Suffolk County Vector Control & Wetlands Management Long Term Plan & Environmental Impact Statement

Task 3 Literature Review
Book 5 Part 1: Mosquitoes Control Agents

Prepared for:

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SUFFOLK COUNTY VECTOR CONTROL AND WETLANDS MANAGEMENT LONG - TERM PLAN AND ENVIRONMENTAL IMPACT STATEMENT

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Executive Summary

This section of the Suffolk County Vector Control and Wetlands Management Long-Term Plan and Generic Environmental Impact Statement addresses the literature review on mosquito control agents. Despite great strides over the last 50 years, mosquito-borne illnesses continue to pose significant risks to parts of the population in the United States. An extensive survey of Mosquito Control agencies outside Suffolk County was conducted to develop an inclusive list of agents and chemicals used to control mosquito populations.

Humans have a history of controlling mosquitoes, and other creatures considered "pests" with substances known as pesticides. Pesticides are agents of biological or chemical origin that control the target organism by killing it or preventing it from engaging in behaviors deemed to be destructive. An emergence in pesticide use began after World War II with the introduction of synthetic organic compounds, the most important of which was DDT. These new chemicals were inexpensive, effective, and enormously popular. During the last 50 years chemical synthesis of pesticides has increased considerably. There are now more than 55 classes and 1,500 individual substances produced in more than 100,000 formulations of pesticides.

Pesticides utilized for mosquito control, historically and presently, are divided into the following classes: *Organochlorines* (e.g.-DDT), *Organophosphates* (e.g.-Malathion), *Pyrethroids* (e.g.-Resmethrin, Sumithrin), *Insect Growth Regulators* (e.g.-Methoprene), *Microbials* (e.g.- Bacillus thuringiensis israelensis [*Bti*]), and *Synergists* (e.g.-Piperonyly Butoxide).

1. Mosquito Control Agents Utilized Outside of Suffolk County

An extensive survey of Mosquito Control agencies outside Suffolk County was conducted to develop an inclusive list of agents and chemicals used to control mosquito populations. Particular effort was placed on regional mosquito control programs. However, other areas of the country were included to examine the spectrum of mosquito control agents utilized under a variety of environmental conditions.

Research methods included e-mail contact with individual Mosquito Control agencies, Internet website investigations, and phone interviews. Initially, e-mail requests were sent to various state and local jurisdictions. Those were followed by website information documentation, and phone calls to clarify specific details. The survey yielded fourteen mosquito control agents that are in common use by the various reporting agencies (Table 2-1).

A complete list of the agencies contacted for information is presented in Table 2-2 on the next page. The results of the survey are presented on the following pages in three (3) tables: Adulticides (Table 2-3), Larvicides (Table 2-4), and Other Control Agents (Table 2-5).

Table 2-1 - Mosquito Control Agents in Common Use

ACTIVE INGREDIENT	PRODUCT TRADE NAME	CLASS	FORMULATIONS
Bacteriological Control			
Bti (*Bacillus thuringiensis israelensis*)	Aquabac / Bactimos / Vectobac / Teknar	Larvicide	Liquid / granules / briquets
Bs (*Bacillus sphaericus*)	Vectolex	Larvicide	Liquid / granules
Insect Growth Regulators			
Methoprene	Altosid	Larvicide	Liquids / granules / briquets
Surface Films			
Petroleum Derivatives	Golden Bear Oil (GB-1111) / Bonide / BVA Oil 13	Larvicide / Pupicide	Liquid
Ethoxylated Alcohol	Agnique MMF	Larvicide / Pupicide	Liquid
Chemical Control			
Temephos	Abate	Larvicide	Liquids / granules / briquets
Malathion	Fyfanon / Atrapa / Microflo	Adulticide	ULV aerosol / thermal fog
Resmethrin	Scourge	Adulticide	ULV aerosol
Sumithrin	Anvil	Adulticide	ULV aerosol
Permethrin	Permanone / Aqua Reslin	Adulticide	ULV aerosol / barrier treatment
Natural Pyrethrum	Pyrocide / Pyrenone	Adulticide / limited larvicide use	ULV aerosol
Fenthion	Baytex / Entex / Tiguvon	Adulticide	ULV aerosol / thermal fog
Naled	Dibrom / Trumpet	Adulticide	ULV aerosol
Chlorpyrifos	Dursban / Lorsban	Adulticide / limited larvicide use	ULV aerosol

Agencies Contacted to Compile Pesticide List:
California - Contra Costa; Coachella Valley; Marin & Sonoma; Los Angeles West; San Gabriel Valley; Shasta; Sutter-Yuba
Connecticut – Dept. of Environmental Protection
Delaware – Dept. of Natural Resources
Florida - East Flagler; Florida Keys; Leon; Manatee; Miami-Dade
Maryland – Dept. of Agriculture
Massachusetts - Bristol; Cape Cod; Central; East Middlesex; Northeast; Norfork; Plymouth; Sussex
Michigan - Saginaw; Tuscola
Minnesota - Metropolitan (Minneapolis, St. Paul)
New Jersey – Dept. of Environmental Protection; Atlantic; Bergen; Camden; Hunterdon; Mercer; Middlesex; Monmouth; Morris; Passaic; Union; Warren
New York - New York City; Nassau
Pennsylvania – Dept. of Environmental Protection

Table 2-2 - Mosquito Control Agencies Contacted

STATE	AGENCIES CONTACTED	
California	• Alameda County Mosquito Abatement District • Coachella Valley Mosquito and Vector Control District • Contra Costa Mosquito and Vector Control District • Greater Los Angeles County Vector Control District • Los Angeles County West Vector Control District • Marin/Sonoma Mosquito Vector Control District • Sacramento-Yolo Mosquito and Vector Control District	• San Gabriel Valley Mosquito and Vector Control District • San Mateo County Mosquito Abatement District • Santa Barbara Coastal Vector Control District • Santa Clara Vector Control District • Shasta Mosquito and Vector Control District • Sutter-Yuba Mosquito and Vector Control District
Connecticut	• State Department of Environmental Protection	
Delaware	• State Department of Natural Resources	
Florida	• Amelia Island Mosquito Control District • Beach Mosquito Control District • Broward County Mosquito Control Section • East Flagler Mosquito Control District • Florida Keys Mosquito Control District	• Lee County Mosquito Control District • Leon County Mosquito Control • Levy County Mosquito Control • Manatee County Mosquito Control District • Miami-Dade Mosquito Control
Maryland	• State Department of Agriculture	
Massachusetts	• Berkshire County Mosquito Control Project • Bristol County Mosquito Control Project • Cape Cod Mosquito Control Project • Central Massachusetts Mosquito Control Project • East Middlesex Mosquito Control Project	• Norfolk County Mosquito Control Project • Northeast Mosquito and Wetlands Management District • Plymouth County Mosquito Control Project • Sussex County Division of Mosquito Control
Michigan	• Saginaw County Mosquito Abatement Commission	• Tuscola County Mosquito Abatement
Minnesota	• Metropolitan Mosquito Control District	
New Jersey	• State Department of Environmental Protection • Atlantic County Office of Mosquito Control • Bergen County Division of Mosquito Control • Burlington County Mosquito Control • Camden County Mosquito Extermination Commission • Cape May County Mosquito Extermination Commission • Cumberland County Mosquito Control Division • Essex County Mosquito Control • Gloucester County Division of Mosquito Control • Hudson County Mosquito Control • Hunterdon County Mosquito Control	• Mercer County Division of Mosquito Control • Middlesex County Mosquito Extermination Commission • Monmouth County Mosquito Extermination Commission • Morris County Mosquito Extermination Commission • Ocean County Mosquito Extermination Commission • Passaic County Division of Mosquito Extermination • Salem County Mosquito Extermination Commission • Somerset County Mosquito Extermination Commission • Sussex County Division of Mosquito Control • Union County Mosquito Extermination Commission • Warren County Mosquito Extermination Commission
New York	• Nassau County Department of Public Works	• New York City Department of Health
Pennsylvania	• State Department of Environmental Protection	

Table 2-3 - Mosquito Control Substances - Adulticides

Category	Malathion	Resmethrin	Sumithrin	Permethrin	Naled	Pyrethrum	Deltamethrin
NYS Registration? (Y/N)	Y	Y	Y	Y	Y	Y	Y
Class of Control: adulticide (A), barrier (B)	A	A	A	A/B	A	A	B
EPA Biopesticide? (Y/N) Chem. Class: Organo-Phosphate (OP), Pyrethroid (P)	N/OP	N/P	N/P	N/P	N/OP	Y	N/P
SCVC past use? (Y/N)	Y	Y	Y	Y	Y	N	Y
SCVC current use? (Y/N)	Y	Y	Y	N	N	N	Y
Use in NE US? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/W	Y/W	Y/W	Y/W	Y/R	Y/R	S
Use on East Coast? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/W	Y/W	Y/W	Y/W	Y/W	Y/R	S
Use elsewhere US? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/S	Y/W	Y/W	Y/W	Y/W	Y/R	S
Persistence (short, medium, long)	Medium	Short	Short	Medium	Short	Short	Long
EPA Toxicity Class[1]	III	III	III	II/III	I	III	III
Label restrictions	Restricted near water, bees	No water setback, .007lb. AI/ acre	No significant restrictions, .0035lb. AI/acre	100 ft. water setback, bee restriction	Bee restrictions	Restrictions near water	Restrictions near water
Generalized/Specialized Use	Hand ULV, aerial ULV, thermal fog	Truck ULV, aerial ULV	Hand ULV, truck ULV, aerial ULV	Hand ULV, truck ULV, aerial ULV, barrier spray	Ground ULV, aerial ULV	Ground ULV, aerial ULV	Barrier spray
Advantages	Less weather dependent	Nearly non-toxic to birds, rapid knockdown	Nearly non-toxic to birds	Nearly non-toxic to birds	Effective in wide range of conditions	Exempt from crop tolerances	
Disadvantages	slow degradation		slower breakdown than Resmethrin	slower degradation than other ULV Pyrethroids	toxic to birds, fish, bees, corrosive		Highly toxic to fish, aquatic invertebrates, bees

1. The EPA classifies pesticides by four classes of toxicity, with Class I being the most toxic and Class IV being the least toxic.

Table 2-4 - Mosquito Control Substances - Larvicides

Category	Bacillus thuringiensis israelensis	Bacillus spaericus	Methoprene	Ethoxylated Fatty Acids	Golden Bear Oil	Temephos
NYS Registration? (Y/N)	Y	Y	Y	Y	Y	Y
Class of Control: larvicide (L), pupacide (P)	L	L	L	L/P	L/P	L
EPA Biopesticide? (Y/N) Chem. Class: Organo-Phosphate (OP), Pyrethroid (P)	Y	Y	Y	N	N	N/OP
SCVC past use? (Y/N)	Y	Y	Y	N	N	Y
SCVC current use? (Y/N)	Y	Y	Y	N	N	N
Use in NE US? (Y/N), Widespread (W), Scattered (S), Rare (R)	Y/W	Y/W	Y/W	Y/S	Y/S	Y/S
Use on East Coast? (Y/N), Widespread (W), Scattered (S), Rare (R)	Y/W	Y/W	Y/W	Y/S	Y/S	Y/W
Use elsewhere in US? (Y/N), Widespread (W), Scattered (S), Rare (R)	Y/W	Y/W	Y/W	Y/S	Y/S	Y/W
Persistence (short, medium, long)	Short	Medium	Short	Medium	Medium	Medium
EPA Toxicity Class[1]	IV	IV	IV	III	III	III
Label restrictions	--	--	Fish habitats for some formulations in New York	--	--	--
Generalized/Specialized Use	Salt marsh, Freshwater, Flood areas	Ditches, catch basins	Salt marsh, drainage areas, catch basins	Variety of habitats, best in containers, artificial breeding sites	Variety of habitats, best in containers, artificial breeding sites	Variety of habitats, stored tires
Advantages	Immediate control, non-toxic to other species, resistance highly unlikely	Best in permanent water	Larvae remain as food source, highly effective in salt marsh			
Disadvantages		residual action		Potential adverse impact to non-targets that use surface film	Potential adverse impact to non-targets that use surface film	Toxic to fish, birds, bees

1. The EPA classifies pesticides by four classes of toxicity, with Class I being the most toxic and Class IV being the least toxic.

Table 2-5 - Mosquito Control Substances – Other Substances

Category	Garlic Oil	Malaoxon	Isomalathion	Piperonyl butoxide
NYS Registration? (Y/N)	N	Not Applicable	Not Applicable	Y
Class of Control: barrier (B), synergist (S), degradate (D)	B	D	D	S
EPA Biopesticide? (Y/N)	Y	N	N	N
SCVC past use? (Y/N)	Y			Y
SCVC current use? (Y/N)	Y			Y
Use in NE US? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/S			Y/W
Use on East Coast? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/S			Y/W
Use elsewhere US? (Y/N) Widespread (W), Scattered (S), Rare (R)	Y/S			Y/W
Persistence (short, medium, long)	Long			
EPA Toxicity Class	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Label restrictions				
Generalized/Specialized Use	Outdoor area repellant			
Advantages	EPA exempt, non-toxic			
Disadvantages				

2. Mosquito Control Agent Priority List

Mosquito Control Agents are further categorized in this document into Primary and Secondary areas of investigation with appropriate investigative levels assigned to each. A complete and extensive literature review will follow on Primary agents. Secondary agents will receive a substantial, but less in-depth review. The results of the categorization effort are presented in Table 2-6 and Table 2-7. The discussion following the tables summarizes how each of the agents was categorized.

Table 2-6 - Primary Mosquito Control Agents

AGENT	CLASS	TRADE NAME
Bti (*Bacillus thuringiensis israelensis*)	Larvicide	Vectobac, Teknar
Bs (*Bacillus sphaericus*)	Larvicide	Vectolex
Methoprene	Larvicide	Altosid
Garlic Oil	Repellant	Garlic Barrier
Malathion	Adulticide	Fyfanon, Atrapa
Resmethrin	Adulticide	Scourge
Sumithrin	Adulticide	Anvil
Permethrin	Adulticide	Permanone
Malaoxon	Degradate	
Isomalathion	Degradate	
Piperonyl butoxide	Synergist	

Table 2-7 - Secondary Mosquito Control Agents

AGENT	CLASS	TRADE NAME
Ethoxylated Fatty Alcohols	Larvicide/Pupicide	Agnique
Temephos	Larvicide	Abate
Naled	Adulticide	Dibrom, Trumpet
Pyrethrum	Adulticide	Pyrocide, Pyrenone
Deltamethrin	Adulticide	Decis
Golden Bear Oil	Larvicide/Pupicide	GB-1111
DEET	Repellant	
Fenthion	Adulticide	Baytex, Entex
Chloripyrifos	Adulticide	Dursban, Lorsban
Octanol	Used in Traps	
Propane	Used in Traps	

2.2.1. Bacteriological Control (Biopesticides)

Bti and Bs are microbial larvicides, and both are naturally occurring bacterium. When ingested by the mosquito larvae, they disrupt the natural digestion process, causing the larvae to die. They are believed to pose a minimal risk to non-target species, are widely used throughout the country, and will be given Primary consideration.

2.2.2. Insect Growth Regulators

Methoprene is a slightly to practically nontoxic compound in EPA Toxicity Class IV. It mimics the action of a mosquito growth-regulating hormone and prevents the larvae from maturing into adults. There are no significant label restrictions on its use. Methoprene has low toxicity to birds and fish, is widely used for mosquito control, and will be given Primary consideration.

2.2.3. Surface Films

Petroleum derivatives (*e.g.* Golden Bear Oil) spread a thin film on the surface of the water, which prevents the transfer of oxygen causing the mosquito larvae/pupae to drown. Ethoxylated Alcohols (Agnique) spread a thin surface film, which makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, also causing them to drown. The window of opportunity for use of these agents is limited within the mosquito life cycle. These agents also prevent the natural transfer of oxygen into the water body. There are also potential impacts to non-target species that rest on the water surface, such as dragonflies and water skimmers. Although they are used by some agencies around the country, their potential is for limited use, where non-target impacts are not of concern. They will therefore be given Secondary consideration.

2.2.4. Chemical Control

Other than Temephos, which is a larvicide, all of the agents listed are adulticides, which kill adult mosquitoes by bringing them in direct contact with a toxic chemical. Temephos is an organophosphate pesticide, and it is the only organophosphate with larvicidal use. Although it presents relatively low risk to birds and terrestrial species, available information suggests that it is more toxic to aquatic invertebrates than alternative larvicides. EPA is limiting its use to areas

where less hazardous alternatives would not be effective. Many current users are limiting its application to pooled water in stored tires. It will be given Secondary consideration.

Resmethrin and Sumithrin are synthetic chemical pesticides that act in a similar manner to pyrethrins, which are derived from chrysanthemum flowers. They are relatively low in toxicity, EPA Toxicity Class III, and do not have significant label restrictions. They are applied as an ultra low volume (ULV) aerosol, which kills adult mosquitoes on contact. Resmethrin and Sumithrin are currently part of the Suffolk County program and will, therefore, be given Primary consideration. Permethrin, as a similar pyrethroid compound being used elsewhere in the country, will also be given Primary consideration. Pyrethroids used in mosquito control are typically mixed with a synergist compound, such as Piperonyl Butoxide, which enhances the effectiveness of the active ingredient. Piperonyl Butoxide will be given Primary consideration.

Malathion is an organophosphate pesticide that is applied as a ULV aerosol, which kills adult mosquitoes on contact. As a component of Suffolk County's current program, it will be given Primary consideration. Malaoxon and Isomalathion, breakdown products of Malathion, will also be given Primary consideration.

Naled is another organophosphate pesticide that is applied as a ULV aerosol. Most use of Naled for mosquito control is in the southern states. There is potential for acute, and some potential for chronic risks to freshwater invertebrates from the use of Naled. Because of its high toxicity, EPA Toxicity Class I, Naled will be given Secondary consideration.

Pyrethrum is a naturally occurring pesticide that is derived from the chrysanthemum flower. It is more expensive to produce than the synthetic pyrethroids, which demonstrate the same efficacy against mosquito populations. It will be given Secondary consideration.

Deltamethrin is considered the most persistent of the synthetic pyrethroids, demonstrating a broad spectrum of toxic effects. Although not reported as a mosquito control agent in our survey, it is included in the literature search as a synthetic pyrethroid with applicability in this area. It can be used as a barrier treatment where its persistence is an advantage. It will be given Secondary consideration.

Fenthion and Chlorpyrifos are organophosphate pesticides with historical use for mosquito control. Both display moderate toxicity to mammals and high toxicity to birds. There was little reported use of these agents, which was primarily in the south, where its use is being phased out. They will be given Secondary consideration.

Also given Secondary consideration are DEET, Octanol, and Propane. DEET is used for personal protection from mosquitoes, and is often the preferred product in government publications. Octanol and propane are utilized in mosquito traps. It is possible that the Long-Term Plan developed in this project may lead to greater or lesser use of these products, and the impacts of those changes should be considered.

2.2.5. Repellants

Garlic oil has been tested as a repellant in public outdoor areas. Because of its potential for inclusion in the County's Long-Term Plan, it will be given Primary consideration.