency projects, and establishment of rates, tolls, fares, and other charges by public agencies to meet operating expenses and financial reserve needs and requirements.

Some activities by government agencies are not considered "projects" under CEQA (Guidelines Secs. 15061(b)(3), 15378(b)(1), 15378(b)(3), 15378(b)(5)). "Non-projects" must generally be either specifically exempted from CEQA by state law, or involve activities for which "it can be seen with certainty" that no environmental effect will occur (Bass, et al., 1996). Examples relevant to the District include "continuing administrative or maintenance activities, such as purchases of supplies, personnel-related actions, and general policy and procedure making (except as they are applied to specific instances which might have environmental impact)" (Guidelines Sec. 15378(b)(3)).

Ongoing projects are activities that were being carried out by a public agency prior to November 23, 1970 (Guidelines Sec. 15261(a)). This exemption is not valid if either: 1) "a substantial portion of public funds allocated for the project have not been spent (by that date), and it is still feasible (at that date) to modify the project to mitigate potentially adverse environmental effects, or to choose feasible alternatives to the project" (Guidelines Sec. 15261(a)(1)); or 2) if the public agency modifies the Project after that date so that the project might "have a new significant effect on the environment" (Guidelines Sec. 15261(a)(2)). Most current District activities predate November 23, 1970, and some of these have remained essential and unchanged during this time. Specifically, direct field surveillance for standing water and mosquito populations by field personnel, and maintenance of access paths to surveillance sites are apparently exempt from further CEQA requirements as ongoing projects. Specific direct mosquito control activities, on the other hand, generally have potentially viable alternatives, and would not be covered by this exemption.

Projects are exempt if they involve only feasibility or planning studies for possible future actions which the District and its Board has not approved, adopted, or funded (Guidelines Sec. 15262).

Ministerial projects are governmental decisions involving little or no personal judgment by the public official as to the wisdom or manner of carrying out the project (Guidelines Secs. 15268, 15357, 15369). The public official merely applies the law to the facts as presented but uses no special discretion or judgment in reaching a decision. Ministerial projects conducted by the District may include determinations that nuisances exist, orders of compliance with notices, assessment of civil penalties, and liens on property for cost to the District in abating nuisances which are defined by law in the California Health and Safety Code, commencing with section 2274.

Emergency projects are actions taken due to a sudden, unexpected occurrence involving a clear and imminent danger, to prevent or mitigate loss of or damage to life, health, property, or essential public services (Pub. Res. Code Secs. 21080(b)(2), (3), (4), 21060.3; Guidelines Secs. 15269, 15359). Emergency projects can include actions required to prevent or mitigate an emergency (Guidelines Sec. 15269(c)). CEQA does not require a formal declaration of an emergency to invoke this exemption. Emergency projects conducted by the District may include the control of mosquitoes in response to known disease activity.

CEQA does not apply to the establishment, modification, structuring, restructuring, or approval of rates, tolls, fares, and other charges by public agencies which the public agency finds are for the purpose of meeting operating expenses; purchasing or leasing supplies, equipment, or materials; meeting financial reserve needs and requirements; and obtaining funds for capital projects (Guidelines Sec. 15273). The District collects property taxes, and negotiates contracts with large land owners, all to provide for the operating expenses, purchase of equipment and supplies, and financial reserves of the District. These activities are exempt from CEQA.

2. Categorical Exemptions

Categorical exemptions are exemptions from CEQA for a class of projects based on a finding by the Secretary of Resources that the class of projects does not have a significant effect on the environment, except in exceptional circumstances. Categorical exemptions which may apply to actions of the District include existing facilities (class 1), replacement or reconstruction (class 2), minor alterations to land (class 4), information collection (class 6), actions by regulatory agencies for protection of natural resources (class 7), actions by regulatory agencies for protection of the environment (class 8), inspections (class 9), enforcement actions by regulatory agencies (class 21), and educational or training programs involving no physical changes (class 22).

Class 1 consists of the operation, repair, maintenance, or minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use beyond that previously existing. District activities which are within the scope of this exemption include operation, repair, maintenance, or minor alteration of existing District facilities; public facilities, such as existing drainage works or sewer treatment facilities; and private facilities, such as ornamental fish ponds, swimming pools and agricultural waste water ponds; and maintenance of existing landscaping, native growth, and water supply reservoirs.

Class 2 consists of replacement or reconstruction of existing structures and facilities where the new structure will be located on the same site as the structure replaced and will have substantially the same purpose and capacity as the structure replaced. District activities which are within the scope of this exemption include replacement or reconstruction of existing District facilities, including the structures and utility systems, or levees, culverts, tide gates, pumps and other water control structures, providing the replacement or reconstruction is substantially the same size, purpose, capacity and involving negligible or no expansion of capacity; public facilities, such as drainage facilities; and private facilities, such as ornamental fish ponds and swimming pools.

Class 4 consists of minor public or private alterations in the condition of land, water, and/or vegetation which do not involve removal of mature, scenic trees. District activities which are within the scope of this exemption include new landscaping at District facilities; removal of minor vegetation or sediment in creeks and other natural channels, agricultural irrigation and drainage ditches, other ditches and flood control channels, storm water retention basins, waste water ponds, spreading grounds, and other environments to assist in water flow which prevents breeding of mosquitoes; and removal of minor vegetation to access mosquito breeding sources.

Class 6 consists of basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource. District activities which are within the scope of this exemption include collection of mosquitoes for mosquito borne disease surveillance; placement of sentinel chicken flocks for mosquito-borne disease surveillance; collection of other insects, such as mosquitoes and mosquito predators to determine population density; and most other research activities undertaken by the District.

Class 7 consists of actions taken by regulatory agencies as authorized by state law or local ordinance to assure the maintenance, restoration, or enhancement of a natural resource where the regulatory process involves procedures for protection of the environment. Because District practices involve detailed procedures for protection of the environment, District activities which might be within the scope of this exemption include all mosquito surveillance and control activities in areas of natural resources such as jurisdictional wetlands.

Class 8 consists of actions taken by regulatory agencies, as authorized by state or local ordinance, to assure the maintenance, restoration, enhancement, or protection of the environment where the regulatory process involves procedures for protection of the environment. Because District practices involve detailed procedures for protection of the environment, District activities which might be within the scope of this exemption include all mosquito surveillance and control activities throughout the District.

Class 9 consists of activities limited entirely to inspections, to check for performance of an operation, or quality, health, or safety of a project. District activities which are within the scope of this exemption include inspections for the presence of mosquitoes throughout the District, and formal studies or other activities to determine the efficacy of specific control operations.

Class 21 consists of actions by regulatory agencies to enforce laws, general rules, standards, or objectives, administered or adopted by the regulatory agency. District activities which are within the scope of this exemption include enforcement of the California Health and Safety Code, commencing with section 2200, and other federal, state, and local laws, regulations, ordinances, and resolutions. California Health and Safety Code sections 2200 through 2360, are hereby incorporated by reference (Appendix F).

Class 22 consists of the adoption, alteration, or termination of educational or training programs which involve no physical alteration in the area affected or which involve physical changes only in the interior of existing school or training structures. District activities which are within the scope of this exemption include the District's public education program which includes newsletters, exhibits at city and other local fairs and special events, elementary education programs available to public and private schools, and public speaking engagements. In addition, staff training, as required by the California Occupational Safety and Health Administration, California Department of Food and Agriculture, California Environmental Protection Agency, Department of Pesticide Regulations, and the California Department of Health Services, may be exempt under this class.

3. Exceptions to the Categorical Exemptions

Pursuant to State CEQA Guidelines Section 15300.2, categorical exemptions may not be used in any of the following situations:

(i) Categorical exemption classes 3, 4, 5, 6, and 11 may not be used where the project "may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies."

(ii) All classes of categorical exemptions "are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time, is significant."

(iii) A categorical exemption may not be used for an activity "where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances."

In the remainder of this CEQA preliminary assessment, the District reevaluates the CEQA exemption status of its mosquito control Program/Project in light of current operations, activities and conditions.

II. DISTRICT POWERS

The District is a regulatory agency with broad powers, formed pursuant to section 2200 et seq of the California Health and Safety Code. Pursuant to Section 2270, the District Board may do any or all of the following:

(a) Take all necessary or proper steps for the control of mosquitoes, flies, or other vectors, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other vectors may disperse from the territory into the district.

(b) Abate as nuisances all standing water and other breeding places for mosquitoes, flies, or other vectors, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other vectors from the territory disperse into the district.

(c) Purchase the supplies and materials, employ the personnel and contract for the services which may be necessary or proper in furtherance of the objects of this chapter.

(d) If necessary or proper in the furtherance of the objects of this chapter, build, construct, repair, and maintain the necessary dikes, levees, cuts, canals, or ditches upon any land and acquire by purchase, condemnation, or by other lawful means, in the name of the district, any lands, rights-of-way, easements, property, or material necessary for any of those purposes.

(e) Make contracts to indemnify or compensate any owner of land or other property for any injury or damage necessarily caused by the use or taking of property for dikes, levees, cuts, canals, or ditches.

(f) Enter upon any property without hinderance or notice, either within the district or so reasonably adjacent thereto that vectors may disperse into the district, for any of the following purposes:

   (1) To inspect to ascertain the presence of vectors or their breeding places.

   (2) To abate public nuisances in accordance with this article, either directly or by giving notice to the property owner to abate a nuisance.

   (3) To ascertain if a notice to abate vectors has been complied with.

   (4) To treat property with appropriate physical, chemical, or biological control measures.

(g) Sell or lease any service, land, rights-of-way, easements, property or material acquired by the district. Equivalent properties may be exchanged, if it is in the best interests of the district to do so.

(h) Borrow money in any fiscal year and repay it in the same or in the next ensuing fiscal year. The amount borrowed in any fiscal year shall not exceed fifteen cents ($0.15) on each one hundred dollars ($100) of assessed valuation of property in the district.

(I) Issue warrants payable at the time stated in the warrant to evidence the obligation to repay money borrowed or any other obligation incurred by the district. Warrants so issued shall draw interest at a rate fixed by the board not to exceed 5 percent per year, payable annually or semiannually as the board may prescribe.

(j) Provide a civil service system for any or all employees of the district.

(k) Assess civil penalties, as determined in the discretion of the board, but not to exceed five hundred dollars ($500) per day for each day that a notice or hearing order to abate a nuisance has not been complied with.
Any sum which may be collected shall become part of the district's general fund to be used solely for vector control purposes.

(l) Levy, by resolution or ordinance, a service charge against any or all parcels of land within the district to pay for the cost of vector surveillance and control. The schedule of charges shall be made, reviewed, and adopted annually after notice and hearing in connection with the schedule. Following the hearing, the board may classify parcels of property according to their use in relation to the cost of vector surveillance and control. The board may bill for the charges annually or more frequently. The charges shall be collected and paid by the county in the same manner as property taxes by the county. The service charge shall be reasonably related to the district's cost for providing vector surveillance and control and shall not be deemed a tax of any kind. Any sum collected shall be used solely for purposes of vector surveillance and control.

(m) Set the tax or assessment rates which are necessary to carry out the purposes of this article.

(n) Do any and all things necessary for, or incident to, the powers granted by, and to carry out the objects specified in, this chapter.

III. PROGRAM/PROJECT DESCRIPTION

The District's Board of Trustees has defined the District's Mission as "to protect the public health and welfare through area-wide, responsive services and programs". Therefore, the District protects the environment by protecting the health and safety of the people living and working within our service area, and by conducting mosquito control activities in a manner that minimizes adverse impacts to other environmental functions.

A. Program/Project Location

The District's activities are conducted within a 796 square mile jurisdiction encompassing all areas contained within Napa County, California. Under section 2270(a) of the Health and Safety Code, the District can also take limited action in bordering areas of Lake, Solano, Sonoma and Yolo Counties if needed to provide mosquito control for residents of Napa County. Therefore, areas actually or potentially impacted by the Project include (Appendix A).

1. The incorporated cities of American Canyon, Calistoga, Napa, St Helena and Yountville.

2. The unincorporated areas of Napa County.

3. Other bordering areas in Lake, Solano, Sonoma and Yolo Counties.

B. Mosquitoes and Mosquito-borne Diseases in the District Service Area

The California Health and Safety Code defines a vector as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal." (Section 2200(f))

The District's Project involves the control of mosquitoes which cause human disease and/or human discomfort to the residents of the District. Certain species of mosquitoes found in Napa County can transmit malaria, St. Louis encephalitis, western equine encephalomyelitis, and potentially other encephalitis viruses. A few species of mosquitoes are also capable of transmitting *Dirofilaria immitis*, the dog heartworm. Although some species of mosquitoes have not been shown to transmit disease, all species can cause human discomfort when the female mosquito bites to obtain blood. Reactions may be as limited as irritation in the area of the bite or as severe as allergic reactions or secondary infections resulting from scratching the irritated area. Additionally, an abundance of mosquitoes can cause economic losses, loss of use of recreational, agricultural, or industrial areas, and loss of the enjoyment of property.

Mosquitoes are extremely mobile and cause the greatest hazard or discomfort away from their breeding site. Each species of mosquito has unique biological requirements and most of them occupy different habitats. In order to effectively control mosquitoes, an integrated mosquito management program must be employed. District policy is to locate and identify mosquito populations, to recommend techniques for their prevention and control, and to anticipate and minimize any interaction between new or uncommon mosquitoes and humans.

C. Integrated Mosquito Management

The District's Project is the surveillance and control of mosquitoes which consists of the following general principles and policies, including identification of mosquito problems, responsive actions to control existing populations of mosquitoes, prevent new sources of mosquitoes from developing and manage their habitat to minimize mosquito production; education of landowners and others on how to minimize mosquito production or interaction with mosquitoes; and provision and administration of funding and institutional support necessary to accomplish these goals.

In order to accomplish effective and environmentally sound mosquito control, the management and manipulation of mosquitoes must be based on careful surveillance of their abundance and/or potential contact with people, and be accomplished by selecting from a wide range of control methods. This dynamic combination of surveillance and control activities into one thoughtful, ecologically sensitive program is generally known as integrated pest management (IPM) (Durso, 1996).

The District's mosquito control Program/Project, like any other IPM program, by definition involves procedures for minimizing potential environmental impacts. The District's Project employs IPM principles by first determining the species and abundance of mosquitoes through evaluation of public service requests and field surveys of immature and adult mosquito populations. Then, if mosquito populations exceed predetermined criteria, the most efficient, effective, and environmentally sensitive means of control is used. For all mosquito species, public education is an important control strategy, and for some mosquitoes it is the District's primary control method. In some situations, water management or other physical control activities (historically known as "source reduction" or "permanent control") can be instituted to reduce mosquito breeding sites. The District also uses biological control such as the planting of mosquitofish in some settings. When these approaches are not effective or are otherwise inappropriate, then pesticides are used to treat specific mosquito-producing or mosquito-harboring areas.

In order to maximize familiarity by the operational staff with specific mosquito sources in the Project area, the District is divided into six mosquito zones. Each zone is assigned a full time mosquito control technician or vector biologist, whose responsibilities include minor physical control, inspection and treatment of known mosquito sources, finding and controlling new sources, and responding to service requests from the public.

Mosquito control activities are conducted at a wide variety of sites throughout the District's Project area. These sites can be roughly divided into those where activities may have have an effect on the natural environment either directly or through drainage, and sites where the potential environmental impacts are negligible. Examples of environmental sites in the project area include tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, storm water detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, irrigated pastures, or agricultural ditches. Examples of "non-environmental" sites include animal troughs, artificial containers, tire piles, fountains, ornamental fish ponds, swimming pools, and animal waste detention ponds.

1. Surveillance and Site Access

Besides being nuisances by disrupting human activities and causing our environment to be uninhabitable, certain mosquitoes may transmit a number of diseases. The diseases of most concern in Napa County are malaria, St. Louis encephalitis (SLE) and western equine encephalomyelitis (WEE) and dog heartworm.

Mosquito populations are surveyed using a variety of field methods and traps. Small volume larval mosquito "dippers" and direct observation are used to evaluate immature populations. Service requests from the public, field landing counts, light traps and carbon dioxide baited traps are used to evaluate adult populations.

Mosquito-borne diseases are surveyed using sentinel chickens, adult mosquitoes, and rarely wild birds. Coops with sentinel chickens are maintained on the property of willing landowners. The District employs standard practices of good animal husbandry to ensure the health and well being of the sentinel animals.

Adult mosquitoes are collected and tested for infection with SLE and WEE virus. Collection is made with small light traps baited with carbon dioxide in the form of dry ice. Although the traps must be placed in vegetated areas with little light competition, care is taken to ensure that placement of traps does not significantly damage any vegetation.

The District might collect wild birds in crow traps that are designed specifically for the collection of small birds such as sparrows and finches. The crow traps are supplied with food and water and remain in good repair to protect the birds from predators. Prior to catching wild birds, banding permits are obtained from the Department of Fish and Game and the District strictly complies with all requirements of the permit. After obtaining a blood sample from the wild bird, the bird is released.

Disposable supplies that are contaminated while collecting blood and tissue are stored in appropriate biohazard containers in the District's laboratory and disposed of in accordance with all applicable laws. Reusable items are cleaned and sterilized before they are used again. The disposal of animal carcasses is in compliance with all Federal, State, and local laws and regulations.

Surveillance is also conducted to determine mosquito habitat (eg. standing water) and the effectiveness of mosquito control operations. Inspections are conducted using techniques with insignificant impacts on the environment. Staff routinely use preexisting accesses such as roadways, open areas, walkways, and trails. Vegetation management (i.e. pruning trees, clearing brush, and herbicide application) is conducted where overgrowth impedes safe access. All of these actions only result in a temporary/localized physical change to the environment with regeneration/regrowth occurring within a span of six to nine months.

In order to access various sites throughout the District for surveillance and control, District staff utilize specialized equipment such as light trucks, all terrain vehicles, boats, and helicopters.

2. Education

The primary goal of the District's activities is to prevent mosquitoes from reaching public nuisance or disease thresholds by managing their habitat while protecting habitat values for their predators and other beneficial organisms. Mosquito prevention is accomplished through public education, including site specific recommendations on water and land use, and by physical control (discussed in a later section of this document).

The District's education program teaches the public how to recognize, prevent, and suppress mosquito breeding on their property. This part of the Project is accomplished through the distribution of brochures, fact sheets, newsletters, participation in local fairs and events, presentations to community organizations, contact with District staff in response to service requests, and public service announcements and news releases. Public education also includes an elementary school program that teaches future adults to be responsible by preventing and/or eliminating mosquito breeding sources, and educates their parents or guardians about District services and how they can reduce mosquito-human interaction.

D. Mosquito Control

When a mosquito source produces mosquitoes above District treatment thresholds (Appendix D), the Technician will generally work with the landowner or responsible agency to reduce the habitat value of the site for mosquitoes ("physical control"). If this is ineffective, then the technician will determine the best method of further treatment, including biological control and chemical control.

1. Physical Control

The District physically manipulates and manages mosquito habitat areas ("breeding sources") to reduce mosquito production. This may include removal of containers and debris, removing standing water from unmaintained swimming pools and spas, removal of vegetation or sediment, interrupting water flow, rotating stored water, pumping and/or filling sources, improving drainage and water circulation systems, breaching or repairing levees, and installing, improving, or removing culverts, tide gates, and other water control structures in wetlands.

In addition to using herbicides at some sites (primarily agricultural ditches and water ponds) to assist with mosquito surveillance, the District also uses herbicides in some areas to reduce mosquito habitat suitability. While the goal is similar to that of physical control, use of herbicides will be discussed under "chemical control", in the CEQA analysis, because the environmental concerns tend to be more similar to those of chemical insecticides than to more conventional physical control activities.

2. Biological Control

The mosquitofish, *Gambusia affinis*, is the District's primary biocontrol agent used against mosquitoes. Mosquitofish are not native to California, but have been widely established in the State since the early 1920's, and now inhabit most natural water bodies. The District rears mosquitfish in ponds throughout Napa Valley and periodically uses nets to collect these fish for use and distribution to appropriate mosquito breeding sites located within the District. When catching mosquitofish from natural settings, other aquatic animals, such as blue gill, sunfish, other freshwater fish, and crustaceans, are sometimes caught accidentally but are returned to the habitat.

District staff place mosquitofish in natural and man-made settings where either previous surveillance has demonstrated a consistently high production of mosquitoes, or where current surveillance indicates that mosquito populations will likely exceed chemical control thresholds without prompt action. Mosquitofish are also made available to the public to control mosquito production only in artificial containers such as ornamental fish ponds, water plant barrels, horse troughs, and abandoned swimming pools.

3. Chemical Control

Since many mosquito breeding sources cannot be adequately controlled with physical control measures or mosquitfish, the District also uses chemical insecticides to control mosquito production where observed mosquito production exceeds District thresholds. The primary types of insecticides used are selective larvicides, which are described in the following section. In addition, when large numbers of adult mosquitoes are present and/or public health is threatened, the District may apply selective, low persistence aerosol adulticides (described later in this document) to mosquito habitats that are a certain distance from residential areas (Appendix D).

F. District Funding

The District's activities are funded through property taxes, service contracts, grants, and civil liabilities, pursuant to Health and Safety Code Sections 2291.2 et seq.

Because mosquitoes are mobile, the District's activities provide general benefits to every property within the District, promoting the habitability of the property by protecting public health and welfare and enhancing the economic development, recreational use, and enjoyment of the property. In addition to the District-wide benefit, each parcel within the District receives an additional special benefit from the District's activities which takes place on, or is available to, each particular parcel.

The District also maintains service contracts with some large land-owners and/or water dischargers, and solicits grants for research and interagency habitat management projects. In some cases, the District accepts civil liability settlements from the Napa County District Attorney or the California Department of Fish and Game when these settlements are directed at habitat management projects consistent with the Districts Mission and IPM Program.

IV. CEQA ANALYSIS OF PROGRAM/PROJECT

The District's Program/Project includes surveillance and site access, education, and physical, biological, and chemical control activities for mosquitoes. The potential application of CEQA requirements, exemptions, and exceptions to each of these classes of activities is analyzed below.

In general, the environmental impacts of the District's different programs are insignificant. In recent years, this view has been strongly supported by a number of large scale programmatic reviews of other mosquito and vector control agencies. Examples include the "Program Evaluation Report" of the Metropolitan Mosquito Control District (Minneapolis/St. Paul, Minnesota) issued by the State of Minnesota's Office of the Legislative Auditor (1999); "Florida Mosquito Control", issued by the inter-agency Florida Coordinating Council on Mosquito Control (1998); the final report of the Scientific Peer Review Panel on nontarget effects in Minnesota (1996); and the EIS and Final Supplemental EIS of the Metropolitan Mosquito Control District (1976, 1986). All of these are cited in the References Section of this document.

A. Surveillance and Site Access

No endangered or threatened species or other legally protected animals are used to test for the presence of disease. For those species that are used, sample sizes are small relative to the indigenous population. Surveillance and inspection activities do not impact an environmental resource of hazardous or critical concern, do not cause a cumulative impact, and do not have a significant effect on the environment and are therefore exempt under class 6 and class 9 categorical exemptions.

Equipment is generally operated using existing passageways such as roads and trails. In some cases, there are no existing roads or trails, but low ground pressure all-terrain vehicles can be used with minimal environmental impacts. If vegetation clearing is needed for foot access to sites, only minor vegetation is removed. If an area does not have an existing passageway, and one is required, the District contacts the landowner or agency with appropriate jurisdiction to request that access be made available. In these cases, the landowner or agency is responsible for determining the environmental impact of constructing an access road or trail. Use of all-terrain vehicles and the removal of minor vegetation, excluding mature scenic trees, does not generally cause significant environmental impact, and would therefore be exempt from CEQA under the class 4,6, and 9 categorical exemptions.

B. Education

Because the public education component of the Project does not directly result in change in the environment, it does not meet the State CEQA Guidelines definition of a "project" and is therefore exempt from further CEQA review. Furthermore, the class 22 categorical exemption covers the adoption, alteration, or termination of educational or training programs which involve no physical alteration in the area affected or which involve physical changes only in the interior of existing school or training structures. Therefore, the District's education activities are exempt under a class 22 categorical exemption. To ensure that the District does not indirectly encourage environmental impacts without CEQA review, the District informs landowners and others who might modify the physical environment in response to our educational programs that they have specific environmental obligations, including compliance with CEQA and permit requirements.

Educational activities also include making recommendations on specific property development and land and water management practices or proposals, in response to ongoing or proposed developments or management practices that may create sources of mosquitoes. The District is not a permitting agency and is not responsible for implementing or approving the recommendations; therefore, property owners or developers are required to prepare and submit their own documents for projects which require CEQA review.

C. Physical Control

The removal of containers, debris, and standing water from unmaintained swimming pools and spas is exempt because these activities will not result in a physical change in the environment, directly or ultimately, and therefore, do not constitute a project under the Public Resources Code Section 21065. These activities would also be categorically exempt from CEQA under class 1 (minor alteration of private and public structures) and class 4 (minor alteration in the condition of land, water, and/or vegetation).

In some cases, the District's involvement in physical control activities is limited to the enforcement of regulations through issuing notices to abate. Enforcement of regulations are exempt under a class 21 categorical exemption. Any physical alteration to the environment is typically carried out by private parties or other governmental agencies. In such cases, the actual physical control activity would be subject to obtaining permits or approval from other agencies, in which case these other agencies would then be the lead agency for CEQA purposes. If the responsible person or entity fails to comply with the District's directives, the District may perform the physical control activity directly. In such case, the District will first evaluate whether or not the emergency statutory exemption from CEQA applies. If so, the District will proceed with the physical control activity. If the emergency statutory exemption does not apply, the District will evaluate whether or not the exceptions to the use of categorical exemptions would apply (designated hazardous or critical areas, significant cumulative impacts, or unusual circumstances). If such limitations do not apply, the District would proceed with the physical control activity under a class 1 and class 4 categorical exemption. If it is determined that exceptions to the exemptions apply, the District would perform a new CEQA review of the specific activity before proceeding, or again approach the landowner for compliance.

On public lands, District staff perform minor physical control through removal of accumulated vegetation or sediment using hand tools, which are generally covered by the class 1 and class 4 categorical exemptions. Where more extensive work is needed, then the District obtains and strictly complies with permits from the U.S. Army Corps of Engineers, the San Francisco Bay Conservation and Development Commission, the San Francisco Regional Water Quality Control Board, the California Department of Fish and Game, the U.S. Fish and Wildlife Service, and any other appropriate regulatory agency. Where the District determines that a physical control project exceeds the scope of the class 1 and class 4 categorical exemptions, then it prepares other CEQA documentation as needed prior to commencement of the proposed work.

D. Biological Control Activities

Mosquitofish are opportunistic feeders and, in addition to mosquitoes, will readily prey on their newborn young, other small fish, and other small aquatic organisms (Ahmed, et al., 1970; Barnickol, 1939; Farley, 1980; Swanson, et al., 1996). Specifically, some researchers have claimed that mosquitofish are implicated in the extirpation of red-legged frogs and other protected species. In order to protect threatened and endangered species and beneficial organisms, the District only releases mosquitofish into environmental sites under strict stocking protocols (Appendix E). Members of the public seeking mosquitofish are explicitly informed not to release *Gambusia* into the environment.

The District's biological control activities, including fish collection, rearing, and release, constitute an ongoing project. Biological control projects conducted by Mosquito Control Districts are generally exempt from further CEQA requirements under the class 7 and class 8 categorical exemptions, and under statutory exemptions for emergency projects to control mosquitoes which present imminent danger to the health and comfort of the residents of the District.

E. Chemical Control (Pesticides)

Chemical control of mosquitoes will be performed with either larvicides (pesticides that kill the organism in the larval stage) or adulticides (pesticides that kill the organism in the adult stage). Larvicides will be selected that are highly selective with little or no effect on non-target organisms, not harmful to plants, biodegradable, non-toxic to mammals, birds, amphibians, and fish, effective, and reasonably priced. Adulticides will be selected that are biodegradable, non-toxic to mammals and birds, and not harmful to vehicles or built structures. If needed for access to mosquito habitat, or to reduce the mosquito larval habitat value of sites overgrown with weeds, specific herbicides might be used by the District.

Every regular employee of the District who handles, applies, or supervises the use of any pesticide for public health purposes is certified by the California Department of Health Services as a vector control technician in mosquito control, terrestrial invertebrate vector control, and vertebrate vector control. The District sometimes employs Seasonal Aides. Pursuant to Title 17 of the California Code of Regulations section 30013, these employees need not be certified by the California Department of Health Services. Seasonal Aides apply pesticides under the instructions and direct supervision of a Certified Vector Control Technician who is responsible for the actions of that person and who is available if and when needed even though the certified technician may not be physically present at the time the pesticide is applied. All employees who handle and apply pesticides are trained pursuant to Title 3 of the California Code of Regulations section 6724. All regular employees who are certified by the California Department of Health Services attend three annual continuing education programs pursuant to Title 17 of the California Code of Regulations section 30061. Training activities will not result in a physical change in the environment, directly or ultimately; therefore, the District's training activities are exempt under a class 22 categorical exemption.

The District uses pesticides that are selective and non-persistent to minimize the risk of significant or cumulative adverse impact on non-target plant or animal life in "environmental sites". All pesticides are stored, handled, and used in accordance with all State, Federal, and local regulations and the manufacturer's recommendations and instructions. Adherence to these regulations, instructions, and recommendations, together with the District's own policies and procedures, will ensure that the District's use of pesticides will not adversely affect the environment.

All liquid pesticide application equipment is equipped with a pressure regulator or other means to measure application volumes and rates, and is calibrated at regular intervals to insure that the proper amount of pesticide is applied. All non-liquid pesticide application equipment is calibrated before use to insure that the proper amount of pesticide is applied.

Some pesticides have different names and slightly different formulations but essentially similar ingredients and modes of action. Therefore, where trade names are listed below, they indicate the current formulations used by the District. The District reserves the right to change materials at any time, and has determined that new materials with essentially the same formulation, mode of action, and mode of application, are adequately covered by this review.

1. Mosquito Larvicides

a. *Bti*

The "Program Evaluation Report" of the Metropolitan Mosquito Control District noted that "our conclusion from reviewing the scientific literature is generally consistent with EPA's position that *BTi* and methoprene.....pose little risk to people and most nontarget species" (State of Minnesota, Office of the Legislative Auditor, 1999).

Pesticides that contain the active ingredient of the bacterium *Bacillus thuringiensis* subspecies *israelensis* (*Bti*), which includes VectoBac® G (biological larvicide granules), VectoBac® 12AS (biological larvicide aqueous suspension), Vectobac TP (biological larvicide technical powder), and Teknar® HP-D (high potency Dipteran biological larvicide), are used for mosquito control. The active ingredient is composed of viable *Bti* endospores and delta-endotoxin crystals. *Bacillus thuringiensis* var. *israelensis*, which occurs naturally in soils and aquatic environments globally, has a highly specific mode of action against a narrow host spectrum, more specifically larvae of mosquitoes and black flies. Larvicidal activity is dependent upon ingestion of these components by the mosquito larvae. Upon ingestion, pH conditions and enzymes in the gut of the larvae rapidly hydrolyze the bacterial endospore material into active subunits which attack the midgut cells. General gut paralysis occurs within a few hours, and the cells of the midgut become extensively damaged causing the formation of holes or ulcers in the stomach wall. The subsequent flow of toxic substances into the larval body cavity causes death within 48 hours.

Biological larvicides, like *Bti*, may be applied to virtually any mosquito breeding source except treated, finished drinking water reservoirs and drinking water receptacles. Oral, dermal, and inhalation toxicity studies have not found any mammalian toxicity (de Barjac, et al., 1980; Mayes, et al., 1989; Siegel and Shadduck, 1990; Siegel, et al., 1987; Shadduck, 1980). Numerous studies have been conducted regarding the effect of *Bacillus thuringiensis* on non-target organisms and the environment. When products that contain *Bti* are applied within label rates, no harmful effects have been found against non-target organisms including tree frog tadpoles, toad tadpoles, California newts, mosquitofish, rainwater killifish, two spine stickleback, bluegill, scuds, side swimmers, purple shore crabs, fairy shrimp, water fleas, mayfly nymphs, damselfly nymphs, dragonfly nymphs, water boatmen nymphs, backswimmers, pygmy backswimmers, scavenger water beetle larvae, predaceous water beetles, flatworms, earthworms, fresh water snails, and mussels (Garcia, et al., 1981; Merritt et al., 1989; Miura et al., 1980; Purcell et al., 1981; Tietze et al., 1993, 1992, 1991). Additionally, some long-term studies in wetland habitats revealed no significant effects on the food chain or inhabitants of the wetlands (Scientific Peer Review Panel, 1996). Based on the technical data and scientific research, *Bti* is generally considered to have minimal immediate or cumulative impact on the environment, and the District uses this type of pesticide in environmental and non-environmental sites.

Some published research has indicated potentially significant environmental impacts of Bti use under some circumstances. In particular, researchers have indicated that Bti can adversely affect midges (Ali et al, 1981; Garcia et al, 1981; Miura, 1981; Miura, 1980; Molloy, 1992; Mulla, et al, 1990; Rodchareon, et al, 1991). These studies are hard to compare to District practices because application rates of the material in these studies often exceeded label rates and District policies. If midge reduction at label rates were demonstrated, then routine Bti applications could affect food supplies for waterfowl in some times and places.

b. *Bacillus sphaericus*

Insecticides that contain the active ingredient of the bacterium *Bacillus sphaericus*, which includes VectoLex® CG (biological larvicide granules), are used for mosquito control in a number of sites, generally where highly organic water or other criteria make *Bti* less appropriate. The mode of action of *Bacillus sphaericus* is the same as *Bti* except that fresh *Bacillus sphaericus* spores that proliferate in the mosquito larvae are released when the larvae dies. These spores are then ingested by other larvae. Oral, dermal, and inhalation toxicity studies have not found any mammalian toxicity (Shadduck, et al, 1980; Siegel and Shadduck, 1990). When *Bacillus sphaericus* products are applied within label rates, no harmful effects have been found against non-target organisms including dragonfly nymphs, damselfly nymphs, mayfly nymphs, chironomids, water boatmen nymphs, backswimmers, diving beetles, water scavenger beetles, marine amphipods, fairy shrimp, copepods, crawfish, mollusks, and amphibians (Ali, 1991; Aly et al., 1985; Holck and Meek, 1987; Mulla, et al., 1984; Walton and Mulla, 1991). This type of pesticide is used in environmental and non-environmental sites. Based on the technical data and scientific research, *Bacillus sphaericus* is generally considered to have minimal immediate or cumulative impact on the environment, and the District may use this type of pesticide in any site.

c. Methoprene

Pesticides that contain the active ingredient methoprene, which includes Altosid® XR Briquets, Altosid® Liquid Larvicide, and Altosid® Pellets, are used to control mosquitoes and midges. Methoprene is an insect growth regulator which controls mosquitoes and midges by interrupting normal metamorphosis. Methoprene is a true analog of mosquito juvenile hormone. During the fourth larval instar stage, juvenile hormone levels drop to very low levels. Methoprene artificially maintains juvenile hormone levels at a higher than normal titer. This higher hormonal level during the latter instar stages prevents the insect from developing into a normal pupa. Since the biology of midges and mosquitoes are similar, methoprene is effective on both insects. Oral, dermal, and inhalation toxicity studies have not found any mammalian toxicity (Hawkins et al., 1977). When methoprene products are applied within label rates, no harmful effects have been found against non-target organisms including 35 species of protozoa, earthworms, leeches, water fleas, shrimp, damselflies, mayflies, water beetles, snails, tadpoles, mosquitofish, ducks, geese, frogs, toads, salamanders, crabs, shrimp, oysters, clams, and algae, and there has been no impact on the food chain. (Batzer and Sjogren, 1986; Barber et al., 1978; Bircher and Ruber, 1988; Boley, 1992; Meyer, 1994; Miura and Takahashi, 1973; Miura and takahashi, 1974; Reish et al., 1985; Scientific Peer Review Panel, 1996; Tietze, et al., 1993, 1992, 1991).

Based on the technical data and scientific research, methoprene is generally considered to have minimal immediate or cumulative impact on the environment, and the District uses this type of pesticide in environmental and non-environmental sites. The District applies methoprene in a variety of formulations, including liquid, pellets, briquettes, and mixed with Bti ("duplex").

Some published research has indicated potentially significant environmental impacts of methoprene use under some circumstances. In particular, researchers have indicated that methoprene can adversely affect midges (Ali, 1991a, b; Lothrop and Mulla, 1998). Many of these studies are hard to compare to District practices because application rates of the material in these studies often exceeded label rates and District policies.

d. Golden Bear 1111 Oil

Pesticides that contain the active ingredient aliphatic petroleum hydrocarbons, which includes Mosquito Larvicide GB-1111® ("Golden Bear 1111" -- the only petroleum oil currently registered in California), are used to control mosquitoes. Golden Bear 1111 evaporates and photodegrades in the environment, has no residual effect, and is slightly phytotoxic when applied at label rates. Golden Bear 1111 kills by suffocation and can be toxic to some air-breathing aquatic insects (diving beetles, immature dragonflies and damselflies), although it has no documented impact to bottom-dwelling organisms (Mulla and Darwazeh, 1981). Studies on a wide range of fish species have demonstrated no toxic effects when applied at label rates (Tietze, et al., 1991; Tietze, et al., 1992; Tietze, et al., 1993; Tietze, et al., 1994). The relatively low persistence of Golden Bear 1111 in the environment indicates that significant movement of this material into open waters is highly unlikely following application to mosquito producing sites.

e. Agnique

Pesticides that contain the active ingredient ethoxylated fatty alcohol, which includes Agnique™ MMF (monomolecular surface film), may be used to control mosquitoes once registered in California. This type of pesticide reduces the surface tension of water and makes it difficult for mosquito larvae and pupae to attach. The film also blocks their breathing tubes and the larvae and pupae drown. Resting adult males and adult egg-laying females that come in contact with the film will also drown. This product can be used in virtually any source of water including potable water and biodegrades into carbon dioxide and water. The lethal inhalation concentration during four hours of exposure is 1.5 to 3.0 milligrams per liter. Ingestion of large quantities may cause gastrointestinal disturbances. Contact with eyes causes irritation which subsides in seven days and prolonged or repeated exposure with skin causes irritation. Studies on non-target effects were conducted on the fresh-water green tree frog, two species of fresh water fish, five species of salt water fish, longnose killifish, grass shrimp, freshwater shrimp, fiddler crab, crayfish, freshwater amphipod, freshwater isopod, fairy shrimp, snails, polychaetes, mayfly nymphs, diving beetles, midges, clam shrimp, backswimmers, water boatmen, water striders, beetle larvae and adults, black mangrove, saltwort, cordgrass, arrowhead, and rice. The only non-target effects observed when the product was applied at label rates were dead adult midges and adult water striders. Based on the available technical data and scientific research, Agnique™ MMF has no apparent significant or cumulative impact on the environment.

2. Mosquito Adulticides

a. Pyrethrins, Pyrethroids and Piperonyl Butoxide

Pesticides that contain the active ingredients resmethrin with piperonyl butoxide (trade name Scourge), permethrin with piperonyl butoxide (trade name Biomist 4+12), and pyrethrin with piperonyl butoxide (trade name MGK Pyrocide 7396), are synthetic or natural pyrethroids used to control adult mosquitoes. These products stimulate nerve cells to produce repetitive discharges and eventually cause paralysis of the insect. Acute toxicity of these materials, depending on formulation and type of synergist used, is low to mammals (Pyrethrin oral LD_{50} = 900 mg/kg; Resmethrin oral LD_{50} = 2,000 mg/kg; permethrin oral LD_{50} is greater than 4,000 mg/kg) (Worthing and Hance, 1991; Matsumura, 1975). Scientific research has also shown that neither Bobwhite quail or Mallard ducklings are harmed when fed 5,000 part per million of the active ingredients in Scourge®. Neither of these products are listed as carcinogens. Recent research in controlled plots in the Central Valley indicated no reductions in the total abundance or biomass of aquatic macroinvertebrates or fish, and a return to previous abundance in 24 hours for flying insects, following label-rate treatments of Pyrethrin and Permethrin [Lawlor, 1997].

Some non-target, beneficial insects may be killed during the ultra-low volume aerosol application of these insecticides. These mosquito adulticides are highly toxic to bees and may only be applied when bees are not present. Fortunately, treatment with these materials for mosquitoes is conducted when bees are not foraging. Scientific research has shown that when Scourge® is applied according to the label, foraging bees are not effected by residual pesticide.

The Legislative Audit of the Metropolitan Mosquito Control District concluded that "studies by EPA and the World Health Organization found that resmethrin and permethrin are broad-spectrum insecticides with the potential to harm other types of insects and aquatic organisms, but they should not be harmful to humans or the environment if applied according to label instructions" (State of Minnesota, Office of the Legislative Auditor, 1999). Although generally safe to humans and the environment, these products are generally only used under unusual situations to control adult mosquitoes when diseases may be transmitted by mosquitoes or when the insect population is so high that they interfere with the enjoyment of the environment. Consistent with the California Legislature's policy for environmental quality, control of adult mosquitoes may be necessary for the health and safety of the people to provide a satisfying living environment.

3. Herbicides

Rodeo and Round Up are glyphosate-based herbicides used by the District to control weeds that overgrow mosquito habitat and obstruct access by fish and/or mosquito control staff. These are selective materials with very low animal toxicity. Rodeo is labeled for aquatic application, while Round Up is labeled for terrestrial use, and both are used in strict conformance with the labels.

Karmex DF is a diuron based herbicide that is used by District staff to prevent growth of grasses and low growing annual weeds on the levees and along the shorelines of waste water ponds of sewage treatment facilities and wineries. This material is also used in strict conformance with the label.

V. EXCEPTIONS TO THE USE OF CATEGORICAL EXEMPTIONS

As noted earlier, Pursuant to State CEQA Guidelines Section 15300.2, categorical exemptions to CEQA requirements for environmental assessment and documentation may not be used in any of the following situations:

(i) Categorical exemption classes 3, 4, 5, 6, and 11 may not be used where the project "may impact on an environmental resource of hazardous or critical concern where designated, precisely mapped, and officially adopted pursuant to law by federal, state, or local agencies."

(ii) All classes of categorical exemptions "are inapplicable when the cumulative impact of successive projects of the same type in the same place, over time, is significant."

(iii) A categorical exemption may not be used for an activity "where there is a reasonable possibility that the activity will have a significant effect on the environment due to unusual circumstances."

The District has carefully considered these exceptions. Since CEQA was passed, the potential environmental impacts of routine mosquito control activities have diminished through the use of increasingly selective pesticides and more extensive surveillance. However, during this same time, there have been dramatic increases in the number of legally protected species associated with wetland habitats, the number of wetland acres that are considered "sensitive", and the general awareness of the ecological and recreational values of wetlands.

In particular, explicit and implicit definitions of "environmental resources of critical concern" and "unusual circumstances" have become increasingly broad. Known or potential habitat for a number of species including the California Clapper Rail, Black Rail, Western Snowy Plover, Salt Marsh Harvest Mouse, Red-Legged Frog, Delta Smelt, Chinook Salmon, Vernal Pool Fairy Shrimp, California Freshwater Shrimp, and Soft Bird's Beak are all found in areas where District activities may occur (see Appendix B for a listing of federal and state species of concern).

In addition, a number of researchers have suggested that routine vector control activities have produced or can produce cumulatively significant environmental impacts. For example, there have been several published claims that non-native fish, including mosquitofish, have contributed to the decline of legally-protected species, including the California Red-legged Frog. Furthermore, the relatively selective and non-persistent pesticides used by the District have also been cited as potentially detrimental to important food resources for waterfowl and wading birds. Finally, concerns over the possible detrimental impacts of ATV use on wetlands have been increasingly issued by the U.S. Fish and Wildlife Service, particularly in regard to federally managed lands.

Therefore, although these exceptions do not ordinarily apply to the District's mosquito surveillance and control activities, it appears that portions of our ongoing and routine actions may now be considered outside the scope of the categorical exemptions.

VI. CONCLUSIONS

Based upon the foregoing discussion and the documents incorporated by reference therein, the District concludes that most District activities are exempt from further CEQA review. However, some specific activities within the District's Project might exceed the scope of the exemptions to CEQA, or might trigger one or more of the exceptions to the exemptions. Therefore the District will undertake an Initial Study, as described in the CEQA Guidelines, of our Project.

A. District Funding, Planning, and Administration

The District is funded through a variety of mechanisms, as described before. No District funding mechanism or activity meets the State CEQA Guidelines definition of a "project" and therefore, CEQA is not applicable to these activities. Furthermore, CEQA does not apply to the establishment, modification, structuring, restructuring, or approval of rates, tolls, fares, and other charges by public agencies which the public agency finds are for the purpose of meeting operating expenses, purchasing or leasing supplies, equipment, or materials, meeting financial reserve needs and requirements, and obtaining funds for capital projects. Therefore, funding of the Project is statutorily exempt.

Planning and routine administrative activities by the District or its Board are also either "non-project" or are otherwise statutorily exempt from further review.

B. Surveillance and Site Access Activities

The District's surveillance, inspection, and site access activities are generally statutorily exempt from further CEQA requirements as ongoing projects. In addition, these activities are generally exempt under the class 6 and class 9 categorical exemptions, and under statutory exemptions for emergency projects to control mosquitoes which present imminent danger to the health and comfort of the residents of the District.

However, evidence exists that under some foreseeable circumstances, use of all-terrain vehicles by the District on some sites might either exceed the scope of these exemptions, or might trigger the exceptions to these exemptions. Therefore, the District will include its surveillance and inspection projects in the proposed CEQA Initial Study.

C. Public Education and Consultation

The public education and training component of the Project does not meet the State CEQA Guidelines definition of a "project" and therefore, CEQA is not applicable to this activity. Furthermore, the class 22 categorical exemption consists of the adoption, alteration, or termination of educational or training programs which involve no physical alteration in the area affected or which involve physical changes only in the interior of existing school or training structures. Therefore, the District's education and training activities are exempt under a class 22 categorical exemption.

D. Physical Control Activities

The District's physical control activities constitute both an ongoing maintenance project and a series of discrete site-specific projects. Physical control projects conducted by Mosquito Control Districts are generally exempt from further CEQA requirements under the class 1,2, 4,7, and 8 categorical exemptions, and under statutory exemptions for emergency projects to control mosquitoes which present imminent danger to the health and comfort of the residents of the District.

However, evidence exists that under some foreseeable circumstances, physical control actions undertaken by the District might either exceed the scope of these exemptions, or might trigger the exceptions to these exemptions. Therefore, the District will include its physical control projects in the proposed CEQA Initial Study.

E. Biological Control Activities

The District's biological control activities, including fish collection, rearing, and release, constitute an ongoing project. Biological control projects conducted by Mosquito Control Districts are generally exempt from further CEQA requirements under the class 7 and class 8 categorical exemptions, and under statutory exemptions for emergency projects to control mosquitoes which present imminent danger to the health and comfort of the residents of the District.

However, evidence exists that under some foreseeable circumstances, mosquitofish stocking undertaken by the District might either exceed the scope of these exemptions, or might trigger the exceptions to these exemptions. Therefore, the District will review its biological control activities in the proposed CEQA Initial Study.

F. Chemical Control Activities

The District's chemical control activities, including use of mosquito larvicides, mosquito adulticides, and herbicides, constitute an ongoing project. Chemical control projects conducted by Mosquito Control Districts are generally exempt from further CEQA requirements under the class 7 and class 8 categorical exemptions, and under statutory exemptions for emergency projects to control mosquitoes which present imminent danger to the health and comfort of the residents of the District.

However, evidence exists that under some foreseeable circumstances, pesticide applications undertaken by the District might either exceed the scope of these exemptions, or might trigger the exceptions to these exemptions. Therefore, the District will review its chemical control activities in the proposed CEQA Initial Study.

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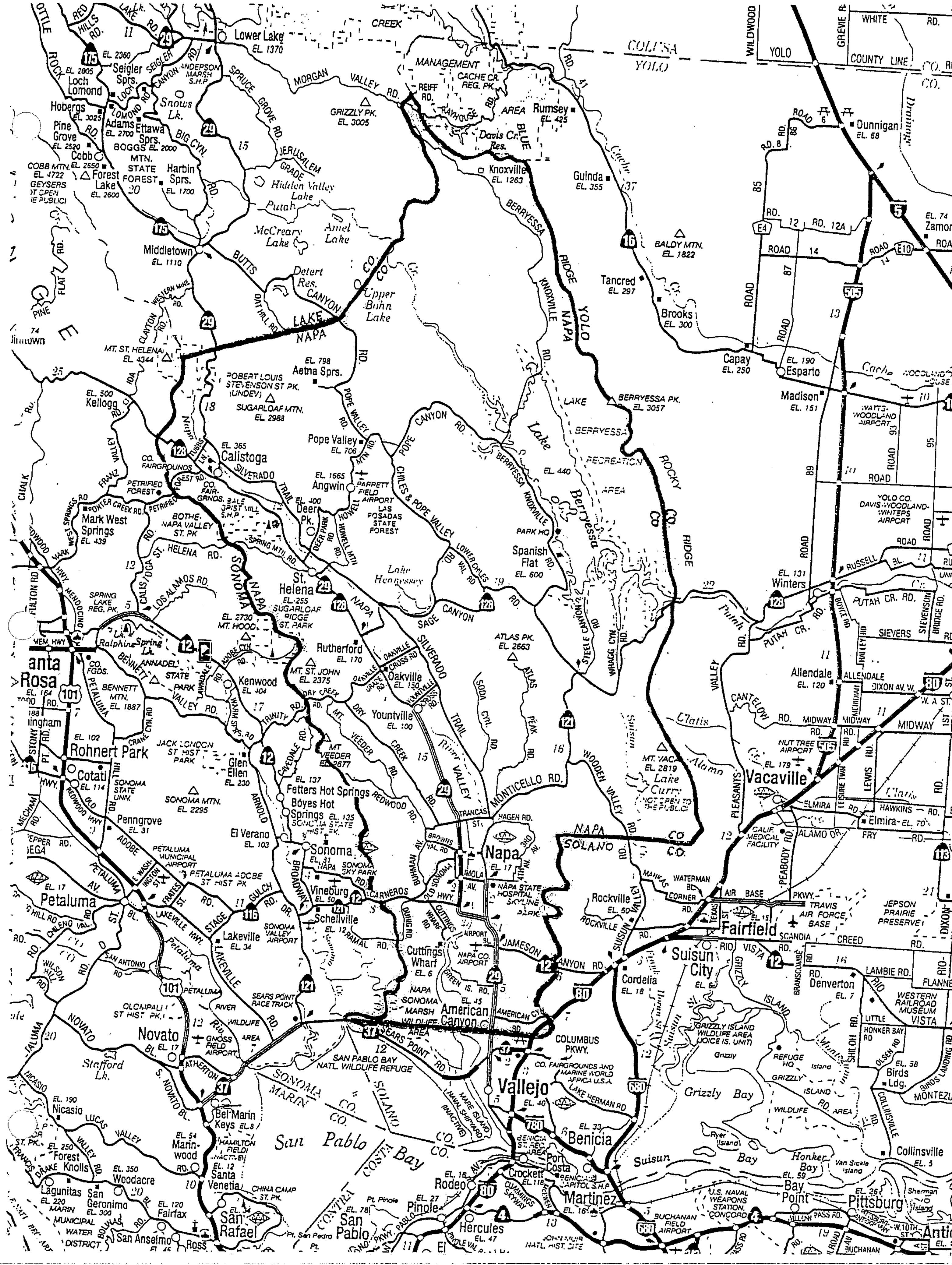
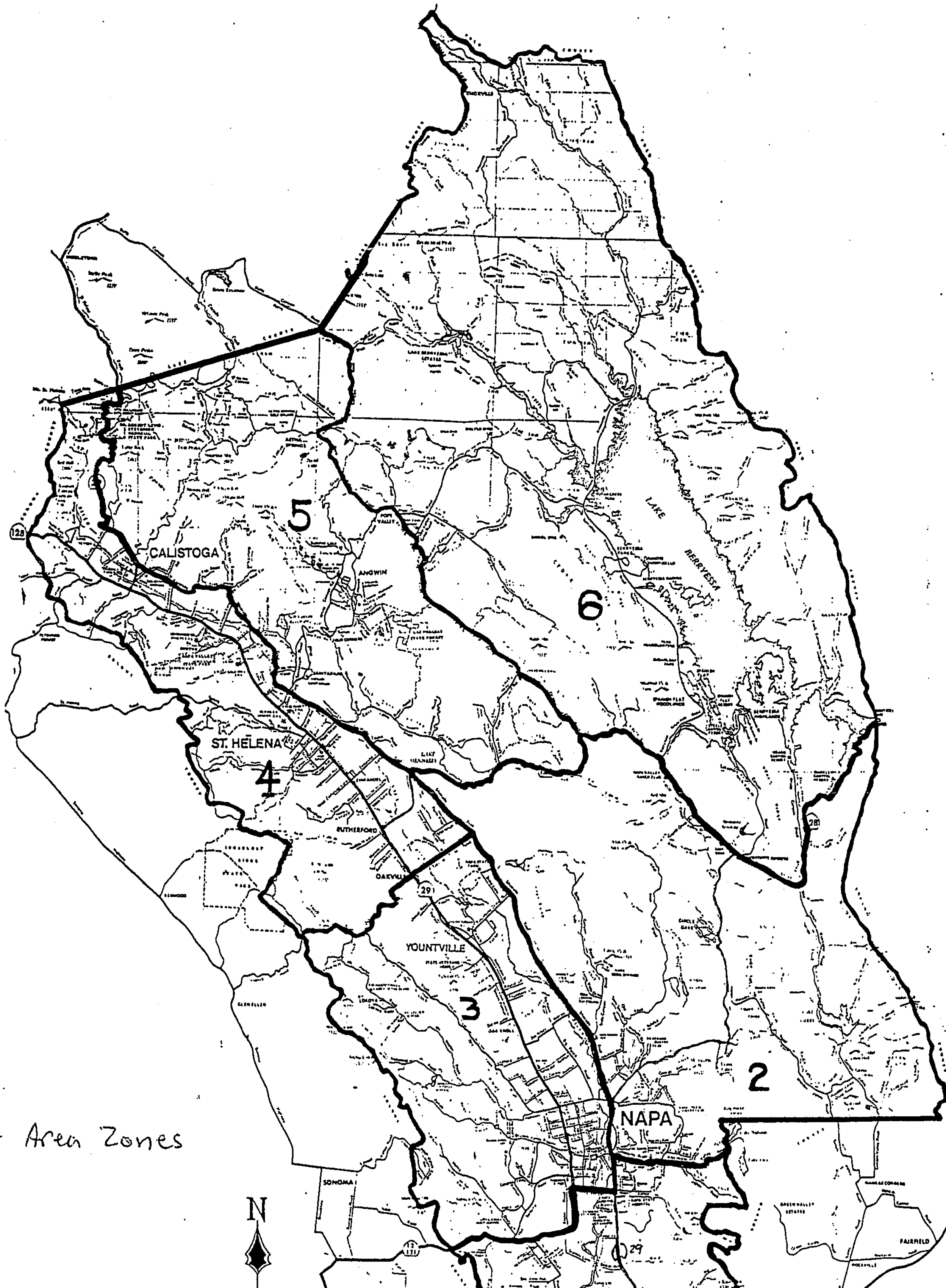
APPENDIX A

DISTRICT BOUNDARIES



Lower Lake
EL. 1370
Seigler Sprs.
Loch Lomond
Hobergs
Pine Grove
Cobb
Adams
Ettawa Sprs.
Boggs Mtn. State Forest
Harbin Sprs.
Snows Lk.
Cobb Mtn. EL. 4722
Forest Lake
Middletown
EL. 1110
Hidden Valley Lake
Putah
McCreary Lake
Amel Lake
Morgan Valley Rd.
Grizzly Pk. EL. 3005
Management
Cache Cr. Reg. Pk.
Area
Rumsey
EL. 425
Davis Cr. Res.
Knoxville
EL. 1263
Guinda
EL. 355
Colusa
Yolo
Wildwood
County Line
Dunnigan
EL. 68
Zamora
Baldy Mtn. EL. 1822
Tancred
EL. 297
Brooks
EL. 300
Capay
EL. 250
Esparto
EL. 190
Madison
EL. 151
Butts Canyon
Detert Res.
Upper Bohn Lake
Lake
Napa
Berryessa
Knoxville Rd.
Yolo Napa Ridge
Mt. St. Helena EL. 4344
Aetna Sprs.
EL. 798
Robert Louis Stevenson St. Pk. (Undev)
Sugarloaf Mtn. EL. 2988
Pope Valley Rd.
Pope Valley
EL. 706
Pope Canyon Rd.
Berryessa Pk. EL. 3057
Lake Berryessa Recreation Area
Kellogg
EL. 500
Calistoga
EL. 365
Silverado Trail
Angwin
EL. 1665
Parrett Field Airport
Las Posadas State Forest
Deer Pk.
Chiles & Pope Valley Rd.
Spanish Flat
EL. 600
Park HQ
Rocky Ridge
Co. Fairgrounds
Petrified Forest
Mark West Springs
EL. 439
Bothe-Napa Valley St. Pk.
St. Helena Rd.
Spring Mtn. Rd.
St. Helena
EL. 255
Sugarloaf Ridge St. Park
Lake Hennessey
Sage Canyon
Steele Canyon Rd.
Whagg Cyn. Rd.
Winters
EL. 131
Putah Cr. Rd.
Russell Bl.
Yolo Co. Davis-Woodland-Winters Airport
Watts-Woodland Airport
Spring Lake Reg. Pk.
Los Alamos Rd.
Lk. Ralphine
Santa Rosa
Bennett Valley Rd.
Annadel State Park
Bennett Mtn. EL. 1887
Kenwood
EL. 404
Mt. Hood EL. 2730
Rutherford
EL. 170
Mt. St. John EL. 2375
Oakville
EL. 150
Oakville Cross Rd.
Yountville
EL. 100
Atlas Pk. EL. 2663
Atlas Peak Rd.
Soda Cyn. Rd.
Dry Creek Rd.
Mt. Veeder EL. 2677
Trinity Rd.
Cavedale Rd.
Glen Ellen
EL. 230
Jack London St. Hist. Park
Sonoma Mtn. EL. 2295
Sonoma State Univ.
Rohnert Park
Cotati
EL. 114
Penngrove
EL. 31
Fetters Hot Springs
EL. 137
Boyes Hot Springs
El Verano
EL. 103
Sonoma
EL. 31
Sonoma State Hist. Pk.
Napa Sonoma Sky Park
Vineburg
EL. 50
Schellville
EL. 12
Sonoma Valley Airport
Lakeville
EL. 34
Lakeville Hwy.
Stage Gulch Rd.
Petaluma
Petaluma Municipal Airport
Petaluma Adobe St. Hist. Pk.
Monticello Rd.
Trancas St.
Napa
EL. 17
Napa State Hospital
Skyline Park
Imola Av.
Carneros Hwy.
Cuttings Wharf
EL. 6
Napa Co. Airport
Jameson Canyon Rd.
Wooden Valley Rd.
Mt. Vaca EL. 2819
Lake Curry (Not Open to the Public)
Napa Solano Co.
Suisun Valley Rd.
Rockville
EL. 50
Cordelia
EL. 18
Fairfield
EL. 15
Travis Air Force Base
Suisun City
Vacaville
Allendale
EL. 120
Nut Tree Airport
Elmira
EL. 70
Calif. Medical Facility
Peabody Rd.
Pleasants Valley Rd.
Midway
Cantelow Rd.
Jepson Prairie Preserve
Dixon
Denverton
Western Railroad Museum
Little Honker Bay
Shiloh Rd.
Birds Landing
Montezuma
Collinsville
EL. 5
Grizzly Island Wildlife Area (Joice Is. Unit)
Grizzly Bay
Suisun Bay
Honker Bay
Bay Point
Pittsburg
Sears Point Race Track
Napa Sonoma Marsh Wildlife Area
American Canyon
EL. 45
Columbus Pkwy.
Co. Fairgrounds and Marine World Africa U.S.A.
Vallejo
EL. 40
Mare Island Naval Shipyard (Inactive)
Benicia
EL. 33
Benicia St. Rec. Area
Benicia Capitol S.H.P.
Port Costa
Crockett
Rodeo
Martinez
U.S. Naval Weapons Station, Concord
Buchanan Field Airport
John Muir Natl. Hist. Site
Hercules
Pinole
San Pablo
San Pablo Bay
San Pablo Bay Natl. Wildlife Refuge
Novato
EL. 17
Olompali St. Hist. Pk.
Gnoss Field Airport
Stafford Lk.
Nicasio
EL. 190
Lucas Valley Rd.
Bel Marin Keys
Hamilton Field (Inactive)
Marinwood
Forest Knolls
Woodacre
Lagunitas
San Geronimo
Fairfax
San Anselmo
Ross
San Rafael
Santa Venetia
China Camp St. Pk.
Sonoma Marin Co.
Solano Co.
Contra Costa Co.



Project Area Zones

APPENDIX B

ENDANGERED AND THREATENED SPECIES IN NAPA COUNTY

Special Status Plants and Animals of Napa County

Common Name	Scientific Name	Status
Plants		
Suisun Marsh Aster	*Aster lentus*	FSC
Clara Hunt's Milk Vetch	*Astragalus clarianus*	FE, ST
San Joaquin SaltBush	*Atriplex joaquiniana*	FSC
Mt St Helena Morning Glory	*Calystegia collina oxyphylla*	FSC
Tiburon Indian Paintbrush	*Castilleja affinis neglecta*	FE, ST
Rincon Ridge Ceanothus	*Ceanothus confusus*	FSC
Calistoga Ceanothus	*Ceanothus divergens*	FSC
Sonoma Ceanothus	*Ceanothus sonomensis*	FSC
Soft Bird's Beak	*Cordylanthus mollis mollis*	FE, SR
Adobe Lily	*Fritillaria pluriflora*	FSC
Two carpellate Western Flax	*Hesperolinon bicarpellatum*	FSC
Brewer's Western Dwarf Flax	*Hesperolinon breweri*	FSC
Drymaria-Like Western Dwarf Flax	*Hesperolinon drymarioides*	FSC
Northern California Black Walnut	*Juglans hindsii*	FSC
Contra Costa Goldfields	*Lasthenia conjugans*	FE
Delta Tule Pea	*Lathyrus jepsonii jepsonii*	FSC
Legenere	*Legenere limosa*	FSC
Mason's lilaeopsis	*Lilaeopsis masonii*	FSC, SR
Sebastopol Meadowfoam	*Limnanthes vinculans*	FE, SE
Hall's Madia	*Madia hallii*	FSC
Few Flowered Navarretia	*Navarretia leucocephala pauciflora*	FE, ST
Calistoga Popcorn Flower	*Plagiobothrys strictus*	FE, ST
Napa Blue Grass	*Poa napensis*	FE, SE
Marin Knotweed	*Polygonium marinense*	FSC
Marin Checkerbloom	*Sidalcea hickmanii viridis*	FSC
Socrates Mine Jewel-Flower	*Streptanthus brachiatus brachiatus*	FSC
Showy Indian Clover	*Trifolium amoenum*	FE
Invertebrates		
California Freshwater Shrimp	*Syncaris pacifica*	FE, SE
Valley Elderberry Longhorn Beetle	*Desmocerus californicus dimorphus*	FT
Vertebrates		
California Red-Legged Frog	*Rana aurora draytonii*	FT
Foothill Yellow-Legged Frog	*Rana boylii*	FSC
Northwestern Pond Turtle	*Clemmys marmorata marmorata*	FSC
Tricolored Blackbird	*Agelaius tricolor*	FSC
Burrowing Owl	*Athene (=Speotyto) canicularia*	FSC
Western Snowy Plover	*Charadrius alexandrinus nivosus*	FT
Saltmarsh Common Yellowthroat	*Gleothypis trichas*	FSC
Bald Eagle	*Haliaeetus leucocephalus*	FT, SE
California Black Rail	*Laterallus jamaicensis coturniculus*	FSC, ST
California Clapper Rail	*Rallus longirostris obsoletus*	FE, SE
Northern Spotted Owl	*Strix occidentalis caurina*	FT
Townsend's Western Big-Eared Bat	*Plecotus townsendii*	FSC
Salt Marsh Harvest Mouse	*Reithrodontomys raviventris raviventris*	FE, SE
Suisun Shrew	*Sorex ornatus sinuosus*	FSC

FE = Federally Endangered
SE = State Endangered
FT = Federally Threatened
ST = State Threatened
FSC = Feredal Species of Concern
SR = State Rare

APPENDIX C

RELEVANT DISTRICT RESOLUTIONS

RESOLUTION OF THE NAPA COUNTY MOSQUITO ABATEMENT DISTRICT ADOPTING PROCEDURES TO BE USED BY THE DISTRICT IN THE ADMINISTRATION OF ITS RESPONSIBILITIES UNDER THE CALIFORNIA ENVIRONMENTAL QUALITY ACT, AND ADOPTING THE STATE CEQA GUIDELINES BY REFERENCE

RESOLUTION NO. 196

At a meeting of the Board of Trustees of the Napa County Mosquito Abatement District, a special district organized and existing under the laws of the State of California, held on the 14th day of April, 1999, at 964 Imola Avenue, Napa, California, a quorum being present, the following Resolution was adopted:

WHEREAS, the Napa County Mosquito Abatement District (District) is required to adopt procedures for administering its responsibilities under the California Environmental Quality Act (CEQA); and

WHEREAS, the State CEQA Guidelines were amended and revised effective October 26, 1998; and

WHEREAS, the District may meet its requirements by adopting the State CEQA Guidelines (Guidelines) by reference and by further adopting specific procedures needed to tailor the guidelines to the District's operations; and

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF TRUSTEES OF THE NAPA COUNTY MOSQUITO ABATEMENT DISTRICT as follows:

Section 1.

The State CEQA Guidelines, revised as of October 26, 1998, and found in Title 14 Section 15000 et seq. of the California Code of Regulations are hereby adopted and by this reference incorporated into this Resolution as though fully set forth herein.

Section 2.

A. The District has not determined any list of ministerial projects in addition to those set forth in the Guidelines. The Manager of the District may determine what is a ministerial project on a case-by-case basis, which may be followed by District Board determination.

B. The District Board hereby determines that the operation, repair, maintenance or minor alteration of the District's administrative facilities and other District facilities are exempt activities pursuant to CEQA Guidelines Section 15301, so long as such operation, repair, maintenance, or minor alteration involves negligible or no expansion of use beyond that previously existing.

C. The District Board hereby determines that the replacement or reconstruction of existing facilities comprising the District's administrative facilities and other District facilities are exempt activities pursuant to CEQA Guidelines Section 15302, so long as such replacement or reconstruction is for structures or facilities where the new structure or facility will be located on the same site as the old, and will have the same purpose and capacity as the structure or facility replaced.

D. The District Board hereby determines that the construction and location of limited numbers of new, small facilities or structures necessary or advisable for the provision of mosquito and vector control related services, and the installation of small, new equipment and facilities in small structures for the provision of such services are exempt activities pursuant to CEQA Guidelines Section 15303, so long as successive projects consisting of such construction and location or installation of the same type in the same place over time do not result in significant cumulative impact. This exemption shall not apply where a project may impact upon an environmental resource of hazardous or critical concern where designated, precisely mapped and officially adopted pursuant to law by federal, state, or local agencies.

<u>Section 3.</u>

The following delegation of responsibility is made pursuant to Section 15025 of the Guidelines.

The Manager of the district, or his/her designee, shall be responsible for the following functions:

A. Initially determining whether a project is exempt, followed by Board determination regarding exemption.

B. Conducting an initial study and deciding whether to prepare a draft EIR or Negative Declaration.

C. Preparing a Negative Declaration or EIR.

D. Evaluating and preparing responses to comments on environmental documents.

E. Filing of notices.

F. Consulting with and obtaining comments from other public agencies and members of the public, as the Manager or his/her designee deems appropriate and as required by law, with regard to the environmental effects of projects.

G. Providing adequate comments on environmental documents that are submitted to the public agency for review.

H. Administering, monitoring, or reporting programs adopted by the Board related to revisions and mitigation measures required by the Board.

Section 4.

A. The public review period for draft EIR's referred to in Section 15087(e) of the Guidelines shall be 30 days from the date of the notice of availability of draft EIR, except that the Manager may extend that period for an additional 30 days, or for an additional 60 days when he or she determines that the draft EIR is unusually complex or lengthy or that the additional time is necessary to allow the public adequate time to review and comment upon the draft EIR. When a draft EIR is submitted to the State Clearinghouse for review by State agencies, the public review period shall not be less than 45 days, unless a shorter period, not less than 30 days, is approved by the State Clearinghouse. The public review period for Negative Declarations shall be 20 days from the date the Notice of Proposal to Adopt Negative Declaration was first posted, published, or mailed as set forth in the Guidelines or such other period as is provided by law, unless in the cases when Negative Declarations are submitted to the State Clearinghouse for review by State agencies, when the public review period shall be not less than 45 days, unless a shorter period, not less than 30 days, is approved by the State Clearinghouse. In the event a Negative Declaration is substantially revised after public notice of its availability has been given but prior to its adoption, the Negative Declaration shall be recirculated pursuant to the procedures and for the time periods set forth in this Section. The public review period for draft EIR's and Negative Declarations submitted to the State Clearinghouse for review by State agencies shall be at least as long as the review period established by the State Clearinghouse.

B. The Manager may submit written requests for shortened review periods to the State Clearinghouse.

Section 5.

The Manager or his/her designee shall compile a list of public agencies, which have jurisdiction by law and/or special expertise with respect to various projects and project locations (Section 15087(h), Guidelines). Depending upon the specific project and the requirements of law, some or all of the listed agencies must be given the opportunity to review and comment upon a draft EIR.

Section 6.

The District's Board of Trustees shall be responsible for determining the adequacy of an EIR or Negative Declaration.

Section 7.

To the extent a District website is available, notices of availability of draft EIR's, notices of intent to adopt Negative Declarations, and notices of public meetings or hearings where an EIR, Negative Declaration, or Notice of Exemption may be acted upon shall be posted on such website.

Section 8.

This Resolution is intended to govern certain procedures pursuant to which the District will prepare, process, and review environmental determinations required by CEQA. CEQA and the Guidelines will govern all substantive issues related to environmental determinations, and procedures not addressed by this Resolution. Where the contents of the Resolution conflict with CEQA or the Guidelines, CEQA or the Guidelines shall control.

I, STEVEN ROSA, the undersigned Secretary of the said Board of Trustees of the Napa County Mosquito Abatement District, a special district, hereby certify that I am the Secretary of said special district, the foregoing is a full, true and correct copy of the Resolution passed by the Board of Trustees thereof at a meeting of said Board held on the day and at the place therein specified, and that said Resolution has never been revoked, rescinded or set aside, and is now in full force and effect.

PASSED AND ADOPTED by the Board of Trustees of the Napa County Mosquito Abatement District April 14, 1999, by the following vote.

AYES: BAILEY, CABRAL, FLINDY, JOHNSON, ROSA, SOMPLE

NOES: NONE

ABSENT: NONE

ABSTAIN: NONE

Steven Rosa, Secretary, Board of Trustees

The Board of Trustees of the Napa County Mosquito Abatement District, in order to comply with provision of Sections 21000 through 21174, California Public Resources Code, hereby sets forth procedures it will use to apply the California environmental Quality Act of 1970, consistent with provisions of Sections 15000 through 15166, California Administrative Code.

1. Definitions.
   a. District means the Napa County Mosquito Abatement District.
   b. Vector means any insect or other animal capable of transmitting human disease or causing human annoyance.
   c. Jurisdiction means within the boundaries of the District or in proximity close enough so that vectors produced outside of the District may affect people within the District.
2. Preparation of environmental impact reports by the District.
   a. Abatement procedures, notices and directions to prevent the recurrence of vector production within the jurisdiction of the District are categorically exempt from the need for environmental impact reports under Section 15108, California Administrative Code.
   b. Routine rearing, transporting, and stocking of the mosquito fish, Gambusia affinis, or similar species within the jurisdiction of the District is categorically exempt from the need for an environmental impact report under Section 15101, California Administrative Code.
   c. Routine pesticide use within the jurisdiction of the District under cooperative agreement with the California Department of Health is categorically exempt from the need for an environmental impact report under Section 15108, California Administrative Code.
   d. Physical change in land or water management systems to mitigate vector production within the jurisdiction of the District is categorically exempt from the need for an environmental impact report if the proposed project meets the criteria enunciated in Section 15104 or other sections of the California Administrative Code. If the project does not meet the stated criteria the District

will prepare or cause to be prepared an environmental impact report or a negative declaration and will comply with preparation, review and filing procedures as set forth in Sections 15083 through 15166, California Administrative Code.

3. Review by the District of environmental impact reports prepared by other public agencies.

   a. The District is empowered by law and possesses special expertise in specific fields, and therefore asserts that, consistent with Section 15161, California Administrative Code, it is to receive for review environmental impact reports prepared by other public agencies if the proposed projects may affect production of vectors within the jurisdiction of the District.

4. The foregoing statements may be amended by motion of the Board of Trustees of the District.

5. The foregoing statements are adopted by motion of the Board of Trustees of the Napa County Mosquito Abatement District on March 14, 1973.

APPENDIX D

DISTRICT TREATMENT AND EQUIPMENT CRITERIA

LARVAL SOURCE TREATMENT CRITERIA

SPECIES	DISTANCE TO POPULATED AREA	TOTAL L/P DENSITY OTHER FACTORS
Ae. dorsalis	0 yards – 5 miles	1 per 10 dips and source ¼ acre or more
Ae. sierrensis	0 – 500 yards	1 per "slurp" with turkey baster
Ae. squamiger	0 – 5 miles	1 per 10 dips and source ¼ acre or more
Ae. washinoi	0 – 500 yards 500 yards – 1 mile	1 per 10 dips 1 per dip and source ¼ acre or more
Cx. erythrothorax	0 – 500 yards	1 per dip
Cx. pipiens	100 – 500 yards 500 yards – 1 mile	1 per 10 dips 5 per dip and source ¼ acre or more
Cx. stignatosoma	0 – 100 yards	1 per 10 dips
Cx. tarsalis	0 – 500 yards 500 yards – 1 mile 1 mile – 2 miles	1 per 10 dips 1 per dip 5+ per dip and source ¼ acre or more
Cs. Incidens	0 – 500 yards 500 yards – 1 mile	1 per dip 10 per dip and source ½ acre or more
Cs. Inornata	500 yards – 1 mile	3 – 5 per dip

NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

PESTICIDE USE CRITERIA

CONDITIONS	OIL	LIQUIDS		GRANULES			FISH
		ALTOSID	BTI	B.S.	ALTOSID	BTI	
Water Temperature less than 65°F	X		X	X		X	
Water Temperature more than 65°F							
Larval Instar 1st – 2nd		X			X		
Larval Instar 4th – pupae			X	X		X	
Fresh Water							
Brackish Water			X			X	*
Low Organic Load							
High Organic Load		X	X		X	X	*
Emergent Vegetation less than 50%							
Emergent Vegetation more than 50%	X	X	X				
Predators Not Abundant							
Predators Abundant	X						**
Endangered Species Absent							
Endangered Species Present		X			X		**

X= DO NOT USE
 * need to acclimate fish
** have biologist evaluate before stocking

B.S. = Bacillus sphaericus

ceqapesticide.tbl

EQUIPMENT CRITERIA

ITEM	CRITERIA FOR TREATMENT USE
Argo with boom	2 acres or more Non-driveable terrain Light to moderately dense vegetation Foot access hazardous (e.g. cracks, etc)
Argo with granulator	1 acre or more Non-driveable terrain Moderate to very thick vegetation
Argo with hose reel	1 acre or more Not accessible by 4x4 with hose reel Spray gun sufficient to treat target area
4x4 with boom	.25 acre or more Driveable terrain Water depth 8 inches or less Sparse to moderate vegetation
4x4 with hose reel (200' hose)	.25 acre to 5 acres Non-driveable terrain but accessible by hose Foot access safe Sparse to moderate vegetation
Polaris ATV with boom	.5 acre to 15 acres Unaccessible by full size 4x4 Treatment does not entail crossing ditches or hazardous terrain Light to moderate vegetation Water depth less than 10 inches
Polaris ATV with power sprayer	Channel over 1,000 yards with access along side Pond .5 acre to 3.5 acres Unaccessible by full size 4x4 Light to moderate vegetation Water depth less than 10 inches Off all public roads
ATV bridges with Argo or Polaris	To be used with the ATV's to cross ditches in the marshes or pastures
Leco, hand-held	Less than 10 acres Foot access Wind less than 8 miles per hour
Leco, with Argo	Less than 10 acres No 4x4 access Wind more than 2 miles per hr. & less than 8 miles per hr.
Leco or Microgen with 4x4	Less than 10 acres Vehicle access Wind more than 2 miles per hr. & less than 8 miles per hr.
Leco, with Polaris	Less than 5 acres Driveable terrain No access by 4x4
Backpack Blower	Walkable terrain Dense vegetation

AERIAL TREATMENT CRITERIA

Aerial control measures to control immature mosquitoes may be instituted when one or more of the following conditions exist:

The area to be treated is inaccessible by conventional ground control methods and fits our treatment criteria

OR

The acreage and conditions are excessive and/or extreme enough to be cost effective to treat by air and fits our treatment criteria

OR

An urgent situation exists where timing is critical or the number of support vehicles are limited because of existing jobs

All aerial treatments must be approved and ordered by a supervisor.

If conditions fit the Aerial Treatment criteria, the operator must supply the supervisor with the following:

1. Thomas Brothers map coordinates.

2. Source number(s) if available.

3. Physical map of target area for pilot, including:
   a. Date of request.
   b. Maximum number of days pilot has to be able to treat the larval population effectively.
   c. Material.
   d. Rate of application.
   e. Acreage to be treated drawn in and marked in red (see example).

4. Written description of location of source.

ceqaaerialcriteria

APPENDIX E

MOSQUITOFISH STOCKING PROTOCOLS

Mosquitofish Stocking Policy

In an effort to minimize unwanted environmental impacts mosquitofish are not placed in sources known or thought to be habitats for endangered, threatened or rare species. Care must be taken when introducing mosquitofish into sources where they can migrate to habitats used by endangered, threatened or rare species. Mosquitofish can still be used in ornamental fish ponds, water gardens and abandoned swimming pools in urban and suburban areas without worrying about endangered species conflicts.

It is against California Department of Fish and Game regulations for private citizens to plant mosquitofish in waters of the State without a permit (Title 14 CCR, Fish and Game Code, Sections 1.63, 238.5 and 6400).

Mosquitofish provided by Napa County Mosquito Abatement District are intended for mosquito control purposes only and should not be introduced in potential mosquito breeding sources by anyone other than certified mosquito control technicians or Fish and Game personnel.

APPENDIX F

PUBLIC HEALTH AND SAFETY CODE, SECTIONS 2200 - 2360

CALIFORNIA HEALTH AND SAFETY CODE

DIVISION 3. PEST ABATEMENT

CHAPTER 5. MOSQUITO ABATEMENT DISTRICTS OR VECTOR CONTROL DISTRICTS

Article 1. General Provisions

§ 2200. Except where the context otherwise requires, the following definitions shall govern construction of this chapter:

(a) "Board" or "district board" refers to the board of trustees of a district.

(b) "City" includes a city and county.

(c) "District" refers to any mosquito abatement district or vector control district formed pursuant to this chapter or pursuant to any law which it supersedes.

(d) "Property" includes water, and the person or agency claiming ownership, title or right to water or who controls the diversion, delivery, conveyance, or flow of water is responsible for abatement of public nuisances, as specified in this chapter or Chapter 8 (commencing with Section 2800), which are caused by or as a result of diversion, delivery, conveyance or control.

(e) "Public nuisance" means any of the following:

(1) (A) Any breeding place for mosquitoes, flies, or other vectors of public health importance which exists by reason of any use made of the land on which it is found, or of any artificial change in its natural condition. Presence of immature arthropods of public health importance shall constitute prima facie evidence that a place is a breeding place for arthropods.

(B) If the board determines that an agricultural operation is growing or processing crops or raising fowl or animals in a manner consistent with proper and accepted practices and standards, as established and followed by similar agricultural operations in the same locality, and employing measures for fly control, for manure management, removal, and disposal, and for disposal of agricultural crop waste, which prevent excessive domestic fly larval development and excessive adult fly emergence on the property, then that place shall not be deemed a public nuisance.

(C) As used in this paragraph, "excessive" means the presence of domestic flies associated with agricultural operations, which do all of the following:

(i) Occur in immature stages and as adults in numbers considerably in excess of those found in the surrounding environment.

(ii) Are associated with the design, layout, and management of agricultural operations.

(iii) Disseminate widely from the property.

(iv) Cause detrimental effects on the public health and well-being of a majority of the surrounding population, as determined by the board.

(2) Water which is a breeding place for mosquitoes, flies, or other arthropods of public health importance.

(3) The presence of rodents or evidence of rodent activity, such as rodent droppings, trails, or evidence of feeding activity.

(f) "Vector" means any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal.

§ 2201. (a) Every notice required by this chapter to be published shall be published in a daily, weekly, or semiweekly newspaper. If there is no daily, weekly, or semiweekly newspaper published within the district or within a subdivision of the district or other territory in which it is required to be published, legal notice shall be posted for the length of time required for its publication in three public places of the district, subdivision, or other territory, as the case may be.

(b) A district may be organized and managed as provided in this chapter, and is authorized to exercise the powers expressly granted or necessarily implied by this chapter.

(c) No district formed or proposed to be formed under this chapter shall be subject to the District Investigation Law of 1933 provided for in Chapter 2 (commencing with Section 58500) of Division 2 of Title 6 of the Government Code.

§ 2202. (a) Except as otherwise provided in subdivision (b), every mosquito abatement district or vector control district employee who handles, applies, or supervises the use of any pesticide for public health purposes, shall be certified by the state department as a vector control technician, in at least one of the following categories commensurate with the assigned duties:

(1) Mosquito control.

(2) Terrestrial invertebrate vector control.

(3) Vertebrate vector control.

(b) The state department may establish, by regulation, exemptions from the requirements of this section which are deemed reasonably necessary to further the purposes of this section.

(c) The state department shall establish by regulation minimum standards for continuing education for any government agency employee certified under Section 116110 and regulations adopted pursuant thereto, who handles, applies, or supervises the use of any pesticide for public health purposes.

(d) An official record of the completed continuing education units shall be maintained by the state department. If a certified technician fails to meet the requirements set forth under subdivision (c), the state department shall suspend the technician's certificate or certificates and immediately notify the technician and the employing district. The state department shall establish by regulation procedures for reinstating a suspended certificate.

(e) The state department shall charge and collect a nonreturnable renewal fee of twenty-five dollars ($25) to be paid by each continuing education certificant on or before the first day of July, or on any other date which is determined by the state department. Each person employed in a position on the effective date of this section which requires certification shall first pay the annual fee the first day of the first July following that date. All new certificants shall first pay the annual fee the first day of the first July following their certification.

(f) The state department shall collect and account for all money received pursuant to this section and shall deposit it in the Mosquitoborne Disease Surveillance Account provided for in Section 25852 of the Government Code. Notwithstanding Section 25852 of the Government Code, fees deposited in the Mosquitoborne Disease Surveillance Account pursuant to this section shall be available for expenditure upon the appropriation by the Legislature to implement this section.

(g) Fees collected pursuant to this section shall be subject to the annual fee increase provisions of Section 110425.

Article 2. Formation

§ 2210. Any territory in one or more counties, having a population of not less than one hundred inhabitants, may be organized as a district.

§ 2211. A petition to form a district may consist of any number of separate instruments. It shall be presented at a regular meeting of the board of supervisors of the county in which the greater portion of the proposed district is located. The petition shall be signed by registered voters residing in the proposed district equal in number to 10 percent of the votes cast for Governor at the last preceding gubernatorial election.

Before a city can be included in the proposed district, its governing body shall request the inclusion of the city by resolution, duly authenticated.

§ 2212. The petition shall set forth and describe the boundaries of the proposed district, and shall request that it be organized as a mosquito abatement district or vector control district. The text of the petition shall state the basis on which the property in the district shall be taxed or assessed for district purposes. The petition may include a plan for zones of benefit or any other proposal which would provide equity in financing the district's purposes. The petition shall be published, for at least two weeks before the time it is to be presented, in the county where the petition is presented, and in each city a portion of which is included in the proposed district.

§ 2213. If any portion of the proposed district lies in another county, the petition and notice shall be likewise published in that county.

§ 2214. When signatures are contained upon more than one instrument, only one copy of the petition need be published. No more than five of the names attached to the petition need appear in the publication of the petition and notice, but the number of signers shall be stated.

§ 2215. The publication of the petition shall include a notice of the time and place of the meeting of the board of supervisors when the petition will be considered, stating that all persons interested may appear and be heard.

§ 2215.5. The districts may also be organized upon the adoption by the board of supervisors of a resolution of intention so to do, in lieu of the procedure provided by this article for the presentation of petitions. In the event the board of supervisors adopts a resolution of intention, the resolution shall follow the procedures established in Sections 2212 and 2215.

§ 2216. At the time stated in the notice of the filing of the petition or the time mentioned in the resolution of intention the board of supervisors shall consider the organization of the district and hear those appearing and all protests and objections to it. It may adjourn the hearing from time to time, not exceeding two months in all.

§ 2217. No defect in the contents of the petition or in the title to or form of the notice or signatures, or lack of signatures thereto, shall vitiate any proceedings, if the petition has a sufficient number of qualified signatures.

§ 2218. On the final hearing the board of supervisors shall make such changes in the proposed boundaries as are advisable, and shall define and establish the boundaries.

§ 2219. If the board of supervisors deems it proper to include any territory not proposed for inclusion within the proposed boundaries, it shall first cause notice of its intention to do so to be mailed to each owner of land in the territory whose name appears as owner on the last completed assessment roll of the county in which the territory lies, addressed to the owner at his address given on the assessment roll, or if no address is given, to his last known address; or if it is not known, at the county seat of the county in which his land lies. The notice shall describe the territory, and shall fix a time, not less than two weeks from the date of mailing, when all persons interested may appear before the board of supervisors and be heard.

§ 2220. The boundaries of a district lying in a city shall not be altered unless the governing board of the city, by resolution, consents to the alteration.

§ 2221. Upon the hearing of the petition the board of supervisors shall determine whether or not the public necessity or welfare of the proposed territory and of its inhabitants requires the formation of the district, and shall also determine whether or not the petition complies with the provisions of this chapter, and for that purpose shall hear all competent and relevant testimony offered.

§ 2222. A finding of the board of supervisors in favor of the genuineness and sufficiency of the petition and notice is final and conclusive against all persons except the State in a suit commenced by the Attorney General.

§ 2223. If, from the testimony given before the board of supervisors, it appears to that board that the public necessity or welfare requires the formation of the district, it shall, by an order entered on its minutes, declare that to be its finding, and shall further declare and order that the territory within the boundaries so fixed and determined be organized as a district, under an appropriate name to be selected by the board of supervisors. The name shall contain the words "mosquito abatement district" or "vector control district."

§ 2224. The county clerk shall immediately file for record in the office of the county recorder of each county in which any portion of the land embraced in the district is situated, and shall also forward to each board of supervisors of each of the other counties, if any, in which any portion of the district is situated, and also shall file with the Secretary of State, a certified copy of the order of the board of supervisors. From and after the date of the filing of the certified copy with the Secretary of State, the district named therein is organized as a district, with all the rights, privileges, and powers set forth in this chapter, or necessarily incident thereto.

§ 2225. If at any time after the board of supervisors has entered its order for organization good cause appears therefor, the district board may, by a two-thirds vote of its members, adopt a resolution reciting the facts, declaring the advisability for a change of the district's name, and setting forth therein a new name for the district. A certified copy of such resolution shall be transmitted to the board of supervisors of the county in which the district, or the greater portion of the land of the district, is situated.

§ 2226. Upon receipt of the certified copy of the resolution the board of supervisors shall:

(a) Enter an order changing the district's name to the name set forth in the resolution.

(b) Transmit a certified copy of the order to the board of supervisors of any other county in which any portion of the district is situated.

(c) Record a certified copy of the order in the office of the county recorder of each of the counties in which any portion of the district is situated.

(d) File a certified copy of the order in the office of the Secretary of State.

(e) File a certified copy of the order in the office of the State Board of Equalization.

From and after the date of the filing of the certified copy with the Secretary of State the new name shall be the official name of the district.

Article 3. Officers

§ 2240. Within 30 days after the filing with the Secretary of State of the certified copy of the order of formation, a governing board of trustees for the district shall be appointed. The district board shall be appointed as follows:

(a) If the district is situated in one county only and consists wholly of unincorporated territory, five members shall be appointed by the board of supervisors of the county.

(b) If the district is situated entirely in one county and includes both incorporated and unincorporated territory, one member may be appointed from the district at large by the board of supervisors of the county, and one member may be appointed from each city, the whole or part of which is situated in the district, by the governing body of the city. If the district board created consists of less than five members, the board of supervisors shall appoint from the district at large enough additional members to make a board of five members.

(c) If the district is situated in two or more counties and is comprised wholly of unincorporated territory, one member shall be appointed from each county or portion of a county situated in the district by the board of supervisors. If the district board created consists of less than five members, the board of supervisors of the county in which the greater portion of the district is situated shall appoint from the district at large enough additional members to make a board of five members.

(d) If the district is situated in two or more counties and consists of both incorporated and unincorporated territory, one member may be appointed by the board of supervisors of each of the counties from that portion of the district lying within its jurisdiction, and one member may be appointed from each city, a portion of which is situated in the district, by the governing body of the city. If the board created consists of less than five members, the board of supervisors in which the greater portion of the district is situated shall appoint from the district at large enough additional members to make a board of five members.

(e) At any time after the appointment of the initial district
board of trustees, the board of supervisors of any county having territory in whole or in part in a district, may at the written request of the existing district board of trustees, increase or decrease the number of members of the board of trustees representing unincorporated territory in the district. The written request of the district board of trustees shall specify the number of members and the region or regions in the unincorporated territory for which an increase or decrease is requested. However, the district board of trustees shall, under no circumstances, consist of less than five members, nor shall the number of members representing unincorporated territory in the entire district exceed five members.

§ 2241. The district board shall be called "The board of trustees of ______________________ mosquito abatement district" or "The board of trustees of ______________________ vector control district."

§ 2242. Each member of the board appointed by the governing body of a city shall be an elector of the city from which he is appointed, and a resident of that portion of the city which is in the district.

§ 2243. Each member appointed from a county or portion of a county shall be an elector of the county and a resident of that portion of the country which is in the district.

§ 2244. Each member appointed at large shall be an elector of the district.

§ 2245. (a) The members of the first board in any district shall classify themselves by lot at their first meeting so that either of the following shall occur:

(1) If the total membership is an even number, the terms of one-half the members shall expire at the end of one year, and the terms of the remainder at the end of two years, from the second

day of the calendar year next succeeding their appointment.

(2) If the total membership is an odd number, the terms of a bare majority of the members shall expire at the end of one year, and the terms of the remainder at the end of two years, from the second day of the calendar year next succeeding their appointment.

(b) The term of each subsequent member shall be two years from and after the expiration of the term of his predecessor.

(c) The first term of any member shall not exceed two years. Each subsequent consecutive reappointment, if any, may be for a term of two or four years, at the discretion of the appointing power.

§ 2246. In the event of the resignation, death, or disability of any member, his successor shall be appointed by the governing body which appointed him.

§ 2247. The members of the first district board shall meet on the first Monday subsequent to 30 days after the filing with the Secretary of State of the certificate of incorporation of the district. They shall organize by the election of one of their members as president and one as secretary.

§ 2248. The members of the district board shall serve without compensation, but the necessary expenses of each member for actual traveling in connection with meetings or business of the board shall be allowed and paid. In lieu of expenses, the district board may by resolution provide for the allowance and payment to the members of the board of a sum not exceeding fifty dollars ($50) per month per member for expenses incurred in attending business meetings of the board.

§ 2249. The secretary shall receive such compensation as shall be fixed by the district board.

§ 2250. The district board shall provide for the time and place of holding its regular meetings, and the manner of calling them, and shall establish rules for its proceedings.

§ 2251. Special meetings may be called by three members, notice of which shall be given to each member at least three hours before the meeting.

§ 2252. All of its sessions, whether regular or special, shall be open to the public.

§ 2253. A majority of the members shall constitute a quorum for the transaction of business.

Article 4. District Powers

§ 2270. The district board may do all of the following:

(a) Take all necessary or proper steps for the control of mosquitoes, flies, or other vectors, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other vectors may disperse from the territory into the district.

(b) Abate as nuisances all standing water and other breeding places for mosquitoes, flies, or other vectors, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other vectors from the territory disperse into the district.

(c) Purchase the supplies and materials, employ the personnel and contract for the services which may be necessary or proper in furtherance of the objects of this chapter.

(d) If necessary or proper in the furtherance of the objects of this chapter, build, construct, repair, and maintain the necessary dikes, levees, cuts, canals, or ditches upon any land and acquire by purchase, condemnation, or by other lawful means, in the name of the district, any lands, rights-of-way, easements, property, or material necessary for any of those purposes.

(e) Make contracts to indemnify or compensate any owner of land or other property for any injury or damage necessarily caused by the use or taking of property for dikes, levees, cuts, canals, or ditches.

(f) Enter upon any property without hinderance or notice, either within the district or so reasonably adjacent thereto that vectors may disperse into the district, for any of the following purposes:

(1) To inspect to ascertain the presence of vectors or their breeding places.

(2) To abate public nuisances in accordance with this article, either directly or by giving notice to the property owner to abate a nuisance.

(3) To ascertain if a notice to abate vectors has been complied with.

(4) To treat property with appropriate physical, chemical, or biological control measures.

(g) Sell or lease any service, land, rights-of-way, easements, property or material acquired by the district. Equivalent properties may be exchanged, if it is in the best interests of the district to do so.

(h) Borrow money in any fiscal year and repay it in the same or in the next ensuing fiscal year. The amount borrowed in any fiscal year shall not exceed fifteen cents ($0.15) on each one hundred dollars ($100) of assessed valuation of property in the district.

(i) Issue warrants payable at the time stated in the warrant to evidence the obligation to repay money borrowed or any other obligation incurred by the district. Warrants so issued shall draw interest at a rate fixed by the board not to exceed 5 percent per year, payable annually or semiannually as the board may prescribe.

(j) Provide a civil service system for any or all employees of the district.

(k) Assess civil penalties, as determined in the discretion of the board, but not to exceed five hundred dollars ($500) per day for each day that a notice or hearing order to abate a nuisance has not been complied with.

Any sum which may be collected shall become part of the district's general fund to be used solely for vector control purposes.

(*l*) Levy, by resolution or ordinance, a service charge against any or all parcels of land within the district to pay for the cost of vector surveillance and control. The schedule of charges shall be made, reviewed, and adopted annually after notice and hearing in connection with the schedule. Following the hearing, the board may classify parcels of property according to their use in relation to the cost of vector surveillance and control. The board may bill for the charges annually or more frequently. The charges shall be collected and paid by the county in the same manner as property taxes by the county. The service charge shall be reasonably related to the district's cost for providing vector surveillance and control and shall not be deemed a tax of any kind. Any sum collected shall be used solely for purposes of vector surveillance and control.

(m) Set the tax or assessment rates which are necessary to carry out the purposes of this article.

(n) Do any and all things necessary for, or incident to, the powers granted by, and to carry out the objects specified in, this chapter.

§ 2272. Except as otherwise provided in Section 2272.5, a public nuisance may be abated in any action or proceeding by any remedy provided by this chapter or any other provision of law.

§ 2272.5. Section 2272 shall not apply to a public nuisance which exists at an agricultural operation by reason of excessive domestic fly larval development and excessive adult fly emergence as defined in subparagraph (C) of paragraph (1) of subdivision (e) of Section 2200. An agricultural nuisance described in this section may be abated in any action or proceeding only by the remedies provided by this chapter. This chapter shall provide the exclusive source of costs and civil penalties which may be assessed by reason of the agricultural nuisance against the owner or operator of an agricultural operation at which the nuisance is found to exist.

§ 2273. The procedures for abatement of nuisances and assessment of the cost thereof as a lien against properties, as provided for pest abatement districts in Chapter 8 (commencing with Section

2800) of this division, may be utilized by the district board as an alternative to the abatement procedures set forth in this chapter.

§ 2274. Whenever a nuisance specified in this chapter exists upon any property, either in the district or in territory not in the district but so situated with respect to the district that mosquitoes, flies, or other vectors from the territory disperse into the district, the district board may notify in writing the owner or party in possession, or the agent of either, of the existence of the nuisance.

§ 2275. The notice shall do all of the following:

(a) State the finding of the district that a public nuisance exists on the property and the location of the nuisance on the property.

(b) Direct the owner or party in possession to take appropriate steps to eliminate, or prevent the recurrence of, the nuisance.

(c) Inform the owner or party in possession that failure to comply with the requirements of subdivision (b) shall subject the owner or party in possession to civil penalties of not more than five hundred dollars ($500) per day for each day the nuisance continues after the time specified for the abatement of the nuisance in the notice.

(d) Inform the owner or party in possession that before complying with the requirements of the notice, the owner or party in possession may appear at a hearing before the district board at a time and place stated in the notice.

§ 2277. The notice shall be served upon the owner of record, or person having charge or possession, of the property upon which the nuisance exists, or upon the agent of either.

§ 2278. The notice may be served by any person authorized by the district board in the same manner as a summons in a civil action, or it may be served by registered mail or personal delivery with proof of service.

§ 2279. If the property belongs to a person who is not a resident of the district, and is not in charge or possession of any person, and there is no tenant or agent of the owner upon whom service can be made, who can after diligent search be found; or if the owner of the property can not after diligent search be found, the notice may be served by posting a copy in a conspicuous place upon the property for a period of 10 days, and by mailing a copy to the owner addressed to his address as given on the last completed assessment roll of the county in which the property is situated, or, in the absence of an address on the roll, to his last known address.

§ 2280. Before complying with the requirements of the notice the owner or party in possession may appear at a hearing before the board at a time and place fixed by the board and stated in the notice. At the hearing the district board shall determine whether the initial findings a set forth in the notice is correct and shall permit the owner or party in possession to present testimony in his behalf. If, after hearing all the facts, the board makes a determination that a nuisance exists on the property, the board shall order compliance with the requirements of the notice or with alternate instructions issued by the board.

Any failure to comply with any order of the board issued pursuant to this section shall subject the owner or party in possession to civil penalties as determined by the discretion of the board which shall not exceed five hundred dollars ($500) per day for each day such order is not complied with.

§ 2280.1. Any judicial review of administrative procedure provided for in this chapter shall be pursuant to Section 1094.5 of the Code of Civil Procedure.

§ 2281. Any recurrence of the nuisance may be deemed to be a continuation of the original nuisance.

§ 2282. In the event that the nuisance is not abated within the time specified in the notice or at the hearing, the district board may abate the nuisance by destroying the larvae or pupae and by taking appropriate measures to prevent the recurrence of further breeding.

§ 2283. All or part of the cost of abatement of a nuisance shall be repaid to the district by the owner of the property, as determined by the district board. However, the owner shall not be required to pay the cost unless, either prior or subsequent to the abatement by the district, a hearing is held by the district board, the property owner is afforded an opportunity to be heard, and it is determined by the district board that a nuisance actually exists, or existed prior to abatement by the district. The district board may use a civil penalty assessment in lieu of charging for actual costs to abate the nuisance, or it may include reasonable costs for abatement as part of a civil penalty assessment.

§ 2283.5. When any nuisance specified in this chapter is found to exist on any property subject to the control of any state or local agency, the district shall notify the state or local agency of the existence of the nuisance. Sections 2275, 2277, 2278, 2280, 2281, and 2282 shall govern the contents of the notice and the manner of serving it, the right of the state or local agency to a hearing before the board, the hearing before the board, and the power of the district to abate the nuisance if it is not abated by the state or local agency. If the state or local agency determines that the order to prevent recurrence of the breeding specified in the notice to abate the nuisance is excessive or inappropriate for the intended use of the land, or if the state or local agency determines that a nuisance, as specified in Section 2200, does not exist, the agency may appeal the decision of the board to the State Director of Health Services within 10 days subsequent to the hearing. The director shall decide the matters on appeal and convey his or her decision to the agency and district within 30 days of the receipt of the appeal. The decision of the director shall be final and conclusive. If the control of the nuisance is performed by the district, the cost for the control is a charge against, and shall be paid from, the maintenance fund or from other funds for the support of the state or local agency.

Any state or local agency and a district may enter into contractual agreements to provide control of nuisances as defined in this chapter. The authority which is granted by this paragraph is in addition to any other authority which a state agency and a district may have to enter into contractual agreements for the control of vectors.

As used in this section, "state agency" means an agency specified in Section 11000 of the Government Code, and "local agency" means a city, county, city and county, district, or other public corporation.

§ 2284. Upon the failure of the property owner or person in possession to pay the cost to the district for all sums expended by the district in abating a nuisance or preventing its recurrence and all civil penalties, the costs shall become a lien upon the property on which the nuisance is abated, or its recurrence prevented, when notice of the lien is filed and recorded as provided in Section 2285. However, if the property has been conveyed prior to the recordation of the lien, the lien shall not attach to the real property, but shall remain the debt of the person who owned the land at the time the costs were incurred, and the debt may be recovered in a civil action by the district board against the debtor.

§ 2285. Notice of the lien, particularly identifying the property on which the nuisance was abated and the amount of such lien, and naming the owner of record of such property, shall be recorded by the district board in the office of the county recorder of the county in which the property is situated within one year after the first item of expenditure by the board or within 90 days after the completion of the work, whichever first occurs. Upon such recordation, such lien shall have the same force, effect and priority as if it had been a judgment lien imposed upon real property which was not exempt from execution, except that it shall attach only to the property described in such notice, and shall continue for 10 years from the time of the recording of such notice unless sooner released or otherwise discharged.

§ 2285.5. The district board may at any time release all or any portion of the property subject to a lien imposed pursuant to Sections 2284 and 2285 from the lien or subordinate such a lien to other liens and encumbrances if it determines that the amount owed is sufficiently secured by a lien on other property or that the release or subordination of such lien will not jeopardize the collection of such amount owed. A certificate by the board, or its designee, to the effect that any property has been released from such lien or that such lien has been subordinated to other liens and encumbrances shall be conclusive evidence that the property has been released or that the lien has been subordinated as provided in such certificate.

§ 2286. An action to foreclose the lien shall be commenced within six months after the filing and recording of the notice of lien.

§ 2287. The action shall be brought by the district board in the name of the district.

§ 2288. When the property is sold, enough of the proceeds to satisfy the lien and the costs of foreclosure shall be paid to the district; and the surplus, if any, shall be paid to the owner of the property if known, and if not known, shall be paid into the court in which the lien was foreclosed for the use of the owner when ascertained.

§ 2289. The lien provisions of this chapter do not apply to the property of any county, city, district, or other public corporation. However, the governing body of the county, city, district, or other public corporation shall repay to any district the amount expended by the district upon any of its property under this chapter upon presentation by the district board of a verified claim or bill.

§ 2290. Any district organized on or after August 14, 1931, and any such district organized prior to that date that elects to do so by a vote taken at an election called and conducted as provided for an election for a tax to raise additional funds for the district, may provide for the destruction and extermination of rats in the district; and may include suitable sums for that purpose in its expense estimates, which shall be raised in the manner provided by law for the raising of other sums for the district.

The district board shall supervise and manage the destruction and extermination of rats in the district by the officers, agents, and employees of the district.

§ 2290.5. Any district may also abate as a nuisance any infestation of rats either by court proceeding or by administrative action and may collect the costs thereof in the same manner provided for the abatement of breeding places for mosquitoes, flies, and other insects.

§ 2291. Any district may conduct vector surveillance and control projects for any part of the district.

§ 2291.1. The district board shall determine which of the projects authorized by Section 2291 shall be carried out and shall determine, as to each project, that it is one of the following:

(a) For the common benefit of the district as a whole.

(b) For the benefit of two or more zones, which may be referred to as participating zones.

(c) For the benefit of a single zone.

§ 2291.2. (a)(1) The district board may institute projects for one or more zones, for the financing and execution of vector surveillance and control projects of common benefit to the zone or zones.

(2) Before beginning a project, the district board shall adopt a resolution which shall specify its intention to undertake the project, estimate the cost to be borne by the zones, state the duration of the assessment, state the general objectives of the surveillance or control project, and fix a time and place for a public hearing and a public meeting on the project. In the

case of more than one zone, the resolution shall specify the proportionate cost to be borne by each of the zones.

(3) Notice of the public meeting and the public hearing shall be given pursuant to Section 54954.6 of the Government Code [within Chapter 9 of Part 1 of Division 2 of Title 5; see also "Ralph M. Brown Act"].

(b) At any time before the time set for the hearing, any owner of any property which is proposed to be assessed may make written protest against the proposed project and assessment. The written protest shall contain a description of the property sufficient to identify the property. If the signer is not shown on the last equalized assessment roll as the owner of that property, the written protest shall contain written evidence that the signer is an owner of the property proposed to be assessed.

(c) At the time and place stated in the notice for the public meeting and the public hearing, the district board shall hear and consider any objections and protests to the proposed project and assessments.

The district board may continue the public meeting and the public hearing from time to time. Any written protest may be withdrawn in writing by the person making the protest at any time before the conclusion of the hearing.

(d) Following the conclusion of the hearing, if the district board finds that the written protests filed and not withdrawn represent 50 percent or more of the total amount of expected revenue from the proposed assessment, the board shall abandon the proposed project and assessment. If the district board finds that the written protests filed and not withdrawn represent less than 50 percent of the total amount of expected revenue from the proposed assessment, the district board may, at its discretion, proceed with or abandon the proposed project and assessment.

(e) The assessments levied pursuant to this section shall be collected at the same time and in the same manner as county taxes. The county may deduct its actual costs incurred for collecting the assessments before remitting the balance to the district. The assessments shall be a lien on all the property benefited thereby. Liens for the assessments shall be of the same force and effect as liens for taxes, and their collection may be enforced by the same means as provided for the enforcement of liens for county taxes.

(f) For the purposes of an assessment levied under this section, the property so assessed within a given zone is equally benefited.

§ 2291.3. The provisions of Section 2291.2 shall be exclusive in determining the proper procedure for the institution of projects under Sections 2291, 2291.1, and 2291.2, any other provision of law notwithstanding.

§ 2291.4. In addition to the powers enumerated in Article 5 (commencing with Section 2300), the board may do any of the following:

(a) Levy taxes or assessments in each or any of the zones and participating zones to pay the cost and expenses of carrying out the projects within, or on behalf of, the respective zones, according to the benefits derived or to be derived by the respective zones, by a levy or assessment upon any or all property within a zone or participating zone, including land, improvements, and personal property.

It is declared that for the purposes of any tax or assessment levied under this subdivision, the property so taxed or assessed within a given zone is equally benefited.

(b) Levy taxes or assessments by the method authorized by subdivision (a) in each or any of the zones, according to the special benefits derived or to be derived by the specific properties therein, to pay the cost and expenses of carrying out any of the projects within or on behalf of the respective zone or zones.

§ 2291.5. Any ordinance or resolution adopted by a district prior to January 1, 1987, pursuant to subdivision (*l*) of Section 2270 which levies an assessment which otherwise meets the requirements of Section 2291.2, shall be deemed to satisfy the requirements of Section 2291.2 and shall continue to be levied and collected notwithstanding the amendment to subdivision (*l*) of Section 2270 by the chapter of the Statutes of 1986 which added this section.

§ 2291.7. In Lake County, any mosquito abatement district, as authorized by the district board, may notwithstanding Section 2291.3, conduct or contract for algae research projects and algae control or abatement projects for any part of the district. In undertaking these projects, the district board shall comply with the procedures set forth in subdivisions (a), (b), (c), and (d) in order to levy a benefit assessment for these projects.

(a) Prior to levying any benefit assessment, the board shall comply with all of the following:

(1) The board shall adopt a resolution which shall specify its intention to undertake the project. The resolution shall include all of the following:

(A) A description of the plan, including, but not limited to, all of the following:

(i) The causes of the algae.

(ii) Alternative methods and associated costs of algae prevention, reduction, and control.

(iii) Mitigation measures, including mitigation of the effects of potential treatment on humans, and on fish and wildlife habitat.

(iv) The agency or agencies with responsibilities for algae prevention, reduction, and control. The plan may reference the environmental document prepared pursuant to Division 13 (commencing with Section 21000) of the Public Resources Code.

(B) The establishment of a benefit assessment zone or zones.
(C) A description of the properties to be assessed.
(D) A description of the cost of each assessment.
(E) A statement specifying the duration of the assessment.

(2) The board shall hold public hearings after notice has been published for three successive weeks in a newspaper of general circulation published in the county seat.

(3) The board shall send notice of the resolution and of the hearings to those owners of property to be assessed at least 14 days prior to the public hearing.

(4) After the public hearing, the plan shall be approved by a majority of the owners of property to be assessed. The board shall take no action to implement the plan or the assessment until after the plan is approved by a majority of owners of property to be assessed.

(b) Any herbicide application for the purpose of algae abatement pursuant to this section shall be subject to the approval of the Department of Fish and Game. The department shall grant approval unless it is determined that the application would cause significant diminishment of green or yellow-green algae or zooplankton.

(c) The assessments levied pursuant to this section shall be collected at the same time, and in the same manner, as county taxes. The county may deduct its actual costs incurred for collecting the assessments before remitting the balance to the district. The assessments shall be a lien on all the property benefited thereby. Liens for the assessments shall be of the same force and effect as liens for taxes, and their collection may be enforced by the same means as for the enforcement of liens for county taxes.

(d) For the purposes of an assessment levied under this section, all properties so assessed within a given zone are equally benefited.

The requirements set forth in this section shall only apply to algae research projects and algae control or abatement projects in Lake County.

In enacting this section, the Legislature does not intend to amend the power of any other district to use any other power authorized by this chapter.

§ 2292. Any person who restrains, hinders, obstructs, or threatens any officer or employee of a district in the performance of that person's duties, or any person who interferes with any work done by, or under the direction of, the district is guilty of a misdemeanor.

§ 2294. In case of dispute between government agencies on the need, or the methods and materials used, to abate or prevent a public health nuisance under this chapter, the matter shall be subject to appeal to the State Director of Health Services within 10 days. The director shall take testimony on the issue, and shall decide the matter on appeal and convey his or her decision to the parties within 30 days of the receipt of the appeal. The decision of the director shall be final and conclusive.

Article 5. Finances and Taxation

§ 2300. On or before August 1 of each year, the district board of each district shall prepare a written estimate of the amount of money necessary for the district's purposes during the next ensuing fiscal year. The amount of money necessary for the district's purposes may include a general reserve for the purpose of defraying district expenses between the beginning of a fiscal year and the time of distribution of tax receipts in a fiscal year. The general reserve shall not exceed 60 percent of the estimated expenditures for a fiscal year.

The amount of money necessary for the district purposes may also include an unappropriated reserve for the purpose of defraying unusual and unanticipated expenses.

Expenditures from the unappropriated reserve may be made only upon an affirmative vote of four-fifths of the members of the district board. The emergency fund shall not exceed 25 percent of the estimated expenditures for a fiscal year.

§ 2302. The county auditor shall allocate to a district its share of property tax revenue pursuant to Chapter 6 (commencing with Section 95) of Part 0.5 of Division 1 of the Revenue and Taxation Code.

§ 2303. Whenever it appears to the district board that the amount of funds required during an ensuing fiscal year will exceed the amount available, the district board may call an election to submit to the electors of the district the question of whether a special tax shall be voted for raising the additional funds pursuant to Article 3.5 (commencing with Section 50075) of Chapter 1 of Part 1 of Division 1 of Title 5 of the Government Code.

§ 2304. Notice of the election shall be published for at least four weeks prior to the election.

§ 2305. No particular form of ballot shall be required, nor shall any informalities in conducting the election invalidate it if it is otherwise fairly conducted

§ 2306. At the election the ballots shall contain the words "Shall the district vote a tax to raise the additional sum of $_____?", or words equivalent thereto.

§ 2307. The district board shall canvass the votes cast at the election, and, if two-thirds of the votes cast are in favor of the imposition of the tax, shall report the result to the board of supervisors of the county in which the district is situated, stating the additional amount of money required to be raised. If the district is more than one county, the additional amount shall be prorated for each county by the district board in the same way that the district's original total estimate of funds is prorated. The district board shall furnish the board of supervisors and auditor of each county a written statement of the apportionment for that county.

§ 2308. The board of supervisors of each county receiving the written statement shall, at the time of levying county taxes, levy an additional tax upon all the taxable property of the district in the county sufficient to raise the amount apportioned to that county.

§ 2309. All taxes and assessments levied under this chapter shall be computed and entered on the county assessment-roll by the county auditor and collected at the same time and in the same manner as other county taxes. When collected, the taxes and assessments shall be paid into the county treasury for the use of the district.

§ 2310. If the district is in more than one county the treasury of the county in which the district is organized is the depository of all funds of the district.

§ 2311. The treasurers of the other counties shall, at any time, not oftener than twice each year, upon the order of the district board settle with the district board and pay over to the treasurer of the county where the district is organized all money in their possession belonging to the district. The last named treasurer shall receipt for the money and place it to the credit of the district.

§ 2312. The funds shall only be withdrawn from the county treasury depository upon the warrant of the district board signed by its president or acting president, and countersigned by its secretary or acting secretary. However, if the county in which the district is situated has adopted a requisition system covering the withdrawal of funds for the purchase of services or supplies, the district board may, by resolution, adopt such system and make withdrawals in accordance therewith.

The board may by resolution authorize the withdrawal of funds from the county treasury depository upon a warrant signed by the principal administrative officer of the district and by a member of the board.

Article 5.1. Standby Charges for Public Health Emergencies

§ 2315. The Legislature finds and declares that unabated outbreaks of mosquitoes pose a serious threat to the public health and safety and that public agencies, including mosquito abatement districts and vector control districts, must be prepared to abate extraordinary outbreaks of mosquitoes. The Legislature further finds and declares that to protect the public health and safety from unabated outbreaks of mosquitoes, it is necessary to enact this article to provide mosquito abatement districts and vector control districts with the ability to abate mosquitoes.

§ 2316. (a) On or before August 10 of each year, the district may adopt an ordinance to fix an emergency mosquito abatement standby charge in the district or any portion of the district.

(b) The ordinance shall establish schedules varying the charges according to land uses. The emergency mosquito abatement standby charge shall not exceed ten dollars ($10) per year for each parcel of land on which the charge is levied.

(c) Any ordinance to fix an emergency mosquito abatement standby charge shall be adopted pursuant to Article 7 (commencing with Section 25120) of Division 2 of Title 3 of the Government Code. The ordinance shall be subject to Article 1 of Chapter 4 (commencing with Section 9300) of Division 9 of the Elections Code.

(d) The ordinance shall not apply to any parcel owned by a local agency, as defined in Section 2211 of the Revenue and Taxation Code.

§ 2317. (a) All revenues generated from the emergency mosquito abatement standby charge ordinance shall be deposited in a separate emergency mosquito abatement trust fund in the county treasury of the county in which the district is organized, except that the county may retain an amount not to exceed the actual costs of performing the duties required by Section 2318.

(b) The trust fund shall not exceed fifty thousand dollars ($50,000) or 25 percent of the district's expenditures for operations and maintenance in the immediately preceding fiscal year, whichever is greater, except that the trust fund may exceed these limits by the amount of interest earned.

(c)(1) The emergency mosquito abatement trust fund shall be used solely for the abatement and extermination of mosquitoes, as provided by Section 2270, except that the district may use 50 percent of any interest earned on the trust fund for the general purposes of the district. Not more than 50 percent of any interest earned on the trust fund may be appropriated for deposit on or before June 30 of each fiscal year in the Mosquitoborne Disease Surveillance Account in the General Fund, created by Section 25852 of the Government Code. Districts which agree to contribute to the Mosquitoborne Disease Surveillance Account shall enter into a cooperative agreement pursuant to subdivision (c) of Section 2426. The funds deposited in the state account, when appropriated by the Legislature, shall be used by the State Department of Health Services to support those mosquitoborne disease field and laboratory surveillance activities which are needed to carry out the provisions of this article. The department shall not commit expenditures for such mosquitoborne disease field and laboratory surveillance activities unless the funds deposited in the Mosquitoborne Disease Surveillance Account are sufficient for the ensuing fiscal year. If the amount of the Mosquitoborne Disease Surveillance Account exceeds the amount required for the ensuing fiscal year, plus a reserve of fifty thousand dollars ($50,000), the excess shall be credited to the participating districts as a reduction in the amount deposited in the Mosquitoborne Disease Surveillance Account for the ensuing fiscal year.

(2) The Legislature finds and declares that the use of district funds for mosquitoborne disease surveillance serves public purpose of a district, as well as a public purpose of the state, within the meaning of Section 6 of Article XVI of the California Constitution.

(d) The district shall not spend any part of the principal of the emergency mosquito abatement trust fund unless the State Director of Health Services has declared that the public health and safety are, or may be, threatened by an unabated outbreak of mosquitoes in a portion or all of the territory within the district, or that conditions require emergency preventive mosquito abatement work, and that the expenditure is necessary to protect the public health and safety.

(e) The department shall adopt emergency regulations to implement, interpret, or make specific the provisions of this article, including, but not limited to, conditions under which the principal of the emergency mosquito abatement trust fund may be expended, and criteria for determining if a district has established adequate emergency mosquito abatement procedures.

(f) Nothing in this section shall be construed as an alternative for the abatement procedures authorized by Article 4 (commencing with Section 2270).

§ 2318. (a) On or before August 10th of each year, the board of trustees shall furnish in writing to the board of supervisors and the county auditor of each affected county a description of each parcel of land within the county upon which a standby charge is to be levied and collected for the current fiscal year, together with the amount of standby charge fixed by the district on each parcel of land.

(b) The board of supervisors, at the time and in the manner required by law for the levying of taxes for county purposes, shall levy the standby charges in the amounts for the respective parcels fixed by the board of trustees.

(c) All county officers charged with the duty of collecting taxes shall collect district standby charges with the regular tax payments to the county. The charges shall be paid to the district's emergency mosquito abatement trust fund.

(d) Charges fixed by the district shall be a lien on all the property benefited thereby. Liens for the charges shall be of the same force and effect as liens for taxes, and their collection may be enforced by the same means as provided for the enforcement of liens for county taxes.

§ 2319. If the district has adopted an ordinance to fix an emergency mosquito abatement standby charge, no state agency or board of supervisors shall alter or deny priority for an allocation of funds to the district solely because the district has an emergency mosquito abatement trust fund.

Article 5.5. Claims

§ 2320. All claims for money or damages against the district are governed by Part 3 (commencing with Section 900) and Part 4 (commencing with Section 940) of Division 3.6 of Title 1 of the Government Code except as provided therein, or by other statutes or regulations expressly applicable thereto.

Article 6. Annexation

§ 2330. (a) Any territory lying contiguous to a district may be annexed to the district. Noncontiguous territory may be annexed to a district if the board of supervisors of each county in which a portion of the territory proposed to be annexed is situated determines, by resolution, that the portion is within a reasonable operational distance of the district.

(b) The provisions of Sections 2291 to 2291.4, inclusive, may be used during the annexation procedures to designate the territory to be annexed as one or more zones of benefit, and the provisions of subdivision (*1*) of Section 2270 may be used to fund vector control in any territory so annexed.

§ 2331. Prior to the annexation of any territory, the district board shall obtain the consent, by resolution, from the board of supervisors of each county in which territory is proposed to be annexed and, by resolution, from the city council of each city in which territory is proposed to be annexed.

§ 2332. The procedures for authorizing and financing control projects under Sections 2291.2 to 2291.4, inclusive, may be used concurrently with, and as the procedures for, annexation of any territory authorized under Section 2331.

Article 7. Consolidation

§ 2360. Two or more contiguous districts may be consolidated.

CHAPTER 8. PEST ABATEMENT DISTRICTS

Article 1. Definitions and General Provisions

§ 2800. "Pest," as used in this chapter, includes any plant, animal, insect, fish, or other matter or material, not under human control, which is offensive to the senses or interferes with the comfortable enjoyment of life, or which is detrimental to the agricultural industry of the State, and is not protected under any other provision of law.

§ 2800.5. As used in this chapter, "public nuisance" includes, but is not limited to, both of the following [also see Civil Code Sections 3479-3484]:

(a) Any breeding place or place of growth of a pest for which a district may be initiated under Section 2822, which exists by reason of any use made of the land on which it is found, or which exists by reason of any artificial change in the

Comment Letters and Notices

STATE OF CALIFORNIA
Governor's Office of Planning and Research
State Clearinghouse

Gray Davis
GOVERNOR

STREET ADDRESS: 1400 TENTH STREET ROOM 222 SACRAMENTO, CALIFORNIA 95814
MAILING ADDRESS: P.O. BOX 3044 SACRAMENTO, CA 95812-3044
916-445-0613 FAX 916-323-3018 www.opr.ca.gov/clearinghouse.html

Loretta Lynch
DIRECTOR

October 1, 1999

RECEIVED OCT 0 4 1999

Wesley A. Maffei
Napa County Mosquito Abatement District
P.O. Box 655
Napa, CA 94559

Subject: Integrated Mosquito Management Program
SCH#: 99092008

Dear Wesley A. Maffei:

The State Clearinghouse submitted the above named Negative Declaration to selected state agencies for review. On the enclosed Document Details Report please note that the Clearinghouse has listed the state agencies that reviewed your document. The review period closed on September 30, 1999, and the comments from the responding agency (ies) is (are) enclosed. If this comment package is not in order, please notify the State Clearinghouse immediately. Please refer to the project's eight-digit State Clearinghouse number in future correspondence so that we may respond promptly.

Please note that Section 21104(c) of the California Public Resources Code states that:

> "A responsible or other public agency shall only make substantive comments regarding those activities involved in a project which are within an area of expertise of the agency or which are required to be carried out or approved by the agency. Those comments shall be supported by specific documentation."

These comments are forwarded for use in preparing your final environmental document. Should you need more information or clarification of the enclosed comments, we recommend that you contact the commenting agency directly.

This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act. Please contact the State Clearinghouse at (916) 445-0613 if you have any questions regarding the environmental review process.

Sincerely,

Terry Roberts

Terry Roberts
Senior Planner, State Clearinghouse

Enclosures
cc: Resources Agency

SCH# 99092008
Project Title Integrated Mosquito Management Program
Lead Agency Napa County

Type neg Negative Declaration

Description On going program of surveillance and control of mosquitues and mosquito-borne disease. General elements include 1) surveillance, 2) Public Education, 3) Physical Control = Habitat Manipulation, 4) Vegetation Management, 5) Biological Control, & 6) Chemical Control

Lead Agency Contact

Name Wesley A. Maffei
Agency Napa County Mosquito Abatement District
Phone 707-258-6044 **Fax**
email
Address P.O. Box 655
City Napa **State** CA **Zip** 94559

Project Location

County Napa
City
Region
Cross Streets
Parcel No.
Township **Range** **Section** **Base**

Proximity to:

Highways
Airports
Railways
Waterways
Schools
Land Use All Designations

Project Issues Air Quality; Archaeologic-Historic; Coastal Zone; Drainage/Absorption; Flood Plain/Flooding; Noise; Soil Erosion/Compaction/Grading; Toxic/Hazardous; Vegetation; Water Quality; Wetland/Riparian; Wildlife

Reviewing Agencies Resources Agency; Department of Conservation; Department of Fish and Game, Region 3; Department of Parks and Recreation; Caltrans, District 4; Department of Health Services; State Water Resources Control Board, Clean Water Program; Regional Water Quality Control Board, Region 2; Department of Toxic Substances Control; Native American Heritage Commission; State Lands Commission

Date Received 09/01/1999 **Start of Review** 09/01/1999 **End of Review** 09/30/1999

Note: Blanks in data fields result from insufficient information provided by lead agency.

STATE OF CALIFORNIA- BUSINESS, TRANSPORTATION AND HOUSING AGENCY GRAY DAVIS, Governor

DEPARTMENT OF TRANSPORTATION
BOX 23660
OAKLAND, CA 94623-0660
(510) 286-4444
TDD (510) 286-4454

RECEIVED OCT 0 4 1999

September 14, 1999

clear
9/30/99
e

NAP-Vars-Vars
NAP000016
99092008

Mr. Wesley A. Maffei, Manager
Napa County Mosquito Abatement District
P O Box 94559
Napa, California 94559

RECEIVED
SEP 20 1999
STATE CLEARINGHOUSE

Dear Mr. Maffei:

Integrated Mosquito Management Program

Thank you for including the California Department of Transportation (Caltrans) in the review of the above referenced project. We have no comments regarding this project.

We appreciate the opportunity to work with you on this project. Should you require additional information or have any questions regarding this letter, please call Bonnit Braxton of my staff at (510) 622-1645.

Sincerely,

HARRY Y. YAHATA
District Director

By Jean CR Finney

JEAN C. R. FINNEY
District Branch Chief
IGR/CEQA

Enclosure

Mail to: State Clearinghouse, 1400 Tenth Street, Sacramento, CA 95814 916/445-0613

Project Title: INTEGRATED MOSQUITO MANAGEMENT PROGRAM

Lead Agency: NAPA COUNTY MOSQUITO ABATEMENT DISTRICT — Contact Person: WESLEY A. MAFFEI

Street Address: P.O. BOX 655 — Phone: (707) 258-6044

City: NAPA — Zip: 94559 — County: NAPA

RECEIVED SEP 1 1999 STATE CLEARINGHOUSE

RECEIVED OCT 4 1999

Project Location:

County: NAPA — City/Nearest Community: ALL AREAS

Cross Streets: — Zip Code: — Total Acres: 510,016

Assessor's Parcel No. — Section: — Twp. — Range: — Base:

Within 2 Miles: State Hwy #: — Waterways: — Airports: — Railways: — Schools:

SEP 07 1999

Document Type:

CEQA: ☐ NOP ☐ Early Cons ☒ Neg Dec ☐ Draft EIR ☐ Supplement/Subsequent EIR (Prior SCH No.) ☐ Other

NEPA: ☐ NOI ☐ EA ☐ Draft EIS ☐ FONSI

Other: ☐ Joint Document ☐ Final Document ☐ Other

Local Action Type:

☐ General Plan Update ☐ General Plan Amendment ☐ General Plan Element ☐ Community Plan ☐ Specific Plan ☐ Master Plan ☐ Planned Unit Development ☐ Site Plan ☐ Rezone ☐ Prezone ☐ Use Permit ☐ Land Division (Subdivision, etc.) ☐ Annexation ☐ Redevelopment ☐ Coastal Permit ☐ Other

Development Type:

☐ Residential: Units ___ Acres ___
☐ Office: Sq.ft. ___ Acres ___ Employees ___
☐ Commercial: Sq.ft. ___ Acres ___ Employees ___
☐ Industrial: Sq.ft. ___ Acres ___ Employees ___
☐ Educational
☐ Recreational
☐ Water Facilities: Type ___ MGD ___
☐ Transportation: Type ___
☐ Mining: Mineral ___
☐ Power: Type ___ Watts ___
☐ Waste Treatment: Type ___
☐ Hazardous Waste: Type ___
☐ Other:

Funding (approx.): Federal $ ___ State $ ___ Total $ 450,000 Annually

Project Issues Discussed in Document:

☐ Aesthetic/Visual ☐ Agricultural Land ☒ Air Quality ☒ Archeological/Historical ☒ Coastal Zone (SF BAY) ☒ Drainage/Absorption ☐ Economic/Jobs ☐ Fiscal ☒ Flood Plain/Flooding ☐ Forest Land/Fire Hazard ☐ Geologic/Seismic ☐ Minerals ☒ Noise ☐ Population/Housing Balance ☐ Public Services/Facilities ☐ Recreation/Parks ☐ Schools/Universities ☐ Septic Systems ☐ Sewer Capacity ☒ Soil Erosion/Compaction/Grading ☐ Solid Waste ☒ Toxic/Hazardous ☐ Traffic/Circulation ☒ Vegetation ☒ Water Quality ☐ Water Supply/Groundwater ☒ Wetland/Riparian ☒ Wildlife ☐ Growth Inducing ☐ Landuse ☐ Cumulative Effects ☐ Other

Present Land Use/Zoning/General Plan Designation:

ALL DESIGNATIONS

Project Description:

On going program of surveillance and control of mosquitoes and mosquito-borne disease. General elements include 1) surveillance, 2) Public Education, 3) physical control = Habitat Manipulation, 4) Vegetation Management, 5) Biological Control, + 6) chemical control.

Revised 3-31-99

State Clearinghouse Contact: Mosie Boyd (916) 445-0613

State Review Began: 9-1-99

Dept. Review to Agency 9-23-99

Agency to SCH 9-28-99

SCH COMPLIANCE 9-30-99

Please note State Clearinghouse Number (SCH#) on all Comments

SCH#: 99092008

Please forward late comments directly to the Lead Agency

AQMD/APCD 2 (Resources: 9/4)

Project Sent to the following State Agencies

X Resources
___ Boating & Waterways
___ Coastal Comm
___ Coastal Consv
___ Colorado Rvr Bd
X Conservation
X Fish & Game # 3
___ Delta Protection Comm
___ Forestry & Fire Prot
___ Historic Preservation
X Parks & Rec
___ Reclamation Board
___ Bay Cons & Dev Comm
___ DWR
___ OES (Emergency Svcs)
Bus Transp Hous
___ Aeronautics
___ CHP
X Caltrans # 4
___ Trans Planning
___ Housing & Com Dev
___ Food & Agriculture
X Health Services

State/Consumer Svcs
___ General Services
___ Public School Construction
Cal EPA
___ ARB
___ Integrated Waste Mgmt Bd
X SWRCB: Clean Water Prog
___ SWRCB: Water Rights
___ SWRCB: Water Quality
___ SWRCB: Bay-Delta Unit
X Reg. WQCB # 2
X Toxic Sub Ctrl-CTC
Yth/Adlt Corrections
___ Corrections
Independent Comm
___ Energy Commission
X NAHC
___ Public Utilities Comm
___ Santa Monica Mtns
X State Lands Comm
___ Tahoe Rgl Plan Agency (TRPA)
___ Other:
___ Other:

ST Helena Star
Sept 2, 1999

LEGAL NOTICES

Continued from page 23

(2.) <u>Zumwalt Ford-Mercury @ 21 Main St.</u> - Request to reclassify the adjacent parcel to the west at 1286 Sulphur Springs Avenue from MR: Medium Density Residential to SC: Service Commercial to allow the future expansion of the automobile business.

ALL INTERESTED PARTIES are invited to attend said **Hearing** and express opinions or submit evidence for or against the proposal as outlined above.

If a person wishes to challenge the nature of the above action in court, they may be limited to raising only those issues that they or someone else raised at the Public Hearing described in this notice, or in written correspondence delivered to the St. Helena City Council at, or prior to said Public Hearing.

Copies of any staff reports will be available for viewing after Friday noon immediately preceding the hearing, at City Hall in the office of the Planning Director and at the St. Helena Public Library.

Information for the hearing impaired may be obtained by calling the City Clerk at (707)963-2741.

BY ORDER OF THE ST. HELENA CITY COUNCIL.
Dated: August 30, 1999
/S- Delia Guijosa
City Clerk
Pub. 9/2/99

<u>PUBLIC NOTICE</u>

NAPA COUNTY
MOSQUITO
ABATEMENT
DISTRICT

PUBLIC NOTICE OF INTENT TO ADOPT MITIGATED NEGATIVE DECLARATION

Pursuant to the provisions of the California environmental Quality Act, the Napa County Mosquito Abatement District has prepared an initial Study and Draft Mitigated Negative Declaration for the DISTRICT's ongoing Integrated Mosquito Management Program.

The Integrated mosquito Management Program of the Napa County Mosquito Abatement District is a long-standing, ongoing program of surveillance and control of mosquitoes, covering the whole of Napa County. The program consists of six types of activities: 1) **Surveillance** for mosquito populations, mosquito habitats, disease pathogens, and public distress associated with mosquitoes: this includes trapping and laboratory analysis of mosquitoes to evaluate populations and disease threats, direct visual inspection of known or suspected mosquito habitats, the use of all-terrain vehicles, maintenance of paths, and public surveys; 2) **Public Education** to encourage and assist reduction or prevention of mosquito habitat on private and public property; 3) Management of mosquito habitat, especially through water control and maintenacce or improvement of channels, tide gates, levees, and other water control facilities, etc. (**"Physical Control"**); 4) applications of herbicides and other forms of **Vegetation Management** to improve survveillance or reduce mosquito populations; 5) Application of the "mosquito fish" *Gambusia affinis*, the bacterium *Bacillus sphaerious*, the fungus *Lagenidium giganteumm*, and possibly other predators or pathogens of mosquitoes (**"Biological Control"**); and 6) Application of non-persistent selective insecticides to reduce populations of larval or adult mosquitoes (**"Chemical Control"**).

Copies of the documents are available for public review from 8:00 am to 4:30 pm Monday to Friday at the District offices at 964 Imola Ave., Napa, CA 94559. (707)258-6044. Please submit comments to Mr. Wesley A. Maffei, Manager, NCMAD, P.O. Box 655, Napa, CA 94559. Written comments will be accepted until 4:30 pm on Monday, October 4, 1999.

The DISTRICT proposes to adopt the Mitigated Negative Declaration at the regular meeting of its Board of Trustees at 7:00 pm on Wednesday, October 13, at the DISTRICT offices at 964 Imola Ave., Napa, CA 94559. This meeting is open to the public, and time will be available for verbal comments.

Pub. 9/2/99

PUBLIC NOTICE

PUBLIC NOTICE
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MOSQUITO ABATEMENT DISTRICT
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(NVR#222 9-2)

NAPA REGISTER
2 SEPT 1999

The Weekly Calistogian

PUBLIC NOTICE

NAPA COUNTY MOSQUITO ABATEMENT DISTRICT

PUBLIC NOTICE OF INTENT TO ADOPT MITIGATED NEGATIVE DECLARATION

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Pub. 9/2/99

PUBLIC NOTICE

NOTICE OF PUBLIC HEARING BY THE CALISTOGA PLANNING COMMISSION TO CONSIDER AN APPLICATION FROM MORE FOR LESS FOR A VARIANCE OF THE ZONING ORDINANCE REQUIREMENTS REGARDING MAXIMUM SIGN COVERAGE

NOTICE IS HEREBY GIVEN by the Planning Commission of the City of Calistoga that a PUBLIC HEARING will be conducted Monday, September 27, 1999, at 7:00 p.m. in the Calistoga Community Center, 1307 Washington Street, City of Calistoga, County of Napa, State of California, at which time and place testimony will be considered on:

V 99-3, Variance request of More for Less to exceed the allowable sign area of 32 square feet. The property is located at 940 Petrified Forest Road, Assessor's Parcel #11-370-024. The request for a variance is exempt from the California Environmental Quality Act (CEQA) under Section 15305.

If you challenge the action of the Planning Commission on the above stated item in court, it may be limited to only those issues raised at the public hearing described in this notice, or in written correspondence delivered to the Planning Commission at, or prior to, the public hearing.

BY ORDER OF THE CITY OF CALISTOGA PLANNING COMMISSION
-S- James C. McCann
Planning and Building Director
City of Calistoga
Pub. 9/2/99

94-0072

ENDORSED

OCT 15 1999

JOHN TUTEUR
Napa County Recorder-County Clerk
By ________ DEPUTY RECORDER - CLERK

October 13, 1999

NOTICE OF DETERMINATION

To:___ Office of Planning and Research
1400 Tenth Street, Room 121
Sacramento, CA 95814

___ County Clerk & Recorder
Napa County
Napa, CA

From: Napa County Mosquito Abatement District
P.O. Box 655
Napa, CA 94559

Subject: Filing of Notice of Determination in Compliance with Section 21108 or 21152 of the California Public Resources Code.

Project Title: INTEGRATED MOSQUITO MANAGEMENT PROGRAM

99092008	Wesley A. Maffei	(707) 258-6044
State Clearinghouse Number (If submitted to Clearinghouse)	Lead Agency Contact Person	Area Code/Telephone/Extension

Project Location: The whole of Napa County

Project Description: The Integrated Mosquito Management Program of the Napa County Mosquito Abatement District is a long-standing, ongoing program of surveillance and control of mosquitoes. The program consists of six types of activities: 1) **Surveillance** for mosquito populations, mosquito habitats, disease pathogens, and public distress associated with mosquitoes; this includes trapping and laboratory analysis of mosquitoes to evaluate populations and disease threats, direct visual inspection of known or suspected mosquito habitats, the use of all-terrain vehicles, maintenance of paths, and public surveys; 2) Public **Education** to encourage and assist reduction or prevention of mosquito habitat on private and public land; 3) Management of mosquito habitat, especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities, etc. ("**Physical Control**"); 4) Applications of herbicides and other forms of **Vegetation Management** to improve surveillance or reduce mosquito populations; 5) Application of the "mosquito fish" *Gambusia affinis*, the bacterium *Bacillus sphaericus*, the fungus *Lagenidium giganteum*, and possibly other predators or pathogens of mosquitoes ("**Biological Control**"); and 6) Application of non-persistent selective insecticides to reduce populations of larval or adult mosquitoes ("**Chemical Control**").

This is to advise that the Napa County Mosquito Abatement District, as the CEQA Lead Agency, has approved the above described project on October 13, 1999 and has made the following determination regarding the above described projects.

1. The project **will not** have a significant effect on the environment.
2. A **Negative Declaration** was prepared for this project pursuant to the provisions of CEQA.
3. Mitigation measures **were** made a condition of the approval of the project.
4. A statement of Overriding Considerations **was not** adopted for this project.

This is to certify that the final Mitigated Negative Declaration with comments and responses and record of project approval is available to the General Public at the Napa County Mosquito Abatement District.

Wesley A Maffei — Manager — 15 OCT 99

Signature (Public Agency) *Title* *Date*

Date received for filing and posting at OPR:

RECEIVED
OCT 15 1999
STATE CLEARINGHOUSE

NAPA COUNTY

JOHN TUTEUR
ASSESSOR-RECORDER-COUNTY CLERK

RECORDER-COUNTY CLERK DIVISION

RECEIVED NOV 29 1999

COUNTY CLERK'S CERTIFICATE OF POSTING

AS REQUIRED BY CEQA, SECTION 21152 (C) OF THE PUBLIC RESOURCE CODE, I, Karen Burzdak DEPUTY RECORDER-COUNTY CLERK CERTIFY THAT I POSTED THE ATTACHED NOTICE IN THE OFFICE OF THE RECORDER-COUNTY CLERK AT 900 COOMBS STREET, ROOM 116, NAPA, CALIFORNIA FOR THE FOLLOWING TIME PERIOD: October 15, 1999 - November 23, 1999.

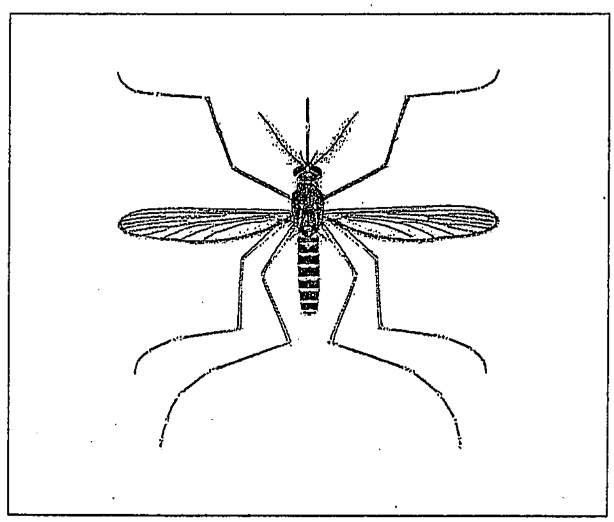
DATE: November 23, 1999

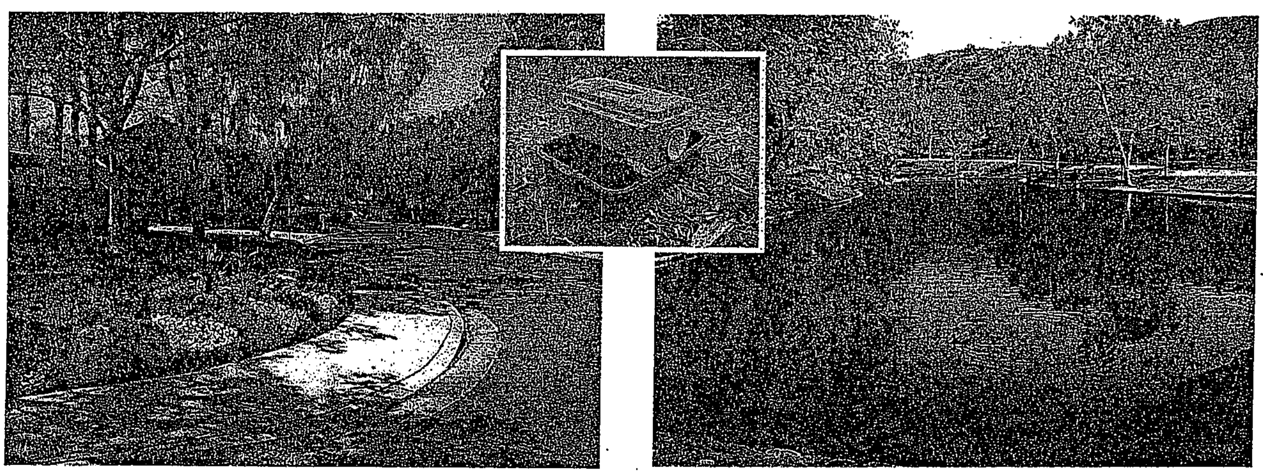
JOHN TUTEUR
RECORDER-COUNTY CLERK

K Burzdak
BY: DEPUTY RECORDER-COUNTY CLERK

(cpostg)

INTEGRATED MOSQUITO SURVEILLANCE PROGRAM GUIDELINES FOR CALIFORNIA





MOSQUITO and VECTOR CONTROL ASSOCIATION of CALIFORNIA

INTEGRATED MOSQUITO SURVEILLANCE PROGRAM GUIDELINES FOR CALIFORNIA

Richard P. Meyer, Ph.D. and William K. Reisen, Ph.D.

MVC
MOSQUITO AND VECTOR CONTROL
ASSOCIATION of CALIFORNIA

MOSQUITO AND VECTOR CONTROL ASSOCIATION OF CALIFORNIA
660 J Street, Suite 480, Sacramento, CA 95814
www.mvcac.org • mvcac@mvcac.org
September 2003

This is a publication of the
MOSQUITO and VECTOR CONTROL ASSOCIATION of CALIFORNIA

For other MVCAC publications or further information, contact:

MVCAC
660 J Street, Suite 480
Sacramento, CA 95814

Telephone: (916) 440-0826
Fax: (916) 442-4182

E-Mail: mvcac@mvcac.org
Web Site: http://www.mvcac.org

CONTENTS

Acknowlegements

The production of these guidelines entitled, "Integrated Mosquito Surveillance Program Guidelines for California" was made possible by the efforts of many individuals, agencies, and a published historical record of exceptional scientific research and documentation. The authors wish to recognize the following individuals and their respective agencies for their support, assistance, and timely comments towards completion of this landmark publication:

The authors want to give due credit to past and present Boards of Directors (William Hazeleur, Presiding President, Shasta MVCD) of the Mosquito and Vector Control Association of California for providing the incentive for preparing this document in cooperation with the California Department of Health Services, Vector-Borne Disease Section (CDHS-VBDS) and the University of California.

California Department of Health Services, Vector-Borne Disease Section: Dr. Vicki Kramer, Stan Husted, and James Tucker are recognized for their cooperation, comments, and perspectives in developing this timely set of guidelines for systematic sampling of adult mosquito populations throughout the state of California.

University of California: Dr. Bruce Eldridge and Dr. Tom Scott, University of California, Davis, both deserve recognition for their technical input and valued advice. Dr. Eldridge is to be duly commended for his early leadership in providing a significant "push" for a standardized statewide adult surveillance program. Dr. William C. Reeves deserves special recognition for his valued insights, thoughtful comments, and second-to-none historical perspectives related to mosquitoes and mosquito sampling.

Orange County Vector Control District: The Orange County Vector Control District, Dr. Robert Sjogren and the District Board of Trustees, should be recognized for providing the time to Dr. Richard Meyer and Justine Keller to draft and format the "guidelines." Justine is singularly cited for her exceptional journalistic skills and expertise in developing the professional style of the final draft guidelines document.

Mosquito and Vector Control Association of California: The following individuals are recognized for either their in-depth review, data supplements, or comments that greatly assisted with the development of the guidelines and final draft document: Dr. James Webb, Orange County Vector Control District; Minoo Madon, Greater Los Angeles County Vector Control District; Dr. Steve Schutz, Contra Costa Mosquito and Vector Control District; and Ken Boyce, Sacramento-Yolo Mosquito and Vector Control District.

The following individuals are recognized for their support and service on the former Entomology and Vertebrate Control Committee and revised Vector and Vector-Borne Disease Committee (Dr. William Reisen, Chair): Dr. Stacy Bearden, San Joaquin County MVCD; Dr. Jeffrey Beehler, formerly Northwest MVCD; Steve Bennett, Orange County VCD; Don Black, West Side MVCD; Dr. Kenn Fujioka, San Gabriel Valley MVCD; Dr. Jack Hazelrigg, Greater Los Angeles County VCD; Allan Inman, Merced County MAD; Ron Keith, Marin Sonoma MVCD; Yolanda Lourenco, Delta VCD; Dr. Branka Lothrop, Coachella Valley MVCD; Wesley Maffei, Napa County MAD; Russ Parman, Santa Clara County VCD; Tim Phillips, Fresno MVCD; Kevin Pinion, Madera County MVCD; Lawrence Shaw, Orange County VCD; Charlie Smith, Consolidated MAD; Dr. Noor Tietze, Santa Clara County VCD; Dr. Wakoli Wekesa, San Bernardino County VCP; Stan Wright, Sacramento-Yolo MVCD; Richard Takahashi, Kern MVCD; and Glenn Yoshimura, Sacramento-Yolo MVCD.

PREFACE

Mosquito surveillance in California currently relies upon adult counts collected by New Jersey or American style light traps (NJLT). Trap counts are averaged by urban, suburban, and rural habitat categories; and the data are submitted to the California Department of Health Services (CDHS), Vector-Borne Disease Section (VBDS). The VBDS compiles a weekly Mosquito Occurrence Report.

Increased human population size, expanded suburban housing, extensive use of security and other competing illumination have combined to limit the sensitivity and efficiency of the NJLT for mosquito surveillance. In many areas, abundance patterns now are resolved using catch sizes that vary less than two orders of magnitude throughout the season.

The current document provides guidelines and protocols for mosquito surveillance by vector control districts and public health agencies in California. Our approach integrates the most effective sampling methods for different target mosquito species over varied terrain and land uses in California. Emphasis is placed on the primary encephalitis virus vector, *Culex tarsalis*; however, it is recognized that mosquito control agencies must monitor and control other species, including well-known secondary vectors.

These guidelines include information on sampling designs, trap deployment patterns and schedules, mosquito processing, data summation, analysis and interpretation, statewide reporting, and extend previous documents focusing on encephalitis virus surveillance (Walsh 1987; Reisen 1995; Kramer 2001).

Integrated Mosquito Surveillance Program Guidelines for California

OVERVIEW

The purpose of the current document is to extend the sensitivity and uniformity of the statewide Mosquito Abundance Surveillance Program. The history of mosquito surveillance in California and sampling objectives are reviewed and recommendations made for standardization, trap placement, and enhancement of sensitivity.

Specific recommendations include:

- Dry ice-baited traps should replace New Jersey light traps as the primary method of monitoring adult mosquito abundance.
- Gravid and New Jersey light traps should be used to augment collections of specific species and habitats.
- All permanent trap sites should be documented via Geographical Positioning Systems and positioned within wetland, rural, and urban strata to monitor mosquitoes and arbovirus infection at potential enzootic, epizootic, and epidemic foci.
- Collections should be anesthetized using triethylamine and processed alive under a microscope to ensure accurate species determinations.
- Voucher adult mosquito specimens should be archived at local agencies or museums.
- Collection records should be entered weekly into electronic format for local analysis and sent to the Vector-borne Disease Section for archiving, analysis, and distribution.

SECTION 1

PAST, PRESENT, AND FUTURE OF MOSQUITO SURVEILLANCE

Mosquito-Borne Pathogens and Their Vectors

To date, 22 arthropod-borne viruses have been isolated in California, of which 10 are known to be transmitted by mosquitoes (Table 1). In the 1920s and 1930s, widespread epizootics among equines crippled agriculture in the Central Valley. In 1930, western equine encephalomyelitis virus (WEE) was isolated in Merced County from the brain of a horse presenting encephalitis symptoms (Meyer et al. 1931). Later WEE was incriminated as one of several pathogens causing polioencephalomyelitis among children, when it was isolated from a deceased patient at Kern General Hospital in Bakersfield, Kern County (Howitt 1938). Multidisciplinary epidemiological investigations quickly determined that *Culex tarsalis*, a species largely ignored by control agencies at that time, was the primary vector and wild birds, the enzootic reservoir (Reeves and Hammon 1962). Subsequent studies in the Sacramento Valley detected the presence of a secondary transmission cycle involving *Ochlerotatus melanimon* and rabbits, especially the jackrabbit, *Lepus californicus* (Hardy 1987). Outside of California, other members of the *Ochlerotatus dorsalis* complex, including *Oc. dorsalis* and *Oc. campestris*, spring snow pool *Ochlerotatus*, and *Culiseta inornata* also have been implicated as vectors (Reisen and Monath 1989).

In 1933, a large encephalitis epidemic occurred among humans in St. Louis, Missouri (Muckenfuss et al. 1934). A virus, later named St. Louis encephalitis (SLE), was isolated from deceased patients, and *Culex* mosquitoes were implicated as vectors by their spatial association with cases (Lumsden 1958). In rural California, *Cx. tarsalis* was confirmed as the primary vector in agricultural areas, both the Central Valley (Reeves and Hammon 1962) and in southeastern California (Meylan et al. 1989; Reisen et al. 1992a). *Culex tarsalis* also seems to be the primary vector in the Los Angeles basin, although isolates also have been made from *Culex quinquefasciatus* and *Culex stigmatosoma* (Reisen et al. 1992b). *Culex quinquefasciatus* is the least competent experimental vector of the three *Culex* species (Hardy et al. 1985), but is the most abundant species in urban habitats and the primary vector of SLE in the central and eastern USA (Mitchell et al. 1980). *Culex stigmatosoma* is an efficient laboratory vector (Hardy et al. 1986) that is difficult to sample as adults, but commonly collected as larvae in urban situations.

The remaining mosquito-borne arboviruses have minimal or no human or animal health importance in California. California encephalitis virus (CE) was determined to be the etiological agent of three human encephalitis cases in 1952 (Hammon and Reeves 1952) and a recent fourth case in 1998 (Eldridge et al. 2001). Although residents of the Central Valley frequently are infected (Stallones et al. 1964), clinical illness seems to be the exception. Although CE was initially isolated from *Cx. tarsalis* (Reeves and Hammon 1952), *Oc. dorsalis* complex mosquitoes actually have been shown to be the primary vector. CE is maintained enzootically by vertical transmission within *Ochlerotatus* populations (Turell et al. 1982) and amplified horizontally in an *Ochlerotatus*-rabbit-rabbit cycle (Reisen et al. 1990a). Jamestown canyon virus (JC) (including the Jerry Slough variant) is recognized as a cause of human illness in the Midwest (Grimstad et al. 1986). Jamestown Canyon virus frequently infects humans in California (Campbell et al. 1989), but has not been associated with disease. This virus has been isolated repeatedly from snow pool *Ochlerotatus* in the Sierra Nevadas and from *Culiseta inornata* in the Central Valley. The remaining viruses in Table 1 have not been associated with human illness, but must be transmitted frequently to humans and domestic animals based on mosquito host-feeding habits. Several horses exhibiting encephalomyelitis symptoms have shown a diagnostic rise in antibody titer against Turlock virus (Milby and Reeves 1990). Other arboviruses, such as West Nile (WN), dengue, yellow fever, and eastern equine encephalomyelitis have been introduced into California, but autochthonous transmission has not been detected.

West Nile virus currently is spreading across North America and most likely will invade California and become established. Experimental vector competence studies indicate that our common mosquito species are susceptible to oral infection and potentially can transmit WN after two weeks incubation at 28°C (Goddard et

Table 1. Mosquito-borne pathogens in California and their vectors.

Pathogens	Vectors
Arboviruses	
Alphavirus	
Western Equine Encephalomyelitis	*Cx. tarsalis, Oc. melanimon*
Flaviviruses	
St. Louis Encephalitis	*Cx. tarsalis, Cx. pipiens* complex, *Cx. stigmatosoma*
Bunyaviruses	
California Encephalitis	*Oc. melanimon, Oc. dorsalis*
Morro Bay	*Ae. squamiger*
Jamestown Canyon [Jerry Slough]	*Cs. inornata*; snow pool *Ochlerotatus*
Northway-like	*Cs. inornata, Anopheles?*
Turlock	*Cx. tarsalis*
Rhabdoviruses	
Hart Park	*Cx. tarsalis*
Gray Lodge	*Cx. tarsalis*
Orbivirus	
Llano Seco	*Cx. tarsalis*
Malaria	
Plasmodium vivax	*An. freeborni, An. hermsi, An. punctipennis*
Filaria	
Dirofilaria immitis	*Ae. vexans, Oc. sierrensis, Cs. incidens*, others?

al. 2002). Based on avian feeding preferences and efficient vector competence, *Culex tarsalis*, *Cx. pipiens, Cx. erythrothorax*, and *Cx. stigmatosoma* probably will be the most important vectors of WN in California. *Culex quinquefasciatus* populations varied considerably, being competent vectors in Kern County, refractory in Coachella Valley, and moderately susceptible in Los Angeles County. The remaining species tested blood feed most frequently on mammalian hosts, but could be important in secondary cycles among susceptible mammalian hosts or as bridge vectors.

Malaria is no longer endemic in California. However, susceptible anopheline vectors persist and introductions have led to autochthonous cases of *Plasmodium vivax* in the Sierra Nevadas in 1952 (Fontaine et al. 1954), the Sacramento Valley in 1986, and the San Diego area in 1988 (Maldonado et al. 1990). Although dissection or molecular methods have not detected infections in California *Anopheles*, several species have been incriminated as potential vectors by their temporal and spatial association with human infections and/or their experimental susceptibility to infection (Porter and Collins 1990). At present, *Anopheles freeborni* is considered to be important in the Sacramento Valley, its sibling species, *An. hermsi*, a vector in the San Joaquin valley and southern California, and *An. punctipennis* in the Sierra Nevadas.

Dog heartworm, *Dirofilaria immitis*, has been detected in dogs throughout California; however, transmission seems to be restricted to Sacramento River drainage and the distribution of the primary vector, *Ochlerotatus sierrensis* (Walters and Lavoipierre 1982; Walters and Lavoipierre 1984). Other potential vectors include *Aedes vexans*, *Anopheles*, and *Culiseta*. There is controversy whether or not transmission occurs in the Los Angeles basin.

History of Surveillance

Adult mosquito populations change markedly in size in response to environmental factors, including water availability, temperature, and the effectiveness of control. Increases in population size concurrently increase the risk of pathogen transmission and levels of annoyance. Vector control agencies in California attempt to limit mosquito population growth by larviciding standing surface water. Monitoring adult populations provides quality control on immature abatement and directs operational intensity, modifications to methodologies, and the initiation of adult control. Control failures punctuated by increases in adult mosquito population size spatially indicate areas of potential health risk due to associated amplification of WEE and SLE.

Mosquito control in California was initiated to suppress populations of pestiferous coastal *Ochlerotatus* near the urban centers of the San Francisco Bay Area and the Los Angeles Basin (Reeves 1996) and *Anopheles* in the malarious areas of the Central Valley (Gray and Fontaine 1957). Sampling for *Ochlerotatus* was done primarily by inspection of larval habitats and by "leg counts" of landing host-seeking females. Leg counts were effective because most of the target species (*Ochlerotatus squamiger, Oc. dorsalis, Oc. taeniorhynchus*) would bite during the day, but varied according to location (distance from larval habitat, sun vs. shade, vegetation, etc.), time of the day, and variation in the attractiveness of the collectors to host-seeking females. This method was later extended to sample foothill (*Oc. sierrensis*) and inland pasture species (*Ochlerotatus melanimon, Oc. nigromaculis, Ae. vexans*).

Sampling *Anopheles* was more difficult because these mosquitoes rarely bite during the day and required evening or all-night bait catches. However, adults could be found resting inside or outside houses and farm buildings (especially outhouses) or under bridges, and timed counts or aspirator catches provided some quantification. In the southeastern United States, nail kegs were used successfully as artificial resting sites to sample *An. quadrimaculatus*.

The discovery in the late 1930s and early 1940s that abundant, but non-pestiferous, *Culex* species were important vectors of encephalitis viruses, dramatically changed the focus of mosquito surveillance and control in California. Initial sampling programs employed timed searches of fixed resting stations, employing habitats, such as those monitored for *Anopheles*. Mosquitoes either were collected by aspirator for definitive species identification and virus isolation attempts or "white-legged *Culex*" were counted in place for population monitoring (Reeves and Hammon 1962). The importance of sampling *Cx. tarsalis* was recognized after resting abundance was demonstrated to be an important risk factor and forecasting variable for encephalitis virus transmission (Reeves and Hammon 1962). Attempts to standardize statewide sampling were initiated by the California Mosquito Control Association (CMCA) in 1953, with the introduction of the 1 ft^3 wooden red box as the "Standard Artificial Resting Station Unit" (Aarons et al. 1953). These small portable units later were replaced by large walk-in red boxes (Nelson 1966; Meyer 1987).

The New Jersey light trap (NJLT) (Mulhern 1942) was introduced into California by the CMCA in 1953 to enhance surveillance and largely replaced resting collections for population monitoring. The NJLTs were advantageous because they were relatively inexpensive to operate, could be used continuously throughout the week eliminating sampling biases due to aberrant weather, were not subject to biases related to collector attractiveness or skill, and could be deployed concurrently at a variety of habitats, thereby allowing the comparison of abundance over both time and space. Trap counts were related retrospectively to encephalitis virus transmission to both sentinel chickens and humans (Olson et al. 1979; Reeves and Milby 1979).

Monitoring mosquitoes attracted to light provided a measure of population size, but these samples were not necessarily related to epidemiologically important variables, such as bites/host /night. In addition, because mosquitoes were collected dead in killing jars, they could not be used for virus isolation. Because encephalitis viruses are zoonoses that utilize birds as reservoir hosts, initial devices to sample live host-seeking females deployed week old chickens as bait in lard can traps (Reeves et al. 1961). Determining infection rates in the mosquitoes and the chicken hosts provided concurrent estimates of mosquito infection and transmission rates. Carbon dioxide (CO_2) was recognized as an important attractant for host-seeking mosquitoes (Reeves 1953). Dry ice, which sublimes to release CO_2, was a cheap, portable replacement for bottled gas, and was used extensively to replace chicken hosts as an attractant in lard can traps (Bailey et al. 1965). Dry ice has proved useful as an attractant for most mosquito species, including members of the *Cx. pipiens* complex that were not phototactic.

Although NJLTs provided an effective measure of mosquito populations near human habitation, power requirements and cumbersome size limited deployment in undeveloped rural areas. To meet this need, the Communicable Disease Center (CDC) developed a small, battery operated light trap for population and arbovirus surveillance (Sudia and Chamberlain 1962). Catch and diversity subsequently were enhanced by hanging dry ice near the CDC traps, thereby collecting both phototactic and host-seeking females. The original CDC design has been modified several times (Encephalitis Virus Surveillance [EVS] traps; [Pfuntner 1979; Rohe and Fall 1979]) and simplified for use in California (Reisen et al. 2000). Several CDC and EVS trap models currently are available commercially (Reisen et al. 2000); however, all versions rely on a battery-powered, down-draft fan to aspirate mosquitoes flying near the dry ice and/or light attractant into a collection cage. These traps currently are used in California as portable devices for the spot assessment of mosquito population size and to collect live specimens for virus isolation. Some control agencies (e.g., Kern MVCD and Orange County VCD) operate CDC or EVS traps in a systematic fashion, thereby providing mosquito population measurements.

Population growth in California has expanded the need to sample mosquitoes in urban and suburban habitats. New Jersey lights traps and in many instances CDC/EVS traps have been relatively ineffective in these habitats, stimulating the search for alternative methods. Buckets filled with hay infusion, chicken manure, or other organic substances were discovered to be attractive oviposition sites and sensitive devices for monitoring urban *Culex*. However, the egg rafts or larvae had to be returned to the laboratory and reared for species identification. Trapping the ovipositing adults in an updraft trap (Reiter 1983) precluded rearing egg rafts and provided gravid females that had previously taken [3] one blood meal for arbovirus testing. Gravid female trap design has been modified to enhance portability and the collection of uninjured females (Cummings 1992).

Current Surveillance Program

Mosquitoes are collected by vector control and public health agencies in California to measure population size and arbovirus infection rates. Population size is measured primarily by NJLTs operated in urban, suburban, and rural habitats. Agency budgets, historical use, electrical requirements, and other logistical considerations determine the number and location of traps and nights of operation per week. Counts are used principally to detect immature control program failures and to track abundance levels during the season. Data are shared regionally and statewide, and currently are the only data readily available for health agencies at the state level. Several agencies also systematically operate CDC or EVS traps baited with dry ice at fixed sites to augment NJLT population measurements. CDC traps also are used to "spot check" areas not sampled by NJLTs for control failures. Agencies with urban *Cx. pipiens* complex problems also deploy gravid female traps to further augment sampling. CDC and gravid trap data usually remain within the agency and currently are not shared at the regional or state levels.

The CDC or EVS traps baited with dry ice are the primary method for collecting mosquitoes for arbovirus testing. Most agencies sample the same general sites year after year because these frequently are problem areas or sites with repeated virus activity. However, trap positions are not always standardized or consistent, and traps usually are operated only when large populations are present. Although these traps frequently collect large numbers of specimens for virus testing, data are inconsistently collected and may miss high infection rates frequently found after peaks in abundance. The numbers of viral isolates made from submissions of pools from each agency are reported statewide; however, data on mosquito counts per trap night and the numbers of pools testing negative frequently are not maintained at the local or state level.

Future of Mosquito Surveillance

Mosquito surveillance in California must adapt to a landscape altered by increasing human population density interspersed with residual agriculture, natural wetlands, parklands, and reclaimed or constructed wetlands. Research and development must produce new sampling methods with enhanced sensitivity to detect small and perhaps focal increases in mosquito abundance throughout this mosaic of varied habitats.

The numbers of mosquitoes collected per NJLT generally have been declining disproportionately to mosquito abundance measured by dry ice baited traps (Reeves and Milby 1989; Wegbreit and Reisen 2000). Throughout California, mean NJLT counts rarely change by several orders of magnitude during a single season, and in many districts, maximal counts average less than one female/trap night. These data therefore are not suitable to delineate changes in abundance over time and space to assess control. In addition, although NJLTs collect several important mosquitoes in California, such as *Cx. tarsalis*, *Oc. melanimon*, and *An. freeborni*, many other species are not phototactic and therefore are not collected by light traps. Failure of this system to monitor *Cx. pipiens* complex species could be especially important if WN becomes established in urban habitats. Declining sensitivity and specificity for phototactic species indicate that the NJLT mosquito surveillance program will need to be extended or replaced in the future.

Enhanced sampling sensitivity especially is required in a shrinking global community with expanding transport of people and goods due to tourism and commerce. The North American Free Trade Agreement (NAFTA) has expanded truck and ground traffic across the Mexican border into California. The trucks first enter through Imperial Valley where there currently is minimal mosquito surveillance and control. Conferring most favored trade status on China undoubtedly will increase further both air and sea traffic from Asia into California, also increasing chances for the introduction of exotic pests, including mosquitoes. The introduction and rapid dissemination of *Aedes albopictus* and *Ochlerotatus japonicus* into the Midwest and eastern USA points out the susceptibility of the USA for exotic introductions. Multiple introductions of *Ae. albopictus* into California from China occurred during 2001 (Madon, et al. 2002), and this species now may have become established in the Los Angeles basin. The successful colonization of the Tucson area in Arizona by *Aedes aegypti* illustrates how habitat modification by irrigation (e.g., "landscape sprinklers") can change unreceptive arid areas into suitable habitat for tropical species. During the past 15 years three new mosquito species (*Ochlerotatus thelcter*, *Aedes purpureipes*, and *Culex erraticus*) have been introduced into southeastern California from the east or south, and would have gone undetected if special sampling programs were not in place (Meyer et al. 1987; Meyer et al. 1988; Lothrop et al. 1998). Although these latter species are not important as vectors, they serve to illustrate California's vulnerability to the establishment of undetected mosquito introductions.

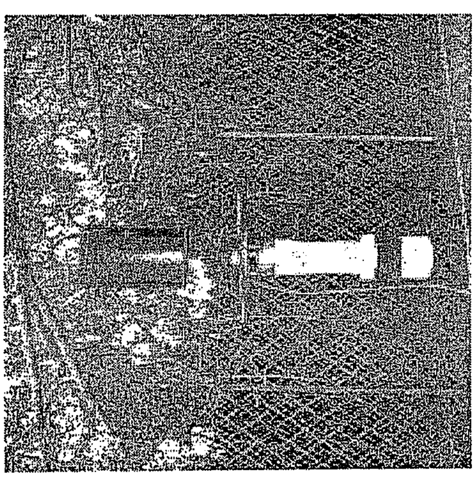
SECTION 2

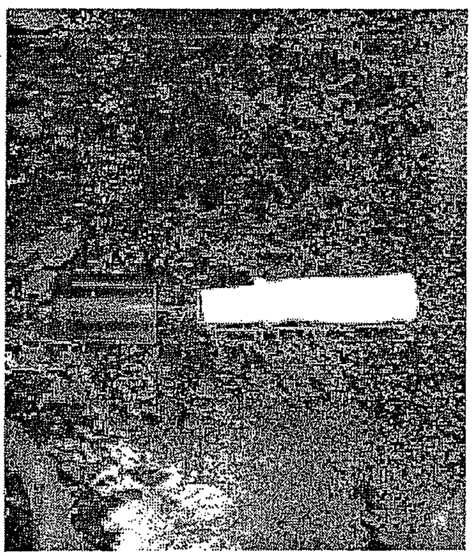
SAMPLING METHODS, RATIONALE, AND DEPLOYMENT DESIGNS

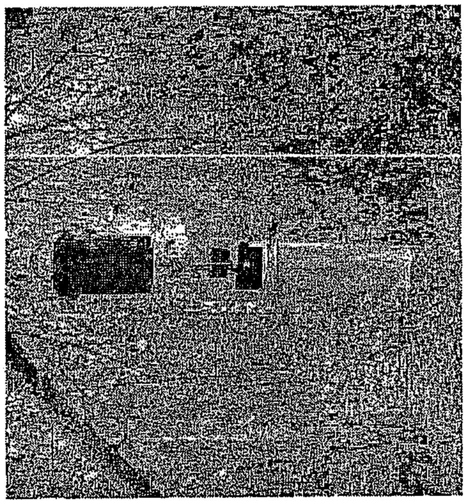
Recommended Trapping Methods (Figure 1)

The need for a universally sensitive and effective sampling device has resulted in the development and recommendation of a variety of trap attractants and designs (Service 1976). Most systems principally employ light and CO_2 as the primary attractants (Newhouse et al. 1966; Kline 1994), but heat (Mosquito Magnet™, American Biophysics) and octenol (Kline 1994) also have been recommended to enhance catch size. Most traps use a down draft fan; however, a two fan system with counter flow geometry technology has been employed to place the source of the attractant odor plume at the aperture of the trap.

To provide adequate geographical coverage and portability to place a sufficient number of traps in the correct microhabitats, traps should be sensitive, lightweight, portable, and economical to procure and operate. Based on our research, review of the literature, and considerations of price and portability, a simplified version of the CDC light trap seems to best fulfill these requirements. However, vector control agencies with available resources may still opt to deploy more expensive units (e.g., Mosquito Magnet™, etc.) if these traps are preferred. Overall, studies demonstrated that trap cost does not reflect trap efficiency. The Arbovirus Field Station (AFS) trap essentially is a simplified CDC trap with the rain shield, light and other electronic features removed, and can be constructed for <$15 each. The trap consists of a four-bladed plastic fan 3.5 in. in diameter attached to a Mabuchi motor mounted within a 4 in. interior diameter plastic pipe (Fig. 1). Maintaining a minimal distance between the fan blades and the pipe wall reduces turbulence and enhances air


Hock CO_2 Trap


UC Arbo CO_2 Trap


BQ-OC CO_2 Trap


Gravid Trap

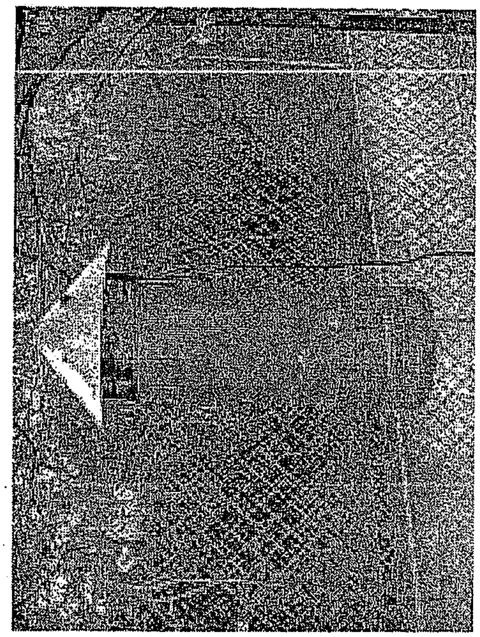

Standard NJ Light Trap

Figure 1. Sampling devices recommended.

movement (Cummings and Meyer 1999). This downdraft trap can be powered either by one rechargeable 8 or 10 amp. hr., 6-volt gel cell battery, or 4 D-cells arranged in series. Mosquitoes flying near the trap entrance are aspirated through the fan into a fine mesh collection bag made from a 1-gal. cardboard carton with a screened lid and four inches wide stockinet sleeve attached to a hole cut into the bottom (Fig. 1). Dry ice (~1-2 lb.) placed within a Styrofoam or plastic paint can holder serves as the attractant for host-seeking mosquitoes. The volume of CO_2 produced by sublimation is related to dry ice volume and surface area, container construction and temperatures, and decreases from >1,000 ml/min at dusk to <25 ml/min at dawn; the overall release rate averages about 500 ml/min (Pfuntner et al. 1988). These release rates appear to be suitable for attracting host-seeking females of most California species (Reeves 1951; Reisen et al. 2000). Because these traps are operated without lights, few insects other than mosquitoes, some flies, and *Culicoides* are captured, thereby expediting the sorting, enumeration, and pooling of mosquitoes.

To reduce variability due to spatial or positional effects, we recommend that traps be hung on fixed standards, each driven into the ground at 5 ft. height (1.6 m) and numbered uniquely. Trap locations should be recorded permanently from global positioning satellites (GPS) and always operated at the same location. Relatively minor changes in trap position often produce marked changes in trap counts. Trap placement should be optimized to measure risk to human populations and take advantage of terrain features. *Culex tarsalis,* for example, frequently is greatest at ecotones near vegetation that functions as congregation or settlement sites (Meyer et al. 1991; Lothrop and Reisen 2001).

A drawback to practically all trapping systems (Table 2) that sample host-seeking females is that most of the specimens captured are unfed nullipars seeking their initial blood meal (Reisen et al. 1983a; Reisen et al. 1995a). Although representative of the age-structure of the host-seeking population, the preponderance of nullipars reduces surveillance sensitivity for arbovirus infections and necessitates the testing of large-sized pools rather than individuals. In contrast, gravid female traps collect mostly females that have digested a blood meal, are ready to oviposit, and therefore have a greater probability of being infected with arboviruses. An exception would be populations of *Cx. tarsalis* that exhibit a high frequency of autogenous egg development (Moore 1963; Reisen et al. 1995a). In urban habitats within the Los Angeles basin, gravid female traps were more sensitive than dry ice baited traps for collecting gravid *Culex quinquefasciatus* mosquitoes (Reisen et al. 1990b). Original updraft fan designs (Reiter 1983) have been modified to enhance portability and the quality of specimens for identification and arbovirus testing (Cummings 1992). Traps originally were baited with an alfalfa/lactalbumin infusion (Reiter 1983); however, recent research has found that chopped bulrush (*Scirpus*) or hay provides a more attractive infusion than the original "recipe" (Reisen et al. 1999; Du and Millar 1999). Gravid traps were not effective in rural or agricultural environments with competing oviposition sources, and an attractant suitable for collecting large numbers of *Cx. tarsalis* has yet to be discovered (Reisen and Meyer 1990). Therefore, at this time we can only recommend the use of gravid female traps to augment the sampling of urban *Cx. quinquefasciatus* females. These traps also may be useful for sampling container breeding species, such as *Ae. albopictus*, but have not been evaluated fully for this purpose in California.

Table 2. Sampling devices and comparative properties.

	CO_2 Traps	NJLT	Gravid Trap
Behavior	Host-Seeking	Phototactic	Ovipositing
Physiological Status	Unfed	All Groups	Gravid
Mosquito	Most	Most	*Culex*
Pros	Most Sensitive	Low Maintenance	Blood Fed Previously
Cons	Deployment	Mosquitoes Dead	Low Diversity

New Jersey Light Trap Supplement

Vector control agencies that choose to continue using the standard New Jersey light traps (NJLT) for in-house surveillance, state surveillance reports, and control evaluation are advised to select sites that are 1) least compromised by competing light sources; 2) largely "unobstructed" with a reasonable panoramic view; and 3) protected from the prevailing winds.

Recommended Processing Methods

Collections should be retrieved from the field soon after sunrise to enhance the survival of the mosquitoes. All collections should be carefully labeled. During transport, collections should be kept humidified and cooled.

Although a variety of procedures are available, we recommend that collections be anesthetized lightly with triethylamine (TEA) for processing. Carbon dioxide gas is useful if the mosquitoes are to be used for procedures where live specimens are needed (e.g., insecticide resistance testing). Usually a cotton swab wetted with TEA and placed on each collection container within a closed container, such as a cardboard box, is sufficient to permanently immobilize the mosquitoes without killing them. TEA does not reduce WEE or SLE titers in mosquitoes (Kramer et al. 1990). Because mosquitoes are processed while alive, there is no need for expensive chill tables. TEA should be used either outdoors in a well-ventilated area or within a fume hood. Following immobilization, specimens can be transferred to labeled Petri dishes for sorting. Mosquitoes can remain immobilized and alive for several days, but we recommend placing the specimens in a cool place, such as the vegetable crisper of a refrigerator if left overnight. All sorting should be done under a binocular dissection microscope at 8-15X for accuracy of data. Fresh specimens also can be used for virus testing.

Comparative Trap Effectiveness

Trap effectiveness includes sensitivity (catch size), diversity (variety of species collected), and accuracy of measuring changes in population size over time and space. Because WEE and SLE are zoonoses that employ birds as reservoir hosts, it is not necessary that catch size provide a numerical estimate of human or horse biting rates (Vaidyanathan and Edman 1997). The history of the surveillance system (Reeves et al. 1990) and sampling method (Reisen and Reeves 1990) development in California has been well documented. The following research was conducted to improve the existing system.

Sensitivity and diversity. Dry ice-baited traps collect as many or more specimens as light traps, resting boxes or animal baited traps (Webb, et al. 1988; Reisen and Reeves 1990). More mosquitoes were collected in AFS traps than lard can traps when both were baited with dry ice (Reisen et al. 1992c), and equal numbers of females with or without the addition of lights (Reisen et al. 1983b). Recent studies showed that for most California mosquito species, AFS traps were more sensitive for collecting female mosquitoes than NJLTs, with the possible exception being *Anopheles freeborni* sampled in rural rice growing habitats in the Sacramento Valley (Meyer et al. 1984; Reisen et al. 1999; Reisen et al. 2002). More female mosquitoes of most species were collected in AFS traps compared to NJLTs augmented with dry ice and operated with the 25-watt bulb turned off (Reisen et al. 2001). AFS traps also collected more females of most *Culex* than commercially available traps marketed by American Biophysics, Hock Corporation, or BioQuip when operated following the manufacturers' recommendations (Reisen et al. 2000). The number of females collected in AFS traps was related to the volume of CO_2 released, and traps baited with 1.5 lbs. of dry ice collected fewer females than traps baited with bottled gas released at 1 or 1.5 liters per minute for the entire night. Pulsing CO_2 gas following American Biophysics recommendations significantly decreased catch size.

Measuring population size. The ability of traps to measure population size can be inferred directly by comparing relative abundance measures with estimates of absolute population size or indirectly by comparing independent measures of abundance. Catch of female *Cx. tarsalis* in AFS traps successfully tracked seasonal trends in population size estimated using mark-release-recapture methods in Kern (Reisen et al. 1992d) and Riverside Counties (Reisen and Lothrop 1995). Relative abundance in females/AFS trap night/month was correlated significantly over time with absolute population size or density in numbers/km^2 estimated by the Lincoln Index, modified to account for low recapture success and daily survival.

The ability of AFS traps to measure spatial patterns in mosquito population size has not been well studied because it has been difficult logistically to provide concurrent estimates of population size in several locations. Catch of *Cx. p. quinquefasciatus* in AFS traps operated in several communities in the Los Angeles basin were well correlated with estimates of population size (Reisen et al. 1991). Too few *Cx. tarsalis* were collected in these studies for similar analysis.

Regression analyses indicated that counts of *Cx. tarsalis* females in AFS traps varied significantly as a function of counts in NJLTs over both time and space (Reisen et al. 2001; Reisen et al. 2002). Although the regression slopes deviated significantly from zero, they varied tremendously among mosquito control agencies when compared by covariance, and therefore a universal conversion ratio or equation could not be extracted from these data. Studies to date have not related spatial patterns of larval occurrence or production levels with spatial patterns of adult catch.

Sentinel Chickens and Adult Mosquito Surveillance

Sentinel chickens are routinely deployed by vector control agencies to detect the presence of encephalitis viruses within their operational jurisdictions. Historically, encephalitis virus seroconversion rates in sentinel chickens have been compared with mosquito light trap indices (e.g., female *Culex tarsalis* per NJLT night) as a threshold determinant for encephalitis virus activity and transmission rates at urban, periurban, and rural locations throughout California.

With the recommended replacement of the NJLT with the CDC-style CO_2 trap, revised encephalitis virus transmission thresholds will require "recalibration" using CO_2 trap based vector abundance data (e.g., female *Culex tarsalis* per trap night). In the process of generating revised CO_2 trap based data, extra care should be taken to separate CO_2 traps from sentinel flocks at distances to reduce proximity biases created by additional attraction presented by the CO_2 and other "attractants" generated by the birds. A minimum separation distance of 50 feet between flocks and CO_2 traps, and allowable up to 100 feet, is necessary t reduce proximity attraction bias. More importantly, th minimal separation distance provides sufficient spac in which to find a suitable location to place a CO_2 tra

Placement of CO_2 traps at sentinel chicken floc locations should focus on sites that present "natur settings" and "boundaries" (e.g., aside vegetatic borders, breaches in landscaping/natural thickets, an beneath trees) for intercepting host-seeking fema mosquitoes. Some sites may require placing traps withi the landscaping that borders the exterior walls c residential structures and outbuildings. In the wor case condition (e.g., no landscaping/vegetation), plac the trap within 18 inches of the most wind protecte wall along the side or back of the structure. Avoi placing traps in front yards, beneath windows, or in manner that blocks "normal" access.

Sampling Designs and Strategies

The primary objective of sampling is to measu change in mosquito population size over time and spac to determine the risk of pathogen transmission, quanti public nuisance, and detect failures in mosquito contro The accuracy and precision of measures of abundanc always must be balanced against budgetary constrain and access in rural habitats. Because adult mosquitoe typically are clumped within the environment, samplin designs must take into account these clumpe distribution patterns. When average counts per tra night are used as triggers or thresholds for contrc escalation, sampling programs should be designed t reduce variation among traps while providing accurat estimates of regional averages. Research usin geographical information systems (GIS) coupled wit remote sensing (RS) data is useful to characterize lan cover and enhance sampling designs by delineatin spatial strata with potentially differing mosquit abundance levels.

Trap deployment strategies may or may not requir prior knowledge of the distribution of mosquitoes withi the environment (Reisen and Lothrop 1999). Uniforr and random trapping designs require no prior knowledg of spatial distribution, provide area-wide coverage estimate of the degree of clumping of mosquitoes withi the environment, and accurately measure area-wid average abundance. These data are useful in detectin control failures, however, considerable effort is expende operating traps in habitats that may produce few mosquitoes. Transect sampling frequently is employed as an alternative form of uniform sampling and frequently exploits terrain access features such as roads or trails. However, arbitrary transects may or may not provide accurate area-wide measures of abundance, because they may miss focal mosquito congregation sites.

In contrast, best estimate methods require prior knowledge of target mosquito species distribution, focusing on landscape features utilized as congregation sites that usually attract large numbers of resting adults. Although this approach may provide numerous specimens for virus monitoring and other purposes and produce an accurate focal depiction of seasonality, these data typically overestimate area-wide mean abundance and may provide inadequate spatial coverage to detect control failures or the creation of new larval habitats. If adequate knowledge of mosquito distribution is available through previous sampling or GIS/RS data, a stratified random design may produce the best overall estimates of mean abundance for the effort. Maps based on land cover patterns can be exploited to allocate traps to ensure area-wide coverage and an accurate measure of area-wide abundance. The utility of the data produced by different sampling designs and trap placement patterns recently was studied in Coachella Valley, utilizing conditional simulations on a data set comprised of 63 AFS traps operated biweekly at 1 mi. intervals in a uniform pattern over a 2 year period (Reisen and Lothrop 1999). The Coachella Valley MVCD mosquito surveillance program currently relies on this uniform trapping grid, with trap spacing at 1-2 mi. intervals.

If the distribution of mosquitoes within an area is unknown, an initial uniform deployment strategy is invaluable in providing spatial data that determines adult congregation sites, estimates regional means, and describes the degree of clumping. Combining this approach with GIS/RS data may allow the allocation of fewer traps to provide ground truthing of hypothesized distribution patterns. Based on careful spatial assessment, decisions can be made to either maintain the uniform pattern but reduce the numbers of traps, or utilize alternative sampling designs.

The above discussion concerns spatial trap placement to measure regional abundance. Decisions on where to place traps at the microhabitat scale and the recognition of adult congregation sites can be equally important in collecting each target mosquito species because each species has its own host-seeking or other behaviors. In-depth studies in Coachella Valley have indicated that host-seeking *Cx. tarsalis* females are most abundant in those traps placed along the boundary (ecotone) between high vs. low vegetation (e.g., tree lines and shrubbery borders). Fewer specimens were collected at traps within or under canopy, over low profile vegetation or sand spits, or at snags over water (Lothrop and Reisen 2001). Similar results were reported in the San Joaquin (Meyer et al. 1989) and Sacramento (Bailey et al. 1965) valleys. Vegetative transitions seem to form flight corridors where host-seeking *Cx. tarsalis* females congregate after emergence and disperse during host-seeking flights.

Based on previous studies, we recommend that traps for sampling host-seeking *Cx. tarsalis* females should be placed at the ecotone between low and elevated profile vegetation. Placing the trap >3 mi. away from or too far under vegetative canopy may markedly reduce trap counts. When possible, traps should be placed on the west of side of elevated vegetation to allow shade from the morning sun to minimize mosquito mortality and on the leeward side to afford protection from prevailing winds and upwind orientation to the CO_2 plume. *Culex tarsalis* feed most frequently upon avian hosts and has evolved a host-seeking strategy to locate roosting/nesting birds. However, other mosquito species that feed frequently on large mammals, such as cattle (e.g., *Ochlerotatus*) may exhibit different hunting strategies; and traps focusing on these species should be positioned accordingly. A final trap deployment scheme should be spatially inclusive of the host-selection patterns and hunting behavior of the target mosquito species.

Cost Analysis

The transition of sampling from a nightly NJLT program to a weekly/biweekly AFS trap program is anticipated to have minor fiscal impact on agency budgets. Increased cost due to AFS trap deployment/ retrieval and dry ice purchase should be compensated, in part, by reduced processing time. When driving time to pickup weekly NJLT specimens and processing time/ trap were compared with the cost of biweekly operation and processing of a systematic CO_2 trap program, costs were considered relatively comparable (R. Takahashi, Pers. Commun., Kern MVCD). However, enhanced sensitivity and the availability of specimens for virus pools should substantially improve both mosquito and arbovirus surveillance programs.

Quality Control

Correct mosquito identification and enumeration is the cornerstone of any surveillance program. Recently, statewide (Meyer and Durso 1993) and regional keys have been made for the mosquitoes of California and workshops held by the MVCAC to ensure their understanding and proper use. Agencies are encouraged to save representative specimens in regional collections and to send voucher specimens to state museums, such as the Bohart Museum at the University of California, Davis, or to the US National Museum.

SECTION 3

DATA ANALYSIS AND REPORTING

Numerical Abundance and Indices

Mosquito trapping programs measure mosquito population size as relative abundance; i.e., catch size standardized by collection effort or traps operated/night/space, or time unit. Traps do not measure density (numbers/unit area) because the size of the area sampled by the trap is not known. Sampling units can be specified by spatial or land cover categories, such as the urban, suburban, and rural criteria currently employed by the NJLT program. These categories are based on human population density and not on habitat factors dictating mosquito abundance, and may be established using census data to establish relative human risk levels. The current classification system could be replaced by an ecologically meaningful analysis of trap locations (established from Global Positioning System, GPS, coordinates) based land cover use determined by remote sensing (RS) and analyzed using geographical information system (GIS) statistics.

Delineation of temporal change is dependent upon the frequency of trap operation. Based upon *Cx. tarsalis* generation time during summer, traps should be operated weekly or biweekly. Mean abundance should be calculated for strata within each district and compared to the moving averages calculated for the past 5 or 10 "normal" or typical years. Data from epidemic or anomalous seasons with >250% change should not be included in these moving averages. Because trap counts typically exhibit a binomial distribution, transformation by $\ln(y+1)$ is necessary to normalize the distribution of the data so that calculating the average provides an accurate estimate of the central tendency of the data (Reisen and Lothrop 1999). Transformation also controls the variance so that it varies independently from the mean, a critical assumption underlying most statistical methods, such as analysis of variance or regression. For reporting, data may be back transformed as $e^y - 1$ and expressed as a geometric mean number of females/species/trap night (also known as William's mean). Geometric means provide a more conservative measure of abundance than arithmetic (i.e., calculated from raw or untransformed data) means that are upwardly biased by elevated outlying counts. These averages can be used directly in determining anomalous increases in mosquito populations that are useful in projecting the risk of an encephalitis virus emergency (Kramer 2001), assessing nuisance, and detecting control problems.

Recommended Reporting

All trap sites and methods should be given a unique number and located spatially by latitude and longitude. Sites should be recorded at both local and state levels. The number of mosquitoes of each species collected/trap/night should be entered into electronic format locally each week using a spreadsheet such as Microsoft Excel or a database, such as Microsoft Access. Data entry should be continuous and not interrupted with repeated column headings or placed in separate weekly spreadsheets. A continuous data series will enhance time-series analysis useful in determining moving averages, deviations from historical averages, and comparing locations. Collection records should be submitted electronically to the VBDS for entry into archival databases, mapping software for visualization, and statewide reporting.

Forecasting Abundance from Variations in Climate Data

Mosquito populations vary over time and space as a function of temperature, water availability, and control operations. Temperature dictates the rate at which populations grow and generations turn over, whereas, surface water area dictates the extent of larval habitat and thereby adult population size. Water availability is related directly or indirectly to precipitation from storm fronts generated in the Pacific Ocean. In California's relatively dry Mediterranean climate, most precipitation falls during the winter months either as rain at low elevations along the coast or within inland valleys or as snow at higher elevations, especially in the Sierra Nevadas. Summer southeasterly monsoons occasionally intrude into southeastern California and deposit rain in focally intense thunderstorms. The quantity of runoff from snow pack during spring dictates reservoir depth, flooding along uncontrolled watersheds, and the cost and availability of water for agriculture during the succeeding summer. During years when water is in excess of regional needs, it frequently is impounded to recharge underground aquifers, greatly expanding the acreage of potential larval habitat.

Culex tarsalis populations are dependent upon surface water during January–February to provide habitat for the F_1 progeny from overwintering females that terminate diapause shortly after the winter solstice, blood feed, and oviposit during winter (Bellamy and Reeves 1963; Reisen et al. 1986; Reisen et al. 1995b). Larval habitats during winter typically are confined to wetlands or riparian corridors and dependent upon winter rains. In contrast, larval habitats during spring and early summer depend on runoff or early agricultural irrigation. Larval habitats during summer usually are created by mismanagement of agricultural irrigation or water from other human activities. The establishment of constructed wetlands provides additional permanent larval habitat fed from municipal wastewater.

In general, climate is what you expect, but weather is what you get. Recent research has shown that climate variation in the New World is dependent strongly upon spatial changes in the Walker oscillation over the western Pacific. These changes dictate where in the Pacific warm water rises to the surface to spawn rain clouds that then are driven to the east by prevailing westerly winds (Glantz 2001). The El Niño-southern oscillation (ENSO) has the strongest impact on California weather and can be predicted in advance by measuring sea surface temperatures (SST) by fixed and drifting buoys. During El Niño conditions, SST warms in the eastern Pacific increasing winter rainfall and snow in California. Ongoing research is modeling relationships among anomalies in ENSO, snow pack in the Sierras, runoff from western slope watersheds, and mosquito abundance. In one preliminary study in Kern County (Wegbreit and Reisen 2000), *Cx. tarsalis* abundance during summer was related closely to the unimpaired flow of the Kern River at Bakersfield and could be predicted accurately from spring measurements of snow depth at the headwaters of the southern fork of the Kern River. Ongoing research will attempt to forecast changes in mosquito abundance and enzootic encephalitis activity from forecasts of snow pack and runoff months in advance to provide health planners and mosquito control agencies projections of relative encephalitis risk.

SECTION 4

REGIONAL MOSQUITO SURVEILLANCE PROGRAMS

Implementing an effective integrated adult mosquito surveillance program for California requires the application of the best mosquito trapping technology to local conditions that effect mosquito diversity and abundance. The extreme diversity of California's landscape, climate, and attendant mosquito problems precludes the use of a single surveillance method or strategy. Instead, local conditions and environmental uniqueness require the development and implementation of "local surveillance strategies" best suited to monitoring mosquitoes associated with urban, periurban, and rural environments. Similarly, indigenous mosquito species exhibit local differences in dominance, association with mosquito-borne pathogens and different abatement priorities for local vector control agencies. In effect, mosquito species vary in their local importance in different parts of the state. However, there remains the universal element of effectively tracking primary and secondary vector species and the pathogens they transmit that are encountered statewide, even if these species do not represent a significant local problem that would be targeted for routine mosquito abatement actions.

The statewide integrated adult mosquito surveillance plan presented herein accounts for both local and regional differences in landscape, climate, and mosquito diversity/dominance. This plan describes surveillance programs for four regions: 1) Coastal Region; 2) Central Valley/Foothill Region; 3) Southern California Region (Greater Los Angles Basin, Inland Empire, and San Diego areas); and 4) Desert Region. Strategies presented for the Central Valley/Foothill Region may be applied to areas inclusive of the eastern Sierra Nevada (e.g., Owens Valley) and Great Basin. A short discussion of the overall interrelationship among topography, climate, and local environmental conditions and their influence on indigenous mosquito problems are presented for each region and form the basis of each regional surveillance plan.

Mosquitoes

Species are targeted by local mosquito abatement agencies as a consequence of their importance in the transmission of mosquito-borne pathogens and their association with citizen complaints. The following mosquitoes should receive priority:

State wide priority: ("A" list of targeted species).

1. *Culex tarsalis*
2. *Culex pipiens pipiens* (northern/central California)
3. *Culex quinquefasciatus* (central/southern California)
4. *Ochlerotatus melanimon*
5. *Anopheles freeborni* (northern/central California)
6. *Anopheles hermsi* (southern California)

Local priority ("B" list of targeted species).

1. *Culex erythrothorax*
2. *Culex stigmatosoma*
3. *Ochlerotatus dorsalis*
4. *Ochlerotatus nigromaculis*
5. *Ochlerotatus squamiger*
6. *Ochlerotatus taeniorhynchus*
7. *Aedes vexans*
8. *Culiseta inornata*
9. *Culiseta incidens*
10. *Anopheles punctipennis*

Surveillance Methods

Standard adult mosquito sampling devi recommended for integrated regional surveilla programs were summarized in Table 2 and include

1. Dry ice or carbon dioxide-baited CDC-typ trap (CO_2T) – universal application.
2. Gravid trap - urban application for samplin house mosquitoes (*Cx. pipiens* and *Cx. quinquefasciatus* and perhaps *Cx. stigmatosoma* and *Aedes albopictus*).
3. NJLT – secondary rural application.

Regional Geographical Designations

I. **Coastal Region** is that portion of California t extends inland from the Pacific Ocean and inclu those vector control agencies within the Coastal Reg of the Mosquito and Vector Control Association California (MVCAC). There may be some exceptio (e.g., Solano County MAD has both costal and Cent Valley elements). Agencies located inland within inner Coast Range also are included. Southe California agencies (excluding Santa Barbara Coas VCD) with coastal elements are included with t regional program for southern California.

II. **Central Valley/Foothill Region** (also applies eastern Sierra, Great Basin and Burney Basi represents the largest area of the statewi surveillance program and includes all counti within the Central Valley (Sacramento and S Joaquin Valleys) or those that immediately bord (foothills to 2500 ft.) the Valley along the weste slope of the Sierra Nevada and inner Coa Ranges. Agencies that provide mosquito abateme to the Owens Valley and Burney Basin should app surveillance recommendations for this region.

III. **Southern California** contains the Greater Lo Angeles Basin inland into the San Bernardino an Moreno Valleys, southward through the Temecu Valley, and southward along the Pacific throug both Orange County and western San Dieg County. The Antelope Valley MVCD is situate on the "high desert" and presents a uniqu transitional condition for surveillance. For continui purposes, the surveillance recommendations for this region can be implemented in Antelope Valley.

IV. Desert Region is confined to the low desert areas of southeastern California and includes the Coachella and Imperial Valleys adjoining the Salton Sea, northwest to Beaumont, and eastward to the Colorado River. The agricultural valleys along the Colorado River include the Mojave and Palo Verde Valleys to the north and Bard Valley to the south.

Model Programs for Rural and Urban Vector Control Agencies

Model adult mosquito surveillance programs for rural and urban landscapes are included as a guide to illustrate trap placement strategies intended to obtain information on mosquito abundance, infection rates, and transmission to sentinel chickens (Figures 2 and 3). Both rural and urban models illustrate "priority" trap placement sites that are arrayed within three surveillance strata, in decreasing priority from S1, S2, to S3. Strata include spatial components associated with production, dispersal and host-seeking behavior, and with mosquito-borne pathogen (virus) maintenance (refer to Tables 3 and 4). For example, stratum S1 includes wetlands, wildlife areas, and riparian (river/stream habitats) sites that have a documented history of mosquito/vector production and conditions associated with pathogen transmission. Stratum S2 includes peripheral sites that secondarily support both mosquito production and pathogen transmission associated with mixed agricultural habitats, woodlands, and well-landscaped/vegetated farmhouse settlement sites. The last stratum, S3, includes largely urbanized landscapes that are impacted by a combination of immigration of rural mosquitoes (e.g., *Cx. tarsalis*) and locally produced "domestic" mosquitoes (e.g., house mosquitoes, *Cx. pipiens* and *Cx. quinquefasciatus).* This stratum represents an important component where tangential transfer ("bridging") of pathogens from infected rural to uninfected urban vectors occurs, placing humans at risk.

Model Rural Adult Mosquito Surveillance Program

Depicted in Figure 2 is a model landscape that is representative of the Central Valley, Owens Valley (in part), and agricultural valleys (Coachella, Imperial, Palo Verde, and Bard) of the southern deserts and Lower Colorado River drainage. The landscape includes S1, S2, and S3 features (Table 3) with selected sites that illustrate priority placements of CO_2 traps, gravid traps, and NJLTs (replacement with CO_2 traps preferred).

Overview: *Culex tarsalis* is the primary vector involved with the enzootic maintenance of both WEE and SLE viruses in the rural agricultural valleys of California (Reeves 1990). Encephalitis virus maintenance and amplification typically is supported at wetland habitats (S1) represented by wildlife areas, riparian corridors, and old fly ways (e.g., west side of San Joaquin Valley), and "obscured" sloughs and other disrupted drainage systems. From these sites during suitable years, either WEE or SLE can spread radially and/or in a directed "chain reaction" pattern and affect epizootic transmission at S2 non-wetlands habitats, such as isolated woodlands, woodland/flyway corridors, and sheltered (vegetated) farms. Viral amplification and dispersal may culminate with cases when humans visit S1 areas or when bitten by mosquitoes in ecotonal S2 and urban S3 settings.

Strategy: The spatial pattern of *Cx. tarsalis* production and the epidemic spread of encephalitis virus (EV) necessitates developing and implementing a surveillance program that prioritizes rural to urban sampling with emphasis on S1, followed by S2 and S3 locations. The placement of CO_2 traps in Figure 2 prioritizes routine sampling of S1 wetlands/riparian sites to provide an early warning of population and virus buildup, monitoring of S2 sites to track both EV spread and associated vector (e.g., *Cx. tarsalis*) risks, and detecting the potential "bridging" of EV (e.g., SLE) from the rural to urban (e.g., *Cx pipiens/Cx. quinquefasciatus*) vectors. Gravid traps are shown deployed within urban areas and along the perimeter interface (periurban) with rural habitats to facilitate monitoring domestic house mosquito abundance and risk assessment involving EV bridging from rural to urban habitats.

Model Urban Adult Mosquito Surveillance Program

A generalized urban landscape typical of the Greater Los Angeles Basin and large cities of the

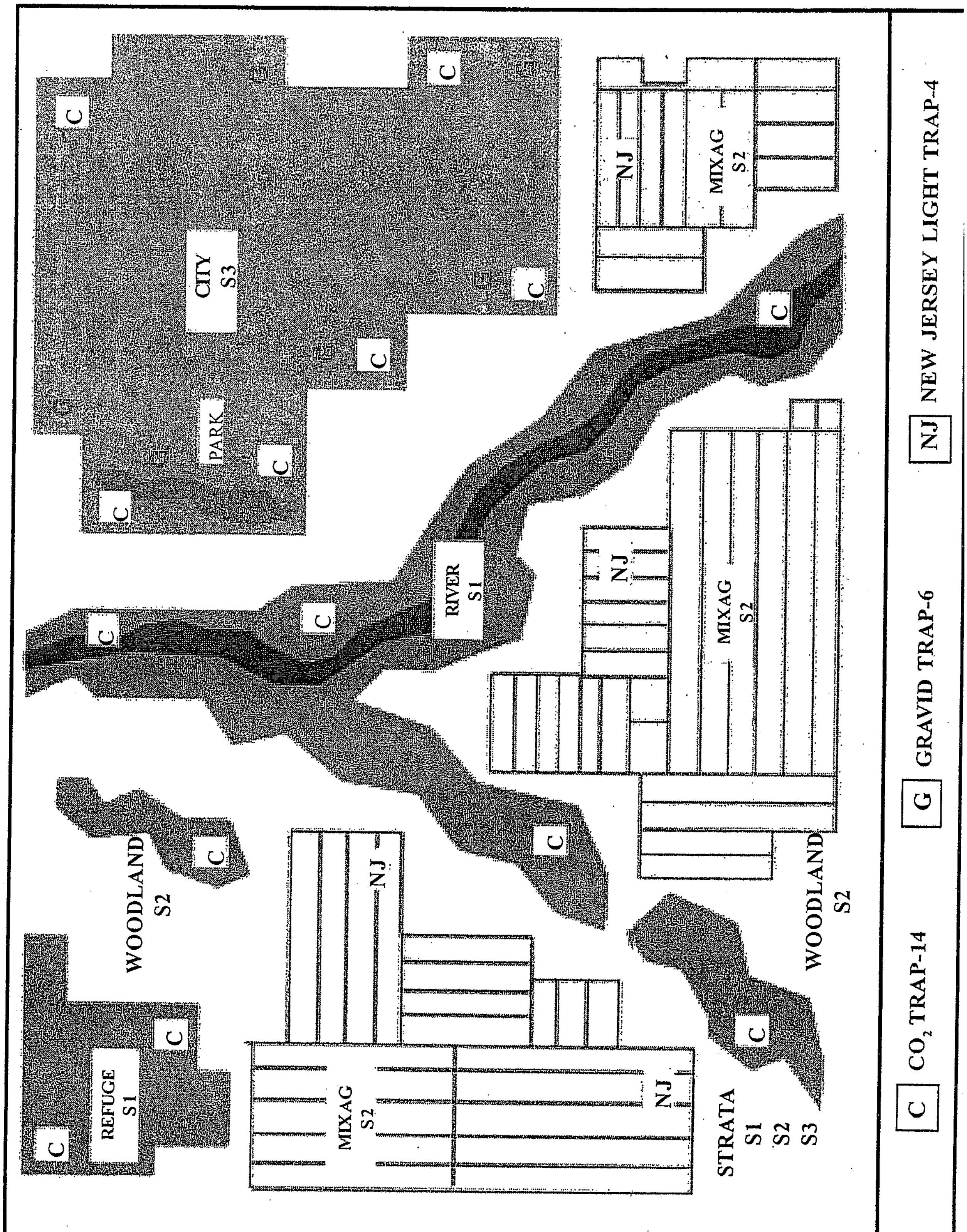

CITY
S3
PARK
RIVER
S1
REFUGE
S1
WOODLAND
S2
WOODLAND
S2
MIXAG
S2
MIXAG
S2
MIXAG
S2
NJ
NJ
NJ
NJ
C
C
C
C
C
C
C
C
C
C
C
C
C
STRATA
S1
S2
S3
C CO2 TRAP-14
G GRAVID TRAP-6
NJ NEW JERSEY LIGHT TRAP-4

Table 3. Integrated mosquito surveillance model--rural land use.

RURAL MIXED - AGRICULTURE & NATURAL		URBAN/RESIDENTIAL "EMBEDDED" IN RURAL
STRATUM 1	STRATUM 2	STRATUM 3
STABLE MOSQUITO/EV SITES *EV ENZOOTIC*	MOSQUITO & EV SECONDARY SITES *EV EPIZOOTIC*	DOMESTIC MOSQUITO SITES *EV EPIDEMIC*
WILDLIFE REFUGEES MITIGATED WETLANDS NATURAL DRAINAGES	RIPARIAN CORRIDORS WOODLAND ISLANDS FARM SETTLEMENTS	STORM & RESIDENTIAL WASTEWATER/WETLANDS ADJACENT SITES
ENCEPHALITIS VIRUSES - *Culex tarsalis* > *Culex pip/quinque* *Ochlerotatus melanimon* *Culex stigmatosoma* *Culex erythrothorax* MALARIA - *Anopheles freeborni* *Anopheles punctipennis*		*Culex pip/quinque* > *Culex tarsalis* *Culex stigmatosoma*
CO_2Ts / SUPPLEMENTAL NJLTs @ FARMS		GRAVID & CO_2Ts

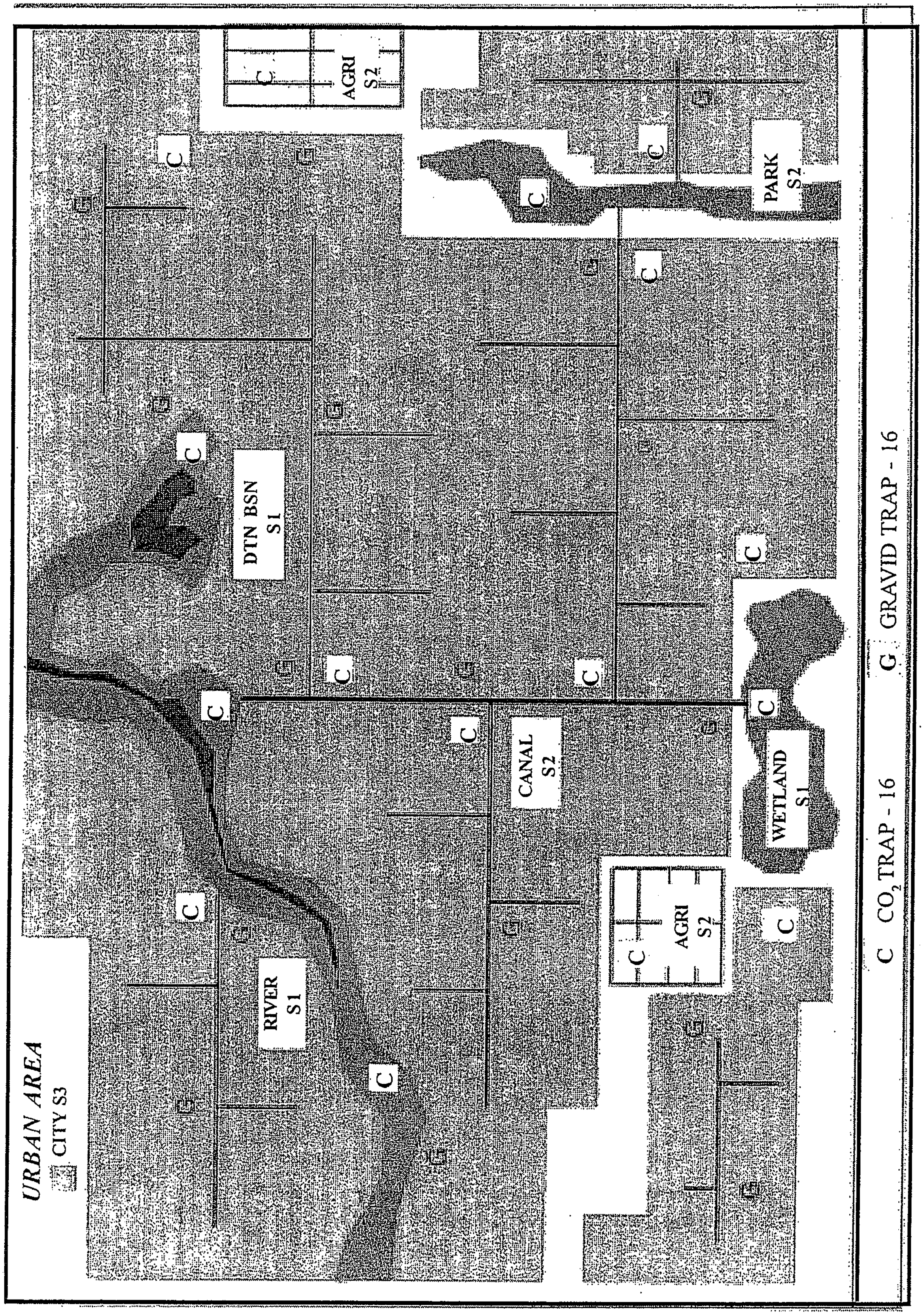


Figure 3. Trap placement strategy--urban land use.

Table 4. Integrated mosquito surveillance model--urban land use.

RURAL MIXED - AGRICULTURE & NATURAL "EMBEDDED IN URBAN/RESIDENTIAL		URBAN/RESIDENTIAL
STRATUM 1	STRATUM 2	STRATUM 3
STABLE MOSQUITO/EV SITES *EV ENZOOTIC*	MOSQUITO & EV SECONDARY SITES *EV EPIZOOTIC*	DOMESTIC MOSQUITO SITES *EV EPIDEMIC*
DETENTION BASINS "NATURAL" WETLANDS NATURAL DRAINAGES	PARK WETLANDS STORM CHANNELS ISOLATED FARMS	RESIDENTIAL STORM/WASTEWATER BACKYARD/DOMESTIC
Culex tarsalis > *Culex pip/quinque* *Culex stigmatosoma* *Culex erythrothorax* MALARIA - *Anopheles freeborni/hermsi* *Anopheles punctipennis*		*Culex pip/quinque* > *Culex tarsalis* *Culex stigmatosoma*
CO_2Ts		GRAVID & CO_2Ts

Central Valley is presented in Figure 3 with spatial elements summarized in Table 4. The landscape includes predominately S3 features, with subordinate S1 and S2 elements.

Overview: Encephalitis virus enzootic activity and subsequent spread is initiated by *Cx. tarsalis* associated with "rural" foci within the urban landscape. From these foci, virus can be spread tangentially and radially into adjoining and distant urban neighborhoods. Movement is facilitated by close proximity and dispersal corridors represented by drainage canals, river channels, and city parks with significant wetlands and ornamental waterworks. Once virus has been introduced into urban habitats and amplified by *Cx. tarsalis*, *Cx. pipiens*/ *Cx. quinquefasciatus* may further amplify and possibly bridge virus to the large susceptible human population. For *Cx. quinquefasciatus*, low vector efficiency may be compensated by large population size.

Strategy: The spatial aspects of "rural" *Cx. tarsalis* production, coupled with the tangential/radial spread of virus to domestic house mosquitoes, illustrate the necessity for an urban surveillance program to prioritize monitoring *Cx. tarsalis* at S1 and S2 sites and the subsequent spread of virus into S3 urban habitats where *Cx. pipiens* or *Cx. quinquefasciatus* serve as the resident vectors. Placement of CO_2 traps and/or a complement of CO_2 and gravid traps as illustrated in Figure 2 shows the spatial strategy to: 1) first detect EV enzootic activity in wetland/riparian habitats (rural foci); 2) monitor bridging of virus from rural foci into urban residential habitats; and 3) subsequent dispersal of virus within predominantly urban habitats. Overall, this strategy may provide limited lead time for public health or vector control agencies to initiate intervention and limit widespread infection in mosquito populations (e.g., SLE and WN).

Regional Surveillance Programs

Vector control agencies in California have an historical understanding of the distribution and seasonality of: 1) mosquito larval habitats; 2) adult population abundance; and 3) enzootic arbovirus activity. The regional plans recognize the importance of population density monitoring and data associated with disease transmission and nuisance complaints.

I. Coastal Region (North of Santa Barbara County):

Coastal areas of central and northern California present vector control agencies with a variety of surveillance problems. Upland from the San Francisco Bay and Sacramento River delta, the region is largely mountainous with numerous valleys and associated rivers, coupled with seasonally intermittent streams. Among the major rivers are the Sacramento (delta), Petaluma, Russian, Salinas, San Benito, and Trinity (far north). Many of these areas currently lack vector surveillance and control programs.

The most notable mosquito problems are created by coastal salt marshes and upland freshwater marshes surrounding the San Francisco Bay and extending eastward through the Suisun Marsh to the Sacramento River delta around Stockton. Smaller elements of marshland are found both above and below the "Bay" with increasing remoteness moving inland through the Coast Ranges. River flows drop dramatically during the summer; and most intermittent streams dry completely, severely limiting mosquito production. Situated within the central Coast Ranges is Clear Lake and surrounding areas that typically are not "coastal," but more "valley" in climate.

The agriculture of the region is limited to the Sacramento Delta and intermont valleys (e.g., Salinas Valley). Where flatlands are not cultivated, the land use is dedicated to urbanization and pastureland. In these areas, many transient sources are created by water management associated with agricultural irrigation practices and urban wastewater disposal. Mitigation practices also have created numerous cattail wetlands either peripheral to communities or embedded as greenbelt components adjacent to residential housing.

Problem coastal mosquitoes include salt marsh species (*Oc. squamiger* and *Oc. dorsalis*), *Oc. melanimon*, and *Culiseta inornata* in association with upland (slightly brackish to fresh water), *Cx. tarsalis* and *Cx. erythrothorax*; and occasionally *Cx. pipiens*, *Cx. stigmatosoma*, and *Culiseta incidens*. Salt marsh mosquitoes, particularly *Oc. squamiger*, disperse at great distances. Further inland, wetlands produce *Anopheles freeborni*, but along the coast, *Anopheles occidentalis* replaces *An. freeborni*. Fortunately, *An. occidentalis* is not considered a public health risk to coastal residents.

Agricultural areas similarly support *Culex*, *Anopheles*, and *Culiseta* in association with wastewater or constructed wetlands. Both mitigated and "natural" cattail (*Typha*) wetlands also produce large numbers of *Cx. erythrothorax*. Foul water sources represented by sumps, cattle drains, and highly polluted catch basins support both *Cx. pipiens* and *Cx. stigmatosoma*. Both species, in association with *Cs. inornata*, constitute the principal mosquito problems found in residential areas remote from wetlands. Mosquito movement is limited by the montane topography with ridges separating parallel valleys and perhaps effectively isolating mosquito populations and pathogens.

Rural Surveillance

Special application of New Jersey Light Traps: New Jersey Light Traps can be integrated with rural and periurban CO_2 traps for evaluating mosquito abundance monitoring and management programs.

Wetlands sites include coastal salt marshes, inland freshwater marshes, wetlands associated with stream/ river courses, and wastewater disposal sites in largely rural to mixed agricultural settings. Rural wetlands represent priority sampling sites based upon historical trends in vector mosquito production and association with mosquito-borne viruses. Although coastal wetlands lack a history of encephalitis virus activity, it should not be taken for granted that this "established" pattern will continue. Instead, efforts should focus on detecting an "unusual" outbreak or accidental introduction of a foreign pathogen, such as West Nile virus (WNV). Trap

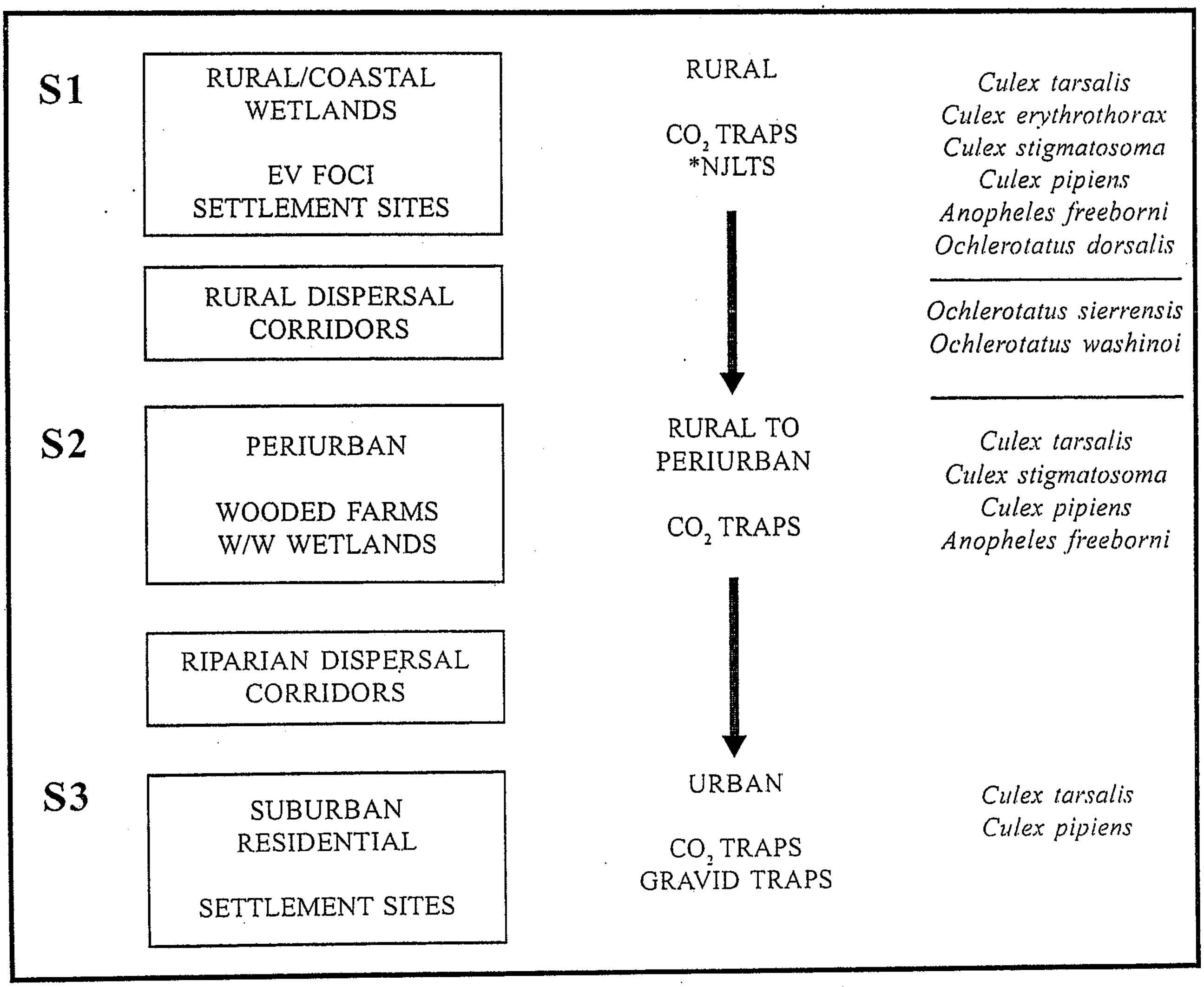


Figure 5. I. Coastal surveillance model. *Special Application.

sites should include peripheral and embedded locations associated with vegetative boundaries and avian populations. These features define sites suitable for mosquito concentration (settlement site) and potentially supportive of virus transmission (Lothrop and Reisen 2001; Lothrop et al. 2001). Wetlands along rivers and streams should also be sampled routinely as transient locations for secondary mosquito production and dispersal as well as possible zones of viral amplification. Rural dispersal corridors would include heavily wooded areas bordering "bottom land" parallel to ridges and low lying canyons that can channel mosquitoes through the gaps in ridgelines and into residential areas.

Mixed Agricultural areas include rural and urban elements that are arrayed within a predominately farmland area. Mosquito production sources are usually man-made, but represent a habitat distinct from rural wetlands (within fractions of a mile to residential/farm dwellings). In the Sacramento River Delta and Salinas Valley, agricultural areas are either transected by or adjoin water courses, and contain small embedded woodlands and well landscaped farm residences. Both woodlands and farm residences represent mosquito settlement sites and may support virus spread.

Urban Surveillance

Mosquito surveillance will require the integrated use of both CO_2 and gravid traps. Spatially, CO_2 traps should be placed on the perimeter of residential areas bordering agriculture, embedded parklands, greenbelts, and waterworks (intermittent streams, ponds, mitigated wetlands, etc.) to monitor *Culex* in addition to *Cx. pipiens/quinquefasciatus*. Gravid traps should be placed at sites complementing perimeter CO_2 trapping to track urban mosquito abundance. This sampling activity would intercept the spread of virus (e.g., possibly WNV) amplified by rural *Cx. tarsalis* to residential *Cx. pipiens* at sites where both species blend in significant numbers to "effectively transfer" virus from rural to urban vertebrate hosts. Additional gravid traps should be placed to track residential *Cx. pipiens* populations as a routine surveillance activity.

Integrated Application

Trap placement designed to detect rural mosquito and encephalitis virus activity and transition to urban mosquito and/or encephalitis virus dispersal.

Key Elements in Spatial Strategy

The keys in developing the spatial strategy for coastal mosquito surveillance are presented in Figure 5 and arranged in three layers depicting transitions from rural to urban habitats. The rural to urban strategy is based upon historical documentation of mosquito-borne encephalitis amplification beginning primarily rural as compared to urban settings. Coastal environs historically have yielded few virus isolates or sentinel sero-conversions. However, systematic sampling should not be abandoned based upon past history, particularly since the Bay Area is located strategically to intercept Pacific Rim commerce containing potential "invasive" mosquito species (e.g., *Aedes albopictus* and other spp.) and mosquito-borne pathogens (e.g., encephalitis viruses like dengue or Japanese encephalitis) affecting humans.

Stratum 1 – Sampling the "upland' fresh water component of coastal wetlands (saltwater and freshwater marshes) and inland rural wetlands supporting *Culex* production should receive the first priority. Additional sites may include extensive seasonal overflow areas along major river courses from where *Culex* and/or *Anopheles* mosquitoes are capable of dispersing into either sparse residential or urban settings.

Stratum 2 – Rural dispersal corridors and mixed agricultural sites (settlement sites) that facilitate the movement of mosquitoes into residential and urban areas should be sampled secondarily in combination with Stratum 1 wetlands. Site selection should consider the likelihood of mosquito infiltration into developed areas. Although most "corridors" may be riparian (follow rivers, streams, slough courses, and vegetation), some can function topographically (e.g., dry arroyos, ravines, connected woodlands, etc.) via "channeling" and/or wind directed dispersal.

Stratum 3 – The outer perimeter of residential neighborhoods oriented to "intercept" mosquitoes dispersing from major rural wetlands sites should be sampled with a combination of CO_2 and gravid traps. Additional CO_2 traps may be operated in the interior of neighborhoods along with gravid traps for sampling urban (peridomestic) house mosquitoes breeding in residential sources (e.g., ornamental ponds, under grounds, catch basins, etc.).

II. Central Valley/Foothill Region: (Strategy applicable to Owens Valley)

The Central Valley of California is perhaps the singular most notable geographic feature of the state and the historical focus for mosquito control and disease surveillance. The region is comprised of a complex pattern of extensive wetlands, mixed agriculture, and expanding urbanization located aside major rivers draining westward from the Sierra Nevada Mountains. Much of the native environment has been removed and brought into agricultural production as annual/perennial crops, orchards, and irrigated pastures. Wetlands, including river courses and flood plain cattail/tule marshes, percolation basins, wildlife refuges, mitigation sites, and vernal pools progressively increase (related to rainfall patterns) moving northward from the desert conditions of the southern San Joaquin Valley to the lush oak savannah typical of the northern Sacramento Valley. These wetlands produce a variety of mosquitoes seasonally, including *Cx. tarsalis*, *Cx. erythrothorax*, *Cx. stigmatosoma*, *Cx. thriambus*, *Cx. pipiens* (north), *Cx. quinquefasciatus* (south), *Anopheles freeborni*, *An. punctipennis*, *Oc. melanimon*, *Oc. nigromaculis*, *Aedes vexans*, *Cs. inornata*, and *Cs. incidens*. Of particular concern is the production of *Cx. tarsalis*, *Oc. melanimon*, and perhaps *Cx. pipiens/ quinquefasciatus* as the principal and secondary vectors of encephalitis viruses. Large populations of *An. freeborni* and *An. punctipennis* make this region similarly receptive for the introduction of human malaria.

Urban development and associated wastewater management has created habitats favorable for the production of *Cx. pipiens* and *Cx. quinquefasciatus*, and *Cx. stigmatosoma* in conjunction with "dairy lagoons" and logging ponds in the extreme northern Sacramento Valley.

Spring flooding of the Valley from the Sierra snowmelt has been managed by damming major river courses at lower elevations in the Sierra foothills. Historically, seasonal flooding produced large spring and early broods of floodwater mosquitoes and triggered mosquito-borne encephalitis outbreaks and occasionally outbreaks of human malaria. By damming the rivers and storing runoff in reservoirs, "floodwater" now is delivered in graduated conveyances to provide domestic and agricultural consumers with a steady water supply throughout the summer months and during drought years. As a result, mosquito production during the summer months is largely related to irrigation water mismanagement (excluding rice production) and the accumulation of urban wastewater in cities and adjoining wastewater wetlands.

Foothills of the inner Coast Ranges (west side) and Sierra Nevada Mountains (east side) are of some interest because wetlands and domestic sites produce significant numbers of mosquitoes on a seasonal basis. By summer, foothill sources either stabilize or dry and abruptly stop producing mosquitoes.

Rural Surveillance

Surveillance strategy for the placement of CO_2 and supplemental New Jersey light traps:

Special application of New Jersey Light Traps: New Jersey Light Traps can be integrated with rural and periurban CO_2 traps for evaluating mosquito abundance monitoring and management programs.

Wetlands include freshwater marshes, wildlife refuges, seasonal river (riparian) overflows, mitigated rural wetlands, major percolation "basins," and wastewater wetlands created by mixed agricultural land use. Weather-related seasonal floodings, coupled with agricultural water use and disposal patterns, are largely responsible for mosquito production in the Central Valley today. Significant populations of *Culex* mosquitoes are generated by seasonal flooding of extensive cattail, tule, and wooded (willow/cottonwood – oaks in the Sacramento Valley) areas associated with river overflows, mitigated wetlands, and wildlife areas with managed water systems. Collectively, these areas produce *Cx. tarsalis*, along with *Cx. erythrothorax*, *Cx. stigmatosoma*, and *Cx. thriambus* (foothills) and among *Anopheles* species, *An. freeborni* and *An. punctipennis* along rivers and streams. Also, wetlands supporting grassy (e.g., salt grass and others) elements flooded, either seasonally or by irrigation, produce abundant hatches of pasture mosquitoes of which *Oc. melanimon* is a known vector of WEE and CE. Emerging from these wetlands sites, *Culex*, *Ochlerotatus* (pasture mosquitoes), and *Anopheles* are capable of long-range dispersal into small town and urban habitats.

Encephalitis viruses also have a history of first being detected at wetlands from where virus is dispersed by mosquitoes and birds. Therefore, a first priority is to establish routine sampling of wetlands sites, and/or adjoining vegetated settlement sites. Mosquito survival is an essential component of encephalitis transmission. Competent female vectors that survive extrinsic incubation represent the component of the population that would become involved with active virus transmission and dispersal.

Foothill areas (up to 2000 ft.) on either side of the Central Valley support abundant spring populations of seasonal wetlands mosquitoes; however, encephalitis viruses rarely are detected in these habitats. Some mosquito control agencies pursue foothill sampling, but it should be understood that if the objective is to monitor risk to encephalitis transmission, then foothill sites may not be the place to prioritize searches. Surveillance efforts should be concentrated on the Valley floor where virus is more likely to be encountered.

Mixed Agriculture: Recommended sites include woodlands and heavily vegetated (sheltered) farm residences, dairies, riparian remnants, and reclaimed vernal ponds and other wastewater elements (components of dispersal corridors) supporting willows, cattails, and tules surrounded by agriculture. The mixed agricultural component is recognized as perhaps the most "dynamic" stratum of the Central Valley surveillance strategy. The continuum of annual (field crops), perennial crops (orchards), and pastureland combine to create a complicated pattern of temporary mosquito breeding with production geared to irrigation, particularly rice fields in the central and northern Valley. Further complicating the matter is the routing of local drainage canals (vegetation borders) and intermittent streams (e.g., Poso Creek in Kern County), plus the strategic location of blind sloughs (no outlets), wastewater wetlands, and irrigated pastures. All of these mosquito breeding sources and/or conveyances affect mosquito dispersal, selection of resting sites, and contact with avian blood meal sources.

The strategy here is to select relatively stable sites with "predictable" mosquito production and/or settlement sites that yield a steady number of *Cx. tarsalis*. Site stability (even if *Cx. tarsalis* abundance is low at < 10 per trap night) provides conditions that facilitate enzootic virus maintenance as evidenced by a long documented history of WEE transmission at the "mosquito poor" Tracy Ranch in Kern County that supports a consistently large house finch population. Other mixed agricultural sites have similar histories of encephalitis virus activity that are correlated with predictable and not necessarily explosive short-lived mosquito production.

The following are suggested sites for mixed agriculture mosquito surveillance. Site selection includes periurban settings where housing density is intermediate between sparse farmhouse and high residential housing densities. Priority sites would include isolated woodlands, wooded or brush riparian (river and stream) dispersal corridors traversing mixed agricultural land, vegetated wastewater disposal sites, mitigated wetlands and restoration areas, and well-landscaped farmhouses. Dairies, oxidation ponds, and wastewater sumps provided with on-site or nearby vegetation cover (trees, brush, etc.) may be alternatively considered if their location contributes to harboring and supporting the dispersal of *Culex* mosquitoes. Irrigated pasture sites with vegetation borders (trees and brush) should be considered for tracking *Ochlerotatus*, primarily *Oc. melanimon*, and occasionally *Cx. tarsalis*, *Cx. pipiens*, *Cx. quinquefasciatus*, and *Cx. stigmatosoma*.

Urban Surveillance

Priority sites for integrated use of CO_2 and gravid traps either border or are within residential neighborhoods. Recommended sites include residential housing bordering urban wetlands (mitigation sites) situated to intercept *Culex* mosquitoes dispersing from rural/mixed agricultural wetlands into these settlement sites. Spatially, a combination of CO_2 and gravid traps should be operated concurrently at the same "interface" to monitor rural *Cx. tarsalis* infiltration into urban development where this species will commingle with either *Cx. pipiens* (Northern San Joaquin and Sacramento Valleys) or *Cx. quinquefasciatus* (central and southern San Joaquin Valley). At the interface, CO_2 traps may effectively sample *Cx. tarsalis*, intrusive *Oc. melanimon*, and either *Cx. pipiens* or *Cx. quinquefasciatus*. Gravid traps provide a better assessment of abundance at sites located within neighborhoods.

The interdiction of *Cx. tarsalis* movement into residential habitats is important because *Cx. tarsalis* carrying encephalitis viruses (e.g., SLE or WNV) can infect residents directly or infect urban reservoirs. In the latter case, house mosquitoes infected by feeding

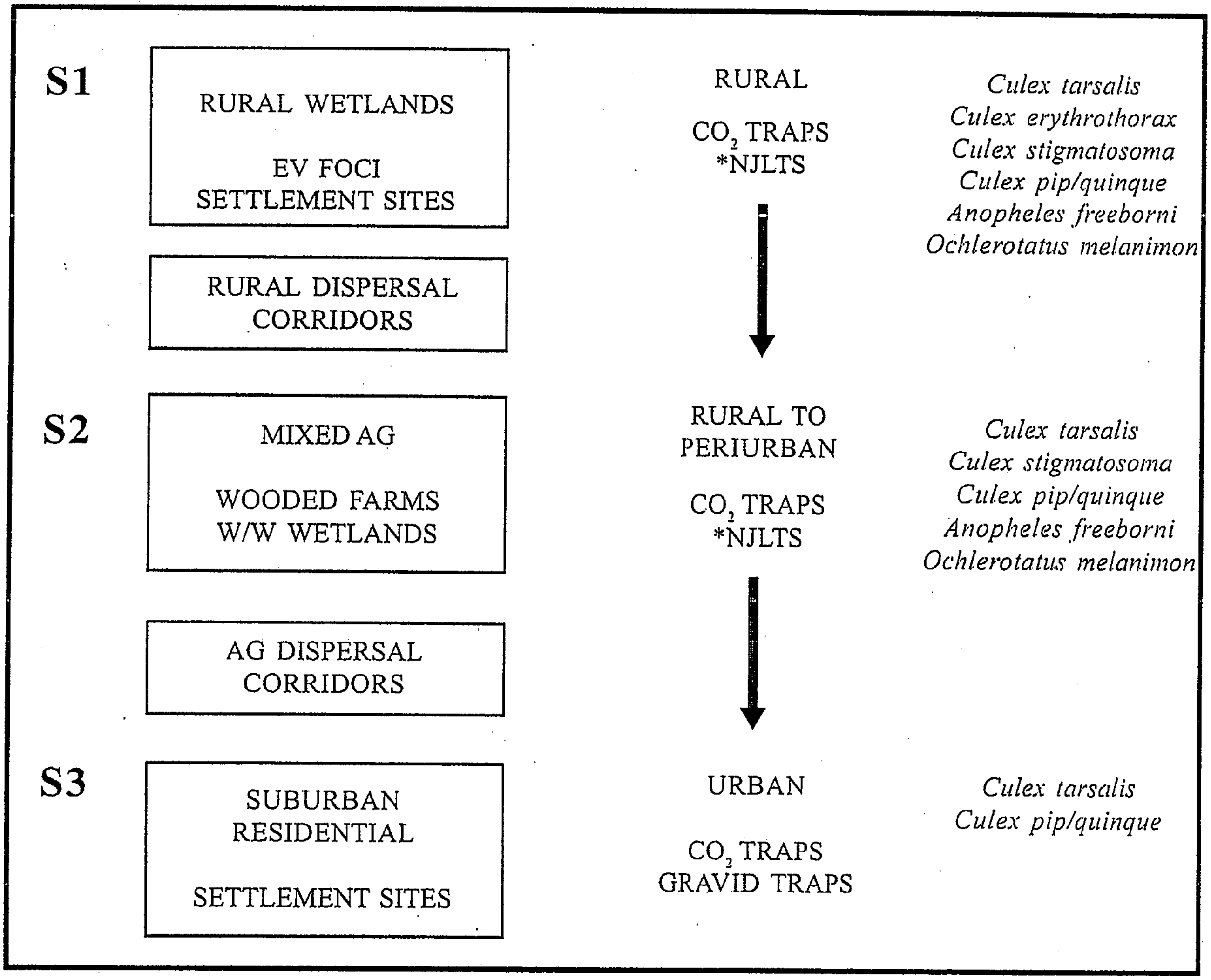


Figure 6. II. Central Valley surveillance model. *Special Application.

on infected reservoirs will facilitate virus dissemination within residential neighborhoods during an outbreak.

Peripheral monitoring should be complemented with some gravid trapping of house mosquitoes within the interior of neighborhoods. Residences (also commercial sites) should be selected on the basis of location as this factor would relate to adjacency to major storm water sites, including sumps, catch basins, and major underground conveyances that produce house mosquitoes.

Integrated Application

Spatial aspects of trap placement strategy related to mosquito production/dispersal and encephalitis virus spread, and preemptive detection of rural to urban mosquito and encephalitis virus dispersal.

Key Elements in Spatial Strategy

The key ecological components (strata) presented in developing the spatial strategy for the Central Valley and adjoining foothills mosquito surveillance are presented in Figure 6. The strata, S1-S3, represent distinct ecological settings and are arranged in a priority sequence to detect virus (e.g., WEE and SLE) dispersal from rural foci into populated urban developments. Priority is given to rural wetlands supporting the production of *Cx. tarsalis* and encephalitis virus reservoirs (e.g., predominantly avians and lesser extent mammals). Coordinated trap placements arrayed beyond primary foci/settlement sites are suggested to monitor possible *Culex* dispersal along corridors (e.g., river and stream courses) and/or other sheltered conveyances (landscape features affording environmental protection), which can effectively "channel" mosquitoes into mixed agricultural settlement sites and eventually residential developments. Where residential developments encroach upon adjacent wetlands and mixed agriculture mosquito production sites (e.g., rice fields and pastures), special consideration should be given to trapping *Culex* (e.g., *Cx. tarsalis*, *Cx. pipiens*, and *Cx. quinquefasciatus*), at the interface between housing and wetlands/agriculture. At this point, rural virus (e.g., SLE in the Central Valley) transfer/bridging can occur from rural to urban vectors. Selective sampling (gravid traps) of residential neighborhoods for house mosquitoes provides supplemental "risk" information from female abundance data and perhaps viral dispersal patterns in the event of an outbreak.

Stratum 1 - Rural wetlands, including wildlife refuges, major river overflows, and associated settlement sites should receive first priority on the basis of continuity of seasonal mosquito production, primarily *Cx. tarsalis*, and historical likelihood of supporting enzootic encephalitis virus transmission. Also included would be significant wetlands surrounded by mixed agricultural land use.

Stratum 2 – Largely mixed agricultural sites with embedded sloughs, river tributaries, streams, woodlands, wastewater wetlands, wooded/landscaped farm residences, and dairies (e.g., dairies with settlement site features – adjoining woodlands) are considered important for providing settlement sites and progressive linkage to create dispersal corridors. Secondarily, these sites are known to additionally support a wide variety of resident and migratory birds and nondomestic mammals (e.g., rodents, lagomorphs, etc.) that can reservoir encephalitis virus.

Stratum 3 - Suburban and residential sites that border mixed agricultural areas or major "urban wetlands" where mosquito infiltration (e.g., *Cx. tarsalis*) can effectively bring rural virus transmission into direct contact with housing residents and/or "bridge" virus from urban to rural vectors (*Cx. tarsalis* to *Cx. pipiens* or *Cx. quinquefasciatus*). Well within residential developments, it is suggested a select numbe of residential sites be sampled by gravid traps to provid an estimate of urban house mosquito abundance in th event of an SLE outbreak.

III. Southern California Region:

The region was created specifically based upo the unique landscape presented by the dominate urba development posed by the Greater Los Angeles Basi and satellite urbanization of the peripheral "inlan empire," and Orange and San Diego Counties Throughout most of California, with the exception o the urban centers around the San Francisco Bay are and coastal southern California, the landscape i predominantly rural with land use dedicated t agriculture; urbanization comprises only a small portio (<10%) of the overall land use. However, the revers occurs in urban southern California where urba development dominates the landscape. This specter o land use requires a significantly different approach t traditional thinking in the spatial application of mosquit surveillance strategies.

Unlike rural areas in the Central Valley wher distance effectively separates rural *Cx. tarsali* production from urban settings, "rural" habitat supporting *Cx. tarsalis* in urban southern California ar typically embedded within and abruptly borde neighborhoods and commercial developments. Therefore, mosquito and viral dispersal do not potentially occu over great distances, but rather over very shor distances (<¼ mile) that lie between small wetland and nearby housing developments; that is, mosquitoes virus, reservoirs, and humans occupy essentially th same space. This association is further reinforced b the ubiquity of residential breeding of house mosquitoe (*Cx. quinquefasciatus*) in urban storm wate conveyances and residential backyards.

Without exception, the dominant mosquito specie is the southern house mosquito (*Cx. quinquefasciatus*) This species outnumbers all other species combined i urban settings. Beyond the urban continuum, the widel scattered elements of embedded rural habitats an significant fresh water wetlands (e.g., San Joaquin Marsh) support *Cx. tarsalis* and *Cx. erythrothorax*, and lesser numbers of *Cx. stigmatosoma*, *Cs. incidens*, and *Cs. inornata*. Salt marshes (e.g., Bolsa Chica) produce both *Oc. squamiger* and *Oc. taeniorhynchus*, but neither of these species is considered a public health concern to residents in affected coastal areas.

Although wetland habitats support a significant number of resident and seasonal birds, urban neighborhood populations of passerines, combined with domestic pets and humans, represent the principal blood meal sources available to host-seeking *Cx. quinquefasciatus*. In addition, the ubiquity of hosts in residential areas presents a unique sampling condition requiring a broader application of gravid trapping as opposed to the standard usage of CO_2 traps. The reason for this is twofold and related to the spatial attributes of hosts and mosquito oviposition sites/sources. First, hosts (e.g., birds, pets, etc.) are uniformly distributed and not aggregated within typical rookeries and/or roosts encountered in rural settings. This phenomenon uniformly disperses host-seeking mosquitoes, and thus reduces the effectiveness of CO_2 traps. Second, oviposition sites are localized, limited and somewhat aggregated within urban neighborhoods, and not dispersed as is the case in most rural settings. Therefore, oviposition traps effectively attract a disproportionately higher number of gravid house mosquitoes to traps placed in sheltered residential sites than at farm houses in rural areas. Using exclusively CO_2 traps would seriously underestimate house mosquito abundance in urban environments and vice versa for gravid traps operated in rural areas.

Rural Surveillance

Wetlands sites include embedded rural wetlands, mitigation sites, riparian corridors, and coastal salt and inland freshwater marshes. Rural wetlands are easily recognized by the presence of willows (*Salix*), Cottonwoods (*Populus*), Mule Fat (*Baccharis*); and a combination of cattails (*Typha*), tules (*Scirpus*), giant reed (*Arudno*), plus various grasses and weeds. Many sites have been created recently as either "ornamental" impoundments (natural areas) or modified from existing intermittent stream beds through mitigation. Many city parks and green belts also contain wetlands elements as a component of the community environmental plan.

Among the more important wetlands areas created as a consequence of flood control management are the Prado and Sepulveda Basins. Beyond these two significant features, remaining sources were created as seasonal wetlands in association with the Los Angeles, San Gabriel, and Santa Ana Rivers. Debris jams disrupting the "river" flow within the "channels" contribute to some wetlands creation and mosquito breeding.

Seasonally, embedded wetlands produce a variety of mosquitoes, including predominately *Culex*, *Anopheles*, and to a lesser extent *Culiseta*. These sites also support both resident and migratory bird populations, sometimes in notable abundance.

Dairies in the western portion of San Bernardino County (e.g., Chino) are historically high producers of foul water mosquitoes, including *Cx. quinquefasciatus* and *Cx. stigmatosoma*. Although considered rural under most conditions/settings, the dairies in the Chino area are located relatively close to residential areas where attacks by house mosquitoes occur throughout the spring and summer, and well into fall.

Rural to Urban Interface (Special Condition) includes the abrupt transition between embedded rural wetlands and residential neighborhoods, a unique transition between rural *Cx. tarsalis* and urban/residential *Cx. quinquefasciatus* for "bridging" encephalitis virus from rural to urban vectors. Where significant embedded wetlands and/or extensive mosquito breeding areas contact residential neighborhoods, a combination strategy of CO_2 and gravid traps should be used to document peripheral *Cx. tarsalis* infiltration and presumptive virus (e.g., SLE) movement into "vulnerable" neighborhoods. Therefore, in addition to wetlands, CO_2 trap sampling should be included at the wetlands/neighborhood interface, plus additional trapping further into the neighborhood to better assess *Cx. tarsalis* and *Cx. quinquefasciatus* blending. Within neighborhoods (refer to urban surveillance section presented below), gravid traps would be operated concurrently to monitor *Cx. quinquefasciatus* associated with residential breeding sources. In the event of WNV introduction into southern California, the abrupt rural "wetlands" to residential movement of virus will be a critical aspect of not only WNV detection, but also a likely scenario for initiating the epidemic spread of the virus.

Urban Surveillance

Residential housing accounts for over 40 percent of indigenous house mosquito production in the Greater Los Angeles Basin. Besides "backyard" *Cx. quinque-*

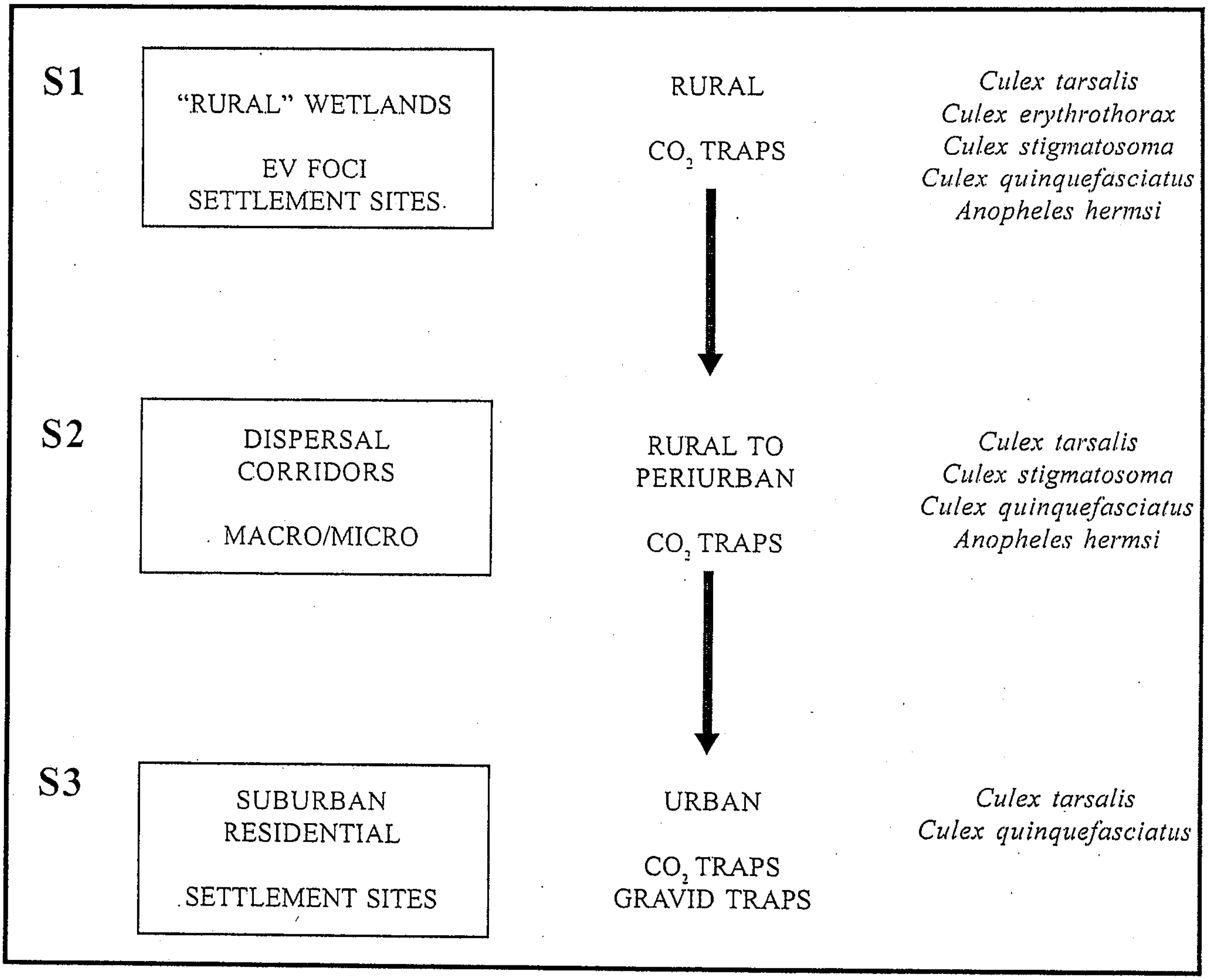


Figure 7. II. Greater LA Basin surveillance model.

fasciatus production, underground storm drains contribute to maintaining house mosquito populations. Overall, the urban breeding pattern produces a regional continuum that presents vector control agencies with a variety of urban surveillance options. Site selection should consider high versus low risk settings where wetlands elements closely abut neighborhoods. Therefore, housing located near parks, green belts with mitigated/natural ponds/lakes (e.g., Harbor Lakes), canals, etc., major river courses (e.g., housing next to Santa Ana, San Gabriel, Los Angeles Rivers, Prado Basin), and a significant wetlands (e.g., San Joaquin Marsh, Bolsa Chica, etc.) should be considered priority surveillance sites. These sites, additionally are characterized by ornamental/natural landscaping that may also function as urban mosquito settlement sites where mosquitoes may aggregate.

Integrated Application

Spatial aspects of trap placement strategy related to mosquito and encephalitis virus movement/distribution and preemptive interdiction of rural to urban mosquito/virus dispersal.

Key Elements in Spatial Strategy

The key ecological components (strata) in developing the spatial strategy for the Greater Los Angeles Basin, inland empire, and Orange and San Diego Counties are presented in Figure 7. Strata are prioritized in three layers that depict the "rural" to urban flow of mosquito/virus from wetlands sites into neighborhoods with further spread facilitated by local vectors supporting neighborhood transmission to resident avians, domestic pets, and humans.

Within the Los Angeles Basin, SLE is maintained enzootically by *Cx. tarsalis* associated with "urban" wetlands. From these sites, virus is further spread by a combination of locally dispersing mosquitoes and/ or long/short range dispersal of infected avian reservoirs; and in time is tangentially passed to *Cx. quinquefasciatus* in urban neighborhoods. Therefore, surveillance is geared to monitor urban wetlands and incorporate additional monitoring of dispersal corridors (short- fractions of a mile, and long- up to many miles) that facilitate mosquito movement into residential areas. It is further suggested that "sensitive" residential sites be included in the basic plan to provide some "backup" tracking/sampling in the event that virus activity appears unrelated to preexisting wetland conditions.

Stratum 1 - Embedded "rural" wetlands and existing major wetlands should receive first priority in monitoring with routine sampling of sites considered most sensitive for the detection of virus based upon historical trends and perceived risk.

Stratum 2 - Dispersal corridors that convey mosquitoes from wetlands to residential areas over either short or long distances are included to track dispersal and provide a mechanism of interdicting virus movement towards residential areas. Also, where the landscape is more open and less developed, as is the case with the Corona dairies and Santa Ana River basin circa the Prado Basin, then a select number of "rural" farm settlement sites should be included. These sites represent potential settlement sites that would promote viral spread (refer to Stratum 2 in the Central Valley and southern deserts strategy).

Stratum 3 - Urban residential sites that are situated to intercept the rural to urban infiltration of wetlands mosquitoes and associated viruses are of priority interest in detecting residential risk to encephalitis transmission. Selected sites located well within residential areas also are recommended as a secondary indication of mosquito abundance and expanded sampling if a mosquito-borne encephalitis outbreak occurs.

IV. Desert Region:

The desert region is unique in both landscape and climate. Located in the southeastern portion of the state, the area is bordered by the Peninsular Ranges and Colorado River. Within this area are located a number of notable geographical features that include the Coachella, Imperial, Palo Verde, and Bard Valleys, along with the Salton Sea and Lower Colorado River Valley. This landscape has been fractionated into mixed agricultural and limited wetlands components represented by embedded wildlife refuges, overflows from the Colorado, New and Alamo Rivers, plus alkaline "sinks" where agricultural waste waters are conveyed (e.g., Coachella Valley) for percolation and disposal. The vegetation profiles that provide shelter at settlement sites (aggregation sites for mosquitoes) include tamarisk, cottonwood, and willow, with arrowhead weed and saltbush contributing to the mosaic of dominant understory vegetation at settlement sites in mixed agricultural and wetlands habitats supported by natural drainage and agricultural wastewater management.

Urbanized areas of southeastern California support modest human populations with perhaps the exception of the Coachella valley where explosive growth is occurring in the communities of La Quinta, Palm Desert, and Thousand Palms. Mosquito production in residential areas is significantly limited by porous sand soil, climate, and more restrictive water conservation measures.

Wildlife surveys indicate that avians generally use the same settlement sites as mosquitoes, being associated with sites that provide shelter from summer heat and adequate protection for both roosting and nesting, respectively. Therefore, both mosquitoes and potential avian hosts occupy the same space and occur spatially confluent. This is very important in developing a trapping strategy that will, by default, simultaneously yield both abundance monitoring and virus isolation options. Mosquito production in the desert region occurs year-round in response to the relatively mild climate. However, peak adult production occurs in the spring and fall with reduced productivity in the intervening hot summer months (June–September). Historical assessments of seasonality have been provided by a combination of NJLT and CO_2 trap monitoring at predominately rural locations in mixed agriculture and wetland environments.

Rural Surveillance

Mixed Agricultural Sites include farm residences, orchards, and "oasis" wastewater disposal flood basins. Historically, residential mixed agricultural sites with heavy landscaping, recognized by shade trees and bush thickets (including saltbush and arrowhead weed) receiving summer irrigation, function as "settlement sites" for resident and migratory birds, and resting/host-seeking *Culex* mosquitoes. Similarly, "oasis" wastewater basins overgrown with a combination of trees (predominately tamarisk and willow) and thickets of saltbush and arrowhead weed probably attract both birds and mosquitoes. Depending upon location, the perimeter of citrus and vegetated (fruit trees and sunflowers) understory of date groves can present microhabitats favorable for trapping *Culex* and other species.

Wetlands sites include riparian corridors/associated overflow and/or oxbow marshland, alkaline/fresh water marshes, and duck clubs/wildlife refuges. Rural settings yielding significant host-seeking mosquitoes in the desert regions have been associated with wetland situations where vegetative cover enhances the settlement site attributes provided by lush vegetation and general cover that maintains high resting site humidity levels during the hot summer months. From these sites, mosquitoes disperse outward opportunistically as local conditions promote seasonal movement into nearby domestic settlement sites (e.g., farm houses, ranches, duck clubs, etc.) and peripheral residential areas. Mosquito dispersal also provides a mechanism to spread encephalitis viruses into settlement areas where extrinsic incubation and transmission can occur under more favorable conditions with overall enhanced mosquito survival being the most critical factor. Therefore, surveillance would include priority placement of CO_2 traps at "wetland" sites supporting vegetation cover and *Culex* breeding. On-site, trap placements that produce the best capture results are just aside the cover (edge) of bordering vegetation (tamarisk/willow, mature cattail/tule, saltbush/arrowhead weed, mule fat, or upland orchards).

Urban Surveillance

Urban mosquito surveillance should include the primary use of CO_2 traps at sites where urban areas contact wetlands, canals, and heavily landscaped parkland sites that can provide breeding sources and shelter to both host-seeking and resting mosquito populations (e.g., mix of both *Cx. tarsalis* and *Cx. quinquefasciatus*). Within neighborhoods, urban surveillance of house mosquitoes (*Cx. quinquefasciatus*) is more practical with the use of gravid traps. Site selection should be based upon spatial parameters, including major storm drains, underground systems, greenbelts with waterworks (canals, ponds, etc.), and sanitation plants.

Integrated Application

Spatial aspects of trap placement are related to mosquito and encephalitis virus movements and preemptive interdiction of rural to urban mosquito and/or encephalitis virus dispersal. The key ecological components presented in developing the spatial strategy for the southern deserts are presented in Figure 8. Strata are arranged in three layers that depict a spatial transition from rural to urban. The rural to urban transition is based upon historical mosquito sampling and virus detection that indicate viral activity first appears usually in rural locations and then progressively spreads outward following dispersal corridors into mixed agricultural settings, and eventually into small cities and urban developments. Dispersal corridors (ecological bridges/conduits) between the three strata present an "accommodating landscape" characterized by a combination of cover associated with a protective microclimate. Corridors should be identified and actively monitored, or at least identified for control operations in the event of an encephalitis outbreak. Below is a brief operational description and prioritized listing of the three key ecological strata recognized as important in providing comprehensive mosquito surveillance in the desert region of California.

Stratum 1 - Rural wetlands and settlement sites should receive first priority in monitoring with routine sampling of those sites that have been demonstrated by previous surveillance efforts to consistently produce mosquitoes and yield virus isolates.

Stratum 2 – Mixed agriculture sites that include farm oasis and wastewater wetlands should be considered secondarily because these may present linkage conditions and corridor dispersal (bridging) from rural viral foci into heavily populated urban areas.

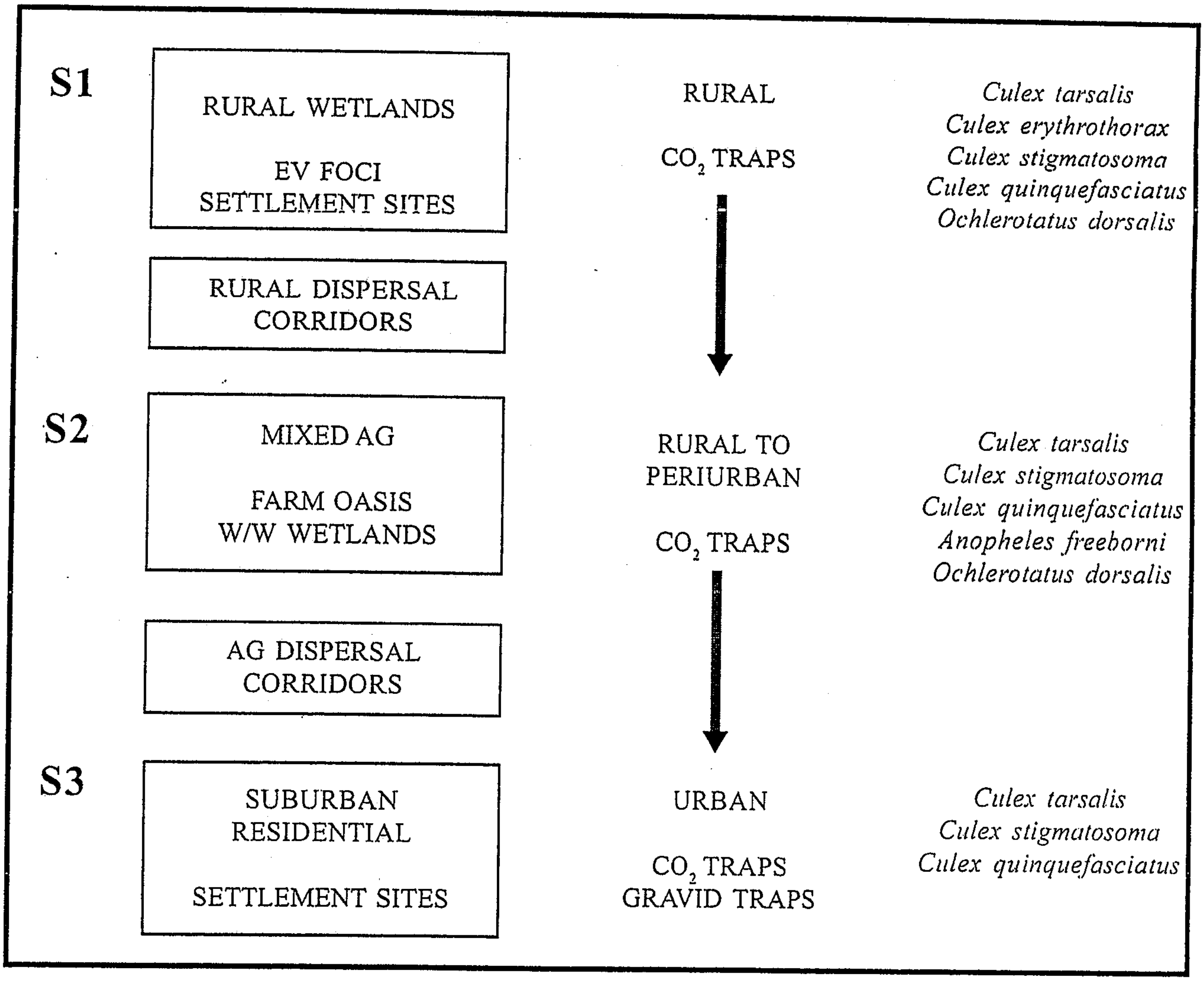


Figure 8. IV. Southern Deserts surveillance model.

Stratum 3 – Suburban and residential sites that spatially represent the likely points of either rural or periurban mosquito infiltration into residential areas. Selected sites located within residential areas should be included as secondary indication of mosquito abundance and supportive sampling in the event of an encephalitis outbreak.

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California Department of Public Health

Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks

Supplement to California Mosquito-Borne Virus Surveillance and Response Plan

CONTENTS

CONTENTS (continued)

Appendices

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Purpose

This document identifies the coordination between the California Department of Public Health (CDPH) and partner agencies in responding to a mosquito-borne disease emergency. It serves as a supplemental document to the *California Mosquito-Borne Virus Surveillance and Response Plan (Response Plan)* and is consistent with the CDPH Emergency Plan, Departmental Administrative Order, and the State Emergency Plan. This document expands on the roles of the agencies mentioned in the *Response Plan* and provides the policy basis for mosquito-borne disease outbreak planning, response, recovery, and mitigation actions.

The document includes the following information:

- Description of how CDPH and federal, state, and local agencies function together in a coordinated escalating emergency response.
- The progression from normal to emergency operations.
- The emergency management structure (Standardized Emergency Management System [SEMS] organization chart for CDPH response), notification system, responsibilities for the various agencies involved in the response, and anticipated agency roles at each jurisdictional (federal, state, local) level.

Authority

The authorities of participating state and local agencies to respond to outbreaks of disease and to exercise emergency powers where necessary are as follows:

- The California Emergency Services Act (Government Code (GC), Title 2, Division 1, Chapter 7, Section 8550 *et seq*): Grants authority to the Governor and chief executives to provide for state assistance in organization and maintenance of emergency programs of counties, establishes the California Emergency Management Agency (CalEMA), and establishes mutual aid procedures.
- California Health and Safety (H&S) Code Sections Pertaining to the Authority of the State Department of Public Health:
    1. Article 1, Chapter 2, Part 1, Division 101 of the H&S Code, commencing with section 100150, particularly sections 100170, 100175, 100180, 100182, and 100185: Establishes authority of the Department to enforce the laws pertaining to public health and the regulations of the department.
    2. Chapter 2, Part 1, Division 105 of the H&S Code, commencing with section 120125: Establishes authority of the Department to investigate and control communicable diseases within the state, including actions against persons, animals or property, such as quarantine, isolation and inspection.
- California H&S Code Sections Pertaining to Local Governing Bodies and Health Officers:
    1. Article 1, Chapter 2, Part 3, Division 101 of the H&S Code, commencing with section 101025: Establishes authority of county board of supervisors to preserve

and protect the public health, and requires the county health officer to enforce county orders, ordinances, and statutes pertaining to public health.

2. Chapter 4, Part 3, Division 101 of the H&S Code, particularly Articles 2, 3, and 4, commencing with sections 101375, 101400, and 101450, respectively: Authorizes cities to consent or contract with the county to perform public health functions, and requires city governing bodies to take actions to protect and preserve public health. In absence of consents or contracts with the county, authorizes cities to appoint a health officer to enforce and observe all orders, ordinances, quarantines, regulations, and statutes relating to public health.

- CDPH, *Emergency Response Plan and Procedures*, January 1994, authorized by:
    1. Executive Order No. W-9-91: Establishes the Department's responsibility to prepare for and respond to emergencies. It mandates emergency preparedness and response assignments for all state agencies and departments under the coordination of CalEMA.
    2. Administrative Order (December 10, 2002): Details the emergency preparedness and response functions of the Department. This Administrative Order guides CalEMA and the Department in coordinating priority tasks and programs related to emergency preparedness, response, and recovery in accordance with the CalEMA *State Emergency Plan*.
    3. Memorandum of Understanding, CDPH and Emergency Medical Services Authority (EMSA), July 1988: Details the relationship between CDPH and the EMSA in planning for and responding to a catastrophic disaster and describes the specific responsibilities of each department.
- EMSA, *Disaster Medical Response Plan*, July 1992.
- *State Emergency Plan*, May 1998: Defines the emergency management system used for all emergencies in California. The plan describes the State's response to disasters, including the response of all levels of government and certain private sector organizations to all natural and man-made emergencies that threaten life, property, and the resources of California. It focuses on the basic requirements for disaster management and coordination under the SEMS. It is intended to be used in conjunction with city, county, operational areas (OA), and state agency plans and associated standard operating procedures.
- Federal Emergency Management Agency, *Federal Response Plan*, April 1999: A signed agreement among 27 Federal departments and agencies, including the American Red Cross, that provides the mechanism for coordinating delivery of Federal assistance and resources to augment efforts of state and local governments overwhelmed by a major disaster or emergency. It supports implementation of the Robert T. Stafford Disaster Relief and Emergency Assistance Act plus individual agency statutory authorities. It provides for damage assessment teams, emergency communications, medical assistance, equipment and supplies, creation of facilities such as a Disaster Field Office and Recovery Mitigation Center.
- Memorandum of Understanding between CDPH, Department of Pesticide Regulation, and county agricultural commissioners provides that CDPH will certify vector control technicians employed by public agencies for safe handling and application of pesticides for vector control to preserve the public health.

1. Pursuant to H&S Code sections 116180 and 106925, agencies that have signed a cooperative agreement with CDPH must employ technicians that are certified by CDPH.
2. As described in Title 3 of the California Code of Regulations (CCR) and other statutory codes, signatories to the cooperative agreement with CDPH also receive a number of exemptions and exclusions to state laws and regulations that would otherwise apply to any person or agency involved in the application of pesticides. Applicable codes and statutes include: Education Code, section 17613; Food and Agriculture Code, section 11408(e); H&S Code, section 25174.7(a)(3); 3CCR 6400(c)(2) and 6400(e), Restricted Materials; 3CCR 6620(a), Vector Control Exemption; 3CCR 6651, Vector Control Exemption; and 3CCR 6760, Employer Responsibility and Exceptions.

- Regional Disaster Medical/Health Coordinator (RDMHC) Emergency Plans: These plans are prepared by each Regional Disaster Medical/Health Coordinator to describe their local disaster response roles.

Scope

As noted previously, this document is intended to serve as an emergency-specific supplement to the *Response Plan*. This document is intended to address only the emergency response for mosquito-borne disease outbreaks.

The relationship of CDPH to the State emergency response structure and the roles and responsibilities of CDPH Executive Staff, and the various divisions, branches, and sections of the Department are described in the CDPH *Emergency Response Plan and Procedures*, January 1994.

This section describes the emergency management structure that will be implemented in response to a mosquito-borne disease outbreak and the expected roles and responsibilities of organizations integral to a successful disease response. The most critical activity and response to an emergency will occur at the local level. General relationships between local, regional, state, and federal response agencies are described. However, details on local, state, and federal response should be developed separately in the form of Standard Operating Procedures (SOPs) by the respective jurisdictions involved. When local, area, and regional resources are exhausted, State and then Federal assets are mobilized.

This plan focuses on naturally occurring events, including novel introductions of virus or mosquito vectors. Incidents that are suspicious or confirmed as intentional bioterrorism acts will require coordination with appropriate federal and state law enforcement agencies with authority over the crisis and consequent management of potential crime scenes.

It is anticipated that when a significant mosquito-borne disease outbreak in California is thought to be imminent, even prior to the proclamation of a local emergency or state of emergency, some aspects of the CDPH emergency response organization (shown in Appendix 3) will be activated. The CDPH response will be conducted in accordance with SEMS, as described in the CDPH emergency plan. The medical response of SEMS will only be activated should there be a human outbreak of mosquito borne disease resulting in a large numbers of patients impacting care delivery of the medical and health system (hospitals, clinics, ambulance providers).

Background

Mosquito-borne viruses belong to a group of arthropod-borne viruses referred to as arboviruses. Although 12 mosquito-borne viruses are known to occur in California, only western equine encephalomyelitis (WEE) virus, St. Louis encephalitis (SLE) virus, and West Nile virus (WNV) have caused or have the potential to cause significant outbreaks of human disease. Consequently, the California Arbovirus Surveillance Program emphasizes forecasting and monitoring the temporal and spatial activity of SLE, WEE, and WNV. All of these viruses are maintained in nature in wild bird-mosquito cycles, and, therefore, are not dependent on infections of humans or domestic animals for their persistence. In California, surveillance and control activities focus on these cycles, which involve primarily (1) *Culex tarsalis* and birds, such as house finches and sparrows for SLE and WEE, and (2) *Culex tarsalis* and *Culex pipiens / quinquefasciatus*, and birds such as crows, ravens, jays, house finches, and sparrows for WNV.

Mosquito control is the only practical method of protecting people and animals from SLE, WEE, and WNV infections. There are no known specific treatments, cures, or vaccines for human diseases caused by these viruses. Infection by WEE virus tends to be most serious in very young children, whereas infection caused by SLE and WNV affects elderly people most seriously. WEE and WNV can be important diseases in horses and ratites. There are effective WEE and WNV vaccines available to protect horses.

California has a comprehensive mosquito-borne disease surveillance program that has monitored mosquito abundance and mosquito-borne virus activity since 1969. The detection of WNV in New York, a virus never recognized prior to 1999 in the Western Hemisphere, prompted the review and enhancement of existing guidelines to ensure appropriate surveillance, prevention, and control activities for WNV (see *Response Plan*). In addition to WNV, California is at risk for introduction of other highly virulent mosquito-borne viruses, such as Japanese encephalitis, Rift Valley fever, and Venezuelan encephalitis viruses. If an existing or introduced virus is detected, it is critical that local and state agencies are prepared to respond in a concerted effort to protect people and animals from infection and disease.

Operating Assumptions

- SEMS will be utilized for the emergency response at all levels.
- Jurisdictional responsibilities will be maintained.
- Information and resource allocation and distribution will follow the SEMS model.
- Public health and vector control response will be coordinated with emergency management agencies.

- Public information releases and recommendations to the public for protective measures will be coordinated between CDPH, CalEMA Joint Information Center (JIC), and local officials. Coordination at the county level will occur between county public health departments, impacted vector control districts, and county emergency management offices.

Local vs. State Level Emergencies

Response to a mosquito-borne virus would be initiated at the local government level. County and city health officers may take any preventive measure that may be necessary to protect and preserve the public health from any public health hazard during a local emergency within his or her jurisdiction. Preventive measure means abatement, correction, removal, or any other protective step that may be taken against any public health hazard that is caused by a disease outbreak that affects the public health (H&S Code sections 101040, 101475). The local governing body of a city and/or county, or local health officer (if he or she has been specifically designated to do so by ordinance adopted by the governing body of the jurisdiction), may proclaim a local emergency (GC 8630). Once a local emergency has been declared, the local health officer has the right to obtain all necessary information about the disease outbreak to abate the emergency and protect the public health. Health officials may provide this information to responding state or local agencies, or to medical and other professional personnel treating victims of the local emergency.

A "State of Emergency" may be proclaimed by the Governor when "conditions of disaster or extreme peril to the safety of persons and property within the state" exist and when the Governor is either requested to do so by the appropriate official of the governing body, or finds that local authorities cannot cope with the emergency (GC section 8625).

Transition to Degrees of Emergency

The thresholds that change the situation from a normal season to an emergency planning phase, and finally to epidemic conditions, potentially resulting in a public health emergency (requiring an emergency response pursuant to the Emergency Services Act, Section 8558(c), Chapter 7 of Division 1 of Title 2 of the Government Code), are described below.

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

Table 1 in the *Response Plan* provides worksheets for assessing risk of WEE, SLE, and WNV transmission. Average risk values for a normal season range from 1.0 to 2.5, emergency planning from 2.6 to 4.0, and epidemic conditions from 4.1 to 5.0. The ratings given are benchmarks only, and may need to be adjusted relative to the conditions in each specific region or biome of the state.

Thresholds for delineating a normal season, emergency planning, and epidemic conditions follow:

Normal Season

- Average or below average snowpack and rainfall; average seasonal temperatures (<65 F)
- *Culex* mosquito abundance at or below five year average (key indicator = adults of vector species)
- No virus infections detected in mosquitoes
- No seroconversions in sentinel chickens
- No WNV infected dead birds
- No human cases

Emergency Planning

- Snowpack and rainfall and/or temperatures above average (66-79 F)
- Adult *Culex* mosquito abundance greater than 5-year average (150% to 300% above normal)
- One or more virus infections detected in mosquitoes (MIR / 1000 is <5)
- One or more seroconversions in single flock or one to two seroconversions in multiple flocks in specific region
- One to five recently infected WNV positive dead birds in specific region
- One human case in broad or specific region
- WEE virus detected in small towns or suburban areas

Epidemic Conditions

- Snowpack, rainfall, and water release rates from flood control dams and/or temperature well above average (>79 F)
- Adult vector population extremely high (>300%)
- Virus infections detected in multiple pools of *Culex tarsalis* or *Culex pipiens* mosquitoes (MIR / 1000 > 5.0)
- More than two seroconversions per flock in multiple flocks in specific region
- More than five recently infected WNV positive dead birds and multiple reports of dead birds in specific region
- More than one human case in specific region
- WEE virus detected in urban or suburban areas

Action Associated with "Trigger Points"

The transition from Normal Season to Epidemic Conditions is based upon an average risk level, calculated from the factors listed above, and is related to specific response levels described in the *Response Plan*.

CDPH will coordinate with key agencies that participate in the *Response Plan* to assure that appropriate actions associated with the three alert levels at normal season, emergency planning, and epidemic conditions are performed as follows:

<u>Normal Season "No Alert Level" Risk rating: 1.0 - 2.5</u>

- Conduct routine public education (eliminate standing water around homes, use personal protection measures)
- Conduct routine mosquito and virus surveillance activities
- Conduct routine mosquito control, with emphasis on larval control
- Inventory pesticides and equipment
- Evaluate pesticide resistance in vector species
- Ensure adequate emergency funding
- Release routine press notices
- Send routine notifications to physicians and veterinarians
- Establish and maintain routine communication with local office of emergency services personnel; obtain Standardized Emergency Management Systems (SEMS) training

<u>Emergency Planning "Alert Level" Risk rating: 2.6-4.0</u>

- Review epidemic response plan
- Enhance public education (include messages on the signs and symptoms of encephalitis; seek medical care if needed; inform public about pesticide applications if appropriate)
- Enhance information to public health providers
- Conduct epidemiological investigations of cases of equine or human disease
- Increase surveillance and control of mosquito larvae
- Increase adult mosquito surveillance
- Increase number of mosquito pools tested for virus
- Conduct or increase localized chemical control of adult mosquitoes as appropriate
- Contact commercial applicators in anticipation of large scale adulticiding
- Review candidate pesticides for availability and susceptibility of vector mosquito species
- Ensure notification of key agencies of presence of viral activity, including the local office of emergency services (Appendix 1)

<u>Epidemic Conditions "Emergency Level" Risk rating: 4.1-5.0</u>

- Conduct full scale media campaign
- Alert physicians and veterinarians
- Conduct active human case detection
- Conduct epidemiological investigations of cases of equine or human disease
- Continue enhanced larval surveillance and control of immature mosquitoes
- Broaden geographic coverage of adult mosquito surveillance
- Accelerate adult mosquito control as appropriate by ground and / or air
- Coordinate the response with the local Office of Emergency Services or if activated, the Emergency Operations Center (EOC)

- Initiate mosquito surveillance and control in geographic regions without an organized vector control program
- Determine whether declaration of a local emergency should be considered by the County Board of Supervisors (or Local Health Officer)
- Determine whether declaration of a "State of Emergency" should be considered by the Governor at the request of designated county or city officials
- Ensure state funds and resources are available to assist local agencies at their request
- Determine whether to activate a Standardized Emergency Management System (SEMS) plan at the local or state level
- Continue mosquito education and control programs until mosquito abundance is substantially reduced and no additional human cases are detected

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Notifications

For normal operations of the Emergency Response System, see previous Section on Scope.

The notification system for a WNV or other mosquito-borne disease emergency event would be keyed to trigger points identified in the *Response Plan.* These trigger points include Normal Season, Emergency Planning, and Epidemic Conditions. Surveillance testing and notification algorithms are described in the Appendices of the *Response Plan.*

The emergency notification system for mosquito-borne virus emergency events is shown in Appendix 1. After surveillance samples are tested locally or submitted by local agencies and tested by appropriate laboratories at the CDPH, California Animal Health and Food Safety Laboratory, and University of California, Davis (UCD) Center for Vectorborne Diseases (CVEC), the results are interpreted by CDPH or locally and average risk ratings are calculated. Notifications are based upon alert levels which include: (1) a "No Alert" normal season, with average risk values < 2.5, with normal environmental conditions and no virus activity detected; (2) an "Alert Level" emergency planning, with average risk values from 2.6 to 4.0 and favorable environmental conditions and indications of virus transmission such as detection of virus in mosquitoes and/or sentinel and wild animals; and (3) an "Emergency Level" epidemic conditions, with average risk values from 4.1 to 5.0, highly favorable environmental conditions, and strong indications of a potential human epidemic such as multiple detections of virus in mosquitoes, sentinel and wild animals and humans, especially near urban populations.

During "No Alert," normal season notification of results is between submitting agencies and CDPH. When risk values reach "Alert Level," emergency planning conditions exist and the submitting agencies, local governments, and appropriate state agencies are notified by CDPH or the local vector control agency. The local regional and state emergency services offices, and the CDPH Operations Center and Joint Emergency Operations Center (DOC/JEOC) for mosquito-borne viruses will also be notified. During an "Emergency Level," when epidemic conditions exist, local governments are notified, Incident Command Posts (ICP) may be formed by local governments, and this may be followed by formation of Operational Area EOCs by CalEMA in counties, REOC, and the SOC in coordination with the DOC/JEOC.

Roles and Responsibilities

Roles and responsibilities of key agencies involved in conducting mosquito-borne virus surveillance and response are outlined in "Key Agency Responsibilities" of the *Response Plan* and are included in the Emergency Response Matrix shown in Appendix 2. The matrix identifies emergency duties of each agency, and where they would fit in a SEMS emergency response organization.

Emergency response to mosquito-borne disease outbreaks includes the following SEMS response levels:

Local Government. This level includes cities, counties, and special districts. Local governments have legal and jurisdictional responsibility for specific areas or functions and are defined in the California Government Code Section 8680.2.

Operational Area (OA). When activated, the OA serves as a resource and information coordination point for all political subdivisions within the geographical boundaries of a county, and between the county jurisdictions and the CalEMA Region. County agricultural commissioners, public and environmental health, and vector control would be coordinated at this level. An OA is the conduit between local governments and the state for coordinating emergency information and situations. The local government would forward emergency information and requests for emergency needs to the OA that would try to fill the resource needs from within the OA. In the event resources have been exhausted, the OA would forward the request to the CalEMA REOC to fill the request with resources from within the region, with state agency resources, or with resources from other public or private entities. The OA EOC is considered the resource and information coordination point for all political subdivisions within the geographical boundaries of a county and between the county jurisdictions and the CalEMA Region.

Region. In SEMS regulations, this level is the CalEMA Regional Office or, when activated, the REOC. Regional coordination of information and resources within the CalEMA region would include state agencies (and local government) that have resources within the boundaries of the CalEMA regions and OAs. When the emergency planning level has been reached and before epidemic conditions exist, local governments will be notified and will establish EOCs followed by an ICP where necessary. Notification and requests for assistance will progress following SEMS from the local government to the OA to the REOC and then to the SOC. CDPH is the lead agency but will be working closely with CalEMA on public information and resource requests. Coordination of fire and law enforcement resources shall be accomplished through their respective mutual aid systems.

State. State agency assistance is coordinated through the CalEMA by the SOC. The SOC is activated any time a REOC is activated or emergency conditions warrant. CalEMA is authorized to task state agencies to provide state resources to mitigate the effects of emergencies or disasters. When state resources have been depleted and federal assistance is required, federal assistance provision is coordinated through the SOC. The SOC is the primary federal contact.

Federal. Federal agencies can be involved in a number of ways. Some Federal agencies will operate at the field level with local governments due to their specific legal and jurisdictional authority. Other Federal agency assistance will be obtained by the submission of a "Request for Federal Assistance" by the SOC. One agency at this level (not a SEMS response level) would include the Federal Emergency Management Agency (FEMA) Region IX in Oakland within the emergency management system and prevention. The Centers for Disease Control and Prevention (CDC) is another Federal agency that might provide assistance. The CDC falls under the Federal Emergency Response Plan's Emergency Support Function 8 - Health and Medical Services Annex.

Each organization will maintain a Situation Report as needed that will be forwarded to CalEMA and the Director of CDPH through the Response Information Management System (RIMS) or by facsimile if RIMS is unavailable.

Standardized Emergency Management System

The Standardized Emergency Management System (SEMS) was developed statewide for responding to and managing all types of emergencies, including public health, that involve a multi-agency and/or multi-jurisdictional response. SEMS is required to be used by all state agencies and any local agency seeking reimbursement for response related personnel costs under disaster assistance programs. This could include overtime costs associated with the emergency response to a declared emergency or when approved by the Governor (see **Recovery Process** section).

From the vector control field operations response level to the state level response, SEMS facilitates priority setting, interagency cooperation, and the efficient flow of resources and information. SEMS also includes mutual aid through the California Master Mutual Aid Agreement and associated discipline-specific mutual aid systems.

The use of the internet-based RIMS links the following to ensure a rapid flow of information and resource support:

- Local governments
- Operational Areas (OA)
- CalEMA Regional Emergency Operations Centers (REOCS)
- State Emergency Operation Center (SOC)
- State Agency Department Operations Centers (DOCs)
- FEMA Region IX
- Other federal agencies

SEMS Functions

The CDPH DOC Organization Chart is shown in Appendix 3. This chart represents a SEMS structure that addresses the five SEMS functions for CDPH to respond to a mosquito-borne disease emergency. Should there be a large number of human cases that impact the medical and health care delivery system requiring state level response, the JEOC would be activated as the CDPH DOC and in conjunction with the EMSA.

CDPH will support field operations and coordinate information from the OA to the State as briefly described below:

A. CDPH is identified as the lead State agency for coordinating mosquito-borne disease outbreak surveillance and response. In the event of a suspected or confirmed mosquito-borne disease outbreak, CDPH will work with CDC, local agencies, and other stakeholders to contain the disease. CDPH will coordinate with CalEMA throughout all of the alert levels.

B. CDPH will establish and work within a Technical Specialist Group to develop, evaluate, refine, and implement disease control policy. The Technical Specialist Group will be comprised of technical and advisory personnel from several programs within CDPH and within other agencies. This group will primarily function in the Planning/Intelligence Section of the CDPH DOC (or in the JEOC if the medical and healthcare system is impacted by the outbreak) (see Appendix 3). The State response will reflect national policy as well as state public and private interests, and will include a communications/public relations component.

C. CDPH, in coordination with CalEMA, will utilize the SEMS response structure to communicate strategic and tactical vector control decisions between the local identifying person(s), county and local government, the State of California, and the Federal Government.

D. CDPH, in coordination with CalEMA, will issue orders in accordance with CalEMA mission tasks in the incident action plan, and oversee the implementation and enforcement of such orders with the assistance of other local, state, and federal agencies. These orders may include expanded vector control operations, aerial insecticide operations for control of adult vectors, efforts to modify the environment to reduce vector mosquito populations, and public outreach and education.

E. CDPH will work with California Department of Food and Agriculture (CDFA) to determine the extent to which CDFA personnel will respond to an animal health emergency.

F. CDPH will determine the extent to which CDPH personnel will respond to a public health emergency. Duties in support of this emergency plan will take priority over all other duties of the Department.

Resource Request

Resource requests must involve close coordination between CDPH, its client base, and the statewide emergency management system. Under SEMS, when local resources are exhausted, additional resources will be mobilized through the OA and the CalEMA REOC. Local authorities maintain local control over mutual aid resources brought to address the disaster within their jurisdictional authority.

Field operations and coordination with local agencies and stakeholders will vary depending on the situation. The incident commander will be the person with legal and jurisdictional authority for the response actions. The incident will follow unified command principles with the appropriate local authority, directing response personnel and resources to carry out tactical decisions and activities within their jurisdiction. In some cases, CDPH may send staff to participate in the ICP or EOC of an OA as Technical Assistants or as part of a unified command. In the case of a local jurisdiction that requests CDPH to take over and manage the response, CDPH will establish an ICP with a CDPH staff person designated as the Incident Commander. In a multi-jurisdictional situation, CDPH may set up an ICP in physical proximity to the affected area (or a VBDS field office) to direct CDPH operational activities in coordination with the affected OAs (and REOC, JEOC, and SOC if activated).

Typical resources are identified in the notification system shown in Appendix 1, including local, county, regional, state, and federal agency resources.

Existing CDPH resources include contracts for emergency aerial insecticide applications. Local resources and capabilities must be exhausted prior to requests for additional state or federal resources.

Mutual Aid Requests under SEMS

The following is presented as an example of how the Mutual Aid request under SEMS works:

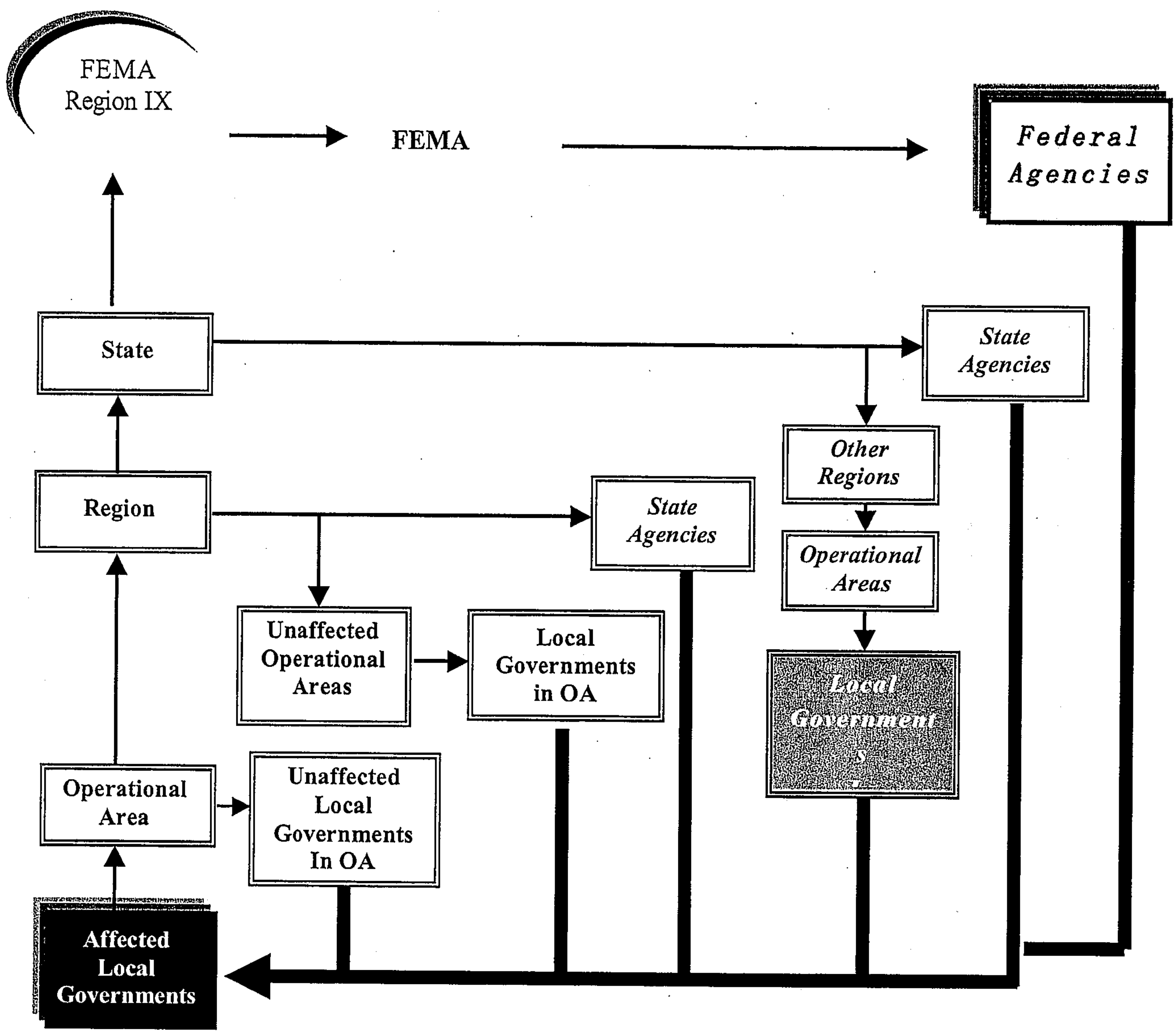
A vector control field operator requests additional resources through his district headquarters. The district headquarters cannot provide the resources or cannot purchase the resources in a timely manner, thus compromising the health and safety of the district's residents. If there are existing agreements with neighboring districts, the vector control district could request assistance through them.

Master Mutual Aid Agreement (MMAA)

If there are no identified agreements, the vector control district could go to their local emergency manager in the OA and request that resources be obtained from other vector control districts through the MMAA. Mutual aid provided under this agreement is available by public agencies without the expectation of reimbursement by the provider.

The local emergency manager in the OA would respond to the resource request. The request would be routed until filled following the illustration on the next page.

Mutual Aid System Concept:
General Flow of Requests and Resources



Resource Requests

OA - Operational Area

Notes: Local governments may request mutual aid directly from other local governments where local agreements exist. Discipline-specific mutual aid systems may have procedures

Request for Federal Resources

There are agreements, although limited in scope, between CDPH and the CDC for resource support. These contracts are currently in place for resources to provide mosquito-borne disease surveillance for WNV activity, including testing of sentinel chickens, mosquito pools, and dead birds. No additional funds from CDC for surveillance or control are anticipated.

The CalEMA is the channel for initiating requests for federal assistance (RFA) that are beyond any existing agreements or contracts and beyond the capabilities of the state. The process may require conditions such as local declarations, and there may be costs associated with the resources. This process is activated by CalEMA when the resources are not available except at the federal level.

Public Information / Risk Communication

Within CDPH, the Office of Public Affairs (OPA) has primary responsibility for dissemination of public health information relative to disease outbreaks. All state level press releases are channeled through OPA. CDPH informs local health departments (LHD) of important communicable disease information using the *CD Brief*. *CD Brief* is sent by fax and by e-mail to health officers, communicable disease controllers, laboratory directors, and to a limited number of private physicians on a weekly basis. The OPA will link with the CalEMA/JIC to ensure coordinated outreach and information dissemination. The California Alert Health Network (CAHAN) will be used to automatically notify local health officers, laboratories, and others in the operational Area, and in the region affected by the emergency by various means to include: e-mail, cell phone, pagers and faxes. CAHAN will be used to disseminate emergency notifications, health updates, advisories, routine information, and it has the capability to update, on a real time basis, planning or operational documents.

The best time to prepare the public for potential consequences is through risk communication prior to an incident.

- CDPH will process and recognize the information and communication linkage between levels of emergency management consistent with principles outlined in SEMS
- CDPH will provide timely and accurate information about mosquito-borne disease outbreaks in order to convey a realistic understanding of risks and measures the public can take to reduce risk
- The public can obtain current and timely information on mosquito-borne diseases by calling 1-877-WNV-BIRD, sending an e-mail to arbovirus@dhs.ca.gov, or by going to the website http://westnile.ca.gov.
- CDPH and local agencies will produce press releases and public information messages through various media, including radio and television, well in advance of an outbreak. These messages detail personal preventative measures that are focused on the current situation.
- CDPH and local agencies will coordinate with the CalEMA/JIC starting at the Alert Level, which can support the statewide distribution of public health notices.

Recovery Process

It is important that the recovery plans are initiated early in the response phase to ensure a smooth transition back to normal day-to-day operations. Emergency response and recovery activities are conducted at the request and under the direction of the affected local government. The recovery process requires documentation of all expenses, including application for disaster assistance through CalEMA and FEMA.

Most disaster assistance programs for this type of disaster would be oriented toward local governments. However, the state Department of Finance will require documentation of expenses for the state-agency emergency response to obtain any fund deficiency requests. Under a State of Emergency, local agencies may be reimbursed for up to 75% of eligible costs under the California Disaster Assistance Act. In a state-only disaster where a federal declaration has not been received, state agencies receive no reimbursement.

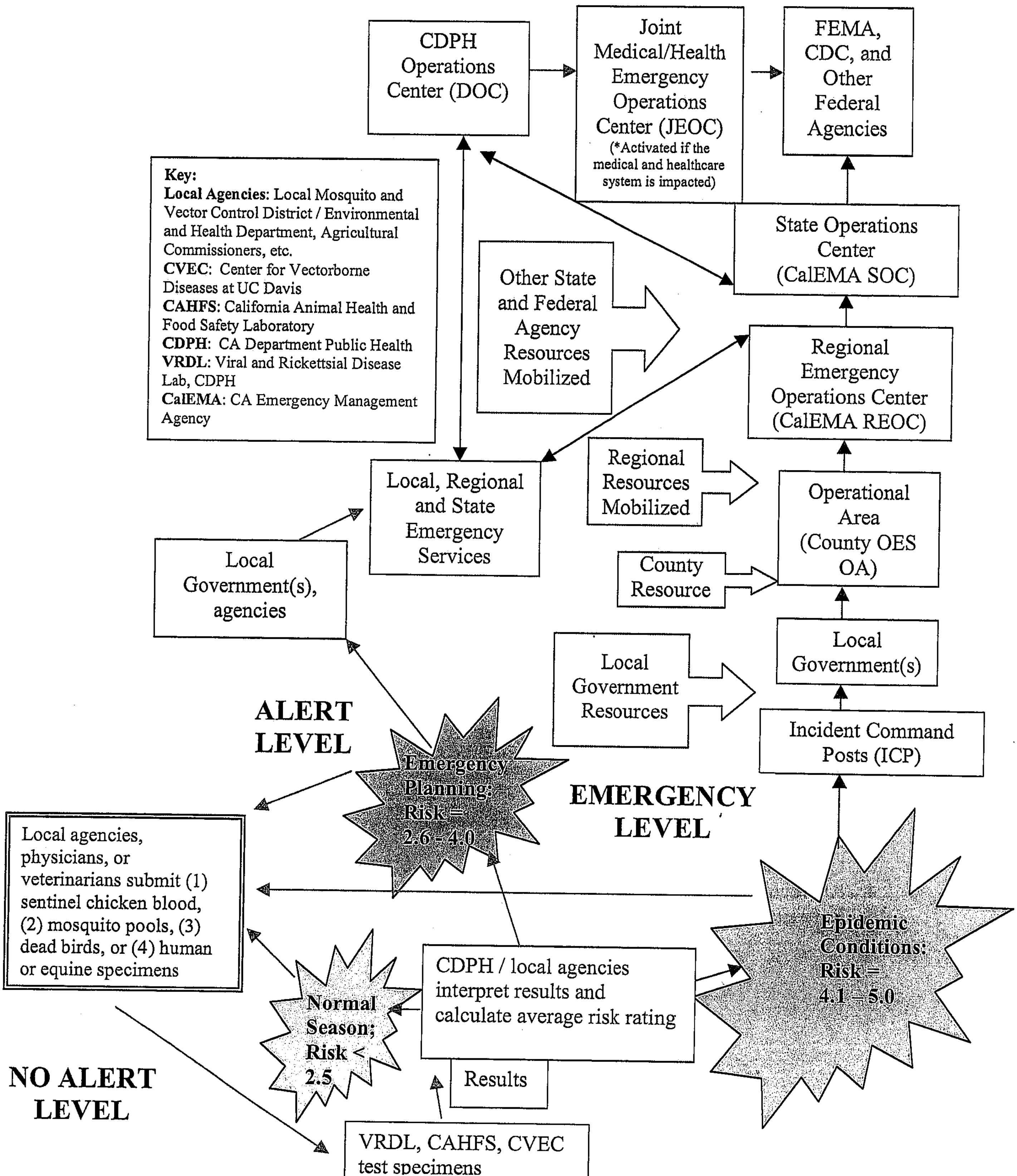
Under a Presidential Proclamation, local government may receive 75% federal reimbursement. The state can reimburse local government 75% of the remaining 25% non-federal share, which equates to 18.75% share for the state and 6.25% for local government. State agencies are only eligible for the 75% federal reimbursement.

Reimbursement of eligible expenses will be in accordance with governing state and/or federal laws and regulations. Reimbursement is contingent upon accurate and thorough record keeping. All participating local government and state agencies will be responsible for maintaining a log of time, events, and expenses in accordance with procedures established by their own agency. This log and record of expenses will be required by CalEMA if state and/or FEMA funding is made available.

Appendices

1. Emergency Event Notification System Flowchart
2. Roles and Responsibilities of Public Agencies
3. CDPH Operations Center/Joint Emergency Operations Center Organizational Chart
4. Abbreviations
5. References

Appendix 1. Emergency Event Notification System Flowchart



Appendix 2
Mosquito-Borne Disease Emergency
Roles and Responsibilities of Public Agencies

Jurisdictional Level	Department/Agency Role
Local Government	Mosquito and Vector Control Agencies • Gather, collate, and interpret regional climate and weather data • Monitor abundance of immature and adult mosquitoes • Collect and submit mosquito pools to CVEC for virus detection • Maintain sentinel chicken flocks, obtain blood samples and send samples to VBDS • Pickup and ship dead birds for necropsy and WNV testing, or test oral swabs from American crows locally via rapid antigen screening assays • Update CDPH weekly of all birds that are independently reported and/or tested by VecTest, RAMP or immunohistochemistry (email: arvobirus@dhs.ca.gov) • Conduct routine control of immature mosquitoes • Conduct control of adult mosquitoes when needed • Educate public on mosquito avoidance and reduction of mosquito breeding sites • Coordinate with local Office of Emergency Services personnel • Communicate regularly with neighboring agencies
	Local Health Departments • Test human specimens for WNV • Refer human specimens to CDPH for further testing • Conduct epidemiological investigations of human cases • Notify local medical community, including hospitals and laboratories if evidence of viral activity present • Collect dead birds and ship carcasses to testing laboratories when needed • Test American crows via rapid assay or RT-PCR as resources allow • Participate in emergency response • Conduct epidemiological investigations of cases of human disease • Report WNV cases to CDPH • Conduct public education

Local Government (Continued)	Environmental Health Departments • Refer to bullets under mosquito and vector control if the Environmental Health Department has a vector control program
	Animal Control Agencies • Monitor and report suspect veterinary cases • Assist in collection of dead bird specimens • Assist in public education
	Local Offices of Emergency Services • Assist in logistical support and public information release • Process disaster declarations as necessary and participate in the local response plan to mobilize local resources • Coordinate with the OA, county, and local government to provide assistance as needed
	County Agriculture Commissioners (CAC) • Provide consultation regarding pesticide use • Single representative from the affected counties participate in the Technical Specialist Group • Coordinate with CDPH and make personnel and facilities available to assist with mosquito control within county • Assist local office of emergency services with disaster declarations and other administrative tasks; participate in the local response plan to mobilize local resources • Coordinate with CDPH and CDFA as a participating local response agency. Assistance may include: activating local emergency response, managing affected animals, humanely destroying animals, and assisting with carcass disposal • Assist in providing information to the media; conduct early outreach to impacted industry and the county general public; communicate with neighboring CAC

State Government	Department of Public Health (Director) • In coordination with the Emergency Preparedness Office, activate the CDPH emergency system as appropriate • Ensure close coordination and communication of CDPH activities with the Health and Human Services Agency, CalEMA, and the Governor to ensure appropriate utilization of public health, medical, security, transportation, and communication resources • Provide policy direction to the emergency response organization • Ensure that all necessary CDPH resources are directed to respond to the emergency • Ensure that continuity of CDPH management and operations is maintained through a clear command authority and identification of staff to assume higher-level responsibilities in the event of the absence or incapacity of key CDPH leadership
	Department of Public Health (Executive Staff) • Staff the Disaster Policy Council at the request of the Director to ensure consensus on policy decisions and carry out these decisions within assigned programs • Provide staff for the Joint Medical/Emergency Operations Center (JEOC) if activated in the event of medical and healthcare system impacts from large numbers of human disease cases • Respond to CDPH, state, or local agency mutual aid needs upon request

State Government (Continued)	Department of Public Health (Chief, Division of Communicable Disease Control)
	• Implement and staff a Department Operations Center (DOC) or Joint Emergency Operations Center (JEOC) if necessary to accomplish all program responsibilities defined in the concept of operations • Ensure that all primary SEMS functions (management, operations, planning, logistics, and finance) are addressed within the DOC and JEOC • Manage the DOC or JEOC to ensure the development of an Incident Action Plan and implementation of the action plan by the Department and various DCDC programs • Provide a DCDC liaison to ensure coordination of Department activities with the DOC or JEOC in Sacramento • Serve as the primary "field" operations location to coordinate State-level disease surveillance, prevention, and control activities to support local government and to fulfill CDPH statutory responsibilities • Ensure close coordination and communication with the JEOC as required for resource assistance and to maintain information flow to the CDPH Director and Executive Staff, EMSA, CalEMA, and other agencies as appropriate
	Department of Public Health (DOC or JEOC) • Coordinate State-level medical and health information and resources by: o Developing Department action plans o Acquiring public health and medical personnel upon request of an affected region o Coordinating resource acquisition and support for CDPH field emergency response activities o Ensuring coordination with the CalEMA SOC or REOC as appropriate o Ensuring information flow to CDPH and EMSA management and executive staff, CalEMA, and other agencies Ensuring coordination and information flow with health management organizations and other providers of medical care, facilities, and supplies

State Government (Continued)	Department of Public Health (Infectious Diseases Branch)
	• Assist with coordination of epidemiological investigations human cases with local health departments as needed • Conduct active surveillance for human WNV cases • Maintain statewide database of human cases • Evaluate human case data • Develop disease control strategies • Provide information and consultation to the public health and medical community • Provide technical assistance for press releases and other guidance related to personal protective measures • Provide media interviews as needed in coordination with OPA
	Department of Public Health (Vector-Borne Disease Section) • Collate adult mosquito abundance data submitted by local agencies; provide summary of data to local agencies • Maintain a WNV information and eead bird reporting hotline (877-WNV-BIRD) and a WNV website: www.westnile.ca.gov • Coordinate submission of specimens for virus testing • Provide supplies for processing mosquito pool and sentinel chicken diagnostic specimens • Test sentinel chicken sera for viral antibodies • Test human specimens for virus • Distribute a weekly bulletin summarizing surveillance test results • Send weekly surveillance results to the UCD interactive website • Provide statewide daily DYCAST human risk maps available through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/) • Provide analysis of DYCAST risk data and notify local agencies when appropriate • Immediately notify local vector control agency and public health officials when evidence of viral activity is found • Conduct epidemiological investigations of cases of human disease • Coordinate and participate in a regional emergency response in conjunction with California Emergency Management Agency • Conduct active surveillance for human cases • Provide oversight to local jurisdictions without defined vector-borne disease programs • Maintain inventory of antigens and antisera to detect exotic viruses

State Government (Continued)	• Provide confirmation of tests done by local agencies
	Department of Public Health (Veterinary Public Health Section) • Coordinate with CDFA for the surveillance and epidemiological investigation of equine and veterinary cases • Coordinate preventive measures to protect zoological collections • Coordinate with CDFA to provide outreach to the veterinary community and other animal health professionals on the surveillance and reporting of suspect veterinary cases
	Department of Public Health (Viral and Rickettsial Diseases Lab) • Coordinate active human case surveillance for WNV including encephalitis, aseptic meningitis, and Acute Flaccid Paralysis cases • Develop and coordinate WNV screening program in public health laboratories within the State to screen high volumes of suspect WNV cases • Perform screening and confirmatory testing for possible WNV cases • Perform comprehensive testing (besides WNV) for encephalitis cases including other arboviruses, herpesviruses, enteroviruses, rabies, and other causes of encephalitidies • Maintain and transmit surveillance data on all WNV surveillance components to CDC • Provide confirmatory testing for commercial laboratories for WNV • Provide information and consultation to local public health departments including local health officers, communicable disease officers and public health laboratorians • Provide media interviews as needed in coordination with CDPH OPA
	California Environmental Protection Agency (Department of Pesticide Regulation) • Coordinate with local jurisdictions to identify and secure the issuance of any necessary permits and/or record any decisions of exemptions from permitting requirements • Assist in securing exemptions from U.S. Environmental Protection Agency for emergency use of insecticides

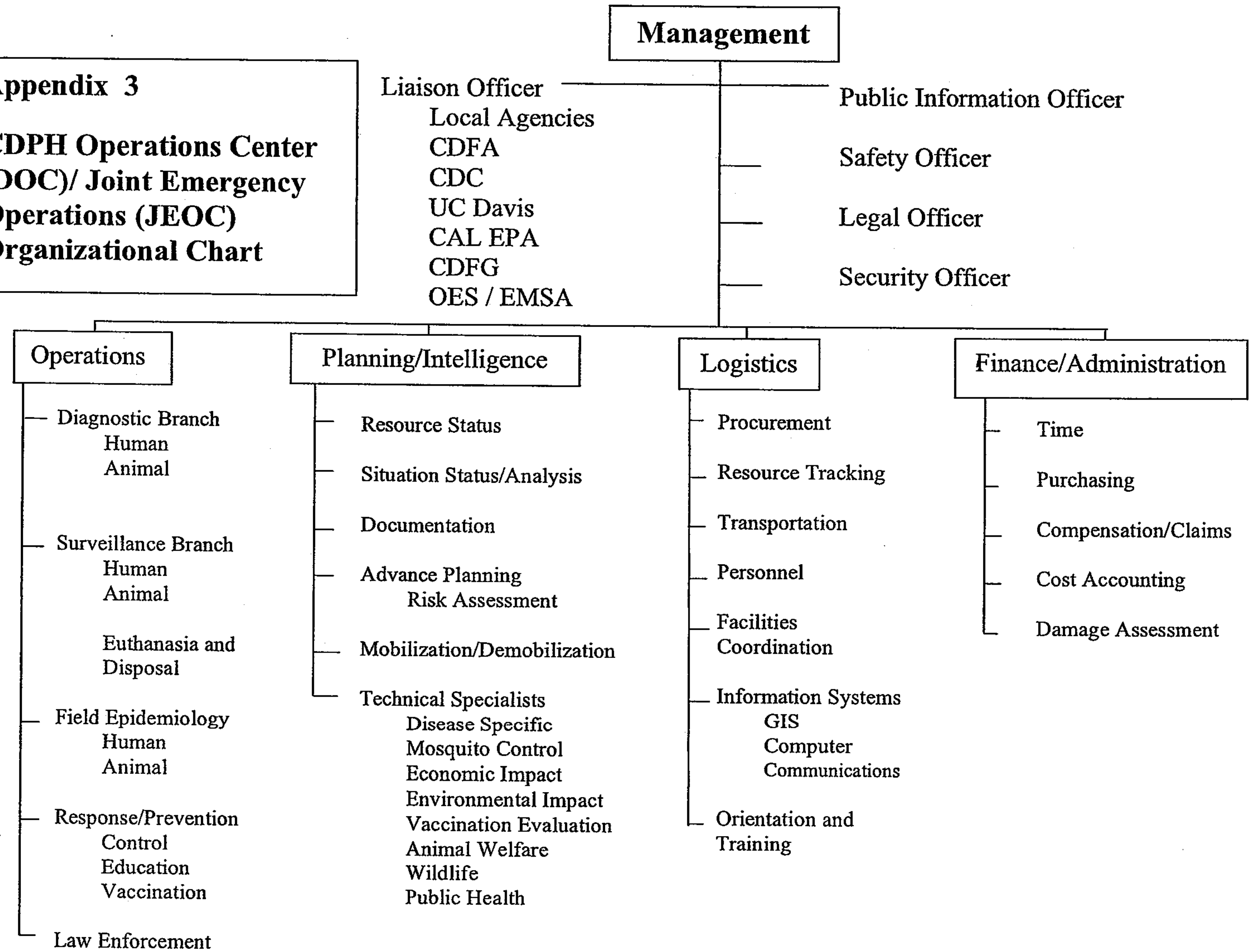
State Government (Continued)	Emergency Medical Services Authority (EMSA)
	• Ensure communication with and education of the local EMSA and emergency departments regarding the disease outbreak and the importance of reporting cases immediately to local public health • Provide staff for the CDPH DOC as requested if the JEOC is not activated EMSA would be activated to respond to the emergency in the event that there are a large number of human outbreak cases that impact the medical and healthcare (hospital, clinics, EMS providers) and would respond when the JEOC is activated • If the JEOC is activated, EMSA will: 1. Staff the JEOC and operate in assigned positions 2. Provide EMS and medical resources as requested by the OAs 3. Alert emergency responders to work with their OAs and REOCs to inventory critical supplies and solve problems 4. Conduct inventory of critical equipment, supplies and personnel, including statewide availability of hospital beds
	California Department of Fish and Game (CDFG) • Coordinate with CDPH/CDFA/U.S. Department of Agriculture and local government and participate as a responding agency if the mosquito-borne virus impacts wildlife, or if tasked by CalEMA • Provide advice on risks to wildlife and methods to respond to and mitigate these risks • If the mosquito-borne virus has a history of affecting wild animals, initiate a surveillance program in the immediate vicinity of the outbreak and determine if the disease has spread to wildlife. Initiate steps to prevent the spread of the disease to susceptible wildlife. • Act as a liaison with the U.S. Fish and Wildlife Service • CDFG Office of Spill Prevention and Response can assist by providing veterinarians and response personnel, and by conducting natural resource damage assessment when requested by CalEMA • Monitor wildlife health relative to mosquito-borne disease • Assist in maintaining dead bird collection permits for disease monitoring • Assist in maintaining wild bird collection permits for disease monitoring

State Government (Continued)	California Department of Food and Agriculture (CDFA) ◦ Notify veterinarians and veterinary diagnostic laboratories about WEE and WNV and testing facilities available at UCD Center for Vectorborne Disease Research • Provide outreach to the general public and livestock and poultry producers on the monitoring and reporting of equine and ratite encephalitides • Facilitate equine and ratite sample submission from the field • Conduct epidemiological investigation of equine cases
	Mosquito and Vector Control Association of California (MVCAC) • Coordinate purchase of sentinel chickens • Receive, track, and disperse payment for surveillance expenses • Coordinate surveillance and response activities among member agencies • Serve as spokesperson for member agencies • Establish liaisons with press and government officials
	California Department of Mental Health (CADMH) • Assess, at the request of CalEMA, mental health needs resulting from a serious mosquito-borne disease outbreak, and through input and decision-making at the local level, activate appropriate interventions to assist persons affected by the outbreak
	California Division of Occupational Safety and Health (CalOSHA) • Provide, as requested by CalEMA, comprehensive on-site safety and health guidance for all personnel • Provide, as requested by CalEMA, guidance for personnel using insecticides that require the wearing of protective clothing and respiratory devices • Provide, as requested by CalEMA, monitoring of on-site personnel to measure exposure levels to insecticides to ensure worker safety is maintained

State Government (Continued)	California Animal Health and Food Safety Laboratory (CAHFS) • Identify and screen dead birds for WNV testing • Conduct necropsies and testing on dead birds • Submit bird tissues to CVEC for testing • Test equine specimens for WNV
	University of California at Davis • Conduct research on arbovirus surveillance, transmission of mosquito-borne diseases, and mosquito ecology and control. • Test mosquito pools and dead birds for endemic and introduced viruses • Provide a proficiency panel of tests for identification of viruses from human, equine, bird, or arthropod vectors to local agencies to ensure quality control • Maintain an interactive website (**http://gateway.calsurv.org**) for dissemination of mosquito-borne virus information and data. • Maintain inventory of antigens, antisera, and viruses to detect the introduction of exotic viruses. • Provide confirmation of tests done by local or state agencies
	California Emergency Management Agency (CalEMA) • Coordinate the local, regional, or statewide emergency response under epidemic conditions in conjunction with CDPH via the Standardized Emergency Management System (SEMS) • Serve as liaison with the Federal Emergency Management Agency (FEMA) in the event a federal disaster has been declared
Federal Government	Centers for Disease Control and Prevention (CDC) • Provide consultation to state and local agencies in California if epidemic conditions exist • Provide national surveillance data to state health departments
	Federal Emergency Management Agency (FEMA) – Region IX in Oakland • Coordinate with CDC emergency operations (ESF 8)

Appendix 3

CDPH Operations Center (DOC)/ Joint Emergency Operations (JEOC) Organizational Chart



Appendix 4: Abbreviations

CAG	Attorney General
CADMH	California Department of Mental Health
CAHFS	California Animal Health and Food Safety Laboratory
CalEMA	California Emergency Management Agency
Cal/EPA	California Environmental Protection Agency
CalOSHA	California Division of Occupational Safety and Health Administration
CCR	California Code of Regulations
CDC	Centers for Disease Control and Prevention, US Department of Health and Human Services
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CHP	California Highway Patrol
CNG	California National Guard
DCDC	Division of Communicable Disease Control
CDPH	Department of Public Health (California)
DOC	CDPH Operations Center
EMSA	Emergency Medical Services Authority, Health and Human Services Agency
FEMA	Federal Emergency Management Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GC	Government Code
H&S	Health and Safety Code
ICP	Incident Command Post
IDB	Infectious Diseases Branch
JEOC	Joint Emergency Operations Center, CDPH and EMSA
JIC	Joint Information Center
LHDs	Local health departments
MIR/1000	Minimum Infection Rate = number of infected mosquitoes/1000 tested
MMAA	Master Mutual Aid Agreement
MVCAC	Mosquito and Vector Control Association of California
OA	Operational Area
OES	Office of Emergency Services
OPA	Office of Public Affairs
REOC	Regional Emergency Operations Center
RIMS	Response Information Management System
SEMS	Standardized Emergency Management System
SLE	St. Louis encephalitis virus
SOC	State Operations Center
UC	University of California
VBDS	Vector-Borne Disease Section
VPHS	Veterinary Public Health Section
WEE	Western equine encephalomyelitis virus
WNV	West Nile virus

Appendix 5: References

Administrative Order (12/10/02)

California Code of Regulations

California Education Code

California Emergency Services Act

California Food and Agriculture Code

California Government Code

California Health and Safety Code

CDPH *California Mosquito-Borne Virus Surveillance & Response Plan* http://www.westnile.ca.gov

Department of Public Health Emergency Operations Plan

Department of Public Health, *Emergency Response Plan and Procedures*, January 1994

Emergency Medical Services Authority, *Disaster Medical Response Plan*, July 1992

Executive Order No. W-9-91

Federal Emergency Management Agency, *Federal Response Pla*n, April 1999

Federal Insecticide, Fungicide, and Rodenticide Act

Memorandum of Understanding, Department of Public Health and Emergency Medical Services Authority, July 1988

Memorandum of Understanding between CDPH, Department of Pesticide Regulation, and County Agricultural Commissioners

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