THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
Department of Agricultural Resources
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Lieutenant Governor

ELLEN ROY HERZFELDER
Secretary

DOUGLAS P. GILLESPIE
Commissioner

MEMORANDUM

To:	Lawrence E. McCormick, General Counsel
From:	Klayne Palmer, Legal Intern
Date:	December 2, 2004
Re:	State Reclamation and Mosquito Control Board – Commissioner Indemnification

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QUESTION PRESENTED

Whether commissioners of the various Mosquito Control Projects/Districts are "special state employees" and, as such, are they indemnified as they carry out their duties and responsibilities as commissioners?

SHORT ANSWER

The commissioners of the various Mosquito Control Projects/Districts within the Commonwealth are considered "public employees" and/or "special state employees" and thereby are entitled to indemnification from the Commonwealth of Massachusetts, while acting within the parameters of their duties and responsibilities as commissioners.

STATEMENT OF FACTS

Recently, due to occurrences and circumstances not mentioned herein, the question has arisen as to the legal status of the commissioners of the various Mosquito Control Projects/Districts organized throughout the Commonwealth of Massachusetts. The duties of the commissioners require them to make decisions regarding the organization, staffing, budget, oversight and management of a particular Mosquito Control Project/District. Those decisions and resulting actions have the potential to lead to disputes and ultimately law suits as a consequence, which might subject commissioners to liability. Commissioners of Mosquito Control Projects/Districts need assurances that the Commonwealth will indemnify them for actions taken within the scope of their duties. The issue of whether each commissioner is indemnified from personal liability has persisted for some time. The time has arrived for this question to be answered in order to show a pledge of loyalty by the Commonwealth to those employed in carrying out state interests, as well as to provide a level of comfort to those employed by it that their actions as agents of the Commonwealth will not subject them to personal liability.

SUMMARY OF APPLICABLE LAW

Under the Massachusetts Tort Claims Act, Title IV, Chapter 258: Section 1, a "public employer" is defined as "*the Commonwealth and any* county, city, town, educational collaborative, or district, including any public health district or joint district or regional health district or regional health board…and any department, office, commission, committee, council, board, division, bureau, institution, agency or *authority thereof including a…board* and commission, which exercises direction and control over the public employee, but not a private contractor with any such public employer…" (emphasis added).

Under the Massachusetts Tort Claims Act a "public employee" is described as "elected or *appointed*, officers or employees of any public employer, whether serving full or *part-time*, *temporary* or permanent, *compensated or uncompensated*, and officers or soldiers of the military forces of the Commonwealth." (emphasis added).

State employees are considered to be public employees, as they are "performing services for or holding an office, position, employment, or membership in a state agency, whether by election, appointment…whether serving with or without compensation, on a full, regular, part-time, intermittent or consultant basis…" M.G.L. c. 268A, § 1(q).

"Special state employees," defined in M.G.L. c. 268A, § 1(o), are the type of state employee:

> 1) Who is performing services or holding an office, position, employment or membership for which no compensation is provided, or
>
> (2) Who is not an elected official and
>
> (a) occupies a position which, by its classification in the state agency involved or by the terms of the contract or conditions of employment, permits personal or private employment during normal working hours, provided that disclosure of such classification or permission is filed in writing with the state ethics commission prior to the commencement of any personal or private employment, or
>
> (b) in fact does not earn compensation as a state employee for an aggregate of more than eight hundred hours during the preceding three hundred and sixty-five days. For this purpose compensation by the day shall be considered as equivalent to compensation for seven hours per day. A special state employee shall be in such a status on days for which he is not compensated as well as on days on which he earns compensation.

Special state employees are not elected officials and are usually not paid for their services. Consequently, they are allowed to be privately employed during the normal working hours. If a particular group of special state employees are compensated, it is limited to compensation for no more than 800 hours over the past year. Currently, commissioners of the Mosquito Control Projects/Districts are compensated at a rate of $100.00 per meeting. (See meeting minutes of

State Reclamation and Mosquito Control Board, February 5, 2004). Some commissioners decline this payment, however, because their duties as a commissioner are an auxiliary responsibility of their regular employment with a municipality for which they are salaried.

The duties and responsibilities of a commissioner of a Mosquito Control Project/District are mandated under the authority of law to oversee and manage a particular mosquito control project or district. M.G.L. c. 252, § 12, states the scope of the commissioners' powers and duties:

> [T]he commissioners shall carry out said improvements in such manner as the board [State Reclamation and Mosquito Control Board] of may approve. The commissioners may employ suitable persons to perform the work under their direction. So far as may be necessary to effect the improvements as approved by the board, the commissioners may take on behalf of the district…lands, easements and rights in lands, if the improvements are for a public use...

M.G.L. c. 252, § 4, further adds that the duties of the commissioners are to "enter on land which the board desires to survey or examine." These sections order the commissioners to carry out the improvements authorized by the State Reclamation and Mosquito Control Board (hereinafter Board). The designation of a commissioner by the Board supports the argument that they are special state employees.

The Massachusetts Tort Claims Act, M.G.L. c. 258, § 2, provides the guidelines for any claims against the Commonwealth for the actions of its employees. It outlines the indemnity procedure and who is covered under state indemnification. It reads, in part:

> Public *employers* shall be liable for injury or loss of property or personal injury or death caused by the negligent or wrongful act or omission of any public employee while acting within the scope of his office or employment, in the same manner and to the same extent as a private individual under like circumstances, except that public employers shall not be liable to levy of execution on any real and personal property to satisfy judgment, and shall not be liable for interest prior to

> judgment or for punitive damages or for any amount in excess of one hundred thousand dollars. (emphasis added).

Thus, public employers shall be wholly liable for judgments obtained against public employees acting within their duties and responsibilities (with certain caveats discussed hereinafter). Claims brought against the Commonwealth or one of its employees are capped at a payout of $100,000.00. M.G.L. c. 258, § 2.

DISCUSSION

I. COMMISSIONERS ARE SPECIAL STATE EMPLOYEES EMPLOYED BY THE BOARD

The State Reclamation and Mosquito Control Board qualifies as a public employer by definition, as M.G.L. c. 258, § 1, defines "public employers" to expressly include all "board[s]" of the Commonwealth. The Board's position as a public employer was established at its creation in 1918 by specifically being placed to "serve in the department of food and agriculture." M.G.L. c. 252, § 2. In 1975, its position as a public employer was reaffirmed in M.G.L. c. 21A, § 8, when the Executive Office of Environmental Affairs was formed and the Board was placed once more under the "department of food and agriculture." As recently as 2003, this placement has been recognized as the Department of Food and Agriculture changed its name to the "department of agricultural resources." M.G.L. c. 21A, § 8 (2003). Further, the Board is authorized to "*employ* necessary engineers, assistants, or other agents" to carry out the duties charged to it, concerning state reclamation and mosquito control. M.G.L. c. 252, § 4. The Board is a public employer in both definition and act. (emphasis added).

The commissioners are charged with fulfilling the Board's directions. M.GL. c. 252, § 12. All work done by the Mosquito Control Projects/Districts is performed under the "direction and supervision" or upon the "approval" of the Board. M.G.L. c. 41, c. 42 or c. 43. As stated in M.G.L. c. 252, § 5, commissioners exist and function in their capacities at the Board's discretion:

> If the board decides that a district should be organized, it shall issue a certificate appointing three, five or seven district commissioners, who shall be sworn to the faithful performance of their duties, and shall authorize said commissioners to form a reclamation district under the following section. The board shall fix the compensation of said commissioners, which shall not exceed ten dollars for each day of actual service, and shall allow them necessary traveling expenses incurred in the performance of their duties. Any commissioner may be removed by the board for cause and the board may fill vacancies. The certificate of appointment of said commissioners shall be revoked by the board when the objects for which they were appointed have been accomplished.

Several key elements confirm these commissioners as public employees and/or special state employees in their work for the State Reclamation Board and Mosquito Control Districts. The most obvious is the statutory language authorizing their "appointment" and thereby employment by the Board. Further, it is granted that the "board shall fix the compensation of said commissioners." Lastly, "[a]ny commissioner may be removed by the board for cause." These commissioners are acting only at the behest of the Board, and are thereby "employed" of the Board, and ultimately the Commonwealth, under whose authority the Board's existence is granted. See M.G.L. c. 252, § 2. Special state employees are state employees and consequently considered public employees. M.G.L. c. 268A, § 1(o, q).

II. THE COMMONWEALTH INDEMNIFIES THE COMMISSIONERS

Chapter 258, the Massachusetts Tort Claims Act, instructs how to reconcile claims brought against the Commonwealth and "its …districts and the officers and employees thereof." Section Two indemnifies "public employees", or those whose employment falls under the umbrella of that definition, from liability due to "injury or loss of property or personal injury or death caused by the negligent or wrongful act or omission…while acting within the scope of his office or employment". This is a clear and unmistakable endorsement of indemnification of commissioners as employees, as by statute they are special state employees, so long as they are acting within the scope of their employment. M.G. L. c. 268A, § 1; M.G.L c. 252, § 12.

In a memorandum dated April 25, 2002, (Re: Legal Status of State Reclamation Board, Including its Districts and Projects), the Executive Office of Environmental Affairs, Department of Food and Agriculture, Human Resources Division, Operational Services Division and the Office of the Comptroller all agreed that "the Board, its districts and projects should continue to enjoy all the rights and benefits of being part of a state department. As such, it is necessary that the responsibilities and obligations of a state department are also met." This includes the responsibility of a public employer to indemnify its employees, e.g. Mosquito Control Project/District Commissioners acting within the scope of their employment. M.G.L. c. 258, § 2.

A. Limitations To Indemnification in Specific Circumstances

The Commonwealth does not indemnify in some limited and narrow circumstances, which include requiring the Commonwealth to be liable to any judicial decisions that require 1) "any real and personal property to satisfy the judgment", 2) "interest" payments or accrual "prior to judgment", 3) "punitive damages" or 4) a liability of the public employer or public employee over and above a cap of "one hundred thousand dollars." M.G.L. c. 258, § 2.

A further parameter to the indemnification provided by the Commonwealth, is that any lawsuit against any commissioner or any other public employee "shall be exclusive of any other civil action or proceeding" on the same subject matter against the Commonwealth or against the public employee or the employee's estate. M.G.L. c. 258, § 2.

In *Ayala v. Boston Housing Authority*, these indemnification boundaries were brought to bear. 404 Mass. 689 (1989). In this case, a tenant brought claims against the authority, seeking damages for injuries to the tenant's children due to lead paint hazards in their apartment, which was rented through the housing authority. *Ayala v. BHA*, 404 Mass. 689 (1989). The tenant argued that the Massachusetts Tort Claims Act did not control the claim, due to the fact that it was contract-based and not a tort. *Ayala,* 404 Mass. at 703. The court held that it did not "rely on the lease between the plaintiffs and the owners in reaching our conclusion." *Id.* Instead, the court relied on statute and affirmed that whether a claimant's injuries are based in contract or tort the "measure of the recoverable damages is the same." *Id.* Plaintiffs seeking legal action against a commissioner acting within the scope of his duties and responsibilities "may not avoid the requirements and limitations" of a maximum recovery of $100,000 against the Commonwealth per claimant. *Id.* at 704. See *Thomas v. Massachusetts Bay Transportation Authority,* 389 Mass. 408, 410 (1983).

The court also reiterated that, as plaintiffs, the tenants "would be entitled only to a single recovery of damages, even if they had established both a contract claim and a tort claim." *Id.* Thus, a final judgment in an action brought against a public employer shall constitute a complete bar to any further action by that claimant against the public employer or the public employee regarding the same subject matter. M.G.L. c. 258, § 2. See *Rae v. Air-Speed, Inc.*, 386 Mass. 187, 196 (1982).

Finally, a caveat exists in the Massachusetts Tort Claims Act that protects the employee and the employer by encouraging their cooperation in any action brought against them by a claimant. Failure to provide such reasonable cooperation on the part of a public employee shall cause the public employee to be jointly liable with the public employer, to the extent that the failure to provide reasonable cooperation prejudiced their defense in the action. Information obtained from the public employee in providing such reasonable cooperation may not be used as evidence in any disciplinary action against the employee. M.G.L. c. 258, § 2.

The policy behind the cooperation requirement is to ensure that the Commonwealth will have access to all necessary data to argue its case efficiently and effectively in behalf of its employed. It further provides protection to the Commonwealth against suits against it from employees.

B. Use of Public Attorney

"The public attorney shall defend the public employee with respect to the cause of action at no cost to the public employee" if the public attorney determines that 1) "the public employee was acting within the scope of his office or employment at the time of the alleged loss, injury, or death" and that 2) the "public employee provides reasonable cooperation to the public employer and public attorney in the defense of any action arising out of the same subject matter." M.G.L. c. 258, § 2.

The Attorney General's Office will represent a commissioner as the need arises. The Attorney General's Office has represented Mosquito Control Project/District employees acting within their duties and responsibilities in the recent past. Once such employee was John Doe[1], employed by Northeast Massachusetts Mosquito and Wetlands Management District. While working on December 16, 1999, Mr. Doe was involved in an automobile accident from which a tort claim arose. Under the Massachusetts Tort Claims Act, the Attorney General's Office took

[1] Employee's name is withheld to protect their identity.

responsibility for the legal action being taken against Mr. Doe and a settlement was reached with the plaintiff in that case.

Lastly, if “in the opinion of the public attorney, representation of the public employee, under this paragraph would result in a conflict of interest, the public attorney shall not be required to represent the public employee.” M.G.L. c. 258, § 2. Under such circumstances, the Commonwealth “shall reimburse the public employee for reasonable attorney fees incurred by the public employee in his defense” provided however, that all “the same conditions exist which are required for representation” of the employee by the public attorney under this section. M.G.L. c. 258, § 2.

CONCLUSION

In sum, according to the above statutory language, commissioners appointed by the Board to oversee and manage the various Mosquito Control Projects/Districts are considered special state employees and are indemnified against official personal liability by the Commonwealth of Massachusetts while acting within the scope of their responsibilities and duties under the auspices of the State Reclamation and Mosquito Control Board.

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Policy 2005-2

MOSQUITO CONTROL BUDGETS AND FUNDING

Introduction and History

Historically, funding for mosquito control projects was "subject to appropriation" by the state legislature based on formulas established in their enabling act of legislation creating the particular project or district. The formulas are based on equalized valuation and/or land area. The funding amounts for each district would appear in the state budget as a separate line item. The district funding would be assessed to member communities via the cherry sheet. Essentially, those municipalities receiving mosquito control services reimburse the state for the costs of providing these services from local aid allocations. In the main, the role of the legislature in its appropriation responsibility was to certify the total amount of aid cities and towns would have available to pay for mosquito control and other services provided by the state.

In FY2001 the original set up was changed from the legislature role regarding "subject to appropriation" to trust accounts. The same mechanism as above applies, however, in that cherry sheet assessments are still estimated and assessed by the state through the Department of Revenue Division of Local Services'. In addition, pursuant to Section 5A of Chapter 252 of the MGL, the State Reclamation and Mosquito Control Board (the Board) has statutory oversight authority of mosquito control districts and projects budgets. The Board certifies to the Division of Local Services and State Comptroller that trust fund expenditures for any fiscal year will not exceed assessments against cities and towns for that fiscal year (see citation below).

Policy 2005-2

MOSQUITO CONTROL BUDGETS AND FUNDING

Notwithstanding the provisions of any general or special law to the contrary, expenditures and other financial uses charged to said fund shall not be subject to appropriation, and shall include salaries and other costs of state employees, operational expenses, acquisition of capital equipment and property, and other expenses deemed necessary to the state reclamation board's successful operation as determined by the director of said board. Revenue and other financial sources credited to said fund shall include funds made available pursuant to this chapter, and interest income from investments made by the treasurer on behalf of the fund. For the purpose of accommodating timing discrepancies between the receipt of revenues and related expenditures, notwithstanding the provisions of any general or special law to the contrary, the board may incur expenses and the comptroller may certify for payment amounts in anticipation of receipts. The board shall annually certify to the comptroller that expenditures for the fiscal year do not exceed related assessments.

Clarification

For the purpose of clarification, the State Reclamation and Mosquito Control Board determined that the Commonwealth funds mosquito control in Massachusetts for eight organized or regional mosquito control districts. State aid appearing on a members cherry sheet is used to pay for the service provided by the district. Revenue generated at the local level, such as property or motor vehicle excise taxes, does not fund mosquito control services in Massachusetts. State funding in the form of local aid distributions are intercepted for the purpose of funding mosquito control assessments and other charge programs.

New Process for Mosquito Control Funding Review and Approval

By law, the Department of Revenue (DOR) must provide municipalities with estimates of cherry sheet receipts and assessments; one such program is for mosquito control services. In the case of the mosquito control program, the DOR will quarterly assess the municipality receiving mosquito control services in **September, December, March, and June**. As a result, it is important that mosquito control budget funding be reviewed on a regular schedule so that DOR can meet its statutory obligations.

MOSQUITO CONTROL BUDGETS AND FUNDING

Therefore, **the Board is establishing the following process** to insure that:

- Both actual and estimated mosquito control assessments are submitted based on a schedule developed by the DOR and the Board (see below). This is to facilitate DOR's publishing of cherry sheets and processing of quarter local aid distributions and assessments;
- The Board makes a formal review and certification of mosquito control district and SRMCB administrative budgets via a vote at one of its annual meetings;
- Mosquito control district and SRMCB administrative budgets comply with state laws pertaining to both requesting and justifying of budgetary increases (if any);
- Mosquito control commissions make sure that communities joining or withdrawing from a mosquito control district indicate on town meeting warrants effective date that membership begins or ends;
- The mosquito control commissions and its Superintendent/Director follow a communication protocol developed by both DOR and the Board.

Mosquito Control Data Submission Schedule

The following schedule must be followed which affects both the current and upcoming fiscal year. *Note: The Board recommend that you enter these dates in your work calendar in order for the Board to meet the DOR deadline.*

Mosquito control Commissions are directed to submit their approved budget numbers to the Board on the following three (3) dates:

On or Before December 30th

- *Preliminary budget figures* for upcoming fiscal year (both mosquito control districts and state reclamation and mosquito control board)
- Updated actual budgets for current fiscal year (both mosquito control districts and state reclamation and mosquito control board)

MOSQUITO CONTROL BUDGETS AND FUNDING

On or Before May 15th

- *Final budget figures* for upcoming fiscal year (both mosquito control districts and state reclamation and mosquito control board)

Note: These figures will appear on final cherry sheets released once the Governor has approved the state budget. These numbers should include any changes to the estimated numbers submitted in the Governor's Budget Recommendation (House 1).

On or Before October 15th

- *Updated actual budgets for current fiscal year* (both mosquito control districts and state reclamation and mosquito control board)

Note: These updates should include any membership changes occurring as a result of fall town meetings.

Mosquito Control Communication Protocol

Communications regarding mosquito control estimated and actual budgets should be done by e-mail. **E-mails should be sent to the projects administrator and copied to all State Reclamation and Mosquito Control Board members**.

The projects administrator, after the Boards approval, will forward estimated and/or actual budgets to DOR using a predefined spreadsheet template.

Any communication with DOR regarding funding assessments must be sent by e-mail to the following e-mail databank@dor.state.ma.us and **copied to the Board.**

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<u>Mosquito Control Funding Questions And Answers</u> (May 2005)

Q. Are funds expended by mosquito control districts and projects state funds?

A. Yes, monies expended to manage and control mosquitoes in Massachusetts are derived from state funding.

Q. How can the funds expended by mosquito control districts and projects be state funds since these monies are assessed or charged to cities and towns via the "cherry sheet" who opt for mosquito control services?

A. The monies assessed or charged to cities and towns are part of the local aid distribution process. Funding assessed or charged are deducted from the local aid payments (which are state derived funds) to cities and towns based on assessments that the Department of Revenue calculates for the service provided (i.e. mosquito control). In other words, revenues collected at the local level from taxes do not fund mosquito control services. Before local aid payments go to local governments, they get reduced for services such as mosquito control.

Q. What is the "cherry sheet"?

A. The Cherry Sheet is the official notification from the Commissioner of Revenue of the next fiscal year's <u>state aid and assessments to cities, towns, and regional school districts.</u>

Mosquito Control Funding Questions And Answers **(May 2005)**

Q. What is the purpose of the "cherry sheet"?

A. The purpose of the Cherry Sheet is to ensure that local budgets reflect realistic estimates of the amount of revenue a municipality and regional school district will actually receive from the state during the upcoming year, as well as the amounts that will be assessed upon local governments to pay for a variety of state or sub-state programs in which they participate. The Tax Rate Recapitulation Sheet, filed by local assessors with the Division of Local Services to certify property tax rates, must reflect the receipts and charges contained on the Cherry Sheet.

Q. Several years ago, mosquito control budgets appeared as line items in the State Budget and the legislature changed this in 1999 to Trust Accounts. Why?

A. The intent of the legislation in 1999 reflects that the mosquito control budgets did not need to be appropriated in the state budget (which is the purpose of the budget) because these funds were assessments against local governments.

Q. Although oversight of mosquito control services in Massachusetts is at the state level, why are these services subject to Proposition 2 ½?

A. Other regional services provided to cities and towns including but not limited to the MBTA, Air Pollution Districts, Regional Transit Authorities and mosquito control are governed by the rules of Proposition 2 ½. These services are reflected on the cherry sheet in the form of assessments and charges. State assessments and charges that appear on the cherry sheet that is not subject to Proposition 2 ½ are those that refer to a specific individual (i.e. health insurance premiums, non-payment of parking violations (rmv surcharges) and tuition assessments for students attending out of district schools). However, the administering agencies or authorities can increase their total assessments by more than 2½ percent if they can demonstrate to the Board and the Division of Local Services that the increase is due to the provision of new services.

Q. Who is the state administering authority for mosquito control regarding mosquito control funding?

A. According to Chapter 252 of the Massachusetts General Laws, the State Reclamation and Mosquito Control Board.

Mosquito Control Funding Questions And Answers (May 2005)

Q. What role do the State Reclamation and Mosquito Control Board play regarding mosquito control funding?

A. State agencies and authorities such as the State Reclamation and Mosquito Control Board certify after its review and approval the actual assessments to the Department of Revenue, Comptroller, and State Treasurer. The Division of Local Services within the Department of Revenue deducts a quarter of each assessment from the local aid distributions for those cities and towns who are members of mosquito control districts and projects.

Q. How are monies or funds that pay for mosquito control derived?

A. There are eight mosquito control districts or projects whose costs are apportioned to member municipalities on the Cherry Sheet. Each district relies on a separate formula based on their enabling Acts of Legislation establishing the mosquito control district or project to apportion its assessment to its member municipalities. All formulas are based on Equalized Valuation; five of the districts' formulas also use land area as a component.

Q. Do mosquito control districts pay for the administration of the State Reclamation and Mosquito Control Board?

A. No! Financing for the administration of the State Reclamation and Mosquito Control Board is assessed to member communities from each district.

Q. Where else can I find additional information on mosquito control funding?

A. Go to the following web sites

http://www.dls.state.ma.us/cherry/csmanual.pdf

http://www.mass.gov/agr/mosquito/index.htm

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TO: Massachusetts Mosquito Control District or Project Commissions

FROM: State Reclamation and Mosquito Control Board

DATE: October 6, 2004

RE: **Motor Vehicle Accident Policy Discussion and Statement**

The State Reclamation and Mosquito Control Board brings to your attention the matter of tort claims, such as motor vehicle accidents, an issue that impacts the mosquito control district or project that you oversee.

Recently, several districts and projects have had claims made against them for damages due to motor vehicle accidents involving the district or project employees. As a result, significant funds have been expended to resolve various claims and these amounts impact all districts and projects as well as the Massachusetts Department of Agricultural Resources through a mechanism known as the **Liability Management Reduction Fund (LMRF).** The payment of these claims highlight the need to remain vigilant in the operation of district or project motor vehicles and the follow-up procedures following an accident.

Two main concerns that need to be addressed are:

1. Districts and Projects shall maintain a process to provide education and incentives to insure safe and professional driving of motor vehicles to minimize both the number and frequency of claims being made on an annual basis.

2. The Office of the Attorney General represents the Department and state employees on all litigation matters, and in such matters, it works directly with the General Counsel of the Massachusetts Department of Agricultural Resources. All communications or correspondence regarding motor vehicle accidents must be referred to said General Counsel. Districts and projects shall not enter into settlements of pending claims without the consultation and assent from the said General Counsel.

Motor Vehicle Accident Discussion and Policy

In accordance with the Massachusetts Tort Act (Chapter 258 of the M.G.L.), those individuals claiming injury must adhere to a strict process whereby s/he submits a presentment letter to a specified authority such as the Office of the Attorney General. These letters are then forwarded to the General Counsel of the Massachusetts Department of Agricultural Resources and/or the Projects Administrator of the State Reclamation and Mosquito Control Board for consideration and resolution.

The Department of Agricultural Resources and the State Reclamation and Mosquito Control Board have established a process to track tort claims such as motor vehicle accidents. A separate letter from the State Reclamation and Mosquito Control Board will be been sent to the Office of the Attorney General handling these matters stating, in part, the following:

> **No mosquito control district or project Commission, Director or Superintendent, or anyone on their behalf, or any staff thereof, are authorized to verbally or in writing approve settlements resulting from presentment of claims concerning torts such as motor vehicle accidents without consultation and assent from the General Counsel of the Department of Agricultural Resources.**

The implementation and following of this policy will prove beneficial to Commissions in a number of ways, including but not limited to, claims being tracked via an inventory schedule to insure timely turnaround, settlements being more uniform and result in savings, and the Superintendent or Director being able to utilize their efforts to focus on issues directly relating to managing mosquitoes. The avoidance of torts such as motor vehicle accidents will enhance the overall image of the district or project, and result in savings. Efficiencies from this policy will allow all districts and projects to better carry out their mandated responsibility of managing mosquitoes.

Your cooperation and prompt attention to this policy is appreciated.

Thank You

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Employee Time Off Policy

To: All Mosquito Control Commissions and Projects

From: State Reclamation and Mosquito Control Board

Date: May 28, 2008

RE: Employee Time Off

The State Reclamation and Mosquito Control Board (SRMCB) approves this policy effective May 28, 2008 directing that the Commonwealth's **listing of Legal Holidays (below) supersedes all statewide Mosquito Control Commission holiday/time off policies and/or practices and must be implemented accordingly.**

Employees that take other days off must use paid leave time off (i.e. vacation time, personal time, pre-approved compensatory time, etc.) or unpaid leave.

The listing of current Legal Holiday Calendar for 2008, 2009, and 2010 given to state employees and published by the Human Resources Division (HRD) for the Commonwealth of Massachusetts is available and may be downloaded at HRD's web site at www.mass.gov and search Legal Holiday Calendar along with further information relative to holidays that fall on Saturdays or Sundays.

Questions or further assistance can be answered by contacting Alisha Bouchard, the Projects Administrator at 617) 626-1715 or email abouchard@state.ma.us.

-Turn over-

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PAUL DIETL
Chief Human Resources Officer

TO: Cabinet Secretaries, Division Directors, Agency Heads, Human Resources Directors, Labor Relations, Payroll and Budget Directors

FROM: Paul Dietl, Chief Human Resources Officer *Paul Dietl*

DATE: April 7, 2008

RE: **Legal Holidays in the Commonwealth of Massachusetts**

Under the date of June 6, 2006, a list of legal holidays and the schedule of dates when they will be observed as set forth in Chapter 4, Section 7; Clause Eighteen was forwarded to you for calendar years 2006, 2007, and 2008. The following is a list of legal holidays and the dates on which they will be observed for calendar years 2008, 2009, and 2010.

Legal Holidays	**2008**	**2009**	**2010**
New Year's Day	January 1	January 1	January 1
Martin Luther King Day	January 21	January 19	January 18
President's Day	February 18	February 16	February 15
Evacuation Day (Suffolk County)	March 17	March 17	March 17
Patriots' Day	April 21	April 20	April 19
Memorial Day	May 26	May 25	May 31
Bunker Hill Day (Suffolk County)	June 17	June 17	June 17
Independence Day	July 4	July 4*	July 4**
Labor Day	September 1	September 7	September 6
Columbus Day	October 13	October 12	October 11
Veterans' Day	November 11	November 11	November 11
Thanksgiving Day	November 27	November 26	November 25
Christmas Day	December 25	December 25	December 25*

* Under the provisions of Chapter 4, Section 7, Clause Eighteen, legal holidays that fall on a Saturday shall be observed on that day. All offices under the jurisdiction of any department of state government shall be open to the public for business on the Friday preceding any Saturday holiday. However, as many employees as possible should be given that Friday off. Employees assigned to work shall be given an additional day off as the law and applicable collective bargaining agreements allow. Whenever possible, the following Monday shall be used as the alternative day off.

Chapter 30, Section 24A provides for the action to be taken in the case of persons employed by the Commonwealth when any legal holiday falls on a Saturday. In addition, Section 11 of the management and confidential employee rules governing paid leave and other benefits and Collective Bargaining Agreements currently in effect cover this subject.

**A legal holiday shall be observed on the day following when said holiday should occur on Sunday (Chapter 4, Section 7, Clause Eighteen).

Introduction

Since the early 1980s the Northeast Massachusetts Mosquito Control and Wetlands Management District (herein referred to as the District) has conducted Open Marsh Water Management (OMWM) as an environmentally sensitive method of controlling mosquitoes on the salt marsh. The adoption of OMWM by the District came about in response to District observations being made on the ditched marshes in northeast Massachusetts, the town of Rowley's dissatisfaction with the ditched marshes, and a presentation on OMWM techniques given at a New Jersey Mosquito Control Association (NJMCA) meeting.

While working on the salt marsh, Walter Montgomery, then Assistant Superintendent of the District, noticed that fish accumulated in the ponds where grid ditches on the salt marsh had become plugged. There appeared to be far fewer mosquito larvae in these blocked ditch pools and a greater success for fish survival throughout the dry back period in comparison with other portions of degraded ditched marsh. The District researched the benefits of implementing OMWM techniques as part of its mosquito control operations, adopting the early program to regional tidal dynamics, and modifying techniques as the District's knowledge grew.

Open marsh water management in itself is a more expensive endeavor than many of the other mosquito control methods available, such as grid ditching or aerial spraying. However, its minimal impact on the resource and its ability to keep mosquitoes in the food web make it environmentally appealing. Until recently, OMWM has been widely recognized by those in the environmental community for its restorative qualities and enhancement of salt marsh wildlife and vegetative communities. Comparison of OMWM pre-alteration and post-alteration mosquito larvae numbers indicates that OMWM is an effective mosquito control method not only in the first two years following implementation but up to twenty years post and beyond.

A review of the District's OMWM activity over a ten year period, as well as from the beginning of the program, indicates that the program offers a high level of efficacy for continued mosquito control. Alternative methods of control serve to reduce immediate mosquito and / or juvenile mosquito populations; however, no other method offers the long term control and increased or stabilizing effect on biodiversity that has been observed by the implementation of OMWM.

History

Open Marsh Water Management (OMWM) was conceived in the 1960s (Jobbins and Ferrigno) to control salt marsh mosquitoes in New Jersey and in other mid Atlantic states. The Northeast Massachusetts Mosquito Control and Wetlands Management District, also known as the District and formerly the Essex County Mosquito Control Project (ECMCP), adopted their own OMWM Program in the early 1980s and wrote the original Standard for OMWM in 1982. The Program was seen by the ECMCP and environmental advocates as a long range salt marsh mosquito control strategy and an environmentally sensitive alternative to pesticide application by air or ground. It was recognized as a superior and much preferred practice of managing the extensive grid ditch system which still dominates most of the salt marshes of Essex County, MA. A cooperative effort involving mosquito control staff, the Town of Rowley, and the Manomet Bird Observatory and funded through a small grant provided by Massachusetts Coastal Zone Management, was initiated to study test plots. In 1983 another small grant was secured from the US Fish and Wildlife Service and an experimental permit was granted by the US Army Corps of Engineers to implement 2 pilot sites which were then studied by ECMCP staff and Dr. Thomas Hruby of the Resource for the North Shore and Office of the Massachusetts Audubon.

The ECMCP received a 3-year Army Corp Individual Permit for OMWM on May 4, 1984. Since then, the Permit has been extended four times for 3-year periods; once in 1987, 1989, 1992, and 1995 and finally in 1998 the Northeast Massachusetts Mosquito Control District and Wetlands Management District, received its first 10-year permit from the Corps of Engineers. Open Marsh Water Management has been implemented for 23 consecutive years and has effectively demonstrated measurable mosquito efficacy based on District data and observation[1]

Alternative methods

Open marsh water management is an observational science and is one tool in the District's Integrated Pest Management program. Other options available to control mosquitoes on the salt marsh include aerial larvicide spraying, ditching, and/or intensive adulticide truck spraying along the coastal roads and inland as needed. Each of these alternatives acts to control mosquito numbers, however, the long term effectiveness of OMWM far outweighs the alternative methods in terms of controlling mosquito numbers and reducing impacts to the environment.

OMWM offers a long range solution to mosquito control by providing increased access to mosquito larval habitat and improved habitat through enhancement of reservoirs for mosquito eating fish. Radials or shallow ditches and improved pannes and ponds are some of the techniques used to provide fish better habitat. Data is collected on juvenile mosquito numbers for one year prior to implementing alterations, and sites are monitored on a post-alteration schedule of one and two years and in most cases five and ten years. The District has also monitored some OMWM sites at fifteen and twenty years post alteration and beyond. The District has also monitored sites at other times or conducted a quick review which provides a narrative of the general condition of the site.

Data is recorded based on protocols in the OMWM standards (Appendix 1). Although it not uncommon to observe hundreds of juvenile mosquitoes in a single collection dip, a maximum of thirty (30) juvenile mosquitoes per dip are counted and recorded so as not to bias the data. The decision to limit the maximum number of juveniles recorded / dip was based upon the original OMWM Advisory Committee's recommendations.

Ditching is a technique used in the past to drain the upper reaches of the salt marsh. There are some historic references to Native American tribes, who inhabited coastal areas of New England, conducting ditching on the salt marsh. However, extensive ditching of the marsh wasn't practiced until after the arrival of the first settlers. Ditching was largely conducted on salt marshes to improve conditions there for pasture and grazing of livestock but also to promote larger yields and allow easier access to harvest hay.

The grid ditch system still evident on our salt marshes today, were dug by hand mostly between 1928 and 1934. Some engineering studies were done to determine where and at what intervals ditches were dug. Ditches were dug in straight rows by hand with sod saws and two man shovels. In 1934, at the peak of this ditching effort, over 11,000 men were employed digging ditches. When completed nearly 3,000 linear miles of salt marsh ditch were dug in Essex County alone. The primary purpose of this era of ditching was to put as many people to work as possible, as this was the time of the Great Depression. No entomological studies were conducted in conjunction with this ditching effort; mosquito control was a secondary consideration at best. However mosquito control was achieved by default as practically every square inch of marsh was drained by the extensive project.

In the late 1940s and early 1950s soldiers returned home from World War II. Housing shortages were a big problem in the more populated areas particularly in and around Boston. A generation of young families, eager to get their lives back on track migrated to the north shore of Massachusetts to start new lives. This migration coincided with the degradation of the grid ditch system created in the 30s. These ditches had not been maintained and likely now produced far more mosquitoes then they had initially eliminated. By many accounts it was so bad some considered the area to be almost uninhabitable. A few local programs were established to try to reopen the ditches but it was impossible to duplicate the labor force that had originally created the ditches.

The draining of the salt marsh effectively depleted much of the habitat needed to support mosquito eating fish. It is likely that ditching also degraded much of the habitat needed to support foraging birds and other predators of the salt marsh, such as fox and coyote. In addition, ditches also act to alter ground water patterns, thereby altering native salt marsh vegetative communities. Poorly maintained ditches eventually result in standing water that is typically too shallow to support fish, but of sufficient depth to support emergent mosquito populations. In fact, the greatest number of juvenile mosquitoes, observed in one study by the District (Januszewski, unpublished) was found in degraded ditch systems rather than in the panne systems tested. Individual dips contained juvenile mosquito numbers in the hundreds. This held true for total numbers of larvae per dip as well as for individual instar numbers per dip with some dips containing over 500 larvae.

The District's aerial larviciding program provides for reduction of mosquito populations present on the marsh at the time of application and is considered a short term approach, conducted throughout the mosquito breeding season. District technicians monitor the salt marsh following potential flooding events (heavy rains, high run tides, etc), collecting data from recoverable dip stations on the marsh in the communities that participate in the aerial larviciding program. The data collected is analyzed to determine areas that require larviciding. Data collection protocols are based on collection methods utilized in the OMWM program. A maximum of thirty (30) larvae / dip are recorded. District technicians work with a contracted aerial applicator to apply larvicide to areas of the salt marsh determined to have sufficient breeding to warrant treatment. The technicians return twenty four hours after treatment to conduct post treatment data collection. This data is then analyzed to determine overall efficacy of the treatment. District aerial larviciding records indicate an 80% - 100% efficacy for each spray event.

Although the District's aerial larviciding program provides a high level of efficacy, each successive flooding event produces a new brood of mosquitoes with no indication of population reduction overall. The District has noted that during recent years weather patterns have changed resulting in an increased number of flooding events on the marsh. This increase has resulted in increased personnel time required for monitoring the marsh and an increased number of spray events per season. In addition, aerial spraying merely reduces the number of mosquito larvae hatching on the marsh at the time of spraying, with no long term changes in the overall number of mosquito larvae.

While aerial spraying reduces the number of mosquito larvae at a given point in time, it does not increase biodiversity on the marsh, nor does it provide any long term control of mosquito breeding. Despite the high rate of efficacy for the aerial spray program, should the District discontinue this program, mosquito numbers on the salt marsh would continue to thrive. This result can be correlated to the fact that aerial spraying does not increase the biodiversity on the marsh, nor does it provide access and refuge for predatory fish to juvenile mosquito habitat. The result is high immediate efficacy with no long term benefit.

Adulticiding using the District's ultra low volume (ULV) truck mounted sprayers is a third alternative method of mosquito control and probably the least efficient method of dealing with large populations of emerging salt marsh mosquitoes which often hatch off as a single brood. However it is the most widely recognized method of control used to address adult mosquito populations. It is certainly the control option most requested for by the general public when salt marsh mosquito numbers increase to a public nuisance level. According to the American Mosquito Control Association:

"Aerial adult mosquito control and ground adult mosquito control using truck mounted equipment are often the most visual aspects of an organized mosquito control program. Although it is often expensive in terms of manpower, equipment and inventory, sometimes difficult to accomplish and more likely to affect non-target organisms if mis-handled, it is the only method to rapidly reduce infected mosquito numbers or to control pest and nuisance mosquitoes from inaccessible breeding areas that are interfering with normal outdoor activities of a community." *(AMCA, http://www.mosquito.org)*

As with aerial larviciding, adulticiding does not provide long term mosquito control, does not increase biodiversity on the salt marsh, and acts only to reduce mosquito numbers at the time of application.

OMWM Advisory Committee

The OMWM Advisory Committee is comprised of federal, state, and local authorities. Other environmental organizations may be invited to participate at the discretion of US Army Corps of Engineers (USACE) and the District. Selected member agencies and organizations supply the District with the appropriate participant's contact information and are responsible for keeping the District appraised of any changes for these points of contact. The points of contact attend the annual meetings and are responsible for identifying and contacting individuals within their respective agencies with the appropriate expertise to respond to any special issues of concern. Member participation on the District's OMWM advisory committee is initially solicited from the following agencies or groups but may be supplemented upon additional request or recommendation:

Federal - Mandatory Participation
US Army Corps of Engineers, USACE
US Environmental Protection Agency, EPA
US Fish and Wildlife Service, USFWS

Federal – Potential Participation
National Marine Fisheries Service (NMFS)

State - (MA) Potential Participation
Department of Conservation and Recreation, DCR
Department of Environmental Protection, DEP
Division of Fish and Wildlife, MDFW[9]
Massachusetts Environmental Policy Act Office, MEPA
Massachusetts Office of Coastal Zone Management, MCZM
State Reclamation and Mosquito Control Board, SRMCB

Local – Potential Participation
Conservation Commission[10]

Other
Ducks Unlimited, DU
Essex County Greenbelt Association, ECGA
Massachusetts Audubon, MA
The Trustees of Reservations, TTOR

Annual Advisory Committee Meeting

The most recent version of OMWM Standards, March 2008 suggests that:

> Committee members are expected to participate in an annual meeting. However the District's workload is unpredictable and may occasionally require an additional meeting(s) to discuss work activities not previously known at the time of the annual meeting. Thirty (30) calendar days prior

to a meeting, a notice specifying the date, time and location of the meeting is sent to all points of contact for the OMWM advisory committee. This notice (either digital / e-mail or written) is sent in advance and should include a proposed project locus map(s) and information depicting anticipated alterations for each project site. Additional materials such as data sheets or summaries will be supplied at the annual meeting upon request.

The purpose of the annual meeting is to review proposed alterations to site specific OMWM projects. The role of the advisory committee is to ask questions and express concerns within the respective areas of agency expertise; advisory committee members should state the resource or species which might be impacted by the project and describe impacts that either individually or cumulatively are considered more than minimal to the specified resource. Advisory committee members are expected to request site visits within 10 days (of the annual meeting) and / or offer comments within 30 calendar days (from the annual meeting date) relative to sites proposed at advisory committee meetings. All comments should be sent to USACE as well as the District. If no comments are received within 30 days of the annual meeting in which the project was presented, the project is considered acceptable and authorized under the conditions of the USACE permit. In the case of unresolved conflict USACE will arbitrate and make the final determination.

Historically, the District has always welcomed inspection and comments relative to site specific concerns from outside of the Advisory Committee and has not implemented site work on several occasions when concerns have been identified that seemingly had no resolution.

Advisory Committee activities from 1998 – 2008

From 1998 – 2008, the District held eleven (11) OMWM Advisory Committee meetings. As per the USACE OMWM permit, each committee member was notified of the meeting in writing. In 2006, notices of open invitation were also sent to interested parties not on the Advisory Committee. Attendance by committee members was sporadic throughout the ten year review period, with no one agency represented at every meeting. Upon review of the minutes, it was suggested that scheduling may be an issue in low attendance. A more likely explanation, as proposed by Walter Montgomery, is due to the continued success of the program and perhaps even a complacency that developed as a result of the Committee's apparent confidence in the District's OMWM Program

The Committee's continued approval of the District's OMWM program can be inferred from statements made by Committee members during the meetings. In 1992, James MacDougall, of the Essex County Greenbelt Association, suggested that the Committee expand its scope to include fresh water management using OMWM as a model to develop the fresh water program. During this same meeting the role of the Advisory Committee was discussed. It was noted that due to the proven success of the OMWM program, the Committee's purpose had become limited.

In 1995, David Sheperdson, of the Executive Office of Environmental Affairs representing the Massachusetts Environmental Protection Act, (MEPA) pointed out that the Advisory Committee had helped to keep OMWM input active, up to date, and offered valuable regulatory input and notification in the development of the GEIR. In 1997, Karen Adams of the US Army Corps of Engineers suggested renewing the permit for a ten year term as opposed to the then current three year term. In addition, David Sheperdson expressed interest in having the District's updated OMWM Standards included in the GEIR final draft.

In November of 2000 it was brought to the Committee's attention that the current water quality permit had no expiration date and a letter was sent to the Massachusetts Department of Environmental Protection, (DEP) asking for clarification on the status of the permit. The District querried whether the permit was to run for the duration of the OMWM program or if it was to run concurrent with the Army Corps of Engineer's permit. In September of 2001, Michelle Abbott of the US Army Corps of Engineers stated that if there was no response from DEP, we could assume that the permit ran concurrent with the 404 permit or the life of the project.

With the retirement of David Sheperdson in 2004, MEPA was not represented on the Advisory Committee. The District sent a letter requesting MEPA to fill the vacant position. At the annual Advisory Committee meeting in December of 2004, Jack Card noted that Janet Hutchins, of MEPA, had stated that OMWM was not a priority for her agency as the successes and benign effects of OMWM had been well documented. It is apparent from the referenced comments that the Committee not only supported the OMWM program, but also supported the District's decision making policies regarding the OMWM program during the ten year review period.

OMWM Activity: 1998 - 2008

As stated, the District has been conducting OMWM since the early 1980s. During that time, the District has surveyed 145 potential OMWM sites for implementation of OMWM alterations. Of these, 33 sites have been rejected for various reasons. These may include but are not limited to lack of observed mosquito breeding, drainage issues due to upland land use and development, property owner denial, and size restrictions on sites too large or small to implement OMWM effectively. From 1998 – 2008 the District collected data and/or completed alterations on 81 separate OMWM sites. Of these, 46 were pre-alteration sites, 29 sites had OMWM alterations completed, and the remaining sites were in various stages of post-alteration monitoring (Tables 1).

Description	Number (n)
Total sites	81
Pre-OMWM	46
Completed projects	29
1-year Post	30
2-year Post	34
5-year Post	7
10-year Post	7
15-year Post	2
Quick Review	31

Table 1: OMWM activities from 1998 - 2008

To determine the level of efficacy of the program, the District created a master database containing data collected since the beginning of the program. This is an ongoing project and therefore the results presented are representative of the program as a whole. Data used to analyze the efficacy of the program include total juvenile mosquitoes per site visit, number of dips per site visit, and total juvenile mosquitoes per dip per site visit for the program as a whole. Fish and bird abundance are recorded based on an abundance code and therefore are not recorded in such a manner that would allow rigorous statistical analysis. These observations are recorded in accordance with the original OMWM Standards. In addition, specific sites were analyzed to provide data on site specific efficacy. These sites were chosen based on the availability of data recorded in the master database and the greater number of monitoring periods noted for each site.(Figures 1 - 4).

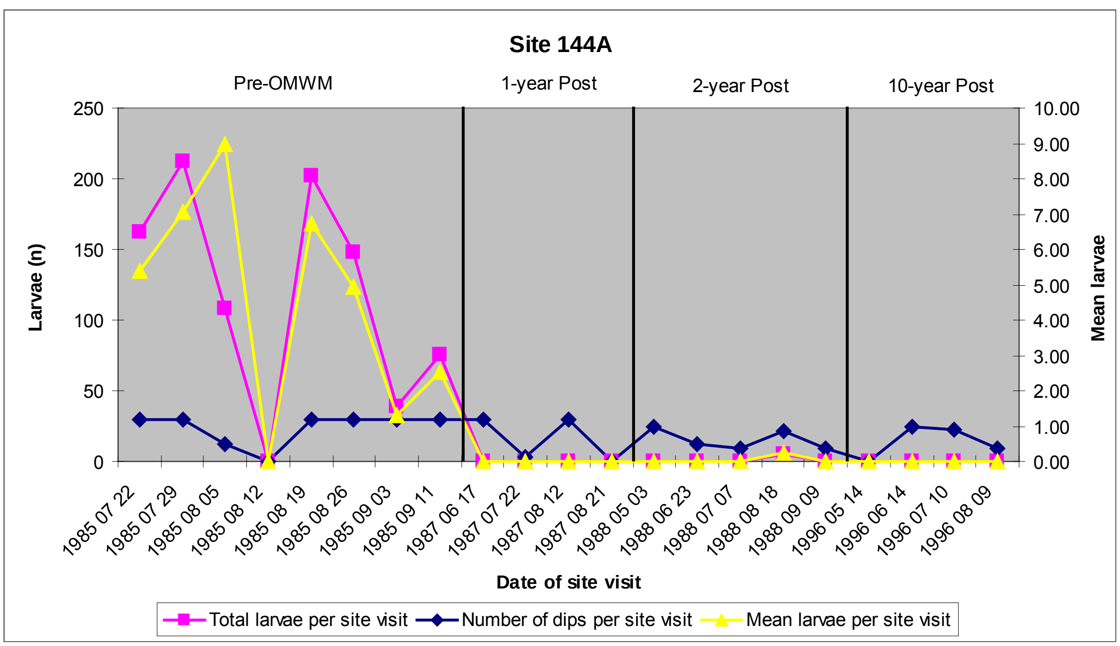

Figure 1: Site 144A, Gloucester

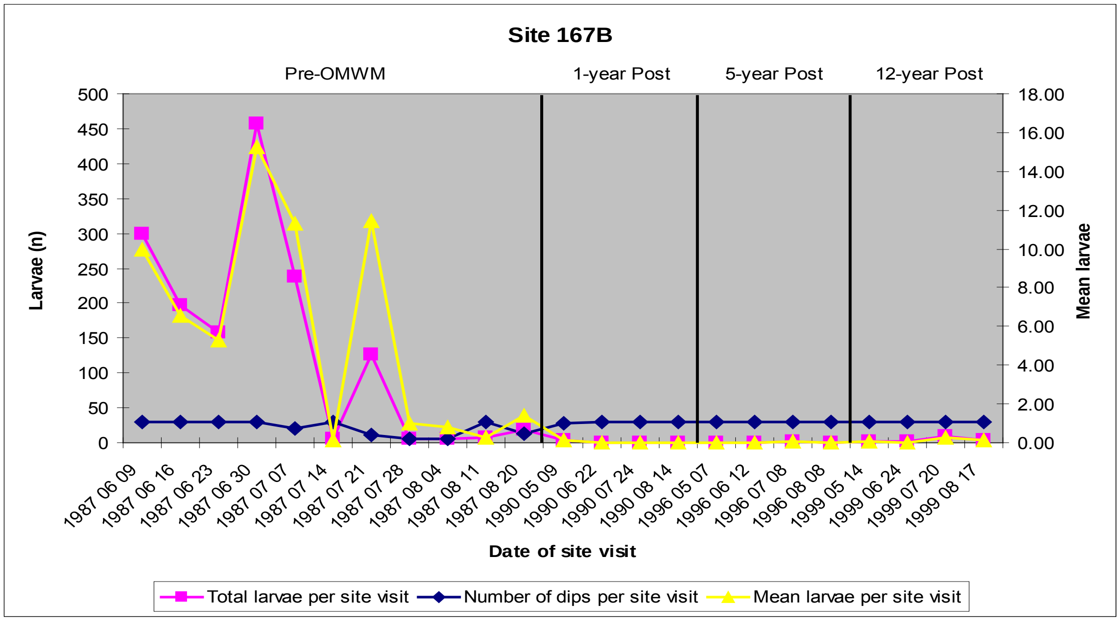

Figure 2: Site 167B, Ipswich

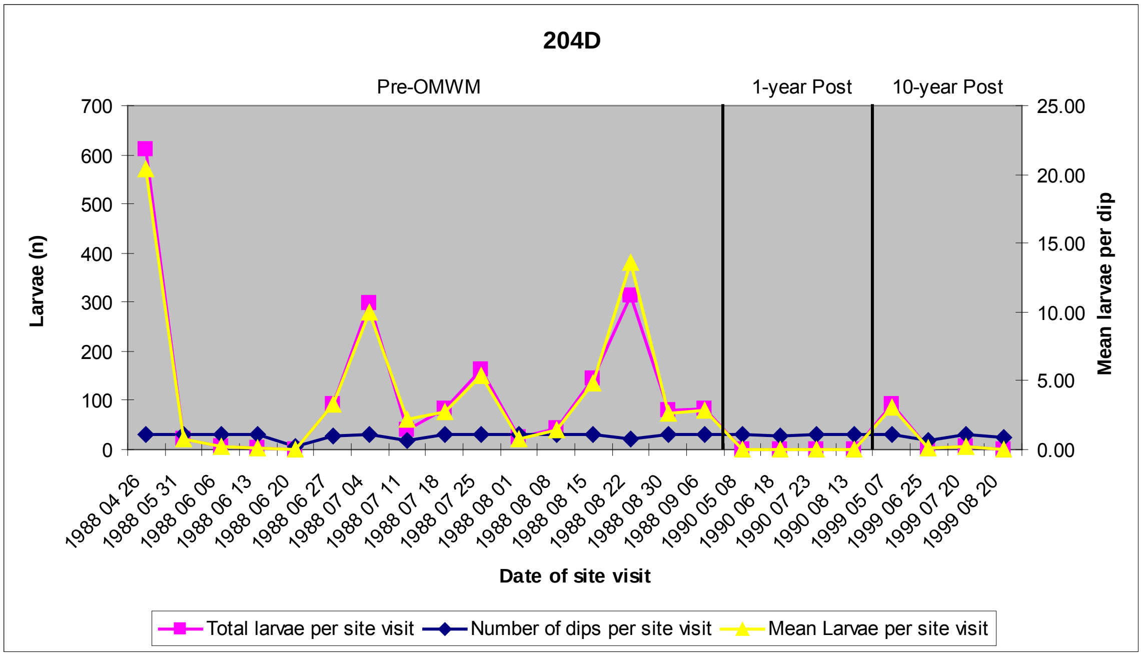

Figure 3: Site 204D, Rowley

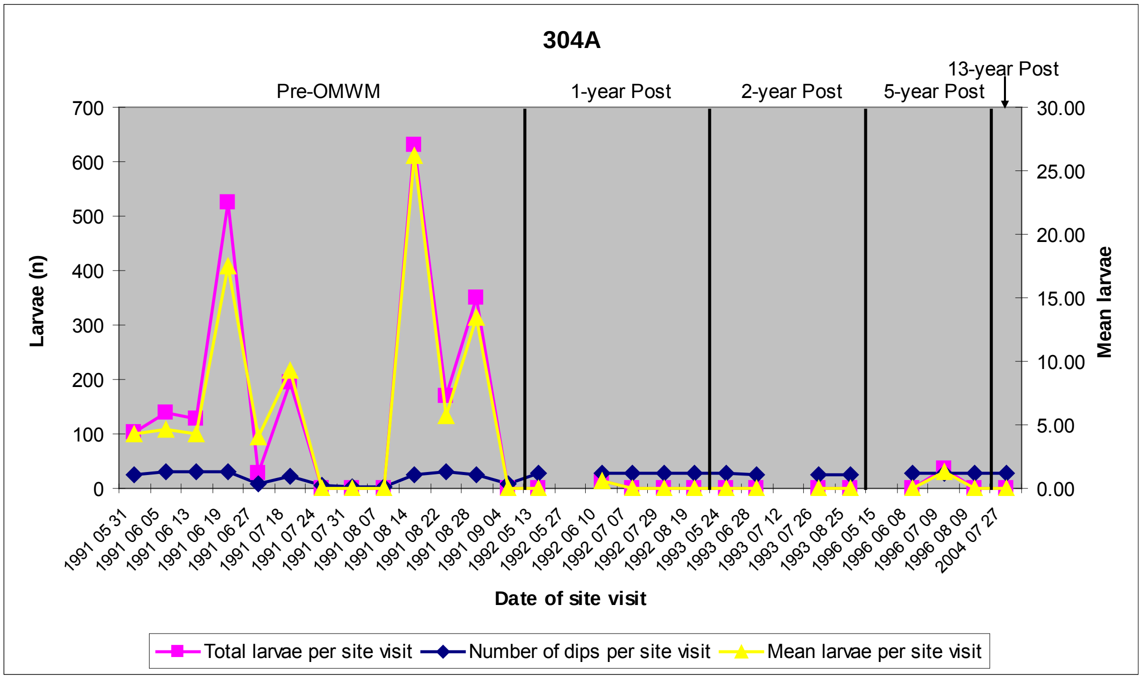

Figure 4: Site 304A, Newbury, Parker River Wildlife Refuge

Each site is unique in its own habitat, tidal hydrology, environmental concerns, vegetative community, land use and topography. These differences are all taken into consideration when collecting and analyzing data prior to conducting OMWM alterations or rejecting the site. The District designs individual site alterations to reflect all these parameters. Site descriptions for six OMWM projects, incorporating monitoring and work prior to and during the past ten years, are provided in Appendix 1.

Results

A total of 644 site visits were analyzed. Of these, 237 represented pre-alteration site visits, with the remaining 407 in various stages of post-alteration monitoring. Sites were arranged chronologically to detect possible environmental variables that may have affected mosquito breeding. The mean total number of juvenile mosquitoes per site visit prior to OMWM alterations was 129 (n = 129) (Figure 5 and Table 2). Following alteration implementation, the mean number of juvenile mosquitoes for all post monitoring periods decreases to 31.32 (n = 31.32, $\alpha = 0.05$, $P = 3.946$) and for the ten year post monitoring period this number decreases to 23.63 (n = 23.63, $\alpha = 0.05$, $P = 1.651$) (Figure 6 and Table 2).

The mean number of juvenile mosquitoes per dip per site visit also showed a marked decrease between the pre-OMWM and post-OMWM alterations. Prior to the alterations the mean number per dip was 5.84 (n = 5.845) (Figure 7 and Table 2). Following alterations the mean number of juvenile mosquitoes per dip per site visit was 1.32 (n = 1.32, $\alpha = 0.05$, $P = 1.03$) and juvenile mosquitoes per dip per site visit for the ten year post monitoring periods was 0.90 (n = 0.90, $\alpha = 0.05$, $P = 5.23$) (Figure 8 and Table 2).

One interesting observation made was in the trend of overall juvenile mosquito numbers. Chronologically there is an increasing trend in the number of juvenile mosquitoes observed prior to implementing OMWM alterations (Figures 5 and 7). Following OMWM alterations the trend in the number of juvenile mosquitoes remains static for total numbers observed (Figure 6) and shows a slight decrease in the number of juvenile mosquitoes per dip per site visit (Figure 8).

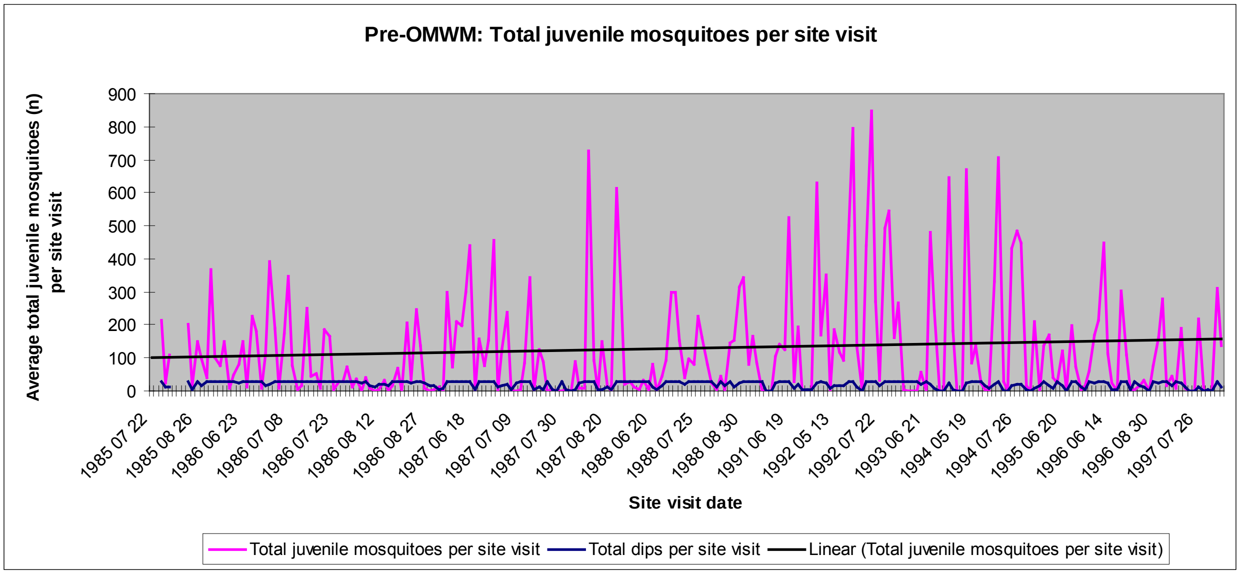

Figure 5: Pre-OMWM total juvenile mosquitoes per site visit

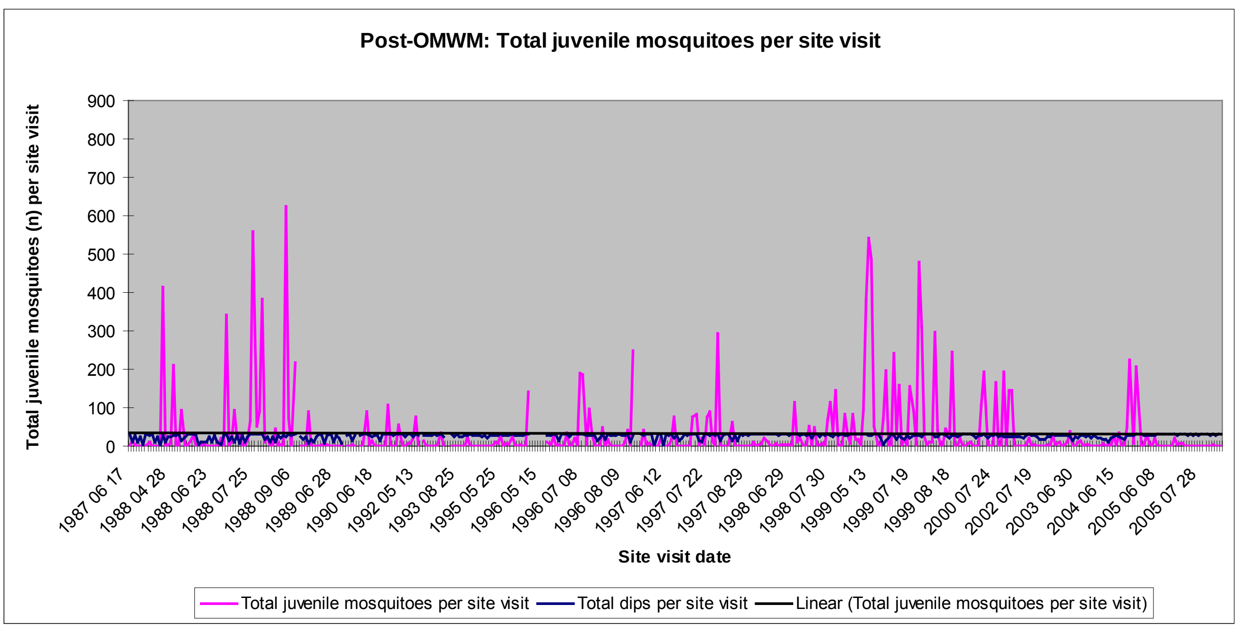

Figure 6: Post-OMWM total juvenile mosquitoes per site visit

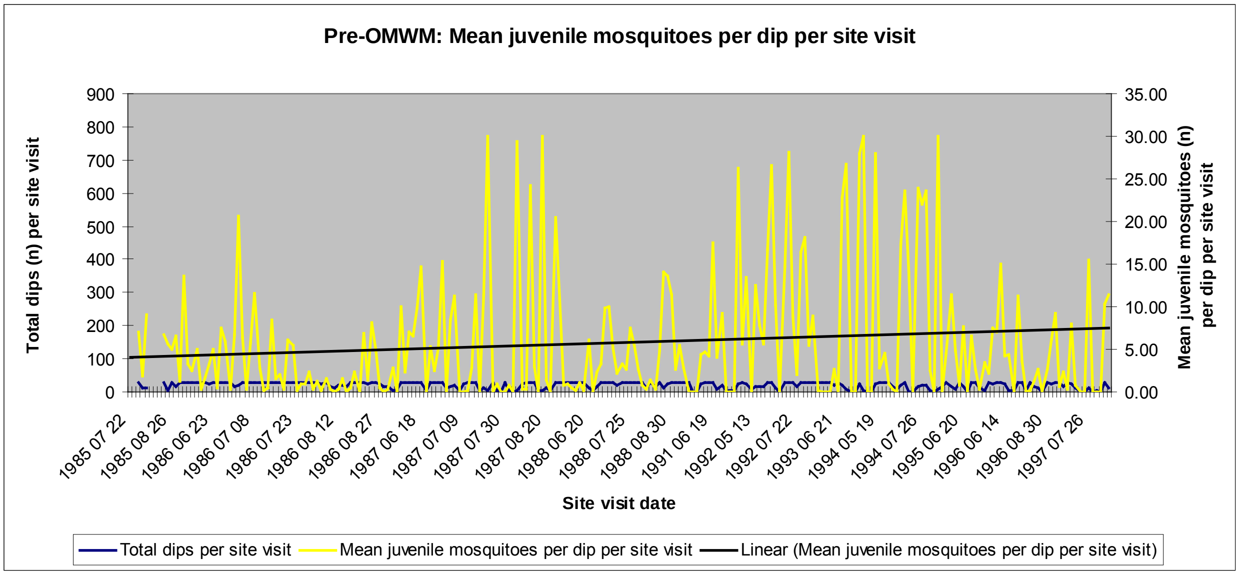

Figure 7: Pre-OMWM mean juvenile mosquitoes per dip per site visit

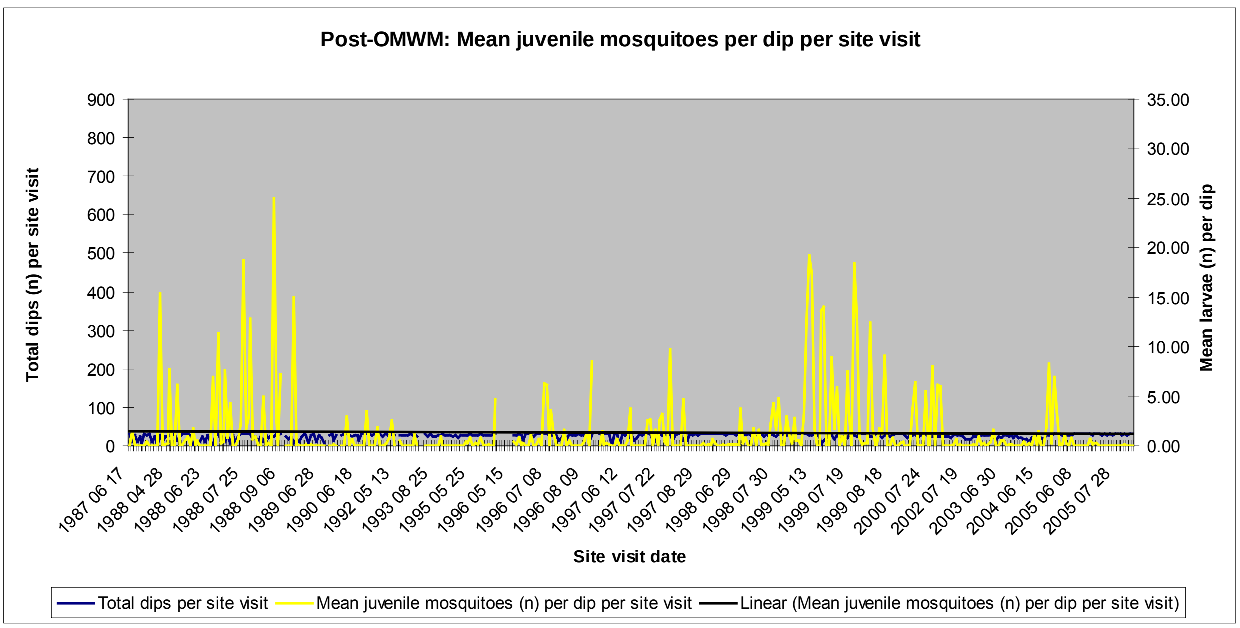

Figure 8: Post-OMWM mean juvenile mosquitoes per dip per site visit

Arranging the data by monitoring period (Figure 9) also shows a decrease in the number of total juvenile mosquitoes and the number of juvenile mosquitoes per dip per site visit after OMWM alterations were implemented. The data suggests a marked increase during post monitoring year thirteen; however, data was obtained on only two site visits for this monitoring period (Table 2). When monitoring periods with < 5 site visits are removed the data shows a continued decrease in the overall number of juvenile mosquitoes with a decreasing trend (Figure 10). Based on the current data, the program has an efficacy range of 49% - 100%, with an overall efficacy of 76%. When monitoring periods with < 5 site visits are removed the efficacy rises to 81% overall. In addition, when long term monitoring periods (8 – 12 years) are isolated from the data, the efficacy rate rises to 89%.

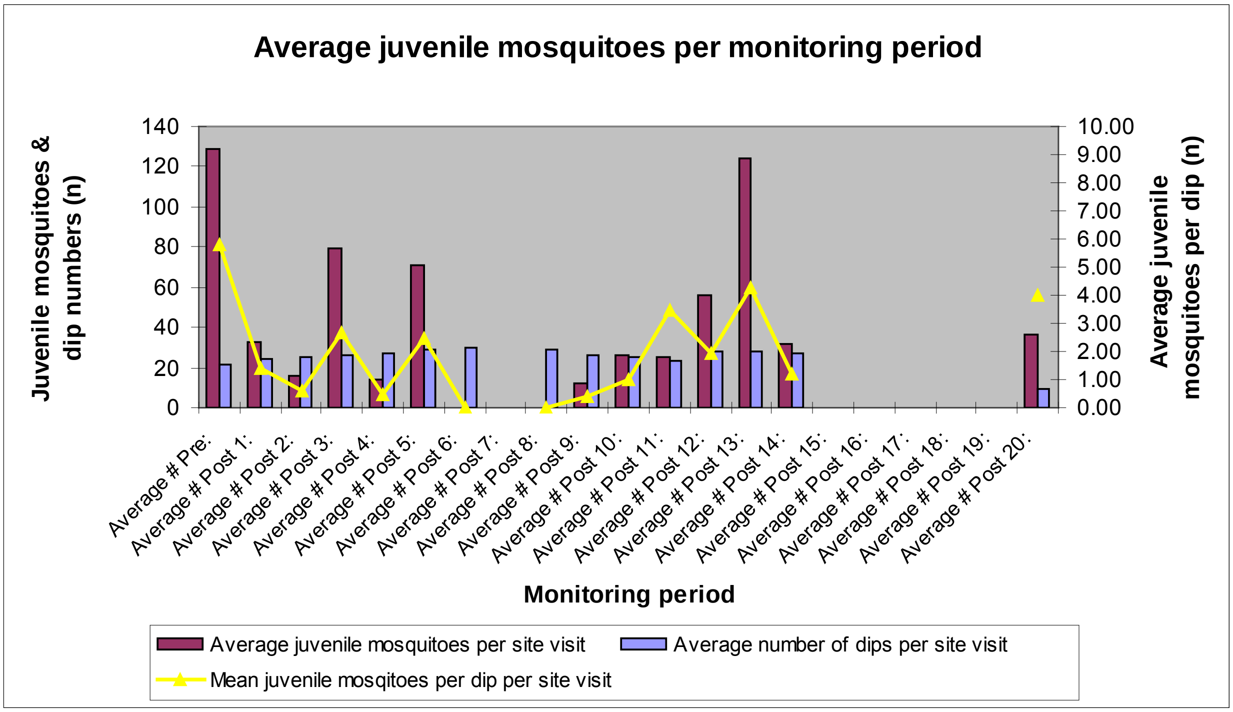

Figure 9: Average juvenile mosquito numbers per monitoring period

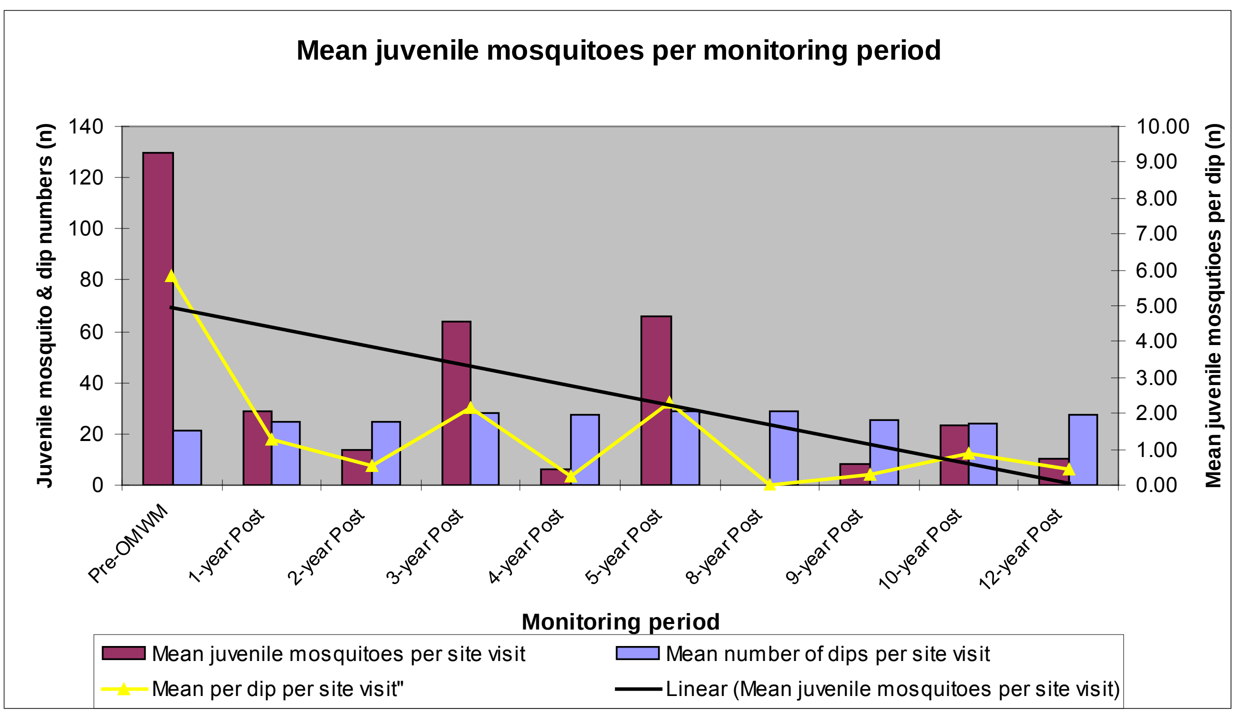

Figure 10: Mean juvenile mosquitoes per monitoring period for periods with 5 ≤ site visits

	Total larvae	# dips	Mean per dip	Total larvae / # dips	% Efficacy	# site visits
Pre-OMWM	129.47	21.04	5.84	6.15		237
1-year Post	28.64	24.71	1.26	1.16	0.78	150
2-year Post	13.93	24.76	0.54	0.56	0.89	106
3-year Post	64.00	27.83	2.16	2.30	0.51	8
4-year Post	6.00	27.17	0.22	0.22	0.95	8
5-year Post	65.84	28.74	2.32	2.29	0.49	34
6-year Post	0.00	30.00	0.00	0.00	1.00	1
7-year Post						0
8-year Post	0.00	28.80	0.00	0.00	1.00	5
9-year Post	8.39	25.67	0.29	0.33	0.94	22
10-year Post	23.63	24.35	0.90	0.97	0.82	56
11-year Post	25.50	25.75	0.87	0.99	0.80	4
12-year Post	10.50	27.50	0.43	0.38	0.92	8
13-year Post	124.00	28.00	4.28	4.43	0.04	2
14-year Post	32.00	27.00	1.19	1.19	0.75	1
15-year Post						0
16-year Post						0
17-year Post						0
18-year Post						0
19-year Post						0
20-year Post	36.00	9.00	4.00	4.00	0.72	1

Table 2: Mean juvenile mosquitoes per monitoring period

Discussion

During the past ten years the District has monitored and / or implemented work on 81 Open Marsh Water Management sites. Many of these sites had been monitored or completed prior to the ten year period in review. The others have had pre-OMWM monitoring conducted but have not yet been implemented. To present a more thorough analysis of our program it was necessary to include and analyze data from throughout the 26 year period in which the District has practiced OMWM. The data analysis presented in this review is therefore representative of the overall program.

From 1998 – 2008 the District's OMWM work was conducted in eleven municipalities and included work on the Parker River Wildlife Refuge and property under ownership of The Trustees of Reservations.(Table 3). Pre-OMWM monitoring was conducted on 46 sites, of which, 24 sites had OMWM alterations implemented. Of the 29 sites that were completed, five had been monitored prior to 1998. The remaining OMWM work consisted of post-alteration monitoring on sites in various stages of the program.

The data recorded to date for the OMWM program is representative of the overall program. In the past, data for each site was entered into a site specific database with each site visit being recorded separately. To conduct the analysis for this report, the District created a master database for the program. Due to the large amount of data collected by the District in the past 26 years, the analysis was conducted on 644 site visits, 237 pre-OMWM and 404 post-OMWM site visits. The results suggest that OMWM not only reduces mosquitoes at the time of implementation, it also acts as a long term solution by reducing the success of juvenile mosquito survival on the salt marsh.

Trend changes in juvenile mosquito numbers prior to and after alterations are difficult to assess. A chronologically increasing trend in juvenile mosquito numbers is observed in pre-OMWM data and may suggest one of two circumstances. The first is that mosquito breeding on the salt marsh is increasing and without long-term control methods, may continue to increase. It would be difficult to conclude that this is happening without further long term research including variables that are beyond the District's capacity to explore. A second possible explanation is that as the District continued to refine and improve the program personnel became more adept at locating juvenile mosquitoes and / or selecting more productive sites. The static trend observed in the number of juvenile mosquitoes observed per site visit and the decreasing trend in the number per dip per site visit suggest the effectiveness of the OMWM program to offer long term mosquito control on the salt marsh.

As OMWM is an observational science, data on fish and bird abundance was recorded using an abundance code. Changes in abundance can be inferred from changes in the abundance recorded and the number of species and / or bird guilds identified, but is limited by the basic identification skills of District personnel. Prior to OMWM alterations, District personnel recorded the majority of sites as having no fish observed or being dry at the recoverable dip station (RDS). Observations of fish being common or abundant were very limited on most pre sites. Following alterations, fish observed at the RDSs were often recorded at levels of higher abundance. There were also instances in both pre and post monitoring periods where fish were not observed due to water or environmental conditions that made it difficult to locate fish. These included, but are not limited to, algal mats, water turbidity, wind, and rain, etc.

Shorebird abundance, and other coastal avian species, was recorded using the same relative abundance code. When confident, District personnel also provided notes specific to species and referenced the type of activity observed. There does not appear to be a clear increase or decrease in the number of birds observed prior to or after alterations; however, we do find that there is in increase in the number of species utilizing the sites after alterations are implemented. This may be due to changes in prey species available after alterations, changes in bird populations along the Atlantic flyway, or increased knowledge and observational skills in District personnel as the program progressed.

During the ten year period the District held 11 Advisory Committee meetings in addition to one workshop on OMWM for committee members not familiar with the program. OMWM 101 was held in September of 2006 to clarify how the District implements the program and what parameters are followed in determining which sites are implemented. All annual meetings have documented agendas. Committee members are provided with an agenda of topics to be discussed prior to the annual meeting and any comments or concerns are discussed during the meeting. There was concern voiced at several meetings over the lack of attendance; however, it was suggested that the continued dialogue with committee members outside of the meetings and the overall success of the program may be the reason committee members did not feel compelled to attend all the meetings. Comments made throughout the ten year period suggest that the committee supports the District's continued implementation of OMWM as a mosquito control technique.

When compared to alternative methods of mosquito control, OMWM is the only technique to offer long term mosquito control benefits on the salt marsh. Open marsh water management allows for periodic monitoring of the sites to collect and record changes in juvenile mosquito abundance and recommend or implement corrections based on those findings. Alternative methods offer short term, immediate reductions in mosquito populations; however, there is no long term control. Adulticiding offers an immediate relief from adult mosquitoes that have already hatched off. Residents living along the immediate coast may be impacted by large broods of hatching mosquitoes resulting in diminished use of their properties and / or quality of life. Although adulticiding does provide relief, it should be used in conjunction with a long term control that will reduce the overall population of mosquitoes hatching from the salt marsh.

Aerial larviciding also provides a short term reduction in mosquito numbers. Areas of the salt marsh that are accessible for treatment by aircraft and are in close proximity to human populations benefit from this method. Although aerial larviciding does reduce juvenile mosquito numbers immediately following application, it does not provide a long term solution to mosquito control. District records indicate a high level of efficacy for this method (80% - 100%) with each application; however, flooding events such as unpredicted high tides or rain events can set another hatch off immediately following the spray event, resulting in increased personnel time and monetary expenditure for control. In the past few years, the District has experienced increased flooding events due to an increased number of rain events early in the season. This has resulted in an increase in the number of spray events the District must conduct to provide area residents with mosquito control.

Ditching may also provide control of salt marsh mosquitoes by draining water off the marsh, but may also result in changes to marsh hydrology and vegetative communities. Without providing access for fish to pannes and reservoirs, a ditched system results in a decrease of biodiversity and possible increase in mosquito breeding without continued maintenance of the ditch system.

It is suggested then that the alternatives do act to provide temporary control and / or relief from coastal mosquitoes; however, environmentally the alternatives do not offer the benefits that OMWM provides. Adulticiding and aerial larviciding will not act to increase ecosystem health or biodiversity and can only be said to offer a temporary control. Ditching on a non-selective basis may offer increased control on a short term basis, but likely will act to negatively alter marsh biodiversity. This can seen by the increase in fish and bird abundance based on District data and species observed on those sites that have been returned from a ditched system to a more natural state.

[1] Dip data collected by personnel as defined in the Essex County Mosquito Control Project's Standards for OMWM indicates a significant decrease in mosquito populations for sites implemented with OMWM.
[2] Species are listed: see District Mosquito Species of Concern
[3] Though local tide charts can be used to set a general time table for post monitoring, salt marsh habitats can be flooded sufficiently to produce a brood of mosquitoes without indicated tidal activity and on very little rainfall.
[4] Though this method is not precise, more accurate and costly methods of measurement are unwarranted. A site's prevalence or not, for flooding frequency is irrelevant in determining whether or where a site supports larval habitat.
[5] The District hopes to develop additional protocols for sampling and collecting soil salinities.
[6] Vegetation transect sampling standards are still being defined.
7 The District hopes to develop additional protocols for sampling and collecting fish data which will include identification of species.
8 The District is working on additional protocols that will address the Massachusetts Endangered Species Act, MESA and OMWM activities within designated habitat.
[9] Natural Heritage and Endangered Species Program
[10] Municipality of proposed project locus

OMWM Reference Library: Updated October 2008

The District continues to review literature in an effort to increase knowledge and refine its mosquito control methods. The references cited here represent this continued effort.

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APPENDIX 1: SITE DESCRIPTIONS
Compiled by Jack Card

100E Ipswich 3.7 acres 4722.5 cuft

Site 100E is located on the Crane Estate in Ipswich ,MA. This was the first site completed under the original Army Corp permit back in1986. Even though this marsh was bordered by a man made channel it was still a very tidal restricted marsh. Receiving tidal influence from a culvert under Argilla Rd. or wash over during a high run tide, parts of this marsh struggled with fresh water influence to the point where phragmites and cattail had aggressively encroached on the saltmarsh. The Trustees of Reservations allowed us to monitor and design a system to address the mosquito breeding and invasive vegetation encroachment. In 1987 an OMWM system was implemented using a bombardier back hoe and plow. 4722.5 cu.ft. of spoil was displaced on this 3.7 acre site. The system contained a gutter ditch to address the invasive vegetation encroachment, a sill ditch to enhance tidal influence, as well as 6 radials, 1 pond, 1 circuit radial and 4 reservoirs. The system worked extremely well. The encroachment of invasives was stopped and retarded in some sections, mosquito breeding was reduced as planned and good fish and bird activity was seen. Some erosion of the sill ditch base released more water than planned over time but didn't jeopardize the systems effectiveness. Deer and human activity along the edge of the gutter ditch eventually reduced further the systems water level but as a result of the culvert replacement prior to the 2000 (15 year) post visit the tidal access was increased. More invasive encroachment was retarded and breeding in locations on a site adjacent were controlled. Due to the increase in tidal influence on this restricted marsh the need for slight adjustments noted during the last review in 2000 to repair the system are on hold till further review by district personnel.

#169E Rowley 1.5 acres 4862.25 cu ft

This 1.5 acre site is located in Rowley on private and Mass Fish and Wildlife property, and is a tidal restricted marsh due to a railroad line. It's a site that historically collects thatch (rack) deposits and is fresh water influenced. Once regularly hayed, this marsh has a large portion of invasive phragmites and a perimeter ditch along the upland edge. The main focus on this site besides being a heavy mosquito breeder was the freshwater influence. Being restricted and having rack deposit issues added to the breeding potential. This site was used prior as an aerial spray monitor station. A selective ditch and 2 perimeter ditches were used to shed off the freshwater influence and as access for predatory fish. The system also containes 4 ponds, 3 pannes and 3 radials which greatly enhanced the fish access throughout the site and reduced the mosquito breeding. Deer traffic and rack are constant issues to be dealt with on this site. Mosquitos and invasives will be influenced by the system functioning properly. Low tidal influence and blockages by the rack make for periodic monitoring and hand maintenance.

204F Newbury Description: 5377.5 cu. ft.

204F is a 2.4 acre site on a back section of salt marsh owned by the Trustees of Reservations. This is a tidal restricted marsh which had a culvert replacement prior to site implementation. Heavily grid ditched and previously hayed this marsh had plugged ditches and isolated pockets of breeding mosquitoes along the upland edge. The primary focus in designing this particular site was increasing wading bird habitat and mosquito control along the upland edge. Some invasives (Phragmites and cattail) that were present on the site were reduced after the first post year and regained area after the 2 year post. Freshwater influence along the north upland corner can have a marked effect on this site during periods of above average rainfall. One ditch plug had to be resecured in 2005. Fish access throughout this system was greatly enhanced due to the 12 ponds and 5 radials which make up the system. Mosquito control is evident by the data collected. We will continue to watch this area for haying encroachment and hopefully can get back to the adjacent marsh and implement a system for mosquito control and invasive vegetation management.

#304A Description: acres 13,320.25 cu ft

304A was the first site on the refuge where the Smalley excavator was used. A large site compared to most it was where ditch plugging to create large pannes and ponds was started. By request of the Fish and Wildlife Service on PRWR ditch plugging was priority to re-establish duck and wadding bird habitat that salt marsh hay ditching had drained off. Spoil from pannes and ponds was used to plug system sections and create Pond #13. Plugging of ditches sufficiently became quite an art form. Unable to use anything other than existing spoils on site, various techniques were used to protect the plugs from top erosion and washout from tidal action as well as animal/ human activity and under ground tunneling and drainage. In 1992 and 2007 adjustments were made to the site to repair water table height and reduce mosquito breeding on an isolated section of marsh. In all 37 radials, 21 ponds, 13 reservoirs and 6 restoration plugs were implemented. Thatch (rack) was an obstacle on this site during the early 1990’s. Tidal events, wind direction, storms ect. Provided less rack deposits by the late 1990’s into 2000 and hasn’t be as prolific as in the past. This site always had fish and bird activity just not enough access for the fish into isolated areas. After OMWM was implemented, bird activity is still active and mosquito breeding has declined dramatically.

#304U Description: 304U 3852 cu ft acres

304U was a smaller site on the PRWR. Some sites boundaries were delineated by topography, ditches , mosquito breeding habitat , cost, ect. This particular site was chosen due to it's pannes and partially closed old ditch. It was able to stand alone without influence of other sites adjacent. The cost of each site is always an issue as in this case as well. The site like others was quite veiny, were as the vegetation and sod surrounding the different shallow pannes functioned as a fish obstruction. Breaking through these blockages and implementing 8 radials, and 6 ponds gave the fish sufficient access to the mosquito breeding, which is reflected in the post data.

#304X Description: 5.663 acres 7381.5 cu ft

304X was the last pre site to be completed at the PRWR. This site contained three large grid ditches that drained water off the site, leaving small isolated pockets of mosquito breeding vegetated with short form Spartina alterniflora and Disticlis spicata (spike grass). As in all PRWR sites the focus as requested was to plug old ditches to create open water for duck and wading bird access. Being able to utilize the existing ditches for spoil deposition allowed us to design and implement 11 ponds, 3 pannes and 23 radials to get fish movement throughout the site. Shallow vegetation mat and high sand veins along the upland edge forced us to utilize shallow pannes along the upland edge to prevent system water level draining. An increase in fish and bird activity followed the implementation of OMWM on this site with a dramatic decline in mosquito larvae.

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Health Consultation

CRANBERRY SAMPLING FOR ANVIL 10 + 10

SOUTHEASTERN MASSACHUSETTS

MARCH 9, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at
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or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

CRANBERRY SAMPLING FOR ANVIL 10 + 10

SOUTHEASTERN MASSACHUSETTS

Prepared By:

Center for Environmental Health
Massachusetts Department of Public Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registr
U.S. Department of Health and Human Services

I. BACKGROUND AND STATEMENT OF ISSUES

This health consultation presents the results of testing of cranberries before and after the aerial application of pesticides over southeastern Massachusetts. The aerial application was conducted to reduce human risk of eastern equine encephalitis (EEE) in that area of the state. The pesticide, Anvil 10+10 contains the active ingredient sumithrin (EPA registration #1021-1688-8329), which is a synthetic pyrethroid compound (piperonyl butoxide is also added to increase potency and duration of effectiveness). Aerial application of Anvil was planned to reduce the level of adult mosquitoes in areas where mosquito and avian surveillance showed the presence of EEE in human-biting mosquitoes, thereby presenting a high level of risk of EEE to humans.

In preparation of the 2006 mosquito season, the Massachusetts Department of Public Health, Center for Environmental Health (MDPH/CEH) had worked with other state agencies to evaluate alternative products for possible aerial application. The chemical properties for Anvil 10+10 provided the widest margins of safety for human and environmental health when used properly by certified professionals trained to use mosquito control pesticides. Studies also show sumithrin to be short-lived in the environment, to break down rapidly in sunlight, and to be less toxic to aquatic species than the alternatives considered (HSDB 2006; ATSDR 2005; Paul et al., 2005).

Anvil is not labeled for use in the air column over agricultural lands. However, the state declared a public health emergency due to the high risk to humans of EEE, and aerial application was warranted. MDPH and the Massachusetts Department of Agricultural Resources applied to the U.S. Environmental Protection Agency (USEPA) for an emergency exemption to apply Anvil over agricultural lands. The emergency exemption was received from EPA on August 3, 2006.

In order to ensure that residues of the pesticide would not be detected on cranberries or if they were, whether exposure opportunities to the residues through consumption of the cranberries would result in health concerns, the MDPH/CEH's Environmental Toxicology Program (CEH/ETP) developed a sampling and analysis plan and coordinated with the Cape Cod Cranberry Growers Association (CCCGA) to conduct the sampling of selected bogs in southeastern Massachusetts. This health consultation will be provided to the USEPA as part of a final report in response to their issuance of the emergency exemption.

II. METHODS

Sampling of cranberries was conducted both before (August 7) and after (August 11) the aerial application on August 8-9, 2006 (application occurred from approximately 8 PM to 2 AM). Sampling was conducted by MDPH/CEH in coordination with representatives of the CCCGA, who accompanied MDPH/CEH staff during each sampling round.

Sample Locations

MDPH/CEH worked with representatives of the CCCGA to identify cranberry bogs located within the aerial application zone (see Figure 1), as well as one bog located outside of the application zone to serve as a control or background. In addition to sampling at the control bog, six different cranberry bogs throughout the aerial application zone were identified for sampling. The locations of these bogs were as follows:

1. Pickens Street, Lakeville
2. Grove Street Middleborough
3. Ward Street, Carver
4. Federal Furnace Road, Carver (duplicate sample collected here)
5. Purchase Street, Middleborough
6. Main Street at Pleasant Street, Plympton
7. Long Neck Road at Every Road in Onset (control)

Figure 2 depicts the general locations of the selected bogs. At the time of sampling, the cranberry crop was not ripe and was not expected to be ready for harvesting for at least another month or more.

Sampling Procedure

Each bog, including the control, was sampled in the same overall manner. Five separate sample jars were collected from each bog from approximately the four corners of the bog and the center. The samples for each bog were composited (mixed) in the laboratory before analysis resulting in a single representative sample from each bog. A total of 2500 mL of cranberries was collected from each bog. Field sample jars were 500 mL in capacity, amber glass, precleaned and certified clean from the manufacturer. Amber (dark) colored bottles were selected because the target analyte (sumethrin) is known to be sensitive to photodegradation.

Three teams conducted the sampling in order to reach all the required geographical areas in a timely manner. For the pre-spray sampling, each team consisted of one member of the CCCGA and two staff from MDPH/CEH. The post-spray sampling was conducted with one member of the CCCGA and one member of MDPH/CEH staff. The cranberries were harvested from the bogs by the members of the CCCGA because of their familiarity with the activity. Cranberries were removed using a traditional cranberry harvesting tool composed of metal and wood in the form of a scoop with teeth. A photo of the tool and sampling activity can be found in Figure 3.

The amount of product for typically filling one jar was scooped from the bog by the CCCGA member. The cranberries were then transferred to the glass jar. Only cranberries were collected in each jar; sticks, vines and other non-cranberry material was excluded to the extent feasible. Each jar was filled to the top, but not packed.

Once they were filled and sealed with the lid, each jar was labeled with the name and number of the bog and the date and time of collection. The same information, along with details about the location of the bog, the locations for the individual samples, and

other no
with ice.

At one location, Federal Furnace Road in Carver as indicated above, a duplicate sample was collected in the same manner as the original sample. Duplicate samples are used to assess the variability in analytical results that originate in the sampling technique or heterogeneity in the bulk material as present in the field. It is a standard quality control practice to collect and analyze duplicate samples for a percentage of sampling sites.

No specific decontamination procedures were used for the sampling tools; however, the "control" bog located in Onset was sampled before the other bogs that team sampled to reduce the potential for cross contamination from the tools used.

Sample Handling and Shipping

Samples were held in the coolers with ice until they were delivered later the same day to the MDPH State Laboratory Institute (SLI) in Jamaica Plain for temporary storage and shipment. At the SLI, the samples were logged in by staff and refrigerated. Samples were kept overnight under refrigeration and then repackaged for shipment to the analytical laboratory (Golden Pacific Laboratories in Fresno, California) the following day. Samples sent to the CA analytical laboratory were packaged with dry ice and sent via UPS next morning service. The samples were received the next morning as expected for each of the two sampling events. Chain of custody forms were used to transmit the samples to the analytical laboratory. Once at Golden Pacific Laboratories, the cranberry samples were kept stored under refrigeration until they were used for analysis.

Sample Analysis

Cranberries were analyzed for the presence of sumithrin, an active ingredient in Anvil 10+10. The handling and analysis of samples at the Golden Pacific Laboratory was conducted in accordance with the written protocol from the laboratory. The analysis protocol includes method development and verification based on the pre-spray samples; Golden Pacific Laboratories has developed and verified testing for sumethrin on other agricultural crops including leaf lettuce, alfalfa, and Sudan grass. A calibration curve was developed to be used to quantify the levels of sumethrin in the cranberry samples using a certified sumethrin reference material.

Cranberry samples were homogenized with dry ice prior to analysis by High-Pressure Liquid Chromatography and Mass Spectroscopy (HPLC/MS/MS). The pre-aerial application samples were subject to fortification with the sumethrin reference standard at 10 and 100 parts per billion (ppb) to ensure that levels of interest could be detected in post-spraying samples. This calibration curve was used to determine if the recovery of sumethrin from the fortified samples was within acceptable limits.

All analyses were performed in accordance with all Standard Operating Procedures (SOPs) for the lab using the calibration curves developed in the method development phase and any changes made to accommodate the novel sample matrix. All deviations from SOPs were documented by the laboratory and described in the report they prepared for MDPH/CEH.

III. RESULTS

Results of all analyses of cranberries for sumithrin revealed no detectable levels of sumethrin in any sample, whether taken prior to the aerial application event or after the event. The laboratory reported the Level of Detection (LOD) was 2 parts per billion (ppb). An LOD is defined as the lowest detectable limit on a given instrument for a given analysis. The level of quantification (LOQ) for the analysis was 10 ppb. The LOQ is defined as the lowest validated level established during method validation. In addition, the methods developed for the analysis of cranberries for sumethrin residues were successful under the quality assurance and quality control procedures used at the laboratory and will be documented in a separate Good Laboratory Practices report to be produced by Golden Pacific Laboratories.

IV. DISCUSSION

Results from the testing of cranberries for sumithrin, an active ingredient of the pesticide used for aerial application in southeastern Massachusetts showed no detectable levels of this compound in any cranberry sample, either pre- or post-application. The post-application samples were taken approximately 48 hours after the application and hence, it is not expected that future applications of this pesticide will result in residues. The 48-hour time period also corresponded to the USEPA requirement in the emergency exemption that a pre-harvest interval of 48 hours must be adhered to.

Although ATSDR does not have any guidance level for exposure opportunities to sumithrin, the USEPA Office of Pesticide Programs and the World Health Organization have published a chronic oral reference dose of 0.071 milligram sumithrin per kilogram body weight per day (mg/kg-d) for this compound (USEPA 1997; WHO 1990). This corresponds to ingesting a little more than 1 mg/day of sumithrin for a 15-kg child, or nearly 5 mg/day of sumithrin for a 70-kg adult. The LOD for sumithrin in the cranberry analyses was 2 ppb, or 0.002 mg/kg. In order for a child to receive 1 mg of sumithrin, the child would have to consume 500 kg, or over 1,000 pounds, of cranberries. An adult would have to consume five times that amount. Thus, the LOD achieved in the analyses of cranberries is well below any level of concern for either children or adults.

V. CONCLUSIONS

Testing of cranberries for sumithrin did not reveal the presence of this compound in cranberries sampled either before or after aerial application. Based on ATSDR criteria, ATSDR would classify the August 8-9, 2006, application of Anvil 10+10 over cranberry bogs as posing "No Public Health Hazard."

VI. RECOMMENDATIONS

The results of the cranberry sampling did not reveal the presence of sumithrin, hence, no specific recommendations or follow-up activities are recommended at this time.

VII. PUBLIC HEALTH ACTION PLAN

Copies of this report will be provided to the U.S. Environmental Protection Agen the Massachusetts Department of Agricultural Resources, the Cranberry Growers Association, and other interested parties.

Preparer of Health Consultation

This document was prepared by the Center for Environmental Health, Massachusett
Department of Public Health. If you have any questions about this document, please contact Suzanne K. Condon, Associate Commissioner, MDPH/CEH, 7th Floor, 250 Washington Street, Boston, MA 02108.

CERTIFICATION

The health consultation for cranberry sampling in Southeastern Massachusetts was prepared by the MDPH under a cooperative agreement with the federal ATSDR It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the Cooperative Agreement partner.

Robert B. Knowles, M.S., REHS
Technical Project Officer, CAPEB
Division of Health Assessment and Consultation
Agency for Toxic Substances & Disease Registry

Alan W. Yarbrough, M.S.
Team Lead, CAPEB
Division of Health Assessment and Consultation
Agency for Toxic Substances & Disease Registry

VIII. REFERENCES

ATSDR. 2005. Toxicological information about insecticides used for eradicating mosquitoes (West Nile virus control). Agency for Toxic Substances and Disease Registry, Atlanta, GA. April 2005.

HSDB. 2006. Hazardous Substances Data Bank, National Library of Medicine, National Toxicology Program. Record on CASRN: 26002-80-2 (Sumithrin).

Paul, E.A., H.A. Simonin, and T.M. Tomajer. 2005. A comparison of the toxicity of synergized and technical formulations of permethrin, sumithrin, and resmethrin to trout. Arch. Environ. Contam. Toxicol. 48(2):251-9.

USEPA. 1997. Reference dose tracking report: sumithrin. U.S. Environmental Protection Agency, Office of Pesticide Programs, February 25, 1997.

WHO. 1990. Environmental Health Criteria 96: d-Phenothrin. International Program on Chemical Safety, World Health Organization, Geneva, Switzerland.

Figure 1
Geographic Extent of August 8, 2006 Aerial Application
Bristol and Plymouth County, MA

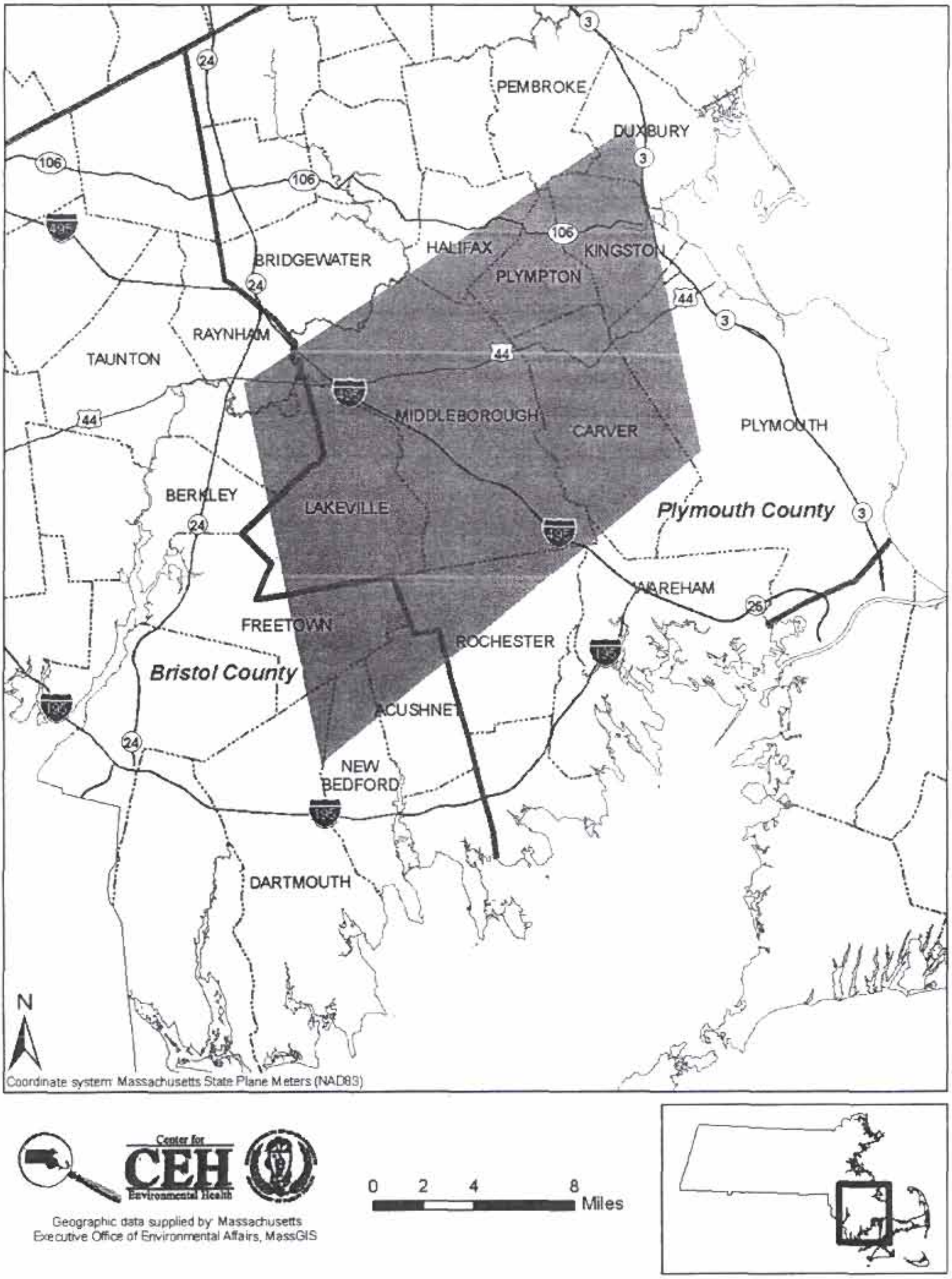
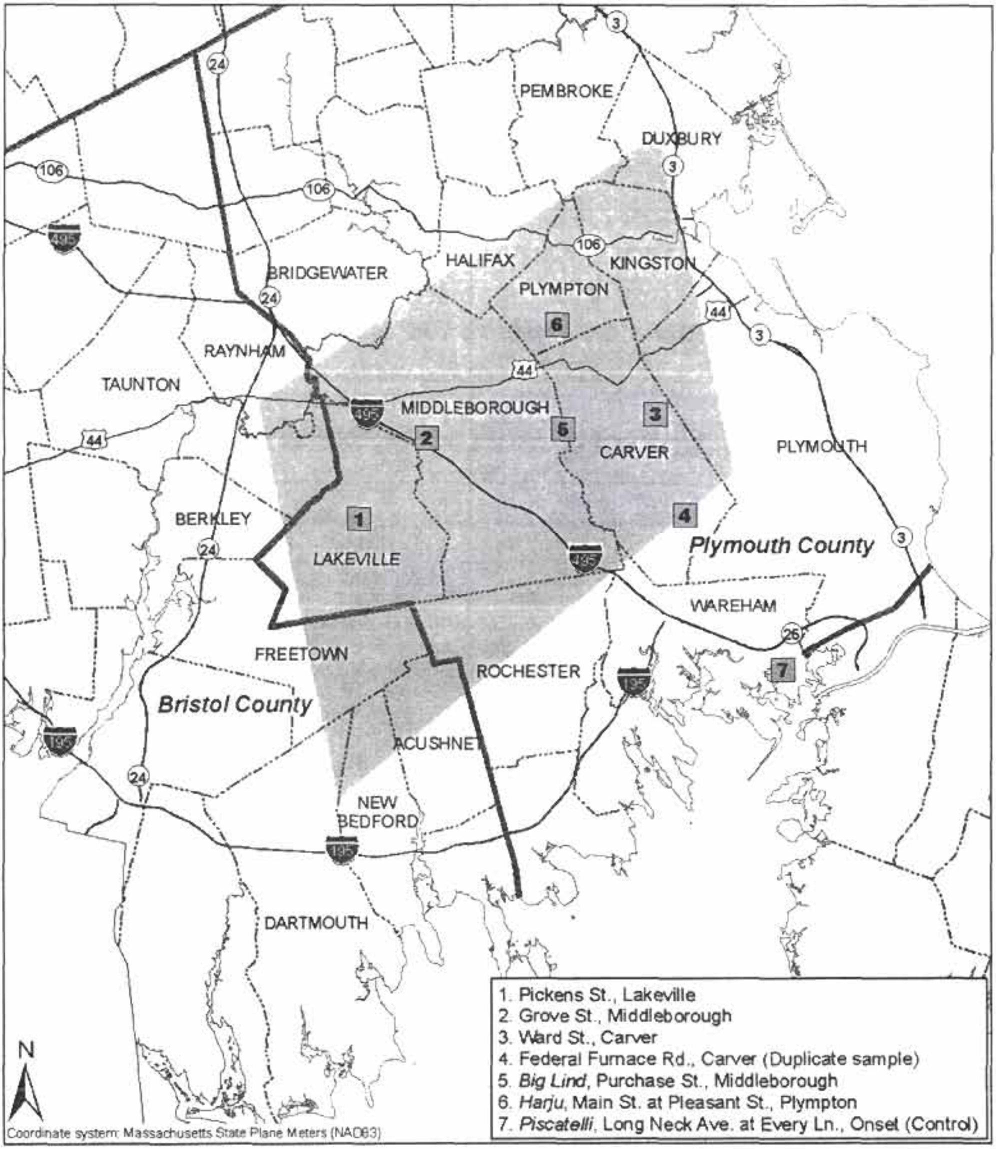


Figure 2
Geographic Extent of August 8, 2006 Aerial Application
with Approximate Bog Sampling Locations
Bristol and Plymouth County, MA



Center for CEH Environmental Health

0 2 4 8 Miles

Geographic data supplied by: Massachusetts Executive Office of Environmental Affairs, MassGIS

Figure 3. Cranberry Sampling Tool and Procedur

Appendix A: Results of Analyses of Cranberries for Sumithrin.

Table 1 of 1
Summary of Sample Analysis Results of Sumithrin in/on cranberries

GPL Study #060242

Date Printed: 1/11/2007
Prepared By:

Extraction Set: 242SET01
Analysis Set: 242SET01
Extraction Date: 8/17/2006
Analysis Date: 8/17/2006
Injection Volume: 20 µl

Standard Injections: Sumithrin

Standard ID	Standard Amount (µg/mL)	Peak Area	Back Calc of Standard (µg/mL)	RPD
669-9	0.250	347.2	0.293	15.8
669-8	0.500	715.6	0.549	9.34
669-7	1.00	1409.8	1.03	2.96
669-6	2.00	2617.3	1.87	-6.72
669-5	5.00	7102.1	4.98	-0.401
669-4	10.0	14373.0	10.0	0.00
669-7	1.00	1360.5	0.997	-0.300

Curve Equation: y = 1.44e+003 (x) -75.4
where y is response in peak area units
and x is concentration in µg/mL ("1/x" weighting)
Coefficient of Determination (r^2): 0.9996
Correlation Coefficient (r): 0.9998
RPD = Relative Percent Difference

$$\text{RPD} = \frac{(\text{Std Back calc} - \text{Std Amount}) \times 2 \times 100}{(\text{Std Back calc} + \text{Std Amount})}$$

NA = Not applicable
LOQ = Limit of Quantitation

Sample Information:

Lab ID	Sample ID	Sample Amount (g)	Final Volume (mL)	Peak Area	Concentration from Curve (ng/mL)	Sample Concentration[1] (ng/g)	Fortification Amount (ng/g)	Percent Recovery[2] (%)
242SET01-1	Control (PISC Composite)	9.96	130	0.0	<0.250	<LOQ	NA	NA
242SET01-2	Low Spike (10 ppb)	10.01	130	1001.0	0.747	9.70	10.0	96.9
242SET01-3	High Spike (100 ppb)	9.99	650	1999.1	1.44	93.7	99.9	93.8
242SET01-4	FF Composite	9.99	130	0.0	<0.250	<LOQ	NA	NA
242SET01-5	FF Dup Composite	9.97	130	0.0	<0.250	<LOQ	NA	NA
242SET01-6	Ward Composite	10.01	130	0.0	<0.250	<LOQ	NA	NA
242SET01-7	PUR Composite	10.01	130	0.0	<0.250	<LOQ	NA	NA
242SET01-8	HAR Composite	10.03	130	0.0	<0.250	<LOQ	NA	NA
242SET01-9	WG Composite	9.96	130	0.0	<0.250	<LOQ	NA	NA
242SET01-10	PIC Composite	9.96	130	0.0	<0.250	<LOQ	NA	NA
242SET01-11	POST-4 FF Composite	9.99	130	0.0	<0.250	<LOQ	NA	NA
242SET01-12	Post-4 Dup FF Composite	10.03	130	0.0	<0.250	<LOQ	NA	NA
242SET01-13	Post-3 Ward Composite	10.03	130	0.0	<0.250	<LOQ	NA	NA
242SET01-14	Post-7 PISC Composite	10.01	130	0.0	<0.250	<LOQ	NA	NA
242SET01-15	Post-5 PUR Composite	10.01	130	0.0	<0.250	<LOQ	NA	NA
242SET01-16	Post-6 HAR Composite	10.00	130	0.0	<0.250	<LOQ	NA	NA
242SET01-17	Post-2 WG Composite	10.00	130	0.0	<0.250	<LOQ	NA	NA
242SET01-18	Post-1 PIC Composite	10.02	130	0.0	<0.250	<LOQ	NA	NA

LOQ = 10 ppb

[1] Sample Conc. in ng/g = (Concentration from Curve in ng/mL x Final Volume in mL) ÷ (Sample Amount in g)

[2] Percent Recovery (%) = Sample Concentration in ng/g ÷ Fortification Amount in ng/g x 100.

Note: Sample Concentration, Percent Recovery and RPD values are calculated by Excel. All other calculations are performed by Analyst. These values are rounded to three significant figures and transcribed to the Excel spreadsheet.

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE DIVISION OF FISHERIES AND WILDLIFE
AND
THE DEPARTMENT OF AGRICULTURAL RESOURCES

I. BACKGROUND, AUTHORITY AND PURPOSE

This Memorandum of Understanding (hereafter referred to as the "agreement") is made and entered into by and between the Division of Fisheries and Wildlife (DFW), and the Department of Agricultural Resources (DAR) under the authority of G.L. c. 21A, s.2. The Department of Agricultural Resources and the Division of Fisheries and Wildlife have a common interest in efficiently and effectively protecting the public health and safety through the control of mosquito born diseases and insuring the protection and conservation of state listed species and their habitats through the implementation of the state Endangered Species Act and associated regulations

II Legal Authorities of the Parties Hereto:

Division of Fisheries and Wildlife

1. The Division of Fisheries and Wildlife is responsible for administering the requirements of the Massachusetts Endangered Species Act found at G.L. c. 131A.
2. It is unlawful except as otherwise provided in G.L. c. 131A for a person to take…any plant or animal species listed as endangered, threatened or of special concern. G.L. c. 131A § 2.
3. The definition of a "person" includes any officer, agent, department or instrumentality of the federal government or any state or its political subdivisions". G.L. c. 131A § 1.
4. The definition of "take"
    - In reference to <u>animals</u> means to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding, or migratory activity or attempt to engage in any such conduct, or to assist such conduct. G.L. c. 131A § 1
    - In reference to <u>plants</u> means to collect, pick, kill, transplant, cut or process or attempt to engage or to assist in any such conduct. G.L. c. 131A § 1

Department of Agricultural Resources

1. The Department of Agricultural Resources is responsible for administering the requirements of the Massachusetts Pesticide Control Act. G.L. c. 132B.
2. The exclusive authority in regulating the labeling, distribution, sale, storage, transportation, use and application, and disposal of pesticides in the Commonwealth shall be determined by G.L. c. 132B.
3. A "Pesticide's" intended use is for preventing, destroying, repelling, or mitigating any pest, and any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. G.L. c. 132B § 2.
4. A "Pest" is an insect, rodent, nematode, fungus, weed, or any other form of terrestrial or aquatic plant or animal life or virus, bacterium, or other micro-organisms on or in living man or other living animal, which is declared to be a pest by the administrator or by the department with the approval of the board. G.L. c. 132B § 2.

TERMS

Responsibilities of the Parties:

Division of Fisheries and Wildlife will:

Consult with the Mosquito Control Districts (MCD), State Reclamation and Mosquito Control Board (SRMCB) and, DAR on the potential non-target impacts of pesticides to state listed species.

Provide a GIS mapping product indicating areas where pesticide application may result in the take of a state listed species and would be subject to the provisions of Chapter 131A and implementing regulations (321CMR 10.0). Maps will be developed as pesticide-product/application specific and mapping design may be altered as maps are used and additional information is developed. Maps will be available by February 1 of each year and will be based on the most up-to-date information on pesticides to be used and method of application provided by DAR.

Provide an expedited review of larviciding or adulticiding that is determined to be necessary to protect the public health and safety as determined by the Department of Public Health and would be conducted in areas delineated by DFW to be subject to 321 CMR 10.0

Conduct annual review of ditch maintenance plans or review individual projects for each District, as required under 321 CMR 10.00.

Conduct workshops and training sessions on the state Endangered Species Act and implementing regulations, with specific reference to impact of pesticide applications.

Allow MCD personnel to set traps and monitor for the presence of mosquitoes carrying diseases. DFW may establish reasonable protocols to ensure that trap locations and monitoring activities do not cause harm to state listed species.

Department of Agricultural Resources will:

Engage in consultation with DFW on the potential non-target impacts to state-listed species of pesticides.

Provide an annual listing of all pesticides used by Projects with information about target location (e.g., catch basins, wetlands, etc), timing of use, method of application (e.g., truck-based, aerial, back-pack sprayer), form of pesticide (e.g., granular, pellet, briquette), brand (when known), target concentration, and other relevant information.

Provide information used by the Pesticide Board to register each pesticide.

Provide *staff expertise* and updates to toxicity information or data/results not widely available as relevant to pesticides and state listed species.

Districts in coordination with SRMCB will provide an annual ditch maintenance plan for DFW review subject to the321 CMR 10.00, 90 days prior to first "work" date.
Sign agreements not to disclose information related to location of specific state listed species.

Allow and facilitate access to work sites during or after an activity to help DFW understand field methods and decision-making.

Provide to DFW as soon as practical any changes in pesticides to be used and application method in the next year.

The two Departments will jointly:

Share and review information, data and analysis of potential impacts relative to the adverse impacts posed by pesticides to state listed species.

Work to develop scientific consensus between the two agencies as to what the impact are, and how they should best be managed.

In the event that a public health emergency is called or appears imminent, both agencies agree to involve the other in any decision making process that would involve either the use of pesticides in the habitat of state listed species, or the limiting of pesticides in state listed species habitat. Both parties recognize that the final determination of what constitutes a threat to public health rests with the Department of Public Health.

III. PERIOD OF AGREEMENT

This agreement will remain in effect unless terminated by a signatory or designee in writing. This agreement may be terminated by either party to the agreement by giving thirty days written notice to the other party of its intention to terminate.

VI. SPECIAL PROVISIONS

A. The Commissioner of DAR, or his designees, the Director of DFW or his designees, and the Commissioner of Fish and Game shall meet annually to review compliance with the provisions of this agreement and develop additional policy and programmatic changes as agreed upon. Amendments to this agreement may be proposed by each party at any time and shall become effective as attachments to the original agreement upon execution of both parties.

B. This agreement shall become effective, and remain in effect, upon the date when signed by the last signatory.

C. DAR and DFW will work collaboratively to minimize or eliminate the adverse impacts associated with use of pesticides on lands under the care and control of DFW.

D. DFW and DAR will work in parallel with Department of Public Health to minimize impacts to state listed species from the aerial adulticiding associated with a "public health emergency" declared under M.G.L. c. 17, § 2A.

IN WITNESS WHEREOF, the parties have executed this memorandum of understanding on the day, month and year indicated:

Mary B. Griffin — 7/12/07

Commissioner, Department of Fish and Game — Date

Wayne F. MacCallum — 7/12/07

Director, Division of Fisheries and Wildlife — Date

[signature] — 7/17/07

Commissioner, Department of Agricultural Resources — Date

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND
ENVIRONMENTAL AFFAIRS
Department of Agricultural Resources
State Reclamation and
Mosquito Control Board
251 Causeway Street, Suite 500
Boston, MA 02114-2151
http://www.mass.gov/agr/mosquito/index.htm

DEVAL L. PATRICK
Governor

TIMOTHY MURRAY
Lt. Governor

Mark S. Buffone, Chairman
Department of Agricultural Resources
Anne Monnelly
Department of Conservation and Recreation
Gary Gonyea
Department of Environmental Protection

IAN A. BOWLES
Secretary

DOUGLAS W. PETERSEN
Commissioner

Alisha Bouchard
Project Administrator
Tel: (617) 626-1715
Fax:(617) 626-1850

Friday, October 24, 2008

Secretary Ian A. Bowles
Attn: MEPA Office
100 Cambridge Street, Suite 900
Boston MA 02114

Dear Secretary Bowles:

On Friday, October 3, 2008, the State Reclamation and Mosquito Control Board ("the Board") met with MEPA Director, Alicia McDevitt, receiving further direction and guidance pertaining to certificates #5027 dated February 15, 2008 and October 25, 1998. The first EIR update, as directed in the certificate, was due within six months. Regretfully, the Board was unable to meet the deadline and would like to file this update as requested including the Board's plan to meet the information needs outlined in the February 15, 2008 certificate.

To date, the Board has submitted an update titled the **Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control** ("the BMP") on November 26, 2007. This document includes best management practices (BMPs) and operational guidance for mosquito control activities conducted in freshwater wetland resource areas.

Resubmitting the BPM with Revisions

As a result of public review, the Board is resubmitting this document with revisions based upon the public comments received. Specifically, the Board made the following changes:

1. Incorporated language provided by the Natural Heritage Endangered Species Program to clarify their programmatic requirements;
2. Clarified in the BMP that, as discussed in MassDEP's Stormwater Management handbooks, the owners of the property that develop the stormwater BMPs, or municipalities that "accept" them through local subdivision approval, are responsible for their operation and maintenance to ensure that the BMPS are operating effectively. Essentially, answering public comments to clarify that the Board and its mosquito control districts are not responsible for the operation and maintenance of stormwater BMPs, but that these structures can be included in the MCDs larvicide treatment plans and MCDs can alert local municipalities when they encounter poorly maintained BMPs;
3. Strengthened the BMP language insuring that the mosquito control districts will survey the project site for mosquito larvae during the standard site inspections to insure the BMP practice is effective in the short and long term. Mosquito dip counts and other post project observations on mosquito breeding viability will be recorded on the field inspection forms. Additionally, the Board has requested that MCDs develop a post- project monitoring procedure before the next mosquito season which will be appended to the BMP as an update.

Submitting Responses to Public Review Comments

Along with the aforementioned revisions, the Board is attaching its responses to comments received during the public review on other mosquito control related issues.

Request for Extension

At this point in time, the Board respectfully requests an extension in order to more fully meet the EIR update outlined in both certificates of February 15, 2008 and October 25, 1998. *Note: Both of these certificates are attached.* The Board anticipates it will reach its goal by the end of March, 2009.

Upcoming Submissions

As discussed with Director McDevitt, the Board expects to file revised Open Marsh Water Management (OMWM) standards along with a document that provides a 10-year review and evaluation of OMWM by the end of the year. Currently, a workgroup has been formed by Coastal Zone Management (CZM) to assist the Board and other MCDs with ongoing state environmental review of OMWM under MEPA, Federal Consistency, and 401 Water Quality Certification. The focus of the work group will be to recommend a monitoring design and integrated protocols that can measure and allow reporting on (1) the effectiveness of mosquito control through salt marsh habitat modifications that increase the presence of mosquito larvae-feeding fish species (primarily Fundulus spp.) and (2) effects on the ecology and functioning of the affected environment and will not pose unreasonable new resource demands on the Districts.

Board Request for Response (RFR) For Consultant Services

The Board has recently posted an RFR with the intent of hiring a consultant to assist the Board and MCDs in addressing other issues outlined in the February 15th certificate. The Scope of Services outlined in the RFR includes the following:

1) Prepare a draft final report outline for SRMCB review and approval.
2) Assist SRMCB in addressing issues raised in comment letters received by the Secretary of EOEEA.
3) Summarize the current mosquito control organization and discuss the changes that have occurred over the past 10 years closing the knowledge gap circa 1998 – 2008.
4) Summarize policy, administrative and other steps taken by SRMCB since issuance of the 1998 GEIR.
5) Describe what and how mosquito control is being currently conducted, how it has changed, and how it has not changed highlighting any improvements and revisions. Improvements can be highlighted by incorporating existing documents maintained by the SRMCB that can be incorporated into the report or referenced as appendices such as Massachusetts state review of a common larvicide used by mosquito control projects called methoprene, Mass DPH workgroup reports, recently adopted policies, and operational reports for each regional mosquito control project, and newly developed Best Management Practices (BMPs).
6) Describe the process of how decisions are made to use pesticides and/or to response to public health situations. This section should highlight and define in crystal clear fashion the use of Integrated Pest Management (IPM) and how the mosquito control projects use it to monitor results to measure the effectiveness and impacts of mosquito control practices. This section can highlight a review of studies done elsewhere on the same practices in similar habitats and cite any Massachusetts data too. This section would catalogue changes in pesticide products and inventory the current products in use now.
7) Discuss limiting factors for current mosquito control practices including but not limited to municipal finance/budget concerns to be regionally sustainable, lack of resources and personnel to conduct peer review research, and operational limitations for example spraying at dusk.
8) Provide a conclusion section that provides a work plan and schedule for developing additional information and procedures to assess and guide SRMCB's mosquito control program for the future if additional resources were available.

The RFR is attached to this letter.

Other Documents attached

The Board also respectfully provides the following documents which pertain to both public comments received and the Secretary's Certificate.

1. 2008 MassDPH Arbovirus Surveillance and Response Plan
2. 2008 Operational Response Plan to Reduce The Risk of Mosquito-Borne Disease in Massachusetts
3. 2006 Aerial Spray Final Summary Reports for August 8^{th} and 9^{th}, and August 22^{nd} through 24^{th}
4. Choice of Anvil 10+10 for Aerial Mosquito Control Memo dated July 28, 2006
5. 2006 EPA Final Report dated March 6, 2007 on use of Anvil 10+10
6. Board letter dated March 4, 2002 to MEPA Director
7. Request for Response (RFR) For Consultant Services

The Board hopes that this filing and upcoming submissions will comply with the Certificate issued February 15, 2008.

Sincerely,

Mark S. Buffone

Mark S. Buffone
Chairman

October 24, 2008 MEPA Filing from State Reclamation and Mosquito Control Board Package and Attachments

1) Cover Letter
2) Revised Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control dated October 24, 2008
3) Board Responses to Public Comments dated October 24, 2008
4) MEPA Certificate #5027 dated February 15, 2008
5) MEPA Certificate #5027dated October 25, 1998
6) Request for Response (RFR) For Consultant Services
7) 2008 MassDPH Arbovirus Surveillance and Response Plan
8) 2008 Operational Response Plan to Reduce The Risk of Mosquito-Borne Disease in Massachusetts
9) 2006 Aerial Spray Final Summary Report for August 8th and 9th
10) 2006 Aerial Spray Final Summary Report for August 22nd through 24th
11) Choice of Anvil 10+10 for Aerial Mosquito Control Memo dated July 28, 2006
12) 2006 EPA Final Report dated March 6, 2007 on use of Anvil 10+10
13) Board letter to MEPA Director dated March 4, 2002

CC: Anne Monnelly, DCR SRMCB Member
Gary Gonyea, DEP SRMCB Member
Alisha Bouchard, SRMCB Projects Administrator
Scott Soares, Assistant Commissioner, DAR
Doug Petersen, DAR Commissioner
Nicholas Zavolas, MEPA
Alicia McDevitt, MEPA Director

THE COMMONWEALTH OF MASSACHUSETTS
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MITT ROMNEY
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TO: Commissioner Douglas P. Gillespie (DAR)
Commissioner Stephen Burrington (DCR)
Acting Commissioner Arleen O'Donnell (DEP)

FROM: State Reclamation and Mosquito Control Board (SRMCB)

DATE: Monday, September 11, 2006

RE: EEE AERIAL ADULTICIDE SPRAYING (Round 2)

As outlined in the State Reclamation and Mosquito Control Board (SRMCB) Mosquito- Borne Disease Response Plan, the Board submits this summary report on the aerial spray operation that began on the evening of Tuesday, August 22nd, commencing at sunset and ending on Thursday evening, August 24th, 2006 at 9:58 PM. Although there were dramatic reductions in mosquito populations in areas treated on August 8th and 9th, a secondary application was determined to be necessary since the area of risk had expanded beyond the initial treatment areas with additional isolations of mosquitoes found positive for EEEv. As a result, this second application was performed in response to a declaration of Public Health Emergency by the Governor regarding an outbreak of mosquito-borne Eastern Equine Encephalitis virus (EEEv) in the region.

Description of Second Spray

As accomplished in the previous aerial application, calibration and characterization of the aerial spraying equipment was conducted on August 22-24, 2006 at the Plymouth County Massachusetts Municipal airport. This was accomplished for three (3) aircraft deployed for aerial application of Anvil 10+10 ULV. Calibrations and characterizations were conducted by Clarke Mosquito Control and Dynamic Aviation staff and overseen by Fran Krenick, National Technical Service Manager, for Clarke Mosquito Control in the presence of John Kenney of MDAR and former Chair of the SRMCB, other SRMCB members, and personnel from the Plymouth County Mosquito Control Project (PCMCP) and Northeastern Massachusetts Mosquito and Wetlands Management District (NMMWMD). The details and documentation of this procedure will be reported in a final post spray report.

The SRMCB and Department of Agricultural Resources (DAR) supervised the aerial spraying that covered an area of approximately 410,296 acres, as calculated by the navigational flight system of the aircraft. The area treated encompassed the municipalities previously treated during the evenings of August 8th and 9th including Middleboro, Lakeville, Carver, Kingston and Plympton, plus parts of the communities of New Bedford, Taunton, Raynham, Freetown, Duxbury, Halifax, Plymouth, Rochester and Acushnet. Other areas treated during this second round of spraying included the municipalities of Abington, Attleboro, Avon, Berkley, Braintree, Bridgewater, Brockton, Dartmouth, Dighton, East Bridgewater, Easton, Fairhaven, Fall River, Hanover, Hanson, Hingham, Holbrook, Mansfield, Mattapoisett, Norwell, Norton, Pembroke, Randolph, Rehoboth, Rockland, Sharon, Stoughton, Wareham, West Bridgewater, Weymouth, and Whitman. (See map on page 8).

Three (3) -twin turbines Beechcraft King Air, Model A90 aircraft were deployed from Dynamic Aviation Company in Virginia. Based on the area treated and the rate of application, 0.62 oz/acre (the maximum allowable amount permitted by the pesticide product label), the aircraft dispensed approximately 1,987 gallons of Anvil 10 +10 ULV EPA # 1021-1688-8329, (a Clarke Mosquito Control product) at a height of 300 feet above the ground, average airspeed of 172.5 mph and an aerosol swath width of 1,000 feet. In addition to the actual amount of product used to reduce the mosquito population, 96 additional gallons of Anvil 10 +10 ULV was used to test droplet sizes and calibrate the delivery apparatus of the aircraft prior to the operation. Thus, the total amount of product used for the entire second aerial spray operation was 2,083 gallons.

Weather conditions during the August 22 – 24, 2006 aerial application ranged from optimal to acceptable. All weather parameters remained within ranges compatible with the product label. These weather conditions also reflected conditions favorable to mosquito activity during the application window. On Tuesday, 8/22/2006 optimal conditions existed during the entire spray window. Those conditions included temperatures ranging from the mid-sixties to the low seventies. Light winds prevailed during the application.

On Wednesday, 8/23/2006 optimal weather conditions occurred at the start of the application window including temperatures in the mid-sixties and light winds. During the latter half of the spray window weather conditions were acceptable with temperatures ranging from 59 degrees to the low sixties with calm wind conditions. The application was halted at approximately 11:50 when temperatures dropped to 58 degrees. On Thursday, 8/24/2006 optimal weather conditions including temperatures in the mid-sixties and light winds were present at the start of the application. The aerial application was completed at approximately 9:50 with acceptable weather conditions including temperatures near sixty degrees with calm conditions.

Results of Second Spray

Overall, the results of the aerial operation, round 2, were very good. Mosquito populations in the treated areas were significantly reduced, and risk to the general public was reduced. Bristol and Plymouth County Mosquito Control Projects staff reported large reductions in mosquito abundance in areas that were treated. Overall, Bristol and Plymouth Counties reported reductions of 88.6% and 60.15%, respectively, in mosquito abundance. Also, trap collections in Norfolk County showed a significant decrease in mosquitoes reporting reductions ranging from 57% to 97%. ***In adjacent areas, a lesser reduction occurred. In non-sprayed areas, the numbers rose.***

These reductions included mosquitos' species that are important as maintenance vectors of EEEv amongst birds and those that are aggressive human biters and suspected to be the bridge vectors of EEEv to people. For example, MDPH State Laboratories Institute reported overall reductions of 79.5 % with noted reductions of mosquito species of concern especially *Cq. perturbans,* a human-biting species. The discrepancies and variability of the measured reductions are attributable to differing methods of analysis as well as confounding factors such as weather changes between pre and post collections, terrain, locations and kinds of traps utilized, and mosquito species. More details of efficacy results can be found on pages 5-7.

Similar results were obtained as reported in the summary report for aerial spraying that took place August 8th and 9th, in that significant impacts to the environment have not been observed as a result of the aerial application during August 22nd through 24th. Water sampling analysis by the Massachusetts Pesticide Analytical Laboratory (MPAL) indicate there were no detectable residues of sumithrin (pyrethroid active ingredient in Anvil 10+10) in surface water and drinking water supplies tested. The synergist Piperonyl Butoxide (PBO) was detected at a very low concentration in a raw water supply and in a finished water supply, but at a concentration below the level of quantification. PBO was not detected in any of the surface water samples after the second spraying. PBO levels were below the expected environmental concentrations (EEC) as estimated by both the Massachusetts Department of Environmental Protection (MDEP) and the U.S. Environmental Protection Agency (EPA). Neither the MDEP nor the EPA has established a maximum contaminant level (MCL) or State drinking water guideline for residues of PBO in drinking water. The levels found do not violate any federal or State laws.

Moreover, the analytical results of the sampling conducted following two rounds of aerial spraying are summarized below by the Massachusetts Department of Environmental Protection, Office of Research and Standards.

- Sumithrin was not detected in any water body sampled.
- Piperonyl butoxide (PBO) was only found in one finished drinking water supply sampled, at a concentration below the limit of quantitation.
- PBO was found at very low concentrations in raw water in Elder's Pond on the 8/10/06 sampling date (0.10 μg/L) and in the Taunton raw water supply on both the 8/24/06 and 8/25/06 sampling dates (0.13 - 0.14 μg/L).
- PBO was found at very low concentrations in three surface water samples on the 8/9/06 sampling date (0.07 - 0.12 μg/L).
- All of these concentrations were well below the health-based drinking water guidance concentration for PBO of 600 μg/L by several orders of magnitude and thus exposure to these concentrations would not produce adverse health effects.

Additionally, there have been no reported unintended effects regarding fish, birds, and or bees. However, no quantitative assessment was performed for these non-target species. The DPH Center for Environmental Health has indicated that there have been reports received by their office but are still in the process of compiling and verifying the details at this point in time. No objective findings have been reported of any alleged adverse effects to the environment to date. The details and documentation of this analysis will be reported in a final post spray report.

Analysis and Recommendations

Mapping: Operationally, problems that occurred in the aerial application of August 8th and 9th 2006 related to GIS mapping for areas to be treated and those to be excluded in the operation. This issue needs to be addressed for future aerial operations with clear responses on how to proceed to improve the process and function of applications. Specifically, these refinements include, but are not limited to, better coordination and communication between all agencies responsible in developing maps for aerial application including exclusion areas. Final maps must be completed and reviewed by all agencies in a timely fashion before being sent to the aerial applicator contractor. Once again there were delays in finalizing GIS mapping which affected the general operational preparation-taking place at the staging area at the Plymouth County Municipal Airport.

Exclusion areas: Again, there was no clear agreement by all agencies to treat or exclude areas that overlap with, or were in very close proximity to, "hot spots" where EEEv was currently and/or historically found even though the Governor signed a declaration of public health emergency. Once again, the SRMCB and DAR, given their responsibility for controlling mosquitoes continued to have significant concerns about the ability to reduce and/or prevent the risk of infection when such areas (priority habitat areas) designated by the Department of Fish and Game were excluded from the spray zone. In addition, the designation of these areas as no-spray zones impacted again on the timely preparation of final GIS mapping for the aerial applicator contractor.

Buffer zones: Some refinements to the process did occur during the second aerial application that included, but was not limited to, insuring correct buffer zones in the final GIS mapping of excluded areas. Additionally, pilot and team briefing occurred before each flight to insure that pilots strictly adhered to no spray/exclusion zones via the AGNAV navigational software. Various state agency representatives were present before the first evening of operation to clarify concerns to minimize and avoid errors.

In sum, the operation was successful in obtaining a positive public health outcome and provided the most meaningful response to this public health emergency.

Aerial Intervention August 22-24, 2006 Efficacy Results

Reported by, Wayne Andrews, Superintendent
Bristol County Mosquito Control Project

Trapping results pre and post adulticide

Species	Total outside spray area		Total inside spray area	
	Pre	Post	Pre	Post
Overall	68	85	184	21
Cs. melanura	16	17	92	9
*Culex**	ND	ND	ND	ND
*Ae. vexans**	ND	ND	ND	ND
*Cq. perturbans**	ND	ND	ND	ND
*Oc. canadensis**	ND	ND	ND	ND

*No Data – Too few collected

Efficacy:

Overall: 88.6%
Culiseta melanura: 90.8%

Traps were set away from the edge of treated zones and priority habitats that were excluded for this aerial application.

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Aerial Intervention August 22-24, 2006 Efficacy Results

Reported by: Ellen Bidlack, Entomologist
Plymouth County Mosquito Control Project

Species	Total outside spray area		Total inside spray area	
	Pre	Post	Pre	Post
Overall	143	55	647	98
Cs. melanura	24	31	430	28
Culex	10	12	157	35
Ae. vexans	35	5	6	6
Cq. perturbans	34	2	23	24
Oc. canadensis	15	0	21	3

There were four traps in the treatment area and 5 outside.

I have figured out our efficacy for the last treatment that began on 22 Aug 06. I have also attached a map of the trap locations used. For this analysis I used collections made on 21 and 25th of August. I did not have enough traps to do the analysis for each night of the spray. I collected from some of the same areas again on Monday and the overall number of mosquitoes has continued to stay low in the spray area unlike the first treatment on the 8th.

Overall: 60.15%

Cs. melanura: 95%
Culex: 81.4%
Oc. canadensis: no control
Ae. vexans: no control
Cq. perturbans: no control

The above data was analyzed by Fran Krenick (National Technical Service Manager for Clarke Mosquito Control) who stated that the numbers of Cq. *perturbans* inside treatment area are very low for both pre and post. Just not enough of a population to have a statistical impact. Twenty-three (23) mosquitoes are not very many. Counts with numbers over 100 all showed significant reduction as the populations were larger pre-treatment and would have greater exposure resulting in a statistically significant reduction in the counts. It appears that the both *Ae. vexans* and *Oc. canadensis* populations were not high enough pre-treatment to be statistically detectible. Overall, it looks very good!!

****

Aerial Intervention August 22-24, 2006 Efficacy Results

Reported by, John J. Smith, Director
Norfolk County Mosquito Control Project

Trapping results for 24-hour post-aerial adulticide of August 23, 2006 through August 25, 2006:

The traps positioned for this efficacy study collected predominately *Culex* species and *Culiseta melanura*.

Outside Treatment Areas:

	% *Culex* (pre/post)	%*melanura* (pre/post)	%Overall (pre/post)
Trap #7 (Medway)	+11(64/71)	+108(36/75)	+61(103/166)

Inside Treatment Areas:

	% *Culex* (pre/post)	%*melanura* (pre/post)	%Overall (pre/post)
Trap #1 (Avon)	-100(5/0)	-100(62/0)	-97(78/2)
Trap#2 (Holbrook)	-81(37/7)	-52(61/29)	-62(109/41)
Trap#3 (Holbrook)	N/A	-90(20/2)	-70(30/9)
Trap#4 (Holbrook)	-100(6/0)	-57(89/38)	-57(106/46)
Trap#5 (Holbrook)	-40(67/40)	-56(198/67)	-66(284/124)
Trap#6 (Weymouth)	N/A	-73(60/17)	-68(72/23)

Trap #1 was well within the treatment zone on day two of the application and showed the highest efficacy. Traps #2 through #5 were within the treatment zones on day two or three of the application but were proximate to the edge of that nights treatment area (within several thousand feet) which may have resulted in the lower efficacy numbers. Traps #2 and #5 were also proximate (@1,000 feet) to a larger exclusion zone (Weymouth Great Pond), which may have also negatively influenced efficacy. Trap#5 was right on the edge of the northern most extend of the treatment area (200 feet south) on day three of the application but showed good reductions in spite of this. Minor collections of *Aedes vexans, Aedes cinereus , Coquilletidia perturbans,* and *Ochlerotatus canadensis* were also observed in the collections (numbers too low for statistical review) and most showed declines 24 hours post treatment.

It is important to note that 24 hours post treatment mosquito collections at the untreated site showed an increase in both *Culex* (+11%) and *Culiseta melanura* (+108%) with an overall mosquito species increase of +61% which further demonstrates the positive impact of this aerial application within the treated area.

Overall the trap collections in Norfolk County showed a significant decrease in mosquitoes collected within the treated zone post application.

The data support a conclusion that the spray led to dramatic reductions in abundance where the spray was actually deployed. In adjacent areas, a lesser reduction occurred. In non-sprayed areas, the numbers rose. We can speculate that the increase was due to either/both immigration from outside the spray zone and/or emergence of new mosquitoes. (R. Pollack)

****

Aerial Intervention August 22-24, 2006 Efficacy Results

Reported by Matthew Osborne
Department of Public Health State Laboratories

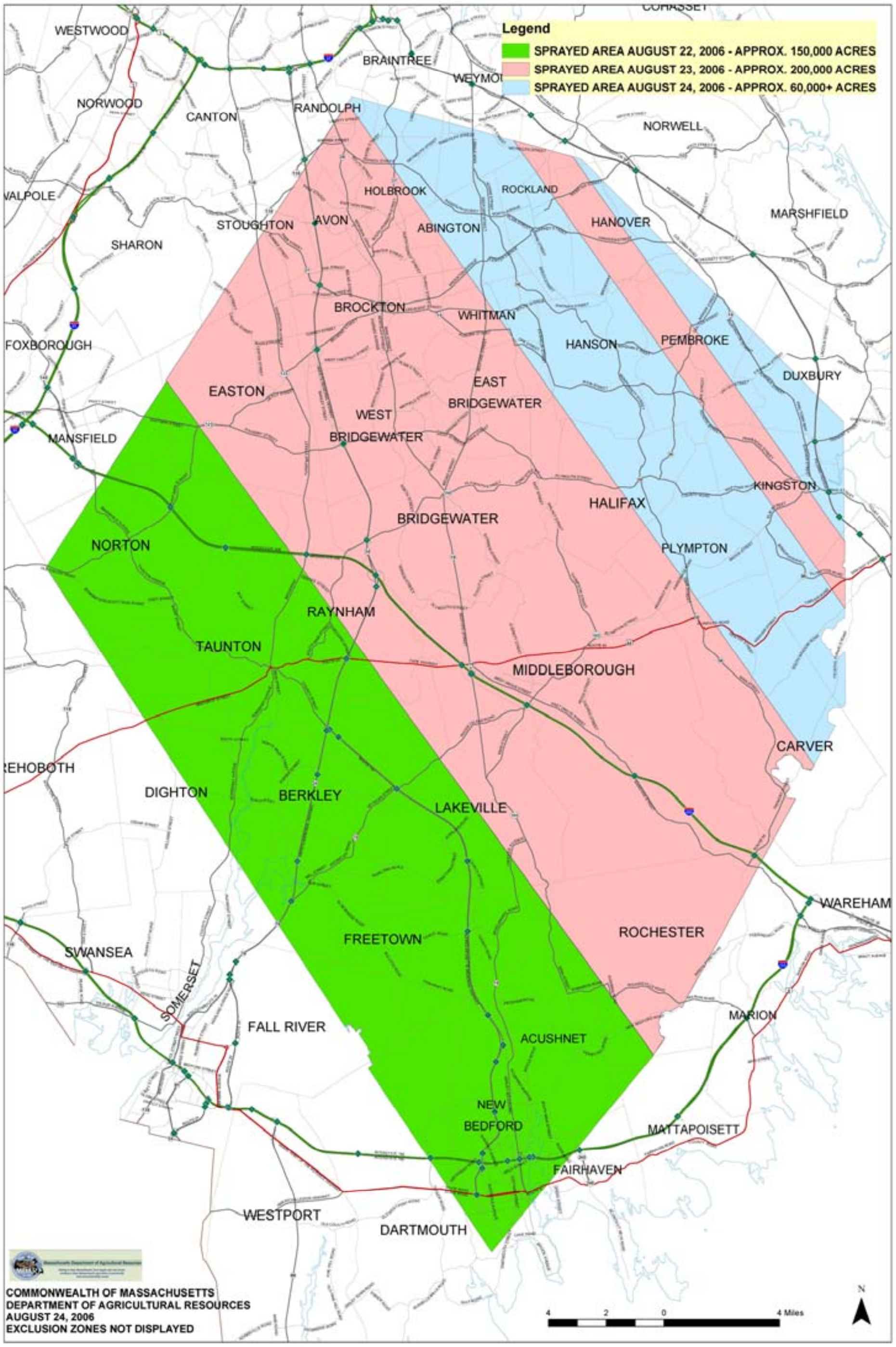
We collected on 8/25. We had five trap sites within and seven outside the spray zone.

Overall: 79.5 % control

Cq. perturbans: 94.1 % control
Oc. canadensis: 58.2 % control
Cs. melanura: 81.3 % control
** Ae. vexans*: 0 % control
**Culex spp* 0 % control

* Our numbers for *Culex spp* and *Ae. vexans* were very low in and out of the zone. With such low numbers the collection of a few individuals skewed the results.

Map showing areas treated by date



Memorandum

To: Elaine Krueger

CC: Suzanne Condon

From: Michael Celona

Date: July 28, 2006

Re: Choice of Anvil 10+10 for Aerial Mosquito Control

The purpose of this memorandum is to summarize the current rationale for the inter-agency decision that the primary choice for future aerial spraying involves using an insecticide containing the active ingredient sumithrin (i.e., Anvil 10+10).

All four pesticide products meet both the Federal and State regulatory standards for registration and that when used in accordance with directions for use, warnings and cautions and for the uses for which they are registered, will not generally cause unreasonable adverse effects on the environment or human health. The chemical properties of sumithrin with consideration of its toxicity and environmental fate profile; overall, indicate that sumithrin provides the widest margins of safety for human and environmental health when used properly by professionals trained to conduct mosquito control. It may be further noted that studies show sumithrin to be short-lived in the environment, to break down rapidly in sunlight, and to be less toxic to aquatic species than the alternatives considered (HSDB, 2006; Paul *et al*, 2005). <u>Based at least in part on these properties, sumithrin is the most widely used product by mosquito control districts for ground-based spraying.</u>

All pesticides which were registered for use in Massachusetts, labeled for aerial application, and included in the State's contract for emergency mosquito management were identified. Staff from the Department of Agricultural Resources, Pesticide Bureau generated a list of the four pesticides that met these three requirements. The four pesticides were Scourge (active ingredient resmethrin), Anvil 10+10 (active ingredient sumithrin), Kontrol 30+30 (active ingredient permethrin), and Fyfanon ULV (active ingredient malathion). These pesticides were subsequently evaluated using several parameters, including:

- Formulation
- Label "Signal Word
- Use classification
- Chemical components

- Percentage of active ingredient
- Application rate
- Half-life
- Aquatic toxicity

Scourge (Resmethrin)

Scourge is the trademark name of a product containing the active ingredient resmethrin. Resmethrin is a synthetic pyrethroid insecticide whose active ingredient is similar to pyrethins, which are derived from chrysanthemum plants (EPA, 2002). Resmethrin has been registered with U.S. Environmental Protection Agency (EPA) since 1971 and has been used in Massachusetts and throughout the U.S. for many years. It is used to control flying and crawling insects in mushroom houses, food handling establishments, the home, lawn, garden, and industrial sites (ATSDR, 2005). Presently, Scourge is classified as a "restricted use" product due to its toxicity to fish, meaning that only certified pesticide applicators or persons under their direct supervision can use it and it cannot be applied in or around waterbodies (EPA, 2002). Of the three pyrethroids products (i.e., permethrin, resmethrin, and sumithrin) evaluated by the Department of Environmental Protection, Office of Research and Standards for aquatic toxicity, resmethrin was ranked second in its toxicity to fish (DEP, 2005). Its half-life in water was measured in hours, which is less than sumithrin (half-life of 1-3 days) and permethrin (half-life of 3-5 days) [Paul *et al*, 2005].

When used in mosquito control, resmethrin, is mixed with both a synergist [i.e., piperonyl butoxide (PBO)] that increases its potency and duration of effectiveness (NPIC, 2006). It is also mixed with a solvent/diluent (e.g. mineral oil). PBO acts by inhibiting the ability of the insect to detoxify the insecticide. PBO is classified by EPA as a possible human carcinogen (EPA, 2004).

Anvil 10+10 (Sumithrin)

Anvil 10+10 is the trademark name of a product containing the active ingredient sumithrin. Sumithrin is a synthetic pyrethroid insecticide whose active ingredient is similar to pyrethins, which are derived from chrysanthemum plants (EPA, 2002). Sumithrin has been registered with EPA since 1975 and in Massachusetts since 1980. It is used commercially (e.g., food handling establishments), as well as by homeowners to control insects in homes and gardens and on pets (HPD, 2006). It is classified as a "general use" product, meaning that its use is not limited to professionals alone, but may be purchased and used by the general public. Of the three pyrethroid products (i.e., permethrin, resmethrin, and sumithrin) evaluated by the Department of Environmental Protection, Office of Research and Standards for aquatic toxicity, sumithrin was the least toxic to fish (DEP, 2005). Its half-life (1-3 days) was more than resmethrin (half-life of hours), but less than permethrin (half-life of 3-5 days) [Paul *et al*, 2005].

When used in mosquito control, sumithrin is mixed with a synergist (i.e., PBO) that increases its potency and duration of effectiveness, and then applied with a solvent/diluent (i.e., mineral oil).

<u>Kontrol 30+30 (Permethrin)</u>

Kontrol 30+30 is the trademark name of a product containing the active ingredient permethrin. Permethrin is also a synthetic pyrethroid insecticide whose active ingredient is similar to pyrethins, which are derived from chrysanthemum plants (EPA, 2002). Permethrin has been registered with EPA since 1977 and has been used in Massachusetts and throughout the U.S. for many years. It is used in products such as household insecticide foggers, tick and flea sprays for pets, termite treatments, and agricultural and livestock insecticides (EPA, 2002; HPD, 2006). It is classified as a "general use" product, meaning that its use is not limited to professionals alone, but may be purchased and used by the general public. Of the three pyrethroids products (i.e., permethrin, resmethrin, and sumithrin) evaluated by the Department of Environmental Protection, Office of Research and Standards for aquatic toxicity, permethrin was ranked second as the most toxic to fish (DEP, 2005). Its half-life in water (half-life of 3-5 days) was more than sumithrin (half-life of 1-3 days) and resmethrin (half-life of hours) [Paul *et al*, 2005].

When used in mosquito control, permethrin, is mixed with both a synergist (i.e., PBO) that increases its potency and duration of effectiveness, and a solvent/diluent (e.g., mineral oil).

Fyfanon ULV (Malathion)

Fyfanon ULV is the trademark name of a product containing the active ingredient malathion. Malathion is a synthetic organophosphate insecticide. It has been registered for use in the U.S. since 1956 and has been used in Massachusetts and throughout the U.S. for many years. Malathion was used in 1990 during the last Massachusetts aerial mosquito spraying event. In addition to mosquito control, it is also used to treat a wide variety of agricultural crops, gardens, and for the control of head lice (HPD, 2006). Its half-life in water, which is the amount of time required for 50% of the chemical to breakdown, was estimated to be between several days and several weeks (ATSDR, 2003). It is a general use pesticide product, meaning that its use is not limited to professionals alone, but may be purchased and used by the general public.

Summary

Based on this summary evaluation and other data (see Table), Anvil 10+10 (sumithrin) appears to be the most optimal product of choice for aerial application, particularly considering that it has the lowest application rates while still being efficacious in killing mosquitoes. Studies show that the primary active ingredient, sumithrin, is short-lived in the environment and breaks down rapidly in sunlight (HSDB, 2006; ATSDR, 2005) and slightly less toxic to aquatic species than the alternatives considered (DEP, 2005; Paul *et al*, 2005).

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Table: Product Characteristics

Product Name	First Active Ingredient	Second Active ingredient	Formulation	Label Signal Wording	Classification	% Active Ingredient	Half-life	Water Solubility	Soil Mobility
Scourge	Resmethrin	Piperonyl butoxide	Ultralow Volume Concentrate	Caution	Restricted Use	18%	Hours	Insoluble	Low to immobile
Anvil 10+10	Sumithrin	Piperonyl butoxide	Ultralow Volume Concentrate	Caution	General Use	10%	1-3 days	Insoluble	Low to immobile
Kontrol 30+30	Permethrin	Piperonyl butoxide	Ultralow Volume Concentrate	Caution	General Use	30%	3-5 days	Insoluble	Low to immobile
Fyfanon ULV	Malathion	N/A	Ultralow Volume Concentrate	Caution	General Use	96.5%	Several days to several weeks	Slightly soluble	Somewhat mobile

THE COMMONWEALTH OF MASSACHUSETTS
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Massachusetts Department of Agricultural Resources

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IAN BOWLES
Secretary

SCOTT J. SOARES
Acting Commissioner

March 6, 2007

Mr. Anthony Britten, Team Leader
Emergency Response Team
U.S. EPA, Office of Pesticide Programs (7504P)
Document Processing Desk (EMEX)
Room S4900, One Potomac Yard
2777 Crystal Drive
Arlington, VA 22202

RE: FINAL REPORT FOR EPA FILE SYMBOL: 06-MA-06

Dear Mr. Dear Mr. Britten:

Dear Mr. Rosenblatt:

Attached please find the final report from the use of Anvil 10+10 (a.i. PBO and d-phenothrin/sumithrin), EPA Reg. No. 1021-1688-8329 in 2006.

This was the first-year that the Department of Agricultural Resources, in cooperation with the Massachusetts Department of Public Health and the State Reclamation and Mosquito Control Board applied Anvil 10+10 over crops under an EPA approved public health emergency exemption. The applications were performed in response to a declaration of public health emergency by the Governor regarding an outbreak of mosquito-borne Eastern Equine Encephalitis virus (EEEv) in the southeastern region of the State.

Should you have any questions related to this final report, please contact me at your convenience.

Sincerely,

Steven Antunes-Kenyon, Environmental Analyst
(617)626-1784

Enclosures (2)
By UPS Overnight
cc: Robert Koethe, EPA Region 1

Total Acreage Treated and Total Amount of Pesticide Used

Overall, 551,290.3 acres were treated with 2,670.3 gallons Anvil 10+10 (0.74 lb. sumithrin and PBO/gal. = 1,976 lb. active ingredients sumithrin and PBO).

First Aerial Application Campaign:
Application began on Tuesday, August 8, 2006 at 7:55 PM and ended on the morning of Wednesday, August 9, 2006 at 1:54 AM. The area treated encompassed the municipalities of Middleboro, Lakeville, Carver, Kingston and Plympton, plus parts of the communities of New Bedford, Taunton, Raynham, Freetown, Duxbury, Halifax, Plymouth, Rochester and Acushnet (see attached map).

- 140, 994.3 acres, as calculated by the GPS-based navigational flight system of the aircraft; and
- Not including gallons used in calibration and droplet size estimation, approximately 683 gallons of Anvil 10 +10 product (0.74 lb. sumithrin and PBO/gal. = 505.42 lb. active ingredients sumithrin and PBO) were used to control mosquitoes and reduce the risks of EEEv infection.

Second Aerial Application Campaign:
Applications began on Tuesday, August 22, 2006 at sunset and ended in evening Thursday, August 24, 2006 at 9:58 PM. The area treated encompassed the municipalities previously treated during the evenings of August 8th and 9th including Middleboro, Lakeville, Carver, Kingston and Plympton, plus parts of the communities of New Bedford, Taunton, Raynham, Freetown, Duxbury, Halifax, Plymouth, Rochester and Acushnet. Other areas treated during this second round of spraying included the municipalities of Abington, Attleboro, Avon, Berkley, Braintree, Bridgewater, Brockton, Dartmouth, Dighton, East Bridgewater, Easton, Fairhaven, Fall River, Hanover, Hanson, Hingham, Holbrook, Mansfield, Mattapoisett, Norwell, Norton, Pembroke, Randolph, Rehoboth, Rockland, Sharon, Stoughton, Wareham, West Bridgewater, Weymouth, and Whitman. (see attached map).

- 410,296 acres, as calculated by the GPS-based navigational flight system of the aircraft; and
- Not including gallons used in calibration and droplet size estimation, approximately 1,987.37 gallons of Anvil 10 +10 product (0.74 lb. sumithrin and PBO/gal. = 1,470.6 lb. active ingredients sumithrin and PBO) were used to control mosquitoes and reduce the risks of EEEv infection.

Discussion of Effectiveness:

The results of the operation were remarkable. In the **First Aerial Application Campaign** mosquito populations in the treated areas were dramatically reduced, and overall risk to the general public was lessened. Bristol and Plymouth County Mosquito Control Projects staff reported large reductions in mosquito abundance in areas that had been so treated. Overall, Bristol and Plymouth Counties reported reductions of 82.8% and 85.5%, respectively, in mosquito abundance. These reductions included mosquitoes of species that are important as maintenance vectors of EEEv amongst birds and those that are aggressive human biters and suspected to be the bridge vectors of EEEv to people. In addition, the staff of the MDPH State Laboratories Institute reported overall reductions of 59.8 % with noted reductions of mosquito species of concern such as *Ae. vexans* and *Cq. perturbans*. The discrepancies and variability of the measured reductions are attributable to differing methods of analysis as well as confounding factors such as weather changes between pre and post collections, terrain, and mosquito species. The results are presented below:

The information in this report was made available through the efforts of various Massachusetts State agencies including the State Reclamation and Mosquito Control Board, the Department of Public Health, the Department of Environmental Protection. The Department is especially grateful for the operational reports submitted by Mark Buffone, Chairman, SRMCB.

Summary of Efficacy Results with Anvil 10+10 First Aerial Application Campaign: Application Dates Tuesday, August 8, 2006 thru Wednesday, August 9,2006

Organization Collecting Data and Trap Used	Individual Target Species	Percent Control
MDPH, State Laboratories using CDC traps baited with 200cc CO_2 per minute.		**Overall: 59.8%**
	Cq. perturbans	35%
	Oc. canadensis	no control
	Cs. melanura	70.1%
	Ae. vexans	65.2%
Bristol County Mosquito Control Project with CDC traps baited with 200cc CO_2 per minute		**Overall: 82.8%**
	Cq. perturbans	87.1%
	Oc. canadensis	72.0%
	Cs. melanura	97.1%
	Ae. vexans 77.2%	77.2%
Plymouth County Mosquito Control Project		**Overall: 85.5% control**
	Cq. perturbans	91.9%
	Oc. canadensis	no control
	Cs. melanura	79.2%
	Ae. vexans	100%

Data from the **Second Aerial Application Campaign** support a conclusion that the spray led to dramatic reductions in abundance where the spray was actually deployed. In adjacent areas, a lesser reduction occurred.

In non-sprayed areas, the numbers of mosquitoes increased. The State Reclamation and Mosquito Control in consultation with the Massachusetts Mosquito Advisory Group (MMAG), speculate that this increase was due to either/both immigration from outside the spray zone and/or emergence of new mosquitoes.

In summary, the operation was successful in obtaining a positive public health outcome and provided the most meaningful response to this public health emergency.

The information in this report was made available through the efforts of various Massachusetts State agencies including the State Reclamation and Mosquito Control Board, the Department of Public Health, the Department of Environmental Protection. The Department is especially grateful for the operational reports submitted by Mark Buffone, Chairman, SRMCB.

Discussion of Effectiveness:

Overall, the results of the aerial operation, round 2, showed good control. Mosquito populations in the treated areas were significantly reduced, and risk to the general public was reduced. Bristol and Plymouth County Mosquito Control Projects staff reported large reductions in mosquito abundance in areas that were treated. Overall, Bristol and Plymouth Counties reported reductions of 88.6% and 60.15%, respectively, in mosquito abundance. Also, trap collections in Norfolk County showed a significant decrease in mosquitoes reporting reductions ranging from 57% to 97%. ***In adjacent areas, a lesser reduction occurred. In non-sprayed areas, the numbers rose.***

These reductions included mosquitos' species that are important as maintenance vectors of EEEv amongst birds and those that are aggressive human biters and suspected to be the bridge vectors of EEEv to people. For example, MDPH State Laboratories Institute reported overall reductions of 79.5 % with noted reductions of mosquito species of concern especially *Cq. perturbans,* a human-biting species. The discrepancies and variability of the measured reductions are attributable to differing methods of analysis as well as confounding factors such as weather changes between pre and post collections, terrain, locations and kinds of traps utilized, and mosquito species.

Description of Unexpected Adverse Effects:

Significant impacts to the environment have not been observed as a result of the aerial application. Additionally, there have been no reported unintended effects regarding fish, birds, and or bees. However, no quantitative assessment was performed for these non-targets. Verbal reports from the Center for Environmental Health indicate only a few human illness reports (n=8) being investigated as a result of the aerial application. No objective findings have been reported of any alleged adverse effects to the environment to date.

Results of Any Monitoring Carried Out:

A multi-agency collaborative effort was undertaken to monitor pesticide residues in surface waters and in cranberries. An informal oral report from the Department of Public Health indicates that residues of sumithrin on cranberries tested were below the limits of detection (not provided) for the methods used. The Department and State Reclamation and Mosquito Control Board have requested documentation of the sampling results.

Water sampling analysis by the Massachusetts Pesticide Analytical Laboratory (MPAL) indicate there were no detectable residues of d-phenothrin/sumithrin in surface water and drinking water supplies tested. The levels of the synergist Piperonyl Butoxide (PBO) were very low and were below the expected environmental concentrations (EEC) as estimated by both the Massachusetts Department of Environmental Protection (MDEP) and the U.S. Environmental Protection Agency (EPA). Neither the MDEP nor the U.S. EPA has established a maximum contaminant level (MCL) or State drinking water guideline for residues of PBO in drinking water. The levels found do not violate any federal or State laws (see attached—3pp. lab summary reports).

Discussion of Any Enforcement Actions:

No enforcement actions were taken by the Department related to this public health emergency exemption.

Method of Disposition of Crop:

No crops were required to be destroyed as a result of these applications in southeastern Massachusetts. The Department worked closely with the media and multiple State agencies including the Department of Public Health

The information in this report was made available through the efforts of various Massachusetts State agencies including the State Reclamation and Mosquito Control Board, the Department of Public Health, the Department of Environmental Protection. The Department is especially grateful for the operational reports submitted by Mark Buffone, Chairman, SRMCB.

and the Department of Environmental Protection to communicate and implement the required grower 2-day PHI and grazing restrictions for treated areas.

The Massachusetts Department of Public Health (MDPH), in cooperation with the Cape Cod Grower's Association collected cranberries from areas treated with Anvil 10+10 ULV. Although a report detailing the methods used and specific results is not currently available, the MDPH has stated that sumithrin levels were not detected, but that low levels of PBO were detected. There is an established tolerance for PBO on cranberries; moreover, there is a general exemption from the requirement of a tolerance for low levels of PBO residues in/on crops.

The information in this report was made available through the efforts of various Massachusetts State agencies including the State Reclamation and Mosquito Control Board, the Department of Public Health, the Department of Environmental Protection. The Department is especially grateful for the operational reports submitted by Mark Buffone, Chairman, SRMCB.

The Commonwealth of Massachusetts
Department of Food and Agriculture
State Reclamation and Mosquito Control Board
251 Causeway Street, Suite 500, Boston, 02114

G. GONYEA, DEP
J. KENNEY, DFA
C. BURNHAM, DEM

TRACY WINE-CORNWELL, SRB
Tel: (617) 626-1715
Fax: (617) 626-1850

March 4, 2002

Mr. Jay Wickersham, Director
Executive Office of Environmental Affairs
Massachusetts Environmental Policy Act Office
251 Causeway St Suite 900
Boston, MA 02114

Dear Mr. Wickersham,

The State Reclamation and Mosquito Control Board (SRB) voted to request that the Mosquito Control Generic Environmental Impact Report (GEIR) be modified from yearly updates to issuing updates as needed, but no less than every three years.

The concept of possibly issuing annual updates, as originally proposed, was unrealistic. Shortly after the GEIR was accepted we lost the services of the person hired to edit the GEIR. The SRB did not have the resources to further modify or search for available information. In the current fiscal situation there are even less resources available than at any time in the past, certainly less than I have ever seen in my tenure.

The original letter of submission did not say that yearly updates would, in fact be issued, but it was the SRB intention to try. However, there was a qualification to that intention. Updates would be done as "new ideas and approaches to mosquito control become known, new pesticides or equipment come on the market or improved techniques are made available." Further, the letter of submission states: "As these improvements come to the Board's attention, and are reviewed and found to be valid and useful, addendum will be issued in order to continually update the report." The letter of submission did not commit to a yearly update.

While research in mosquito control methods is ongoing nationally, there is little in new equipment, chemicals or techniques that come to the front yearly. Much of what is used, as standard practice nationally is the same as it has been for years. New ideas and approaches to mosquito control do not change significantly from year to year.

The GEIR certificate, as issued, went beyond what the SRB intended and proposed, when it called for yearly updates.

The above lack of resources and significant changes from year to year not withstanding, there has been progress toward changes that will be added to the GEIR.

The SRB working with researchers from the University of Massachusetts are developing Best Management Practices for balancing mosquito control and wetlands interests. This project, which has been proceeding for some time, is expected to be completed this year.

The SRB has adopted a policy whereby complaints concerning mosquito control from the public or any agency will be addressed upon receipt by the SRB of such complaint, in writing together with any and all supporting information, evidence, statements photos or other documentation. The SRB cannot address such complaints if they are not furnished to the Board.

MA DPH convened work groups last year to study various issues such as pesticides to be used, threshold of action etc. Representatives from various interested groups, such as Audubon, SRB, Fish & Wildlife, Boards of Health, Universities and interested members of the public made up the work groups. While the groups did not, in all cases, issue final reports, much valuable information was assembled by the DPH project, which could be included in future changes of the GEIR.

Changes are being made to the manner in which the public will be notified of the timing and locations of ground adulticide applications.

The question of the appropriate response to West Nile Virus bearing mosquitoes is changing yearly as CDC, MA DPH and others study and learn more. This also will be added to the GEIR once an accepted response policy is finally determined.

An extensive review of methoprene when used as a mosquito larvicide was recently conducted by the Pesticide Bureau staff and reported to the Pesticide Board in various public meetings. This review could also be included in a change to the GEIR..

These are some of the changes which are coming, and which will be added to the GEIR. They are not yet ready, and we recommend that they should be put forth to be added to the GEIR at the same time, rather than piecemeal.

Therefore, the SRB requests that the Secretary's Certificate for the GEIR be amended as above.

Yours truly,

John Kenney

John Kenney, Chairman
State Reclamation and Mosquito Control Board

Zavolas, Nicholas (EEA)

From: Matthew Selby [mselby@ashlandmass.com]
Sent: Tuesday, January 22, 2008 3:25 PM
To: 'Nicholas.zavolas@state.ma.us'
Subject: Comments on EOEAA #5027

Secretary Ian A. Bowles
EOEAA, Attn: MEPA Office
Nicholas Zavolas, EOEAA #5027
100 Cambridge Street, Suite 900
Boston, MA 02114

Secretary Bowles:

I am writing to you on behalf of the Ashland Conservation Commission in regards to the Mosquito Control Generic Environmental Impact Report (GIER) Update and Best Management Practices and Guidance for Freshwater Mosquito Control.

MSACC.01

The Town of Ashland is a member of the Central Massachusetts Mosquito Control Project and crews are very active in our town, clearing and digging ditches through wetlands, trapping mosquitoes and applying pesticides. Because mosquito control work is exempt from the Wetlands Protection Act, all of this work – including taking large machinery into jurisdictional wetlands – is done without the oversight of the Conservation Commission. Rather, an annual report is filed with the Town each winter indicating the mosquito-related activities in the town, from where pesticides were applied to the location and length of streams "cleaned" (2,225 feet in 2006).

The stated goal of the Central Massachusetts Mosquito Control Project is "to reduce mosquito exposure to the public, and the potential for disease transmission by mosquitoes, by utilizing proven, sound mosquito control techniques." Yet the proposed Best Management Practices for Freshwater Mosquito Control lack any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat. Rather than repeated ditching and pesticide management, freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation and fish barriers (e.g. undersized culverts). Mosquito control practices should be consistent with the principles of integrated pest management, and the methods should be studied for their effectiveness. Perhaps a local university could monitor the activities of Mosquito Control and prove their effectiveness.

MSACC.02 MSACC.03 MSACC.04

If a Citizens Advisory Committee (CAC) is to be created, it should include technical and public stakeholder representatives who are independent of the mosquito control districts, such as local boards of health, conservation commissions, wetlands restoration experts, watershed associations, the Department of Public Health and experts in the effects of pesticides on human health and the environment. MSACC.05

Because Mosquito Control operations are exempt from the Wetlands Protection Act, it is vital that MEPA review continue to document the effectiveness of mosquito control practices in protecting public health and on the environmental impacts of these activities. Therefore, we are asking that the previous MEPA certificate be upheld and strengthened and that the requirements for annual updates through MEPA be continued and used to develop and refine Best Management Practices.

Thanks for your time and attention to this matter.

The Ashland Conservation Commission
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Matthew Selby, Conservation Agent
Town of Ashland
101 Main Street, Ashland MA 01721
p: 508-881-0100 x656
f: 508-881-0102
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Zavolas, Nicholas (EEA)

From: Carol Harley [susurrusrising@juno.com]
Sent: Tuesday, January 15, 2008 4:33 PM
To: Zavolas, Nicholas (DEP)
Subject: comment regarding mosquito control and wetlands decisions

Mr. Zavolas / Honorable Secretary Bowles, As a lifelong resident of Massachusetts and taxpayer since 1980, I am writing to express my concern for the health of the Commonwealth of Massachusetts' wetlands, and specifically to comment on mosquito control efforts. I understand there is a public comment period which closes on January 23.

First and foremost, the current mosquito control districts operating in Massachusetts under the State Reclamation and Mosquito Control Board (SRMCB) and MGL Ch. 252 are exempt from the Wetlands Protection Act, and can operate heavy machinery or apply pesticides in wetlands without conservation commission review or approval. I see this "status quo" as a situation that likely endangers public health and the web of ecosystems in our beautiful Commonwealth. CH.01

Therefore, I urge you to:
· Support accountability in wetlands alterations and pesticide application · Continue MEPA Review of mosquito control practices

In my opinion:
· Freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation, and fish barriers (e.g. undersized culverts), rather than ditching and pesticide applications CH.02

· Continued MEPA review is needed to document the effectiveness of current mosquito control practices in protecting public health, and on the environmental impacts of these activities

· Existing documents should be submitted to MEPA for public review (e.g., a report on the 2006 aerial spraying of 425,000 acres) CH.04

· Any Citizens Advisory Committee should include technical and public stakeholder representatives who are independent of the mosquito districts CH.05

Thank you for your consideration in this matter.

Respectfully yours,
Carol Harley
15 Parker Street
Rochdale, MA 01542

N2

Town of Stow
Conservation Commission

380 Great Road
Stow, Massachusetts 01775
(978) 897-8615
FAX (978) 897-4534

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JAN 17 2008
MEPA

January 15, 2008

Secretary Ian Bowles
Executive Office of Energy and Environmental Affairs
Attn: Nicholas Zavolas, EOEA #5027
MEPA Office
100 Cambridge Street
Boston, MA 02114

Re: EOEEA #5027, GEIR Update. Massachusetts Best Practices and Guidance for Freshwater Mosquito Control

Dear Secretary Bowles:

The Stow Conservation Commission offers the following comments on the proposed Special Review Procedure offered by the State Reclamation and Mosquito Control Board to supercede the requirement that Mosquito Control continue to be reviewed under the Massachusetts Environmental Policy Act as a Generic Environmental Impact Report (EOEEA #5027).

The proposed SRP would replace annual GEIR updates with updates every 5 years. The proposed SRP envisions creation of a Citizen Advisory Committee (CAC) to provide advice to the Board as it provides updates. The CAC would be comprised of representatives of each of the 9 mosquito control districts, a representative of the Department of Public Health, a representative of the Environmental Community, and a citizen activist.

The Stow Conservation Commission believes that the proposed CAC is heavily weighted toward the districts and does not provide adequate balance from the environmental community. We feel that the CAC should be enlarged to include several additional members; including a representative of the state's conservation commissions, a member from the Massachusetts Division of Fisheries and Wildlife, and someone from the academic community with expertise in the effects of pesticides on the environment. SCC.01

The report does not present any evidence that common mosquito control practices, such as wetland ditching, are effective in actually reducing mosquito breeding habitat; nor does it quantify the impact of such practices on sensitive species or on fisheries, that can provide natural control of mosquito populations. We believe that the State Reclamation and Mosquito Control Board should be required to undertake such studies. Should the CAC be created, they should be tasked with oversight of these studies. SCC.02 SCC.03

Very truly yours,

STOW CONSERVATION COMMISSION

Ingeborg E Hegemann Clark

Ingeborg Hegemann Clark, Chair
On Behalf of the Stow Conservation Commission

Zavolas, Nicholas (EEA)

From: Judith Eiseman [judyeiseman@comcast.net]
Sent: Thursday, January 17, 2008 12:20 PM
To: Zavolas, Nicholas (DEP)
Cc: Ian Bowles
Subject: EOEEA # 5027 Mosquito Control GEIR Update

Secretary Ian A. Bowles
EOEEA, Attn: MEPA Office
Nicholas Zavolas, EOEEA # 5027
100 Cambridge Street, Suite 900
Boston MA 02114
Attention: nicholas.zavolas@state.ma.us

Secretary Bowles:

JE.01

As a Past President of MACC, I have always been concerned that the nine mosquito control districts operating in Massachusetts are exempt from the Wetlands Protection Act, and can operate heavy machinery or apply pesticides in wetlands without conservation commission review or approval. These actions constitute major alterations to these important wetland ecosystems. Freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (fish and birds and dragonflies, etc.) and t reduce water pollution, sedimentation, and fish barriers, rather than repeated ditching and pesticide applications. **At a bare minimum, any Citizens Advisory Committee (CAC) must be constituted to include technical and public stakeholder representatives who are expert and independent of the mosquito districts and who have time to devote to the Committee.** The proposed "fox in the hen house" scenario is simply not tenable or even sensible. JE.02

The fact that the 1998 MEPA Certificate called for annual updates and additional study and research and that this is th first update filed in 10 years is enough to raise ones eyebrows. That instead of addressing the issues raised in the previous MEPA review, it asks that the MEPA Certificate be rescinded, is flabbergasting. The proposed "Best Management Practices for Freshwater Mosquito Control" lack any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat. I find myself outraged by the seeming capitulation to the everlasting *status quo* -- one that bows to pesticide use and ditching rather than reconsideration of the basis for continuing current behavior. JE.03

Questions must be asked and answered as to how much environmental destruction is happening and how many citizen: are actually being both helped and/or hurt by these activities? Assuming that mosquito control is a de facto public benefit is not enough. None of us like the little nuisances, but the actual threat from them may well be less damaging than the means being used to control them. I believe that a Special Review Procedure that includes reasonable accountability provisions is appropriate.

Thank you for your attention.

Judith Eiseman
88 Arnold Road
Pelham, MA 01002
413-253-2932

Zavolas, Nicholas (EEA)

From: PeasoupGraphics [peasoupgraphics@comcast.net]

Sent: Thursday, January 17, 2008 3:27 PM

To: Zavolas, Nicholas (DEP)

Subject: Mosquito Control Monitoring Concerns

To Secretary Ian A. Bowles
EOEEA, Attn: MEPA Office
Nicholas Zavolas, EOEEA # 5027

LS.01

I am very concerned that, because mosquito districts are routinely altering wetlands and applying pesticides in large areas o the state, that MEPA review are continued to document 1) the effectiveness of current mosquito control practices in protecting public health and 2) the environmental impacts of these activities;

LS.02

Existing documents should continue to be submitted to MEPA for public review, e.g. 2006 report on aerial spraying o 425,000 acres.

LS.03

I strongly feel that any Citizens Advisory Committee (CAC) should include technical and public stakeholder representatives who are independent of the mosquito districts. I addition, freshwater mosquito control practices shoul focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g fish) and to reduce water pollution, sedimentation, and fish barriers (e.g. undersized culverts), rather than repeated ditching and pesticide applications.Mosquito districts routinely alter wetlands and apply pesticides throughout large areas of the state; LS.(

Lynn Southey, Wellfleet town resident.

LS.04

January 23, 2008

Secretary Ian A. Bowles
EOEEA, Attn: MEPA Office
Nicholas Zavolas, EOEEA # 5027
100 Cambridge Street, Suite 900
Boston MA 02114

Re: **EOEEA #5027 - Mosquito Control Generic Environmental Impact Report (GEIR) Update and Best Management Practices (BMPs) and Guidance for Freshwater Mosquito Control**

Dear Secretary Bowles:

The undersigned organizations and individuals submit the following comments on the update to the Mosquito Control GEIR, which consists of a draft guidance manual on *Best Management Practices [*BMPs*] and Guidance for Freshwater Mosquito Control* and a request for the 1998 MEPA Certificate to be rescinded and replaced with a new Special Review Procedure. This request by the State Reclamation and Mosquito Control Board (SRMCB) is open-ended and vague, providing for a Citizens Advisory Committee (CAC) primarily composed of representatives of the nine mosquito districts themselves, without any clear scope of work or provisions for accountability and transparency. **We oppose the request as submitted. We support continuation of review under the Massachusetts Environmental Policy Act (MEPA) through a new Special Review Procedure that includes clear procedural and substantive provisions as well as opportunities for meaningful involvement by all interested and affected stakeholders**, as described further below.

For the past 25 years, the Commonwealth's mosquito control program has been undergoing MEPA review. Progress has been slow. The Environmental Notification Form (ENF) was filed in 1983. After 15 years, the Final GEIR was produced. In response, the MEPA Certificate stated: *[T]he GEIR falls short of the ambitious goal of providing the basis for all future mosquito control projects.* The Certificate called for annual updates and additional study and research.

While we are pleased to see the guidance manual issued, we are concerned that this is the first update in 10 years, whereas annual updates were required. During all this time, mosquito control districts continued to operate heavy equipment in wetlands and apply pesticides across large areas of the Massachusetts landscape without the benefit of standardized BMPs or documentation of the effects of these activities on mosquito populations, human health, or the environment. MA.01 MA.02

Focus on Human Health and IPM

Although the vast majority of mosquitoes in Massachusetts do not carry disease, there is a small but nevertheless serious risk to human health from diseases transmitted by mosquito bites. Eastern Equine Encephalitis (EEE) and West Nile Virus (WNV), while rare, can cause serious illness or even death. Climate change may increase mosquito habitat and expand the range of mosquito-borne diseases not presently found in Massachusetts. Therefore, we support a program of mosquito control based on Integrated Pest Management (IPM) principles and consistent with the recommendations of the Centers for Disease Control and the Environmental Protection Agency[1]. MA.03

[1] http://www.epa.gov/pesticides/health/mosquitoes/mosquitojoint.htm#ipm

Wetlands Degradation and Mosquito Habitat

The Commonwealth's wetlands and waterways are affected by serious and ongoing stresses and damage including but not limited to:

- stormwater runoff and other nonpoint source pollution;
- erosion and sedimentation;
- more than 30,000 culverts and dams that block passage of fish and other aquatic life;
- water withdrawals that reduce streamflows; and
- invasive species.

These conditions not only harm the freshwater ecosystems upon which both people and a host of native species depend, they also create conditions that are ideal for mosquitoes while destroying habitat for fish and other mosquito predators. While we do not expect mosquito control districts to remedy the many problems caused by a wide range of human activities, they should work cooperatively with municipalities, state agencies, watershed groups, and others to restore wetlands. Where a culvert blocks flow or a stormwater discharge dumps sediment and untreated stormwater into streams, permanent solutions can be implemented that will restore fisheries and reduce the need for continual dredging of ditches or application of pesticides. The districts should engage in new partnerships and restoration projects that benefit both the environment and human health.

MA.04

Guidance Manual on Best Management Practices for Freshwater Mosquito Control

The manual submitted by the SRMCB as an update to MEPA provides guidance on how districts should plan and undertake projects in order to comply with the laws that apply to their work, such as the federal Clean Water Act, 401 Water Quality Certification, and the Massachusetts Endangered Species Act. The mosquito districts are exempt from the Massachusetts Wetlands Protection Act.

There is a serious flaw in this manual: it lacks any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat. On page 4, "Monitoring the effectiveness of the activity" is listed as one of the five key steps in project planning. Yet, the section on Monitoring Project Effectiveness (p. 16-17) only discussed stabilization of soils disturbed by the work. There is no mention of how to determine whether mosquito habitat or populations have been reduced.

MA.05

The manual also fails to address opportunities for the mosquito districts to work with the communities they serve to reduce mosquito habitat associated with stormwater management, instead noting that the districts are "not responsible for the operation, maintenance, monitoring, or treatment of larval habitat of stormwater BMPs." It is unfortunate that the SRMCB and districts do not see it as part of their job to cooperate with municipalities to assist in improving the design and management of stormwater facilities to reduce breeding habitat. The manual also lacks any mention of the extensive opportunities for districts to partner with others to restore streams and wetlands, improve fisheries, and reduce mosquito habitat.

MA.06

MEPA Jurisdiction and Ongoing Programmatic Review

The SRMCB filing notes that the MEPA regulations updated in 1998 no longer require GEIRs. First, it should be noted that the final MEPA Certificate was issued after the new regulations went into effect[2], therefore there was clearly intent by MEPA that the review would continue even with the regulatory change. Nevertheless, the work of mosquito control districts is still subject to MEPA because the districts alter extensive areas of wetlands, rare species habitats, and Areas of Critical Environmental Concern, and

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[2] MEPA regulations effective 7/1/98; Final Certificate on Mosquito GEIR issued 12/18/98.

are subject to 401 Water Quality Certification and Massachusetts Endangered Species Act permits (MEPA thresholds at 301 CMR 11.03(2), (3), and (11)). **It is preferable for all concerned to continue a programmatic review of these and other aspects of mosquito control rather than requiring individual ENFs for wetlands management and work in rare species habitat.** The latter approach would be cumbersome for the districts, whereas continued MEPA review can provide a streamlined process that best supports continual development and refinement of statewide BMPs.

Other Updates Should be Filed

The SRMCB has undertaken extensive work over the past several years in cooperation with the districts, the Department of Public Health (DPH), MassWildlife, and other agencies and experts, resulting in issuance of numerous plans, guidelines, analyses, and policies. None of these documents have been filed with MEPA as part of the required annual update process, even though some are available on the SRMCB website. A few examples of documents that have been completed and which should be noticed immediately as further updates for MEPA review include: MA.07

SRMCB *Operational Response Plan To Reduce The Risk Of Mosquito-Borne Disease In Massachusetts*
http://www.mass.gov/agr/mosquito/updates.htm

DPH's *2007 Massachusetts Arbovirus Surveillance And Response Plan*[3]
http://www.mass.gov/dph/wnv/arbovirus_surveillance_plan.pdf

Report on the 2006 aerial spraying of 425,000 acres in Southeastern Massachusetts and associated updated protocols developed with DPH and other agencies
http://www.mass.gov/agr/mosquito/eee-areal-spraying.htm

Recently adopted Reclamation Board Policies:
http://www.mass.gov/agr/mosquito/policies.htm
Mosquito Misting Systems Policy
and
Mosquito Adulticide Pesticide Label Bee Precautions Policy

These and other existing documents should immediately be submitted for review. Ongoing updates should continue to occur annually. The SRMCB has recently instituted an annual reporting form for districts to report on their activities – the completed forms should be part of the annual updates submitted to MEPA for public review.

Citizens Advisory Committee (CAC)

The SRMCB has requested a new Special review procedure including appointment of a CAC that would have a majority of member (nine) from the mosquito districts, along with one from DPH, one environmental group, and one citizen. This is not an independent advisory committee, but instead a formula for the districts to advise themselves. Nothing is to be gained from this other than additional meetings and self-serving approval of practices the committee members undertake.

If a CAC is appointed, it should have a clear mandate to assist the SRMCB in developing BMPs designed to protect human health and the environment and to improve the accountability of mosquito control work

[3] The 1998 GEIR stated that the 1991 version of this DPH plan would govern any future aerial spraying. Yet, in 2006, aerial spraying was undertaken based on an updated plan that had never been noticed for public review through MEPA.

in demonstrating the outcomes associated with their activities. The CAC members should include technical and public stakeholder representatives who are independent of the mosquito districts, including: | MA.08

- DPH Center for Environmental Health;
- MassWildlife;
- Experts in the effects of pesticides on human health and the environment;
- Watershed associations;
- Wetlands restoration experts;
- Conservation commissions, and
- Local boards of health.

Conclusion

Although the MEPA regulations no longer refer to GEIRs, programmatic review should be maintained under a Special Review Procedure that includes reasonable accountability provisions. We recommend issuance of a new Certificate that requires immediate submission of existing updated plans and policies as well as continued annual reporting. The scope should be focused on submission of substantive information related to BMPs based on IPM and demonstration of the effects of mosquito district activities on human health and the environment.

Sincerely,

Organizations:

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Becky Smith, Drinking Water Organizer
Clean Water Action
Clean Water Fund
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Mettie Whipple, Executive Director
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Ana Zarina Asuaje Solon, President
Lucia Dolan, Maeve Ward, Co-Chairs
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Ken Pruitt, Executive Director
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John Reinhardt, President
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Samantha Woods, Executive Director
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Frank Albani, Director
Soule Homestead Education Center
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Carolyn LaMarre, Executive Director
Taunton River Watershed Alliance
P.O. Box 1116, Taunton MA 02780

Don Ogden and Glen Ayers, co-hosts
The Enviro Show, WXOJ-LP 103.3fm
Northampton, MA

Donna M. Brownell, President
WEST (Watchdogs for an Environmentally Safe Town)
PO Box 690, Westminster MA 01473

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Lindsay Martucci
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Deirdre C. Menoyo
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Jones River Watershed Association, Inc.

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www.jonesriver.org

January 22, 2008

Secretary Ian A. Bowles
EOEEA, Attn: MEPA Office
Nicholas Zavolas, EOEEA # 5027
100 Cambridge Street, Suite 900
Boston MA 02114

Re: **EOEEA #5027 - Mosquito Control Generic Environmental Impact Report (GEIR) Update and Best Management Practices (BMPs) and Guidance for Freshwater Mosquito Control**

Dear Secretary Bowles:

On Behalf of the Jones River Watershed Association I submit the following comments on the update to the Mosquito Control GEIR, which consists of a draft guidance manual on *Best Management Practices [*BMPs*] and Guidance for Freshwater Mosquito Control* and a request for the 1998 MEPA Certificate to be rescinded and replaced with a new Special Review Procedure. We have signed on to a letter drafted by Mass Audubon and join them in opposition to this request by the State Reclamation and Mosquito Control Board (SRMCB.)

Jones River Watershed Association (JRWA) has publicly been at odds with the methods and procedures undertaken by the SRMCB, the Mosquito Control Districts and the Commonwealth during times of public health threat and declared emergencies. In 1990 and in 2006 JRWA sought injunctive relief in the courts to prevent and avoid the aerial application of pesticides on fragile ecosystems as a method to curb the threat of EEE which had gotten beyond the reach of effective mosquito control. However, JRWA understands that the threat of EEE to human health is very concerning and very real, and we would like to assist the Commonwealth in arriving at a mosquito control program that is effective, affordable, and protective of the public health and our fragile environmental resources. We do not think that the proposed "Special Review Procedure" will accomplish a new and effective program because the proposed team would be focused on advising the SRMCB updates—which are proposed on a five year cycle.

We are disappointed that the present update does not recount the events of 2006, the monitoring data, the pesticide application and the results, or the chosen methods for chemical control. **We are eager for the additional updates that are promised and request a schedule for these long overdue accounts.** JRWA.01

JRWA has been engaged with SRMCB, DAR, DPH, DEP and other state agencies on a cyclic basis regarding broad scale application of pesticides dating back to the early 80's even before JRWA was formally organized. We have endured three occurrences of aerial application during that time which have noticeable impact on the nature and health of beneficial organisms, as well as on people. Frankly we are appalled that the antiquated and politically compromised system of Mosquito Control Districts with their uneven budgets and questionable environmental accounting continues as an exempt activity under Massachusetts law. MEPA is the ONLY public review procedure—it cannot be given over to a CAC at this time—**Please do not rescind the 1998 Certificate on the GEIR!** JRWA.02

JRWA understands and is sensitive to the difficult nature of mosquito control and disease prevention. We appreciate the hard word and dedication of the personnel who labor within the existing system to find the latest effective product, try a new trap, count these tiny pests, and pool their disease quotient. But it seems that the system is defeating them. If they do a good job or just get lucky with a dry year, their budget takes a hit. When the EEE cycle recurs and disease threatens, enormous sums of money are spent on the aerial acrobats from out-of-state. It is hard to win, and the science becomes compromised and we make no progress—as evidenced by the 1998 GEIR and this "update" that is ten years late.

The political structure is also fractured. The districts are semi-governmental autonomous entities with the benefit of state employees, and the blessings and curse of a state budget. The 1998 Certificate required updates on the GEIR as a means of tracking, building and developing a public discussion on the important topic of mosquito control. Now we have the SCMCB trying to duck under the sheets again with its own CAC which it will call to session to comment and stamp its occasional reports to MEPA, much like the MCDs which now sent a "courtesy" notice to the Conservation Commission when they choose to work in wetlands. We need a complete overhaul, and MEPA requirements are a good place to hold the discussion. JRWA.03

BMP

The Freshwater BMP that was submitted by SRMCB for public comment now is deficient in several critical ways. In our opinion, the first issue to address, which is not even mentioned, is mosquito and environmental monitoring as the underlying basis for MCD activities/wetland management. It is not unusual today for "mosquito control activities" to occur where someone wants to avoid filing with a conservation commission. After all, mosquito control is an exempt activity, so why not clear the stream without filing? We need to set a standard for the mosquito breeding evidence that is available for public review, and understand the human health threat associated with that evidence. This means that not only do we need to count breeding species and their EEE evidence, but calculate how the environment will handle the elevated threat and what assistance to give. JRWA believes that the methods of assessing the risk must include additional environmental factors—not just wetness, temperature and incidence of EEE in birds, but other evidence as well: include evidence of predators and an assessment of where the threat to human life exists, and an alternatives analysis that would indicate how best to control it. When practices are performed and control measures taken, we need scientifically based independent monitoring to evaluate the program, not simply justify it. JRWA.04

Because the districts have been in place for quite some time and have a long record of breeding sites, it should be possible to develop local maps for public disclosure and public hearing in communities where mosquito control is necessary to protect public health. These maps and information should clearly describe the problem, location, habitat issues and recommended treatment(s). When this happens, the local community could have some input and participate in effective local action. Now, the public is only engaged in personal protection during emergencies. Worse, SRMCB and the MCD so segment their activities that they can do more harm then good. For example, regular and repeated uses of pesticides from truck mounted sprayers can negatively impact breeding sites for beneficial organisms and may also have other serious impacts. These actions can alter natural balance and elevate the incidence of the rapid reproducing mosquitoes apparently requiring recurring treatment that is harmful both to people and the environment. JRWA.05

Freshwater wetland alterations should not be segmented from all other mosquito control activities. All BMPs—to be a BMP and follow IPM—must be related! An example of our concerns is the repeated aerial application of larvacides by helicopter to Blackwater swamp, followed by weekly applications of adulticide to youth athletic ball fields, which also use fertilizers and artificial irrigation to make the grass grow. We are not aware of any effort to evaluate the compounding of chemicals in the environment or the impact on this valuable and rare ecosystem. While JRWA is busy trying to get fish back to Blackwater Pond by relieving a JRWA.06

downstream dam—the stream is clogging and the pond is losing oxygen and growing submerged algae mats. Can we develop a system for all of us to work for a healthy environment that will understand and conquer the persistent incidence of EEE in Blackwater Swamp?

Mosquito Control activities—whether wetland alterations or pesticide applications—lack supervision and environmental monitoring. Without this critical component it is impossible to think that we will develop a truly effective program that protects human health and the environment—especially at a time when climatic warming is causing extensive change in global and regional ecosystems. JRWA.07

E. Stormwater

p. 17 states:

> The SRMCB and its mosquito control districts and /projects are not responsible for the operation, maintenance, monitoring, or treatment mosquito larval habitat of stormwater BMPs. Typically, the owners of the property that develop the stormwater BMPs, or municipalities that "accept" them through local subdivision approval, are responsible for their operation and maintenance. JRWA.08

This is concerning because of the increasing incidence of West Nile virus and its relationship to stormwater systems. It is not likely that local towns have the knowledge to effectively control or monitor mosquito breeding in stormwater basins and other structures. Furthermore, it is not really true that the SRMCB is uninvolved in stormwater infrastructure management as evidenced by the widespread use by the MCDs of growth inhibitors in catch basins which discharge to waterways. We take note of the legal action by the New Jersey /New York lobstermen against the state's mosquito control practices which were thought to negatively affect the larval stage of lobsters.

Conclusion

Effective mosquito control requires holistic management of political, financial and environmental factors. The Commonwealth of Massachusetts does not enjoy a program of Best Management of even the environmental factors that will protect the citizens from recurring assaults from EEE and insurgent West Nile Virus. To develop an effective program it is essential that the agencies that claim jurisdiction employ an effective strategy that will not only monitor the incidence of mosquitoes and prevalence of virus threat, but will work to understand how to help the natural environment function effectively where it can, and to manage our infrastructure and alterations in such a way so as to control artificial breeding habitats and manage risk to human residents. To do this the SRMCB should recruit public involvement, should expand its monitoring of the environment, and should employ new and better systems that have a chance to be more effective while not damaging the very biological and environmental systems upon which we ultimately depend. We ask the Secretary to set a schedule for the SRMCB to report, through MEPA, on the use of pesticides in the environment for mosquito control, and the methods for environmental monitoring both of the effectiveness of the MCD programs and the impact of its BMPs. We ask that the 1998 Certificate remain in effect, and if an SRP is employed that it take on the entire issue and structure of mosquito control and risk management.

As always, we appreciate the opportunity to continue to comment on matters of importance to our members and our environment. Thank You.

Very truly,

Pine duBois
Executive Director

N:

Green Futures

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Fall River, Massachusetts 02724-0144
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www.greenfutures.org
info@greenfutures.org

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MEPA

"Citizen action for better communities."

January 18, 2008

Ian A. Bowles, Secretary
Executive Office of Energy and Environmental Affairs
Attn: MEPA Office – Mr. Nicholas Zavolas
EOEEA #5027
100 Cambridge Street, Suite 900
Boston, MA 02114

Re: EOEEA #5027: Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control.

Dear Secretary Bowles:

We at Green Futures have reviewed the above-referenced filing and have the following comments:

MEPA Review: Continued MEPA review is necessary to ensure the protection of public health and our shared environment. Locally, Bristol County Mosquito Control has drained and altered wetlands resulting in the loss of wildlife diversity with seemingly little impact on the area's mosquito population. The only major beneficiaries of these actions seem to be promoters of ill-conceived development projects that amazingly appear on the "reclaimed" land and, of course, these wetland altering projects provide employment for mosquito control personnel. During the 2006 spraying frenzy, we received numerous complaints of Mosquito Control employees fog-spraying "Anvil" …an endocrine disruptor, on organic gardens, a municipal water supply watershed, and private property. As one can see, continued MEPA review is desperately needed to determine if the activities of the State Reclamation and Mosquito Control Board and the mosquito control districts under their jurisdiction are engaging in effective practices regarding mosquito control, public safety, and natural environmental health. Requirements for annual updates through MEPA are a necessity. GF.01

Altering Wetlands and Ditching: Years of altering, draining, channeling and ditching of wetlands has shown little, if any, reduction in mosquito populations. Where are the studies of locally altered wetlands and/or documentation that conclusively show these alterations work? Let's put the brakes on the mosquito control scam. Mosquito control GF.02

practices should focus on encouraging natural mosquito predators and restoring and improving wetlands. Eastern Massachusetts is replete with swamps, marshes and other wetland types of all sizes. To think ditching, altering and draining will have a major impact on mosquito populations is folly. To spray or fog pesticides, killing prey and predator alike, should be criminal. Restore the wetlands.

Citizens Advisory Board: A Citizens Advisory Board should be composed of individuals free from influence and independent of the mosquito control districts. Members of the Citizens Advisory Board should include scientists expert in the effects of pesticides on human health, entomologists, wetlands biologists, ecologists, individuals from local watershed and environmental organizations, representatives from local land trusts, organic farmers, apiarists and fish culturists.

New Role for Mosquito Control Bureaucrats: Modern technology presents us with an array of mosquito eliminating and repellent devices for our yards and effective repellents for use by individuals that can be applied to clothes and/or skin. Isn't it past time mosquito control folks stopped beating Mother Nature with an "Anvil" and instead embarked on yearlong educational campaigns and outreach on how people can live with mosquitoes most of the time and when, at certain times and locations when mosquitoes may pose a threat to public health, how to then avoid them? We think that would be preferable to feeding the yearly news media frenzy and damaging human health and the environment whenever a few disease carrying mosquitoes are found. Why doesn't the state alter the landscape and spray for bee, hornet and wasp control? How many people have had allergic reactions to venomous insect stings over the past fifty years? How many have died? How do those statistics compare to those of mosquito caused EEE sickness and death? The answers might prove interesting. GF.03

Sincerely,

Tim Bennett

Timothy Bennett, President
Green Futures, Inc.

Cc: Massachusetts Department of Conservation and Recreation
Massachusetts Department of Fish and Game
The Trustees of Reservations
Massachusetts Audubon Society
The Nature Conservancy
The Taunton River Watershed Alliance
Massachusetts Sportsmen's Council

The Nature Conservancy
Protecting nature. Preserving life.

Massachusetts Chapter
205 Portland Street, Suite 400
Boston, MA 02114-1708
617.227.7017/Voice · 617.227.7688/Fax

January 23, 2008

Secretary Ian A. Bowles
Executive Office of Energy and Environmental Affairs
Attn: Nicholas Zavolas, MEPA Office
100 Cambridge Street, Suite 900
Boston MA 02114

Re: EOEEA #5027 - Mosquito Control Generic Environmental Impact Report (GEIR) Update and Best Management Practices (BMPs) and Guidance for Freshwater Mosquito Control

Dear Secretary Bowles:

On behalf of The Nature Conservancy, I am submitting the following comments on the update the Mosquito Control GEIR, which consists of a draft guidance manual on Best Management Practices [BMPs], Guidance for Freshwater Mosquito Control, and a request for the 1998 MEPA Certificate to be rescinded and replaced with a new Special Review Procedure. The mission of The Nature Conservancy ("the Conservancy") is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. With the help of public and private partners, The Conservancy has protected more than 23,000 acres of land and water in Massachusetts.

Because of the serious risk to human health from mosquito borne illness, The Nature Conservancy does support a program of mosquito control that is based on Integrated Pest Management (IPM) principles and best practices for safeguarding both public health and the environment. However, the Conservancy opposes the request to rescind the 1998 MEPA Certificate. The Conservancy feels that MEPA should continue programmatic review of mosquito control activities because they alter extensive areas of wetlands, rare species habitats, and Areas of Critical Environmental Concern, and are subject to 401 Water Quality Certification and Massachusetts Endangered Species Act permits. Regular MEPA review would provide a unified process to support development and refinement of mosquito control practices statewide, while providing a mechanism for on-going review and comment by all affected stakeholders.

Though the 1998 MEPA Certificate called for annual updates and additional study and research, no such materials have been submitted until now. We are pleased to see the guidance manual now submitted by the State Reclamation/Mosquito Control Board (SRMCB), but feel the manual should include provisions for monitoring success in reducing mosquito breeding habitat, and address opportunities for working with municipalities and other potential partners to reduce mosquito habitat through improved storm water management and restoration of wetlands, streams and fisheries. We also feel the proposed Citizen's Advisory Committee would be more meaningful if it included technical and stakeholder representatives who are independent of the mosquito control districts, and was given a clear mandate to aid in refining BMPs to protect human health and the environment, based on a review of actual effectiveness measures.

NC.01

NC.03

In conclusion, The Nature Conservancy recommends issuance of a new Certificate that requires submission of existing updated plans and policies as well as continued annual reporting. The scope should be focused on substantive information related to BMPs and demonstration of the effects of mosquito district activities on human health and the environment. | NC.02

Sincerely,

Loring Schwarz
Acting Massachusetts State Director

Zavolas, Nicholas (EEA)

From: Babb-Brott, Deerin (EEA)
Sent: Wednesday, January 23, 2008 2:01 PM
To: Zavolas, Nicholas (EEA)
Subject: FW: MEPA review of mosquito control practices

-----Original Message-----
From: Bowles, Ian (EEA)
Sent: Wednesday, January 23, 2008 1:57 PM
To: Babb-Brott, Deerin (EEA)
Subject: Fw: MEPA review of mosquito control practices

----- Original Message -----
From: Alexandra Dawson <adawson@crocker.com>
To: Bowles, Ian (EEA) <Ian.Bowles@state.ma.us>
Sent: Wed Jan 23 13:45:32 2008
Subject: MEPA review of mosquito control practices

Dear Secretary Bowles,
Although I have never met you, MACC (where I was once president) reports that you have a strong background in environmental protection. I am therefore moved to suggest that you resist current efforts to weaken the MEPA program. MEPA is not only important in itself, even though people who do not understand the deeper currents of political influence often brush it off; it is also your only direct control over environmental protection (other than the ACEC program, which has more or less disappeared).

In the well-intentioned name of "streamlining" permits for projects of all sorts, the MEPA jurisdiction is in danger of being nibbled to nothing. The latest manifestation of this trend is the proposal to simplify mosquito control operations by substituting for current MEPA review the supervision of a committee controlled entirely by the mosquito control districts. (I know this is not how the plan has been presented to you, but this will be the long-term effect.) The districts' work alters extensive areas of wetlands and rare species and is exempted from the Wetlands Protection Act. MEPA review is our best hope of providing public scrutiny over this work. AO.01

Today is the deadline for comment on the proposed new regulations. I strongly urge you to look carefully at this and any other proposal to weaken the MEPA law. Alexandra Dawson

Zavolas, Nicholas (EEA)

From: McDevitt, Alicia (EEA)
Sent: Friday, January 18, 2008 2:51 PM
To: Babb-Brott, Deerin (EEA); Zavolas, Nicholas (EEA)
Subject: FW: 5027 Mosquito Control GEIR update
Attachments: GENERIC ANNUAL OPERATIONS REPORT (draft).doc

I assume that MEPA staff is simply incorporating these comments into the special review procedure for the mosquito control boa and that there's nothing we need to do on the legal end, but please let me know if I'm wrong about that.

Thanks,

Alicia Barton McDevitt
Deputy General Counsel
Executive Office of Energy and Environmental Affairs
100 Cambridge Street, Suite 900
Boston, MA 02114
617-626-1132
alicia.mcdevitt@state.ma.us

From: Heidi Ricci [mailto:hricci@massaudubon.org]
Sent: Monday, January 07, 2008 4:15 PM
To: Deerin Babb-Brott (E-mail); Zavolas, Nicholas (DEP)
Cc: Ken Kimmell (E-mail); McDevitt, Alicia (EEA); Glenn Haas; Mark Buffone; Monnelly, Anne (DCR)
Subject: 5027 Mosquito Control GEIR update

Deerin and Nick

Are you aware of this effort by the Reclamation Board to formulate an annual reporting form for the districts to complete and submit? I am pleased they are taking this step, but confused as to why they have made no mention of it in their current MEPA filing. I have asked them to clarify. I am attaching the current draft of the form. MA.HR.01

There are also many other existing documents that should have been noted and made available with the recent GEIR update, e. reports on the 2006 aerial spraying, various protocols and technical analyses such as a technical memo describing why Anvil wa chosen for aerial spraying - this pesticide wasn't available in 1998 and therefore was not described in the GEIR. Since the agencies did a comparative analysis of this chemical vs. others for aerial spraying and then used that analysis to select this new chemical, that clearly is an "update" to the GEIR that should have been included for public review. There are also other documents that were circulated to people involved in last year's Working Groups, e.g. protocols for monitoring mosquitoes, wate supplies, and other aspects in the event of aerial spraying. MA.HR.02

I will compile a list of existing documents that effectively update the practices described in the 1998 GEIR but that have never been filed with MEPA, and will submit them with further more formal comments during the current comment period. Meanwhile, am sending this as a preliminary comment.

Please see my comments below on the new annual reporting form. While I see many positive benefits of this form and reporting process, I object to the use of a definition of IPM that departs from state law. | MA.HR.03

The proposed Special Review Procedure is very open ended. I request a formal Scope (I'll provide suggestions in my further comments), and the annual reporting requirement should be upheld. If nothing else is new each year, the SRMCB could simply provide a link to the districts' annual reports which they intend to begin gathering per the attached new form. They have said the plan to post the reports on the SRMCB website so if they do that it should be simple to publish a notice of availability in the Monitor annually linking people to the website. MA.HR.04

Heidi

P.S. There is also a compilation of comments on the attached form, circulated among the informal group that the SRMCB convened via email to help them draft the form. I have that information but am not attaching it at this point since it is a compilatic of emails from various people and reflects a number of items that are still under discussion. I would be happy to share with you my comments on the draft form if you wish.

-----Original Message-----
From: Heidi Ricci
Sent: Monday, January 07, 2008 3:44 PM
To: 'Timothy Deschamps'; Bouchard, Alisha (AGR); Brad Mitchell; Glenn Haas; Kim King; Mark Buffone
Cc: 'Monnelly, Anne (DCR)'
Subject: RE: Last chance to comment before it goes to SRB

Thanks Tim.

The forms should request submission of maps (if available) showing where treatments, ditch maintenance, etc. have been performed. I realize not all districts will have maps and those that do will have a variety of formats, but the reporting form should nevertheless ask for such info. to the extent it is available.

I strenuously object to the use of the SRMCB's IPM/IMM definition. Administrative policies cannot supercede law.

MA.HR.03

MA Pesticide Control Act: http://www.mass.gov/legis/laws/mgl/132b-2.htm

> "Integrated pest management", a comprehensive strategy of pest control whose major objective is to achieve desired levels of pest control in an environmentally responsible manner by combining multiple pest control measures to reduce the need for reliance on chemical pesticides; more specifically, a combination of pest controls which addresses conditi[o]r that support pests and may include, but is not limited to, the use of monitoring techniques to determine immediate and ongoing need for pest control, increased sanitation, physical barrier methods, the use of natural pest enemies and a judicious use of lowest risk pesticides when necessary.

Furthermore, the last sentence of the SRMCB's IPM policy is not supported by evidence due to the lack of a standardized pre an post treatment monitoring program or any quantification of side effects on human health and the environment (which are also important to Massachusetts' quality of life). It is an opinion stated as fact.

Heidi

E. Heidi Ricci
Senior Policy Analyst
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PLEASE HELP PROTECT THE NATURE OF MASSACHUSETTS --- JOIN MASS AUDUBON TODAY!!!! CALL 1-800-283-8266 OR VISIT OUR WEBSITE WWW.MASSAUDUBON.ORG THANKS!

-----Original Message-----
From: Timothy Deschamps [mailto:deschamps@cmmcp.org]
Sent: Monday, January 07, 2008 3:00 PM
To: Bouchard, Alisha (AGR); Brad Mitchell; Glenn Haas; Heidi Ricci; Kim King; Mark Buffone
Subject: Last chance to comment before it goes to SRB

Attached is the latest working draft of the annual report, please look this over and have comments to me before the end of business tomorrow (Tues. the 8th) - I plan to send this to SRB the first thing Wednesday.

Thank you very much to everyone, your participation has made this task a productive one, I appreciat[e] your comments and concerns. I think we have a good start and look forward to working with everyone again at some time in the future.

Timothy D. Deschamps, Executive Director
Central Mass. Mosquito Control Project
111 Otis St. Northborough, MA 01531
(508) 393-3055 www.cmmcp.org

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

NZ

Wayne F. MacCallum, *Director*

RECEIVED

JAN 25 2008

MEPA

22 January 2008

Ian A. Bowles, Secretary
Executive Office of Environmental Affairs
Attention: MEPA Office
EOEA No. 5027
100 Cambridge St.
Boston, Massachusetts 02114

Project Name:	*draft Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control*
Proponent:	*MA Department of Agricultural Resources, State Reclamation and Mosquito Control Board*
Location:	*Statewide*
NHESP Tracking No.	*07-23830*

Dear Secretary Bowles:

The Natural Heritage & Endangered Species Program (NHESP) of the Massachusetts Division of Fisheries & Wildlife has reviewed the MA Department of Agricultural Resources' draft Massachusetts Best Management Practices (BMPs) and Guidance for Freshwater Mosquito Control and would like to offer the following comments.

As noted in the draft BMPs, the NHESP has consulted with the State Reclamation Board over the last several years to improve communication and coordination of the review of proposed activities within areas subject to the jurisdiction of the MA Endangered Species Act (M.G.L. c. 131A) and its implementing regulations (MESA, 321 CMR 10.00). The BMPs include pre-work review and work practices that will likely be of general benefit to the affected areas. The documentation of pre-existing conditions and a thorough *Site Plan* will greatly improve site-specific knowledge in a unified format between Mosquito Control Districts (MCDs). We recognize that the BMPs represent a lengthy negotiated document between several agencies. The BMPs present a clear list of agencies with a role in the review of projects and provides clear steps for MCDs to follow. This will also benefit the public who is provided a greater insight into the review, selection and work association with the MCDs.

The BMPs include a brief summary of the MESA (see 2. b) which requires clarification. We submit the attached regulatory description to replace "Section 2.b Rare and Endangered Species" (see "Revised Section 2. b."). NHESR1 .01

In response to the 1998 Generic Environmental Impact Report, the Secretary of EOEA stated, "The SRMCB and, the GEIR acknowledge that additional study and research work is necessary to truly document the effectiveness of mosquito control techniques and their impact on the environment, particularly as they relate to freshwater project[s]." The NHESP finds that this lack of research and study remains nine years after the GEIR was completed. It is still unclear if the proposed methods are effective NHESP.c .02

Division of Fisheries and Wildlife
Field Headquarters, One Rabbit Hill Road, Westborough, MA 01581 (508) 389-6300 Fax (508) 389-7891
An Agency of the Department of Fish & Game

at controlling mosquito populations, rather than simply mitigating nuisance issues. The BMP's section "E. Monitoring Project Effectiveness" is only focused on whether or not the soil stability of the site has been maintained after project work. There continues to be a lack of effort to document the post-project mosquito populations that can be tied to the project work, no effort to monitor invasive plant community responses to the disturbance (as needed), and no monitoring at sufficiently frequent or long-term periods to understand the actual effectiveness of the mosquito control effort nor the environmental impacts. We think there is a necessary and important role for the MCDs to implement monitoring programs that help refine and inform mosquito control practices in Massachusetts that can be demonstrated to affect mosquito populations in ways relevant to human health and the health of the Commonwealth's biodiversity.

The NHESP has worked collaboratively with the MCDs regarding work described in the BMPs to avoid harm to state-listed species. In general, we have been able to find work-practices, timing and other consideration that avoid harm to state-listed species. The NHESP is presently working with the MCDs to establish filing procedures and leverage mapping tools (eg, Arcview) that will prove an efficient annual review of work pursuant to the MESA. We have conducted the first of several training sessions to help ensure the review process is smooth and efficient.

The NHESP notes that our staff member Misty-Anne R. Marold (formerly Ralston), when at the University of Massachusetts-Amherst, helped develop an earlier draft version of these BMPs. We appreciate the opportunity to comment on this project.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director

Revised Section 2. b.

The Massachusetts Endangered Species Act (M.G.L. c. 131A) and its implementing regulations (MESA, 321 CMR 10.00) establish procedures for the listing and protection of state-listed plants and animals. The MESA regulations include project review filing requirements for projects or activities that are located within a *Priority Habitat of State-listed Rare Species* (*"Priority Habitat"*). The MESA is administered by the Natural Heritage and Endangered Species Program (NHESP) of the MA Division of Fisheries & Wildlife, and prohibits the "take" of state-listed species. The "take" of state-listed species is defined as "in reference to animals, means to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct, and in reference to plants, means to collect, pick, kill, transplant, cut or process or attempt to engage or to assist in any such conduct. Disruption of nesting, breeding, feeding or migratory activity may result from, but is not limited to, the modification, degradation or destruction of Habitat" (321 CMR 10.02).

MCDs should consult the most recent edition of the *MA Rare & Endangered Species Habitat Atlas* to determine if a proposed project will occur within *Priority Habitat* and the relevant NHESP guidance information to determine if direct filing with pursuant to the MESA is required.

If a filing with the NHESP is required, filing should consider access, egress, spoil/soil deposition or spreads or other activities related to the project occur within *Priority Habitat,* then the MCD should send the required information to the NHESP for review pursuant to the MESA. In general, the Site Plan should include sufficient detail and mapping to clarify the location of all work areas and the form of work (eg, mechanical work or hand work).

- Within 30 days of receiving a filing, the NHESP will provide a response letter indicating whether or not the submission is complete. If the submission is complete, the NHESP will provide a letter determining if the project will result in a "take" within 60 days of the date of posting of the first letter. (321 CMR 10.18)
- In this letter, the NHESP will determine whether or not a project, as currently proposed, will (a) avoid a "take" as proposed, or with conditions and may proceed without further review; or (b) will result in a "take" of State-listed Rare Species and cannot proceed as proposed (321 CMR 10.18).
- If a project is determined to result in a "take" then it may be possible to redesign the project to avoid a "take". If such revisions are not possible, then projects resulting in a "take" may only be permitted if they qualify for a MESA Conservation & Management Permit (321 CMR 10.23).
- The *MA Rare & Endangered Species Habitat Atlas* is currently available as a bound book, a compact disk with electronic viewer technology, as downloadable data for ArcView from MassGIS, and online using the MassGIS viewer. Details are available at: http://www.mass.gov/dfwele/dfw/nhesp/publications/nhesp_pubs.htm
- The NHESP's mailing address for MESA reviews can be found at: http://www.mass.gov/dfwele/dfw/nhesp/regulatory_review/reg_review_contacts.htm

Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control

October 24, 2008

Compiled and edited by:

University of Massachusetts - Amherst
Department of Natural Resources Conservation

Massachusetts Department of Agricultural Resources
State Reclamation and Mosquito Control Board

Massachusetts Department of Environmental Protection
Bureau of Resource Protection

Table of Contents

Appendices

The design of this manual draws extensively from the *Massachusetts Forestry Best Management Manual* developed by Kittredge and Parker (1995). We wish to thank these authors for their permission to use materials from this manual. Additionally, this manual draws extensively from the ditch maintenance procedures and policies developed by the Northeast and Norfolk Mosquito Control Districts.

Design Credits:

This project has been financed partially with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (MassDEP) under a Section 104(b) (3) Water Quality and Wetland Grant. The mention of trade names or commercial products does not constitute endorsement.

1. WHY BMPs (BEST MANAGEMENT PRACTICES)?

Mosquito control in Massachusetts is overseen by the State Reclamation and Mosquito Control Board (SRMCB) (http://www.mass.gov/agr/mosquito/). Mosquito control is conducted in communities that are members of a regional mosquito control district. Mosquito Control Districts (MCDs),[1] acting under the authority of the SRCMB and MGL Chapter 252, work directly with local communities to control mosquito infestations and thereby alleviate a nuisance, protect public health and promote quality of life for those communities. Recognizing the various public benefits of mosquito control programs, there is also the need to understand and minimize unnecessary impacts to wetland resources that may result from these activities. Integrated Pest Management (IPM) techniques for mosquito control may involve wetlands management, including, but not limited to, physical alterations to resource areas. Wetlands management, as an IPM technique, is designed to minimize wetland impacts. Mechanical and hand clearing techniques are implemented on a site-specific basis and while some techniques may eliminate areas of temporary standing water, others may simply improve drainage and ebb flows through the surrounding floodplain. These activities may sometimes disturb stream banks and/or the surrounding resource areas.

The purpose of this guidance is two-fold. First, it is designed to provide recommended practices for proper planning of freshwater mosquito control activities, consistent with applicable regulations. Second, it provides MCD personnel with a set of *Best Management Practices* (BMPs) for freshwater mosquito control activities involving wetlands management that will help minimize disturbance to stream banks and surrounding resource areas and control sediment discharges that may cause unnecessary impacts to:

- Wetland resources and adjacent areas,
- Drinking water supplies, and
- Fish and wildlife habitats**.**

The need for this manual was identified, in part, from recommendations made in the 1998 Generic Environmental Impact Report (GEIR) developed for mosquito control by the State Reclamation and Mosquito Control Board within the Department of Agricultural Resources, (DAR). The Final GEIR was required of the SRMCB by the Massachusetts Environmental Policy Act (MGL Ch.30A § 61). The Secretary's certificate on the GEIR required that the SRMCB provide periodic updates on issues involving source reduction methods, including the results of working with the water quality certification program and Natural Heritage and Endangered Species Program to improve notice and record keeping practices and minimize potential negative impacts from source reduction activities in wetlands and other resource areas. This guidance serves as an update on the dialogue between these programs.

[1] The term Mosquito Control District (MCD) includes those entities established as Mosquito Control Projects by their enabling legislation e.g. Norfolk County Mosquito Control Project.

It also outlines agreed upon steps that can be taken to allow these programs to achieve their respective goals and legislative mandates. In addition to providing better protection for wetland resources, BMPs for freshwater mosquito control activities by MCDs involving wetland management may also reduce the need for other kinds of mosquito management activities such as larviciding and adulticiding.

This document is designed for use by mosquito control personnel to guide them in planning and implementing freshwater mosquito control activities. The attached appendices provide standardized documents for site plans, notification, and documenting complaints and/or evidence of mosquitoes.

The success and effectiveness of these BMPs depends on mutual cooperation between MCD's, the SRMCB, local governments, and the regulatory community. Timely and responsive communication among these groups is important to the success of these efforts.

2. PLANNING

Comprehensive mosquito control planning is the **most important BMP, and the first to consider**: For any freshwater mosquito control activity that involves mechanical wetlands management, the following five steps are recommended to MCDs:

A. Complete the Mosquito Control *Complaint and Documentation Form* (Appendix 1) to document the presence or conditions likely to support mosquito breeding;

B. Review legal requirements for the proposed work site;

C. Prepare a *Site Plan* as described on page 10 (see sample *Site Plan* in Appendix 2);

D. Notify affected property owners and local, state, and federal agencies of the planned activity. (See sample Appendix 3); and

E. Monitor the effectiveness of the activity and environmental impacts of mosquito control work.

Following these five steps will help to ensure that all applicable regulatory requirements are met and that the activity implements the appropriate BMPs to minimize impacts to wetland resource areas. Proper notification will promote better communication among MCDs and environmental agency staff, as well as the general public interested in the benefits of the MCD activity. Monitoring provides a means to evaluate the success of the activity and information for how to improve future activities.

A. Identifying the Need for the Mosquito Control Activity in Freshwater Wetlands

Documentation of the need for mosquito control at a particular activity site should include:

- Description of the causes and effects of the mosquito breeding habitat on site (i.e., sediments, blocked culverts);
- Evidence as recorded in Mosquito Control *Complaint and Documentation Form* (Appendix 1) of mosquito breeding or infestation from one or more of the following sources:
  - Previous larviciding site records;
  - Larvae / adult data from field sampling and dip counts;
  - Aspirations of adult mosquitoes or landing counts (at the discretion of the field technician);
  - Complaints from residents or public officials; and
  - Observations from mosquito control personnel as recorded including site conditions that are conducive to mosquito breeding.

B. Review of Legal Requirements for Proposed Activities in Freshwater Wetlands

Once the need for the activity has been established, the legal requirements for mosquito control activities in wetland resource areas should be evaluated.

The State Reclamation and Mosquito Control Board (SRMCB) was established by MGL Ch.252 (Improvement of Lowlands and Swamps statute) and incorporated provisions of Ch. 199 and 699 of the Acts of 1960. This state board is housed within the MA Department of Agricultural Resources (DAR) and has authority under this law to:

1. To drain or flow a meadow, swamp, marsh, beach or other low land held by two or more proprietors,

2. To remove obstructions in rivers or streams leading thereto or there from, and

3. To eradicate mosquitoes in **any** area infested thereby, including, in respect to each such purpose, purposes incidental thereto, such improvements may be made as provided in this chapter.

Many state environmental statutes specifically exempt mosquito control work authorized under the provisions of M.G.L. c. 252, including, most notably, M.G.L. c. 131, § 40 (Wetlands Protection Act) and M.G.L. c. 40, § 8C, (Conservation Commission Authority).

MDCs should also review the applicability of legal and regulatory requirements of other programs, such, but not limited to, the following:

1. Federal Law:

The U.S. Army Corps of Engineers (USACE) regulates and requires a permit for all work in navigable (tidal) waters under Section 10 of the Rivers and Harbors Act, with almost all work requiring written authorization. Activities subject to Section 10 (33 U.S.C. 403) include construction, excavation, or deposition of materials in, over, or under such waters, or any work, which would affect the course, location, condition, or capacity of those waters. In addition, the Corps regulates and requires a permit for the discharge of fill in waters of the U.S. under Section 404 of the Clean Water Act, which includes fill associated with mosquito ditches in tidal and non-tidal wetlands under Corps jurisdiction. Waters of the U.S. include jurisdictional wetlands as defined in 33 CFR 328.3(b). (See: http://www.usace.army.mil/cw/cecwo/reg/33cfr328.htm) Fill material is defined in 33 CFR 323.2 (e) (1). (See:http://www.usace.army.mil/cw/cecwo/reg/laws/Def_of_Fill_Rule.pdf)

In Massachusetts, the mosquito control activities under jurisdiction of the Corps are subject to the terms and conditions outlined in the Massachusetts Programmatic General Permit (PGP). (See: http://www.nae.usace.army.mil/reg/mapgp.pdf)

A Corps July 2004 mosquito-ditching letter (See: http://www.nae.usace.army.mil/reg/MosquitoDitchingGuidanceLetter.pdf) provides guidance on regulated vs. non-regulated activities commonly employed by the mosquito control districts.

For a complete review of specific 404 requirements and additional guidance, contact the New England District of the United States Army Corps of Engineers at: http://www.nae.usace.army.mil/reg/index.htm

2. State Law:

a. 401 Water Quality Certificate

Section 401 of the Clean Water Act requires States to confirm that federally permitted projects comply with state water quality standards. Such confirmations are issued in the form of "401" Water Quality Certificates.
Work in freshwater wetlands is exempt from the requirements of a Section 401 Water Quality Certificate IF:

- The activity does not involve fill (e.g. side-casting) ***OR***
- The activity involves fill in "waters of the US" but the activity qualifies as a Category 1 (i.e. < 5,000 square feet of fill) activity under the Corps'

Massachusetts Programmatic General Permit (the "PGP"). See the PGP requirements at: (http://www.nae.usace.army.mil/reg/mapgp.pdf)

Work in freshwater wetlands is subject to the requirements of Section 401 Water Quality Certificate IF:

- The activities alter or temporarily impact wetland areas that do not qualify for Category I (e.g. > 5,000 square feet of fill or in stream activities conducted between October 1 and June 30) under the Massachusetts Programmatic General permit (Note: some areas < 5,000 square feet may be regulated by the USACOE if the wetlands are considered to be historically significant or constitute federal special aquatic sites)
- Any activity resulting in any discharge of dredged or fill material to any Outstanding Resource Water, isolated vegetated wetland identified as habitat for rare and endangered species per 314 CMR 9.04 (see: http://www.massgov/dep/water/laws/regulati.htm#wqual)

Outstanding Resource Waters (ORWs)

Water Quality Certificates are also required for activities involving the discharge of dredged or fill materials in water resources classified as *Outstanding Resource Waters* (ORWs) by the MA Department of Environmental Protection (MassDEP) at 314 CMR 4.04. ORWs include those waters deemed to comprise outstanding socio-economic, recreational, ecological and/or aesthetic values. Any new or increased discharge into an ORW is prohibited unless a 401 *Water Quality Certification* is obtained from MassDEP. Specific restrictions to work in ORWs include:

- No discharge of dredge or fill material into wetlands or waters are allowed within 400 ft of the high water mark of a Class A surface water that is used as a source of public drinking water.

- No discharge of dredge or fill material is allowed to a *Certified* vernal pool.

- Wetlands bordering Class A, B, SB or SA *Outstanding Resource Waters* are designated as ORWs to the boundary of the defined area.

The locations of designated ORWs (http://www.state.ma.us/mgis/orw.htm) should be reviewed by MCD personnel to determine if the site falls within an area designated as an ORW. When required, a 401 *Water Quality Certification* is issued by the appropriate regional MassDEP office. The MCD and the appropriate MassDEP Regional Office should work cooperatively to effectuate project objectives and compliance with permit conditions. For regional office addresses, see: http://www.mass.gov/dep/about/region/findyour.htm)

b. Rare and Endangered Species

The Massachusetts Endangered Species Act (M.G.L. c.131A) and its implementing regulations (MESA, 321 CMR 10.00) establish procedures for the listing and protection of state-listed plants and animals. The MESA regulations include project review filing requirements for projects or activities that are located within a Priority Habitat of State-listed Rare Species ("Priority Habitat"). The MESA is administered by the Natural Heritage and Endangered Species Program (NHESP) of the MA Division of Fisheries & Wildlife, and prohibits the "take" of state-listed species. The "take" of state-listed species is defined as "in reference to animals, means to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct, and in reference to plants, means to collect, pick, kill, transplant, cut or process or attempt to engage or to assist in any such conduct. Disruption of nesting, breeding, feeding or migratory activity may result from, but is not limited to, the modification, degradation or destruction of Habitat" (321 CMR 10.02).

MDCs should consult the most recent edition of the *MA Rare & Endangered Species Habitat Atlas* to determine if a proposed project will occur within *Priority Habitat* and the relevant NHESP guidance information to determine if direct filing with pursuant to the MESA is required.

If a filing with the NHESP is required, filing should consider access, egress, spoil/soil deposition or spreads or other activities related to the project occur within *Priority Habitat*, and then the MCD should send the required information to the NHESP review pursuant to the MESA. In general, the Site Plan should include sufficient detail and mapping to clarify the location of all work areas and the form of work (e.g., mechanical work or hand work).

- Within 30 days of receiving a filing, the NHESP will provide a response letter indicating whether or not the submission is complete. If the submission is complete, the NHESP will provide a letter determining if the project will result in a "take" within 60 days of the date of posting of the first letter. (321 CMR 10.18)**.**

- In this letter, the NHESP will determine whether or not a project, as currently proposed, will (a)avoid a "take" as proposed, or with conditions and may proceed without further review, or (b) will result in a "take" of State-listed Rare Species and cannot proceed as proposed (321 CMR 10.23).

- If a project is determined to result in a "take" then it may be possible to redesign the project to avoid a "take". If such revisions are not possible, then projects resulting in a "take" may only be permitted if they qualify for a MESA Conservation & Management Permit (321 CMR 10.23).

- The *MA Rare &Endangered Species Habitat Atlas* is currently available as a bound book, a compact disk with electronic viewer technology, as downloadable data for Arc View from MassGIS, and online using the MassGIS viewer. Details are available at: http://www/mass/gov/dfwele/dfw/nhesp/publications/nhesp_pubs.htm

- The NHESP's mailing address for MESA reviews can be found at: http://www.mass.gov/dfwele/dfw/nhesp/regulatory_review/reg_review_contats.htm

c. Certified Vernal Pools

A vernal pool is a confined basin depression which, at least in most years, holds water for at least two continuous months during the spring and/or summer, and which is free of adult fish populations. These areas often provide essential breeding habitat for amphibians such as wood frogs and spotted salamanders as well as for certain kinds of invertebrates. Certified vernal pools are classified as *Outstanding Resource Waters*, and, as such, require a *Water Quality Certification* from Mass DEP when work resulting in a discharge of dredged or fill material is proposed in them. Certified vernal pools are those that have been verified through fieldwork and certified by NHESP. For certified vernal pool locations, MCDs should review the most recent edition of the "*Massachusetts Natural Heritage Atlas*" http://www.mass.gov/dfwele/dfw/nhesp/nhesp.htm.

- Typical permit conditions will require that MCDs avoid all work in certified vernal pools and establish a 50-foot filter strip around vernal pools in which no disturbance to the ground vegetation is allowed. Creation of ruts deeper than 6 inches within 200 feet of a vernal pool should also be avoided as they represent barriers to amphibian migration.

d. Water Supplies

For work within the watersheds of the Quabbin, Ware River, or Wachusett Reservoir water supplies, a permit may be required from the Department of Conservation and Recreation (DCR) Division of Water Supply Protection (see: http://www.mass.gov/dcr/aboutDCR.htm). For watershed locations, see: http://www.mass.gov/dcr/waterSupply/watershed/water.htm.

e. Areas of Critical Environmental Concern

An *Area of Critical Environmental Concern* (ACEC) is an area containing concentrations of highly significant environmental resources that has been formally designated by the Secretary of Energy and Environmental Affairs. Environmental features that these critical areas may include range from wetlands and water supply areas to rare species habitats and agricultural areas. The designation directs state environmental agencies to take actions to preserve, restore and enhance the resources of an ACEC, and is intended to encourage and facilitate stewardship.

As required by the ACEC regulations, state environmental agencies are directed to administer programs, revise regulations, and review Project Sites subject to their jurisdiction in order to preserve, restore, and enhance the resources of an ACEC. The *Massachusetts Environmental Policy Act* (MEPA) and the associated regulations (301 CMR 11.00) require review of activities within ACECs that need certain state permits, use state funding, or involve state agency actions. The purpose of a MEPA review within an ACEC is to ensure that the proposed projects will avoid or minimize adverse impacts to the resources of the ACEC. As of October 2007, 28 ACECs covering approximately 241,000 acres in 73 municipalities have been designated. Special care should be taken to protect these sensitive areas. http://www.mass.gov/dcr/stewardship/acec/acecs.htm.[2]

f. Massachusetts Environmental Policy Act

An Environmental Notification Form (ENF) must be obtained from the MA Executive Office of Environmental Affairs, in accordance with the Massachusetts Environmental Policy Act (MEPA), 301 CMR 11.00, if:

- The activity is within an *Area of Critical Environmental Concern* (See: http://www.mass.gov/dcr/waterSupply/watershed/water.htm) and a state permit or funding is required for the activity.
- If a state permit or funding as described above is required and a MEPA threshold, found at 301 CMR 11.03, is exceeded, (see MEPA regulatory thresholds at: http://www.mass.gov/envir/mepa/thirdlevelpages/meparegulations/meparegulations.htm) For example, new ditch construction exceeding 5,000 square feet of BVW would likely require submittal of an ENF. Maintenance of existing ditches is likely exempt from this requirement as Corps jurisdiction for ditch maintenance projects is determined on a site by site basis, using best professional judgment, and taking into account the wetland functions and values.

g. Chapter 91: Waterways Regulations

As provided in the waterway regulations at 310 CMR 9.04(1)(e), projects require review if they occur below the high water mark of any non-tidal river or stream on which public funds have been expended for stream clearance, channel improvement, or any form of flood control or prevention work, either upstream or downstream within the river basin, except for any portion of any such river or stream which is not normally navigable during any season, by any vessel including canoe, kayak, raft, or

[2] The original ACEC designations or subsequent ACEC Resource Management Plans and wetland restoration plans for these areas should be reviewed. Those covering large marsh or wetland area may specifically include mosquito control activities as part of their respective management plans.

rowboat. If mosquito control activities are subject to these provisions, see: http://www.mass.gov/dep/water/approvals/ch91wo.doc for instructions and http://www.mass.gov/dep/water/approvals/ch91apwo.doc for a copy of the applicable waterway license application form.

C. Completing the Site Plan

The next step in the planning process is for MCD personnel to complete the *Site Plan* (Appendix 2) for each site where mechanized wetlands management activities are proposed. The purpose of the *Site Plan* is to guide mosquito control personnel in planning and implementing work in freshwater wetlands whose objective is to control mosquitoes. The *Site Plan* also should provide sufficient information to determine whether the activity meets regulatory requirements. The *Site Plan* can include site-specific information on the following: project purpose, sensitive areas, current and proposed site conditions, proposed alteration, BMPs, and plan map.

1. Site Information and History

This section of the *Site Plan* provides information on the MCD proposing the management activity in freshwater wetlands and general background information on the site including:

- Location;
- MCD preparing the *Site Plan*;
- Present and Past (if known or different) land use in the area of activity (i.e., suburban, industrial, agricultural, open space).

If known, the history of prior work (i.e., ditch maintenance or previous freshwater wetlands management activities) at the site location is helpful to determine U.S. Army Corps of Engineer jurisdiction over ditch maintenance activities. Evidence of previous ditch maintenance may be demonstrated to be "reasonably evident" from one or more of the following sources:

- Physical evidence, such as spoil deposits, soil profiles, tree stumps, structures, etc.
- Historical evidence such as municipal, state, or mosquito control records, aerial photographs, or maps; evidence of historic stream channel.
- Documented recollection of residents, abutters, or public officials, etc.

2. Purpose of Freshwater Wetland Work

- Identify the type of work proposed;
- Mosquito breeding documentation

3. Identification of Sensitive Area

- Identify the presence of sensitive areas that may trigger regulatory review.

4. Documentation of Site Conditions

A variety of pre-existing site conditions should be documented on the *Site Plan*, including:

- Natural stream **channel** or constructed **ditch**
- Channel/Ditch type (main, lateral, sub-lateral);
- Hydrology of channel/ditch flow (intermittent or perennial, if known)
- Wetland vegetation present (i.e., forested, shrub, emergent, wet meadow or open water);
- Cross section dimensions of current channel/ditch profile at no greater than 100 foot intervals, but in all cases a minimum of two profiles, including:
  a. Top and bottom channel/ditch widths;
  b. Depth of channel/ditch from top of bank;
  c. Side slope ratios;
  d. Locations of existing spoil deposits.

- Soil profile within the channel to depths sufficient to document the depth of organic and, if applicable, mineral layers. Core samples to be taken at 100 ft intervals with hand auger.
- Indicate staging areas, access points, and locations where removed material will be disposed if deposited within wetland resource areas.
- Representative, dated photographs of the site taken from established, fully recoverable set points depicted on accompanying maps.

5. Proposed Alteration and BMPs

This section of the *Site Plan* provides a description of the proposed work at the site, detailing the following:

- Tentative proposed start assumed to be 30 days from the written notice date or the stated specific date or date range;
- Estimated length/area and type of each ditch/wetland resource area being altered (length expressed in feet and area in square feet);
- An estimate of the amount of spoil to be removed from each ditch, expressed in cubic feet;
- Location of spoil deposition if left in wetland resource areas;
- Estimated cross section dimensions of finished ditch profile, including:
  a. Top and bottom channel widths;
  b. Depth of channel from top of bank;
  c. Side slope ratios if altered from original profile;

Identify all BMPs to be used for vegetation removal, sediment disposal, erosion and sedimentation control. Indicate location of BMPs on the site map.

6. Site Plan Maps

Two maps are needed as part of the *Site Plan*. The first map is a section of the USGS quadrangle map of the area showing the location of the proposed site. Additionally, a plan, aerial photo from MassGIS, or computer-generated map of the site should be included (See Appendix 2). This map should include:

- Named cross streets, gravel or paved roads (annotated);
- Known feeder streams or water conveyances into the site;
- All set-points (i.e. location and orientation) used for photographs;
- Known natural and human-made hydrologic connections (i.e., pond outflows, streams, culverts);
- Location of certified vernal pools, if present;
- Aerial and/or ground-based photographs or digital images depicting features requiring mediation. Location and direction or bearing (north, south, east, or west – upstream or downstream) of photographs should be marked on the accompanying maps.

D. Notification

Notification of the appropriate parties regarding the proposed activity serves to:

- Enhance communications between property owners and abutters, and local, state and federal agencies;
- Save time by avoiding misunderstandings;
- Build public support for mosquito control work in the community.

Notification of mechanical wetlands management activities should consist of:

- Sending a *Standard Notification* by mail and / or e-mail thirty (30) calendar days prior to initiating work. The Notification should include a narrative, an aerial photograph or other site plan map, and the section of the USGS topographic map depicting the site location (See: Appendix 3) and any supporting documentation to:

    a. Conservation Commission: Voluntary notification to the applicable Conservation Commissions is recommended even though MCD work is exempt as authorized by Chapter 252 MGL;
    b. Public Water Supply Authority, if necessary;
    c. Appropriate Regional MassDEP office to the attention of the Wetlands & Waterways Program http://www.mass.gov/dep/about/regional.htm;
    d. District Office of the U.S. Army Corps of Engineers;
    e. Natural Heritage and Endangered Species Program, if applicable.

- Relevant notification information is also recommended to be sent to the following:

a. All property owners or persons legally in control of property where work is to be conducted;
b. Dig Safe and any non-member utility companies (e.g. Municipal Water/Sewer Departments and State Highway Departments) prior to excavation.

- Posting of a sign at the site, visible from the nearest public way, will include the MCD name, pertinent contact information and a reference that work is being conducted pursuant to MGL Chapter 252

3. BEST MANAGEMENT PRACTICES

A. Vegetation Disturbance

An important BMP goal of any wetlands management activity is to minimize unnecessary disturbance to vegetation. This will reduce the potential for erosion and sedimentation into the water body and help to maintain water quality and wildlife and fisheries habitats.

- Locate access and travel pathways where feasible to avoid steep slopes, wetland resource areas, and certified vernal pools, while minimizing loss of vegetation.
- All reasonable efforts should be made to minimize soil erosion and loss of bank stability.

It may be more cost effective and efficient to maneuver along a longer access path to minimize erosion. The pathway with the least impact may involve having the machinery work from opposite banks along different segments. To the extent possible and practical:

- Use environmentally sensitive low-ground pressure equipment and hand clearing when and where feasible for the purpose of equipment and work access.
- Minimize tree cutting and, if possible, focus access areas in grass and shrub areas.
- If at all possible, avoid the operation of heavy equipment directly within the channel.
- Work should proceed with appropriate sediment control structures in place. See the section relating to sediment containment in channels for more information. Excavation of the channel is limited to the historic grade, dimensions and channel course as described in *Site Plan.*

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- All disturbed banks and access pathways should be graded and stabilized by reseeding and / or planting with native species and /or mulching to resist erosion after the activity is completed. See the section on *Erosion and Sedimentation Control* below for more information.

As part of any MCD's effort to control mosquitoes by the improvement of stream flow and restoration of stream channel characteristics, and to the extent practicable, consideration should be given to preserving natural conditions and promoting fish habitat. Naturally deposited wood in streams is very important to stream ecology and can provide fish habitat to promote natural predation. If MCD activities involve placement of a new culvert, construction standards are required to conform to the stream crossing standards contained in Appendix E: Massachusetts River and Stream Crossing Standards of the Massachusetts Wildlife Habitat Protection Guidance for Inland Wetlands –, March 2006. See link: http://www.mass.gov/dep/water/laws/wldhab.pdf. While not required, consideration should also be given to these standards for activities involving culvert replacement, maintenance and repair.

B. Cut Vegetation

- Trees and brush (slash) should only be cut as necessary to allow safe transport and work space for mechanized equipment and personnel during mosquito control activities. If feasible, cut vegetation should be removed from the wetland. Slash that cannot be removed from the site should be placed on upland areas rather than wetland areas, unless removal will result in significant additional wetland impacts as defined by the ACOE, or cause significant additional slash. Because piles of slash represent a fire danger, slash should be spread out or chipped instead of piled. In proximity to stream channels, slash should be chipped or deposited in a manner or location where movement towards the waterway is unlikely. Consideration should also be given to slash disposal that avoids the spread of invasive species. To reduce negative aesthetic impacts, slash should not be left in close proximity to the outer edge of a highway.

C. Sediment Disposal

- Sediments excavated from the channel or bank should be deposited in such a manner to prevent reentry into the water body.
- If possible, excavated sediments should be deposited on an adjacent upland and the deposition of excavated sediments in wetlands should be avoided. Sediment deposition on adjacent wetlands may trigger federal 404 jurisdiction and possible state 401 reviews. The following practices are recommended for soil management beyond wetland jurisdiction:
  - Mineral soils should not be removed from channels unless they impede the water flow and cause the channel to deviate from the original configuration. If excavated, these mineral soils should be deposited off site. Alternatively, they may be placed on *upland* areas, spread thinly and graded for proper runoff.
  - Road sand removed from channels should be deposited off site. On-site sand disposal may be placed on upland areas outside wetland

resource areas (e.g. 200 feet beyond stream banks if possible), spread thinly, and graded for proper runoff.

- On-site upland stockpiling of sediments is not recommended, however, provided appropriate erosion control structures are used when necessary - stockpiles for the purpose of dewatering for removal or stockpiling of material while waiting for the availability of equipment for relocation is acceptable. See the next section on *Erosion Control* for more information.

D. Erosion & Sedimentation Control

Wetland management activities for mosquito control may result in impacts to adjacent and downstream wetland resources. Increased turbidity and loss of vegetative cover could affect water quality as well as the habitat for a variety of organisms. Erosion control measures are recommended when necessary, to reduce the potential for sediments entering the water body during the work phase, inactive periods (e.g., overnight, on weekends or during down times), and the post-work phase. Numerous erosion control techniques are available, some of which are described in the *Western Massachusetts Streambank Protection Guide: Handbook for Controlling Erosion in Western Massachusetts Streams.* Franklin, Hampden, & Hampshire Conservation District, Northampton, MA 1998. The *Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban* Areas may also be consulted. See: http://www.mass.gov/dep/water/esfull.pdf. The appropriate erosion control measure should be selected to prevent the potential for erosion and increased turbidity into nearby water bodies.

The use of checkdams is recommended when necessary, for in-channel sediment control. A variety of materials may be used for checkdams depending upon site-specific conditions. These materials include stone, coir, rice, straw or other fiber rolls, burlap and straw or hay bales. The proper selection of the checkdam composition should be based upon the water velocity in the channel. For example, the use of stone checkdams is recommended for higher velocity channels. For lower velocity channels, it may be feasible to block a downstream culvert with a permeable barrier. Filter material such as burlap fencing or piled burlap will decrease the velocity enough to cause sediments to be deposited upstream of the barrier while allowing the water to pass. If straw or hay bales are used, they should be placed in trenches about 4 inches deep, staked to the ground in two places, and placed with there ends (just not corners) abutting each other. If silt fencing is used, the lower edge should be placed in a 4-inch trench, which is then backfilled with soil. Straw or hay bales and silt fence may be used down slope of a disturbed area to keep water-carrying sediments from entering the water body.

- ❑ If sediment builds up behind the sediment control structures during construction, it must be removed periodically to maintain necessary effectiveness.

- Inspection of the site should occur during or immediately after a rainstorm to determine the effectiveness of sediment control measures and to correct or repair the controls if they are ineffective or have need of repair.
- After the disturbed site is stabilized, clean out collected sediments before removing all sediment control structures.

E. Monitoring Project Effectiveness

Although disturbed areas typically re-vegetate naturally, site restoration and stabilization may be accelerated by reseeding or mulching. . The following erosion control and soil stabilization measures are encouraged and may be employed based upon specific site conditions such as steepness of slopes, soil types, vegetation, thickness of soil deposits, and proximity of deposits to the channel. Stabilization methods may include:

- Mulching limits surface erosion, suppresses weeds, retains soil moisture and can add some organic material to soil. As a major source of invasive exotic species, the use of hay should be discouraged unless it is certain that it was obtained from a local site free of invasive species. A thin layer of wood chips or straw (if available)-may be used. Straw is effective for erosion control and can be spread by hand or broadcast from machine. However, straw can be blown by the wind so in exposed areas should be anchored. It can be punched or crimpled into the soil by hand with a rake or mechanically.

- When possible a small-vegetated buffer strip (approximately 3-4 feet wide) should be left between the channel bank and the spoil deposits.

- Silt fencing or straw bales may be used site specifically (see previous recommendations). Do not leave the bales or fence in place as a permanent erosion control structure as these may serve as a barrier to wildlife movements.

- Disturbed soils may be reseeded. Grasses and other herbaceous cover can stabilize bare soil and minimize erosion. Native seed source is preferable for re-seeding. A compromise alternative is to use plants that germinate quickly to stabilize soils, but are not highly aggressive and will not persist or spread. In the meantime, the soil is immediately stabilized, and the regrowth of native vegetation is allowed to progress. Several options are commercially available:

Seed mixture[a]	Lbs/acre	Lbs/1,000ft^2	Soil pH range
Domestic ryegrass	20	0.45	4.5-7.5
Creeping red fescue, Redtop, Tall fescue	20 2 20	0.45 0.05 0.45	4.5-7.5

Recommended seeding times are from April 15 to June 15 or August 1 to September 15. However, winter rye may be used as a temporary cover and seeds between August 15 and October 15.

- MCD staff should conduct periodic inspections during the first two months after completion of the activity to document any deficiencies in erosion control and to recommend maintenance requirements.

- As part of each periodic inspection, MCD staff shall correct all deficiencies promptly.

In addition to monitoring the stability of the BMPs, the MCDs will survey the project site during their standard site inspections to insure the BMP practice is effective in the short and long term. The MCDs and other state agencies will continue to work towards augmenting the post-project monitoring data they currently collect to addresses environmental concerns.

E. Stormwater Best Management Practices and Mosquito Breeding

Thorough review of proposed designs, proper implementation during the construction phase, routine inspections of operation, and regular maintenance will not only provide better stormwater protection but also discourage the use of these areas by vector species. In addition, scheduled maintenance intervals provide an opportunity to control mosquitoes at the site by the use of effective larvicides by credentialed professionals. For a list of specific stormwater design, operation, and maintenance practices to reduce the likelihood of mosquitoes breeding in Stormwater treatment BMPs, see: *Stormwater Management: Volume Two Stormwater Technical Handbook* (2008). http://www.mass.gov/dep/water/laws/policies.htm#storm

As discussed in MassDEP's 2008 Stormwater Management handbooks and in the Wetlands Protection regulations (310 CMR 10.05(6)(k)9), the owners of the property that develop the stormwater BMPs, or municipalities that "accept" them through local subdivision approval, are responsible for their operation and maintenance to insure that the stormwater BMPs are operating effectively. Although the SRMCB and its mosquito control districts and projects are not responsible for the operation and maintenance of stormwater BMPs, these structures can be included in the MCDs larvicide treatment plans. MCDs will alert local Municipalities when they encounter poorly maintained BMPs.

4. Acknowledgments

Curtice R. Griffin – University of Massachusetts
Misty-Anne Marold - Massachusetts Department of Fish and Wildlife
MaryAnn Dipinto – Massachusetts Department of Environmental Protection (DEP)
Gary Gonyea – Massachusetts Department of Environmental Protection (DEP)
Thomas Maguire – Massachusetts Department of Environmental Protection (DEP)
Michael Stroman - Massachusetts Department of Environmental Protection (DEP)
David M. Keddell –United States Army Corps of Engineers (USACE)
John Kenny – Massachusetts Department of Agricultural Resources (DAR)
Mark S. Buffone – Massachusetts Department of Agricultural Resources (DAR) & State Reclamation and Mosquito Control Board (SRMCB)
Timothy Deschamps – Central Massachusetts Mosquito Control Project
Nicole Granger – Central Massachusetts Mosquito Control Project
Caroline E. Haviland – Norfolk County Mosquito Control Project
David Henley - East Middlesex County Mosquito Control Project
Amanda Hope – Central Massachusetts Mosquito Control Project
Priscilla Matton – Bristol County Mosquito Control Project
Walter Montgomery – Northeast Massachusetts Mosquito Control & Wetlands Management District
Gabrielle Sakolsky - Cape Cod Mosquito Control Project
Emily DW Sullivan – Northeast Massachusetts Mosquito Control & Wetlands Management District

5. Literature Cited

Department of Environmental Protection, Commonwealth of Massachusetts. 1997. Stormwater Management, Volume II: Stormwater Technical Handbook. Publication No. 1781–250–1800–4/97-6.52-C.R. Boston. http://www.state.ma.us/MassDEP/brp/stormwtr/files/swmpolv2.pdf

Department of Food and Agriculture, Commonwealth of Massachusetts. 1998. Final Generic Environment Impact Report.

Appendix 1

Mosquito Control Complaint and Documentation Form

Larviciding Records ☐ Mapped Larviciding Site ☐

Field Personnel's Observation Notes☐

____

____

____

____

____

Residents/Public Officials Complaints☐

Name Date

____

____

____

Subject of Complaint (Comments)

____

Larvae or Adult Mosquitoes Observed at Site ☐
Dipper Data (see attached sheets) ☐

Comments / Date(s)

____

____

Appendix 2

Site Plan for Mechanized Wetlands Management Activities

Date: _/_/_

Site Information:

Location ______________________ Preparer of Plan ______________

Town(s) ______________________ District/Project name ______________________

Road(s) ______________________ Mailing address ______________________

____

Contact ____

Approx. start date: ____/____/____ Phone: ______________________

Work Purpose *(check all that apply)*

- ❑ Mosquito Control ❑ Sediment removal ❑ Culvert replacement
- ❑ Drainage or flood control ❑ Stream bank Restoration ❑ Obstruction removal

Mosquito Observation Data **(check all that apply)**

- ❑ Previous Larviciding ❑ Dip counts ❑ Landing counts ❑ Complaints
- ❑ Observations of field personnel

Additional comments:

____

Sensitive Areas

Site work area checked for occurrence of:

- ❑ Rare & endangered species - *MA Natural Heritage Atlas*
- ❑ Certified vernal pools - *MA Natural Heritage Atlas*
- ❑ Outstanding Resource Waters – MassGIS *Map of Outstanding Resource Waters* (http://www.state.ma.us/mgis/orw.htm)
- ❑ Areas of Critical Environmental Concern – Appendix 7

If any of these sensitive areas occur at the work site, refer to regulatory requirements section of the *MA Mosquito Control BMP and Guidance for Freshwater Mosquito Controll* and indicate location on site work map.

Erosion Control, Soil Stabilization & Sediment Containment (ESS)

Indicate location on map →	**ESS-1**	**ESS-2**	**ESS-3**	**ESS-4**
Straw bales				
Silt fences				
Reseeding				
Mulching				
Straw/Hay bales in water channel				
Water quality swales				
Sediment traps				
Planting				
Other:				

Additional Comments:

____

____

____

____

Proposed Alteration

Total length (ft) ____________ Total spoil removed __________ (approx. cubic yards)
Mineral: _____________ (c.y.) Organic: _____________ (c.y.)

Location of proposed spoil deposits: (indicate on site plan map)

____

Approximate Area (sq. ft) of spoil displaced to wetland

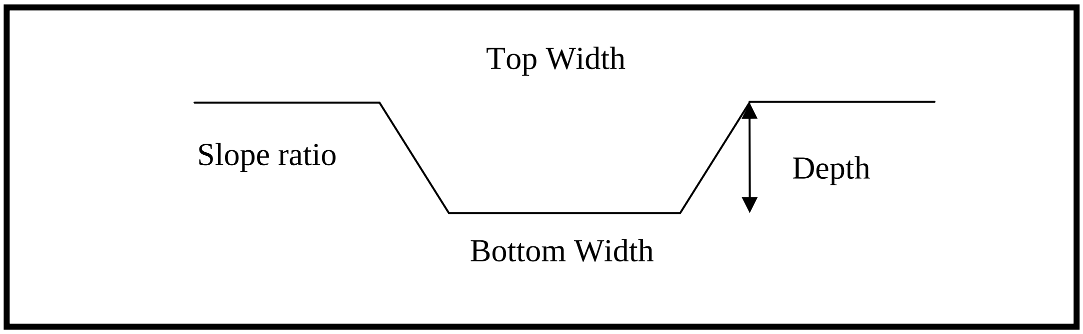
____

Site Conditions

Ditch type ________Linear ft __________ Flow _________Wetland type(s) ___________

Codes: **Ditch type:** **Flow:** **Wetland type:**

MA Main IT Intermittent FO Forested EM Emergent OW Open water
LA Lateral PE Perennial SH Shrub WM Wet meadow
SL Sub lateral



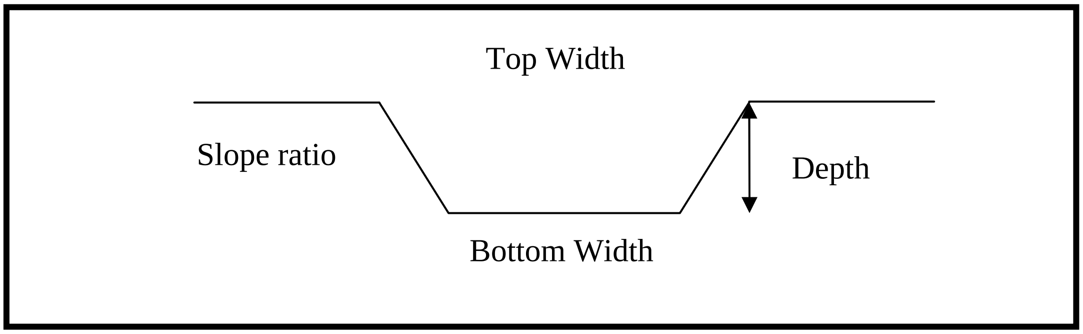
Dimensions	Existing	Proposed
Top width		
Slope ratio		
Depth		
Bottom width		

Comments:

Site Conditions

Ditch type ______ Linear ft __________________ Flow __________ Wetland type(s) _______

Codes:	Ditch type:	Flow:	Wetland type:		
	MA Main	IT Intermittent	FO Forested	EM Emergent	OW Open water
	LA Lateral	PE Perennial	SH Shrub	WM Wet meadow	SL Sub lateral



Dimensions	Existing	Proposed
Top width		
Slope ratio		
Depth		
Bottom width		

Comments:

____

____

____

____

Proposed Alteration Summary (Include if more than 1 ditch)

Ditch Type	Number	Total Cubic Yards Displaced	
		On Wetland	On Upland

Total Cubic Yards Displaced ___________________ On Wetland
Total Cubic Yards Displaced ___________________ On Upland

Comments:

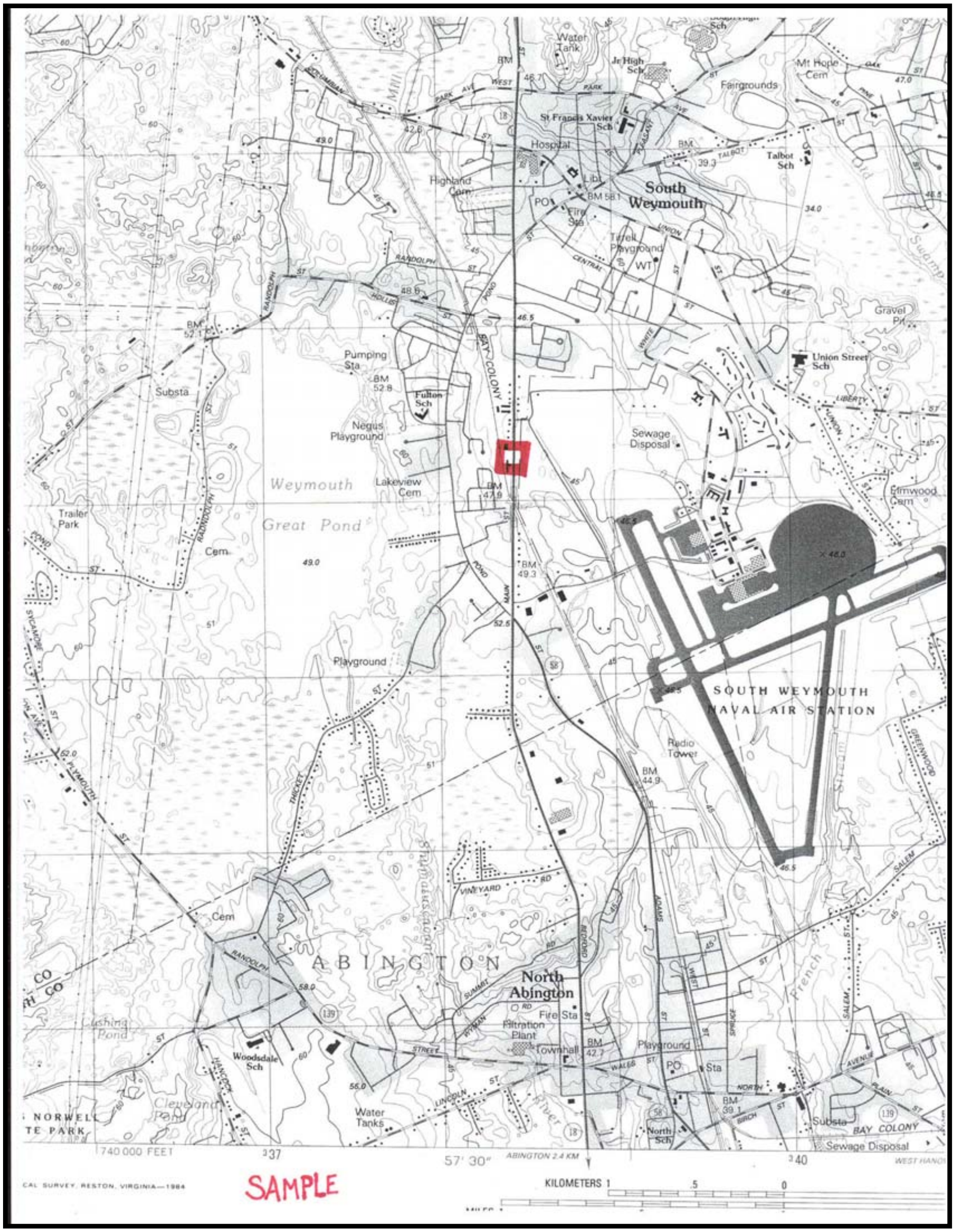
Soil Profile (representative)

Organic Depth: __________ (inches) Mineral (if applicable): _____________ (inches)

Notes: (Types, Colors, Hydrology, etc)

Site Plan Map

Submit both a copy of the USGS Topographic map with site circled and attach a copy of the Site Plan Map (i.e. aerial photograph or MassGIS if available) depicting the site location and proposed work with the Standard Notification Form to the appropriate Department. The photo should include the following information marked on it at a minimum: equipment access points (name nearby streets), approximate locations of all work areas, locations of erosion control (ESS) measures implemented (from previous section above), and locations of dredge spoil deposits.



Appendix 3

MCD Letterhead

Date

Municipal Conservation Commission
Street
City/Town, MA Zip

Re: Site # Mechanized Ditch Maintenance Project

Dear __________,

The (Specific MC District/Project) is proposing wetlands management activities as described below in compliance and accordance with Chapter 252 of the General Laws of the Commonwealth of Massachusetts on the site indicated on the attached topographic map in City/Town, Massachusetts.

Site number i.e. (NW0801 or 524A Methuen) involves a brief, but detailed description of the freshwater activity including: the reason for site selection (i.e. Public Official/Municipal Department or Commission, Resident, MCD Personnel) location (Town, street names, direction of ditch or stream in relation to street) estimated length of ditch to be maintained, and any additional information each district/project deems necessary.

The Notification may include a unique statement [i.e. although exempt from the Commission's jurisdiction, we invite inspection and comments, welcoming the opportunity to address any concerns that the Commission may have in regards to the proposed activity on this site. Please feel free to call me at the number listed above.]

If we do not hear from the Department / Commission within 30 days after the date of this notice, we will assume that there are no concerns regarding the proposed activity on this site and work will tentatively commence thereafter / specific date / date range.

Respectfully,

Name
Title (ex. Wetlands Project Coordinator)

Enclosed Location Map and Site Plan Map

Additional Notification furnished to:
US Army Corps of Engineers
MA Department of Environmental Protection (proper) Regional Office

RESPONSE TO COMMENTS

This Response to Comments is submitted as requested by the Certificate of the Secretary of Environmental Affairs issued on February 15, 2008 for the Mosquito Control Program GEIR update EEA# 5027. A copy of the Secretary's Certificate is included at the end of this section.

The following Section responds to comment letters from state government agencies, local municipal officials, private organizations and individuals received by the Secretary regarding the Mosquito Control GEIR update titled, *Massachusetts Best Management Practices and Guidance for Freshwater Mosquito Control (Freshwater Mosquito BMP Manual),* submitted by the State Reclamation and Mosquito Control Board (SRMCB) on November 26, 2007. In addition, the SRMCB also provides responses to comments received that were more germane to the Mosquito Control GEIR and Mosquito Control practices in general. These comments and responses were incorporated in the Freshwater Mosquito BMP comments and responses.

All letters have been assigned an abbreviation, listed below in Table 1-1. Specific comments within each letter specific to the Freshwater Mosquito BMP Manual are noted in the margin with this abbreviation and a sequential numbering. Preceding each letter is a listing of comments accompanied by a response.

<u>Table 1-1 Comment Letters Received</u>

Commenter	**Abbreviation**
Mathew Selby, Ashland Conservation Commission	**MSACC**
Carol Harley	**CH**
Town of Stow, Conservation Commission	**SCC**
Judith Eiseman	**JE**
Lynn Southey	**LS**
Mass Audubon	**MA**
Jones River Watershed Association, Inc.	**JRWA**
Green Futures	**GF**
The Nature Conservancy	**NC**
Alexandra Dawson	**AC**
Mass Audubon – Heidi Ricci	**MAHR**
Natural Heritage and Endangered Species Program	**NHESP**
Miscellaneous Comments	**MC**

MATHEW SELBY, ASHLAND CONSERVATION COMMISSION

MSACC.01 *Because mosquito control work is exempt from the Wetlands Protection Act, all of this work – including taking large machinery into jurisdictional wetlands – is done without the oversight of the Conservation Commission.*

Yes, mosquito control district work is exempt pursuant to Chapter 252 of the MGL. However, the Freshwater Mosquito BMP recommends (but does not require) that MCDs notify the applicable Conservation Commission. Also, MCDs, as a matter of practice, currently and historically, contact their local conservation commissions as well as abutters regarding the proposed work not only to notify all parties of the work but also to provide an opportunity to comment and provide additional information on the proposed project. Additionally, while exempt from the Wetland Protection Act, if MCDs projects exceed certain limits they are subject to ACOE 404 and 401 Water Quality Certification. Finally, if the project is within Rare and Endangered Species Habitat, a project notice is filed with MassDFW. The freshwater mosquito BMP document purpose is to standardized MCDs activities in freshwater wetland areas.

MCDs use low-ground pressure equipment in sensitive sites that require such equipment and perform hand clearing when and where feasible for equipment and work access to mitigate negative environmental impacts. Additionally, the MCDs to mitigate potential impacts will schedule work in environmentally sensitive areas during the winter months when the ground is frozen and plants are dormant.

MSACC.02 *Yet the proposed Best Management Practices for Freshwater Mosquito Control lack any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat.*

Yes, the Board agrees that pre and post monitoring is justified. The Board will work with MCDs to develop a protocol to be appended to the Freshwater Mosquito BMP as an update by the 2009 mosquito season. However, it is also important to recognize that some sites are deemed a problem by the MCD staff before mosquitoes become apparent because of historical records or because the topography / ecology of the site is consistent with one that would likely pose a problem as the mosquito season progressed.

MSACC.03 *Rather than repeated ditching and pesticide management, freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation and fish barriers (e.g. undersized culverts).*

The mandate to control mosquitoes (Chapter 252) is meant to offer the greatest relief from both nuisance and disease bearing mosquitoes. The MCDs take into account the legal aspects of any action, the efficacy of any intervention, the impact upon the environment, the financial costs, and the preferences of community members. MCDs are not mandated to restore wetlands, but they consider such activities if they mitigate a current or future mosquito problem, and if the MCD is empowered to perform the activities.

Any increase in biodiversity and improvement in aesthetics that result from mosquito wetland activities is normally a secondary benefit of proper mosquito control using IPM. In many cases, work by MCDs will result in secondary beneficial results such as enhancing habitat for fish and other mosquito predators as observed in Open Marsh Water Management (OMWM) in coastal ecosystems. OMWM is effective as mosquito control largely because the channels, ponds, and other constructed waterways provide permanent habitats for predators such as fish. The purpose of the Freshwater Mosquito BMP is to control or reduce the conditions that lead to mosquito development by maintaining and/or repairing (thus enhancing) the wetland or waterway. These Freshwater Mosquito BMPs are consistent with the principles of Integrated Pest Management (IPM), and if successful, can reduce the use of pesticides in these particular sites.

MSACC.04 *Mosquito Control practices should be consistent with the principles of integrated pest management, and the methods should be studied for effectiveness.*

Mosquito Control practices in Massachusetts are consistent with the principles of Integrated Pest Management (IPM) approaches which means that the MCDs control mosquitoes utilizing a combination of chemical, physical, and biological methods e.g. Open Marsh Water Management (OMWM). The MCDs rely on surveillance and monitoring to guide them in their intervention decisions. Also, the MCDs incorporate education and outreach within these programs as another important element to IPM. Pesticides are an acceptable and often necessary component of any IPM program. The use of pesticides in Massachusetts is extensively regulated by the Department of Agricultural Resources. MCDs are funded to carry out an operational mandate and are not established or funded as research institutions. The methods that are employed in Massachusetts are consistent with methods used nationally. Research to improve mosquito management and reduce potential environmental impacts is ongoing and the Board monitors and welcomes and adopts such advances when practical.

MSACC.05 *If a Citizens Advisory Committee (CAC) is to be created, it should include technical and public stakeholder representatives who are independent of the mosquito control districts, such as local boards of health, conservation commissions, wetland restoration experts, watershed associations, the Department of Public Health, and experts in the effects of pesticides on human health and the environment.*

The fact that the SRMCB has initiated a Special Review Procedure (SRP) to facilitate updating the current GEIR that previously had an extensive CAC negates the need for a CAC for these updates. However, the Board does not object to convening a small group annually per MEPA's instructions to discuss concerns from representatives mentioned in the comment.

CAROL HARLEY

CH.01 *First and foremost, the current mosquito control districts operating in Massachusetts under the State Reclamation and Mosquito Control Board (SRMCB) and MGL Ch. 252 are exempt from the Wetlands Protection Act, and can operate heavy machinery or apply pesticides in wetlands without conservation commission review or approval.*

See response MSACC.01.

CH.02 *Freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation, and fish barriers (e.g. undersized culverts), rather than ditching and pesticide applications.*

See response MSACC.03.

In addition, inland freshwater mosquito control practices include removal of excessive sedimentation and obstructions in streams to improve the flow of water and reduce stagnant water. MCDs do not, as a general practice, create new "ditches" in freshwater wetland resource areas. The larvicides MCDs apply directly to wetlands are types that are very selective and environmentally benign such as *Bacillus thurengensis israelensis* (Bti) a microbial pesticide. MCDs have worked with local DPWs to replace under-sized culverts and remove obstructions in streams to improve fish migration. One of the goals of the Freshwater Mosquito BMP is to provide standardization in order to guide mosquito control activities such as these that are exempt from the Wetland Protection Act.

CH.03 *Freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation and fish barriers (e.g. undersized culverts), rather than repeated ditching and pesticide management*

See response to MSACC.03.

CH.04 *Existing documents should be submitted to MEPA for public review (e.g. a report on the 2006 aerial spraying of 425,000 acres).*

All applicable documents have been attached including but not limited to final reports summarizing both the August 8th and 9th, 2006 and August 22nd, through 24th aerial applications, 2008 MassDPH Arbovirus Surveillance and Response Plan, 2008 Operational Response Plan to Reduce The Risk of Mosquito-Borne Disease in Massachusetts, Choice of Anvil 10+10 for Aerial Mosquito Control dated July 28, 2006, and the 2006 EPA Final Report dated March 6, 2007 on use of Anvil 10+10.

CH.05 *Any Citizens Advisory Committee should include technical and public stakeholder representatives who are independent of the mosquito control districts.* **See response to MSACC.05.**

TOWN OF STOW, CONSERVATION COMMISSION

SCC.01 *The Stow Conservation Commission believes that the proposed CAC is heavily weighted toward the Districts and does not provide adequate balance from the environmental community.*

See response to MSACC.05.

SCC.02 *The report does not present any evidence that common mosquito control practices, such as wetland ditching, are effective in actually reducing mosquito breeding habitat;*

The purpose of the Freshwater Mosquito BMP is to provide standards to guide mosquito control activities in freshwater wetlands. Water Management projects in these areas meet the dual aim of being an effective means of mosquito control while at the same time minimizing negative impacts to the ecosystem. Mosquito Control agencies in many states have conducted this kind of work for many years. Over the long term, impacts to the ecosystem, if any, tend to be short-term and the result of work activities at the site rather than permanent changes to the ecosystem. Finally, MCDs share your interest in research regarding effectiveness and environmental impacts of water management or source reduction work. However, these efforts are constrained by lack of staff and/or funding. MCDs and the Board would welcome ideas to support these initiatives.

SCC.03 *Nor does it quantify the impact of such practices on sensitive species or on fisheries, that can provide natural control of mosquito populations. We believe the State Reclamation and Mosquito Control Board should be required to undertake such studies.*

The Board disagrees and believes that is not the responsibility of the Board or MCDs. Further, it is not within the scope of the Board's or MCD's expertise nor is it part of its statutory mandate. This kind of environmental monitoring is best performed by other state agencies with the appropriate personnel, expertise and mandate.

JUDITH EISEMAN

JE.01 *I have always been concerned that the nine mosquito control districts operating in Massachusetts are exempt from the Wetlands Protection Act, and can operate heavy machinery or apply pesticides in wetlands without conservation commission review or approval.*

See response MSACC.01.

JE.02 *At a bare minimum, any Citizens Advisory Committee (CAC) must be constituted to include technical and public stakeholder representatives who are expert and independent of the mosquito control districts and have time to devote to the Committee.*

See response to MSACC.05.

JE.03 *The fact that the 1998 MEPA Certificate called for annual updates and additional study and research and that this is the first update filed in 10 years is enough to raise ones eyebrows.*

The Board agrees that this filing could be perceived as an improvement after a number of years. However, the Board sought guidance from MEPA over the years on the best approach to accomplish the annual updates. As a result, the Board was directed to develop a website as a means to accomplish and achieve this goal. Currently, the website continues to be strengthened and updated as needed. When significant improvements to mosquito control practices are available, they are adopted. Such changes do not occur with great frequency. Early in this process, the Board acknowledged that annual updates were unrealistic and suggested an alternative timeline in a letter to MEPA Director dated March 4, 2002 (copy attached). While the Board did not receive a written response to this request, verbal communication with MEPA staff indicated that an acceptable alternative approach would allow the SRMCB to post new information as it became available on the DAR/SRMCB web site. This approach was adopted as previously stated.

JE.04 *The proposed "Best Management Practices for Freshwater Mosquito Control" lacks any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat.*

See Response to MSACC.02.

LYNN SOUTHEY (LS)

LS.01 *I am very concerned that because mosquito control districts are routinely altering wetland and applying pesticides in large areas of the state, that the MEPA review are [sic] continued to document 1) the effectiveness of current mosquito control practices in protecting public health and 2) the environmental impact of these activities;*

See Response to CH 04.

LS.02 *Existing documents should continue to be submitted to MEPA for public review, e.g. 2006 report on aerial spraying of 425,000 acres.*

See Response to CH.04.

LS.03 *I strongly feel that any Citizens Advisory Committee (CAC) should include technical and public stakeholder representatives who are independent of the mosquito districts.*

See response to MSACC.05.

LS.04 *I [sic] addition, Freshwater mosquito control practices should focus on improving and restoring the health of wetlands and waterways to enhance habitat for mosquito predators (e.g. fish) and to reduce water pollution, sedimentation and fish barriers (e.g. undersized culverts), rather than repeated ditching and pesticide management*

See Response MSACC.03.

MASS AUDUBON

MA.01 *We are concerned that this is the first update in ten years, whereas annual updates were required.*

See Response JE.03.

MA.02 *During all this time, mosquito control districts continued to operate heavy equipment in wetlands and apply pesticides across large areas of the Massachusetts landscape without benefit of standardized BMPs or documentation of the effects of these activities on mosquito populations, human health, or the environment.*

See Responses MSACC.03. SCC.02, and CH .02

MA.03 *Therefore, we support a program of mosquito control base on Integrated Pest Management (IPM) principles and consistent with the recommendations of the Centers for Disease Control and the Environmental Protection Agency.*

See Response MSACC.04.

MA.04 *While we do not expect mosquito control districts to remedy the many problems caused by a wide range of human activities, they should work cooperatively with municipalities, state agencies, watershed groups, and others to restore wetlands.*

The Board appreciates the sentiment expressed and notes that MCDs have a long history of working cooperatively with municipalities and other groups that have wetland concerns which overlap with the MCD mandate to control mosquitoes. However, such parties must realize that the primary goal of water management projects conducted by mosquito control projects is to reduce the presence of mosquitoes and the conditions conducive to the development of mosquitoes. Wetland restoration benefits that are realized by such work are secondary to the MCD primary purpose. There are situations where such restoration may increase the development of mosquito populations and increase public health risks associated with arboviruses; such as, Eastern Equine Encephalitis virus (EEEv). In addition to oversight provided by diverse state and federal entities, each MCD reports to its own Commission. Commission members represent the interests of the communities serviced by the MCD.

MA.05 *There is a serious flaw in this manual: it lacks any provisions for monitoring the success or failure of the work in reducing mosquito breeding habitat.*

See Response to MSACC.02

MA.06 *The manual also fails to address opportunities for the mosquito control districts to work with the communities they serve to reduce mosquito habitat associated with stormwater management, instead noting that the districts are "not responsible for the operation, maintenance, monitoring, or treatment of larval habitat of stormwater BMPs." It is unfortunate that the SRMCB and districts do not see it as part of their job to cooperate with municipalities to assist in improving the design and management of stormwater facilities to reduce breeding habitat. The manual also lacks any mention of the extensive opportunities for districts to partner with others to restore streams and wetlands, improve fisheries, and reduce mosquito habitat.*

The Board disagrees. MCDs are not responsible for the operation, maintenance, monitoring, and or treatment of stormwater structures.

According to MassDEP's 2008 Stormwater Management handbooks and Wetlands Protection regulations (310 CMR 10.05(6)(k)(9), the owners of the property that develop the stormwater BMPs, or municipalities that "accept" them through local subdivision approval, are responsible for their operation and maintenance. When requested, MCDs do work with municipalities to help address these issues, including, but not limited to larvicide treatment plans. MCDs will alert municipalities when they encounter poorly maintained structures, as these situations can be associated with the increase development of mosquitoes and subsequent risks of arbovirus such as West Nile virus.

MA.07 *The SRMCB has undertaken extensive work over the past several years in cooperation with the districts, the Department of Public Health (DPH). MassWildlife, and other agencies and experts, resulting in issuance of numerous plans, guidelines, analyses, and policies. None of these documents have been filed with MEPA as part of the required annual update process, even though some are available on the SRMCB website. ……These and other existing documents should immediately be submitted for review.*

The Board has attached these documents. The 1991 DPH Vector Control plan was extensively revised after the introduction of WNv in Massachusetts in 2000. Over thirty local and state agencies and environmental groups were involved during the process of development of an Arbovirus State Response and Surveillance plan. DPH widely distributed the plan thorough a series of statewide public meetings and made the plan available both through direct mailings to local BOHs and by posting on the DPH web site. Updates and revisions are made annually to the plan if needed by a collaborative effort with input from local BOH's and others. Recommendations for Mosquito Control from the CDC and EPA have been incorporated into the current State Response and Surveillance Plan and are an integral part of the local MCD programs.

MA.08 *The CAC members should include technical and public stakeholder representatives who are independent of the mosquito control districts, including: DPH Center for Environmental Health; MassWildlife; Experts in the effects of pesticides on human health and the environment; Watershed Associations; Wetlands Restoration experts; Conservation commissions, and Local Boards of Health.*

See response to MSACC.05.

JONES RIVER WATERSHED ASSOCIATION, INC.

JRWA.01 *We are disappointed that the present update does not recount the events of 2006, the monitoring data, the pesticide application and the results, or the chosen methods for chemical control.*

See Response to CH.04

JRWA.02 *We have endured three occurrences of aerial application during that time which have noticeable impact on the nature and health of beneficial organisms, as well as on people.*

Each aerial adulticide application in 1990 and again in 2006 was performed after a declaration of a public health emergency by the Governor. The goals of any mosquito control intervention that targets the adult stage is to reduce mosquito abundance as a means of limiting 1) the force of transmission of mosquito borne disease agents, and 2) the nuisance caused by biting mosquitoes. Complete elimination of mosquitoes neither is possible nor a goal. Regardless of the kind of insecticide applied or the manner of its application, some mosquitoes will survive. No species of mosquito (or any other creature) has been eradicated because of mosquito control efforts. Monitoring prior to and after any spraying was performed to document overall reductions of mosquito populations, and potential impacts. The Board worked closely with various state agencies, most notably the Department of Public Health, and utilized its own operational plan to insure that steps were taken to mitigate and avoid potential negative impacts to people and the environment. During the 2006 spray events the Board and other State agencies collected data on: macroinvertebrate species composition, water quality samples from streams, pre and post treatment water samples from public water suppliers, conducted surveys of lakes for fish kills, contacted local beekeeper associations, collected samples from Cranberry growers. The Board refers you to further details in its current version of the *Operational Response Plan To Reduce The Risk Of Mosquito-Borne Disease In Massachusetts* and *MassDPH Arbovirus State Response and Surveillance Plan* attached.

As discussed in the attached spray reports, no adverse impacts to the environment were observed through these sampling efforts. Ultimately, the potential risks associated with such emergency operations are outweighed by the public health benefits. Also, See Response MA.HR.01

JRWA.03 *Now we have the SCMCB trying to duck under the sheets again with its own CAC which it will call to session to comment and stamp its occasional reports to MEPA, much like the MCDs which now sent a "courtesy" notice to the Conservation Commission when they choose to work in wetlands.*

See Response MSACC.05 and MSACC.01

JRWA.04 *The Freshwater BMP that was submitted by SRMCB for public comment now is deficient in several critical ways. In our opinion, the first issue to address, which is not even mentioned, is mosquito and environmental monitoring as the underlying basis for MCD activities/wetland management. It is not unusual today for "mosquito control activities" to occur where someone wants to avoid filing with a conservation commission. After all, mosquito control is an exempt activity, so why not clear the stream without filing? We need to set a standard for the mosquito breeding evidence that is available for public review, and understand the human health threat associated with that evidence. This means that not only do we need to count breeding species and their EEE evidence, but calculate how the environment will handle the elevated threat and what assistance to give.*

See Response MSACC.02

JRWA.05 *Because the districts have been in place for quite some time and have a long record of breeding sites, it should be possible to develop local maps for public disclosure and public hearing in communities where mosquito control is necessary to protect public health. These maps and information should clearly describe the problem, location, habitat issues and recommended treatment(s).*

The Board notes that MCDs do have maps and other records available for review by the public at MCDs facilities; however, the Board disagrees that such information be necessarily presented at public hearings. Where such MCD operations are conducted especially for arbovirus suppression, the Board works closely with the following parties to review and evaluate diverse risk factors pertaining to emergency operations to conduct aerial applications when necessary:

- **The MDPH, CEH and SLI epidemiologists and entomologists;**
- **The MDFW and NHESP;**
- **The Massachusetts Mosquito Advisory Group (MAG); and**
- **The experienced staff and experts within the MCDs.**

The maps that are developed are utilized by those professionals dealing with emergency situations along with carrying out well vetted response plans to intervene in the most meaningful manner.

JRWA.06 *We are not aware of any effort to evaluate the compounding of chemicals in the environment or the impact on this valuable and rare ecosystem. While JRWA is busy trying to get fish back to Blackwater Pond by relieving a downstream dam-the stream is clogging and the pond is losing oxygen and growing submerged algae mats.*

The use of pesticides in Massachusetts is extensively regulated by the Department of Agricultural Resources as mentioned in MACC.04. There is a significant body of scientific data, developed to support registration with U.S. EPA, supporting a finding that the chemicals registered for mosquito control in Massachusetts do not appreciably bioaccumulate. The larvicides and adult mosquito control products are not associated with increased aquatic plant growth. Such issues as eutrophication are water quality issues that stem from non-mosquito control related activities. The conditions that you cite in your comment are not related to mosquito control; but rather may also be conducive to the development of mosquitoes.

JRWA.07 *Mosquito Control activities-whether wetland alterations or pesticide applications-lack supervision and environmental monitoring.*

Many MCDs now employ wetland specialists that are dedicated to conduct work in freshwater wetlands and other sensitive environments. However, the Board agrees that there is room for improvement and has, in recent years, taken action to improve oversight. For example, the Board recently required that all MCDs submit annual operation reports. The adoption of the Freshwater Mosquito BMP provides an additional oversight mechanism which ensures that MCDs are using standard practices that aim to achieve the duel purpose of reducing mosquitoes and mitigating potential impacts to the environment.

JRWA.08 *The SRMCB and its mosquito control districts and/projects are not responsible for the operation, maintenance, monitoring, or treatment mosquito larval habitat of stormwater BMPs. Typically, the owners of the property that develop the stormwater BMPs, or municipalities that "accept" them through local subdivision approval, are responsible for their operation and maintenance. This is concerning [sic] because of the increasing incidence of West Nile virus and its relationship to stormwater systems. It is not likely that local towns have the knowledge to effectively control or monitor mosquito breeding in stormwater basins and other structures. Widespread use by the MCDs of growth inhibitors in catch basins which discharge to waterways.*

Although it is true that MCDs are not responsible for the operation, maintenance, monitoring, or treatment mosquito larval habitat of stormwater BMPs, as noted in Response MA.06 when requested, MCDs do work with municipalities to help address these issues, including, but not

limited to larvicide treatment plans. Also, MCDs will alert municipalities when they encounter poorly maintained structures. Further, the Department of Agricultural Resources does make available training to municipal personnel pertaining to monitoring and treatment of catchbasins or stormwater structures. This training includes discussion of mosquito development in catch basins, West Nile virus, mosquito control practices, pesticide labeling, and applicable safety precautions. Individuals who successfully pass the Department's exam are issued a temporary permit for use of select of mosquito larvicides, limited to application of dry formulations of methoprene and microbial larvicides in catch basins.

Presently there is only one insect growth regulator, methoprene, which is registered for use in controlling mosquitoes in such outdoor sites as catch basins. The discharge of methoprene treated waters from such sites does not present significant risks to non-target organisms. This is due in-part to the extremely low application rates of product, the rapid rate of degradation of methoprene in the environment and the specific mode of action.

GREEN FUTURES

GF.01 *The only major beneficiaries of these actions seem to be promoters of ill-conceived development projects that amazingly appear on the "reclaimed" land and, of course, these wetland altering projects provide employment for mosquito control personnel. During the 2006 spraying frenzy, we received numerous complaints of Mosquito Control employees for-spraying "Anvil"… an endocrine disruptor, on organic gardens, a municipal water supply watershed, and PHE private property*.

See MSACC.02

The Board disagrees with the characterization of the emergency public health aerial applications during 2006. These efforts provided benefits to the public in terms of enhancing the quality of life and reducing public health risks for the citizens of Massachusetts. Great effort went into coordination and planning in anticipation of an arbovirus threat in order to be ready to respond in a timely fashion to suppress human risk from a serious mosquito-borne disease as well as minimize impacts to the environment.

The Board refers you to its current version of the *Operational Response Plan To Reduce The Risk Of Mosquito-Borne Disease In Massachusetts* and *Mass DPH Arbovirus State Response and Surveillance Plan* attached.

The aerial application occurred at dusk and into the evening hours. As a result, overlap with outdoor human activities was minimized and few human illnesses were reported. However, after further investigation, no objective findings were found. There were no documented unintended effects regarding fish, birds, and or bees. Further, water sampling analysis by the Massachusetts Pesticide Analytical Laboratory (MPAL) indicated there were no detectable residues of d-phenothrin/sumithrin or Anvil 10+10 ULV in surface water and drinking water supplies tested.

The potential for effects of the pyrethroid sumithrin, active ingredient in Anvil 10+10 ULV, on the endocrine system have not been substantiated. Human and other non-target organism exposure is extremely limited given that the maximum rate of application for the product is 0.62 fluid ounces per acre. Moreover, the chemical properties of sumithrin are such that this extremely small amount of chemical is then degraded rapidly in the environment.

During the public health emergency (PHE), certified organic farms were excluded from the area of application. The public received pre-notification; such that, individuals with farms and gardens in the treated areas would follow the required 48-preharvest interval specified by the EPA as a precaution to further minimize exposure from residues in harvested produce.

The Board notes that the Massachusetts Department of Public Health (MDPH), in cooperation with the Cape Cod Grower's Association collected cranberries from areas treated with Anvil 10+10 ULV. The report from the MDPH indicates that sumithrin levels were not detected, but that very low levels of Piperonly Butoxide (PBO) were detected below the established maximum allowable residue level in/on cranberries.

It is important to note that by itself PBO does not have insecticidal properties, but is added to enhance or synergize the effectiveness of certain pyrethroid insecticides; such as, Anvil 10+10. Given its extremely low toxicity and common use, there is a general exemption from the requirement of a tolerance for low levels of PBO residues in/on most crops.

During the emergency spray event, all no-spray areas were adhered to by MCD employees. Please note that during a PHE such as was declared, the Board and MCDs are authorized to conduct ground spray operations in all mosquito habitats including private property previously designated as a no-spray area.

GF.02 *Years of altering, draining, channeling and ditching of wetlands has shown little, if any, reduction in mosquito populations. Where are the studies of locally altered wetlands and/or documentation that conclusively show these alterations work? Mosquito control practices should focus on encouraging natural mosquito predators and restoring and improving wetlands.*

See response to MSACC.03.

GF.03 *Modern technology presents us with an array of mosquito eliminating and repellent devices for our yards and effective repellents for use by individuals that can be applied to clothes and/or skin.*

Part of what is done in mosquito control is to educate the public to the need for avoiding mosquito bites and to use the various effective mosquito repellents such as DEET. However, the array of mosquito eliminating and electronic repellent devices available to the homeowner in many cases are marketed without the benefit of scientific validation to claims made by the manufacturers. However, several devices have been studied and to date these kinds of devices do not provide the claimed benefits. For example, electronic zappers have been shown to attract and kill other kinds of nocturnal insects such as moths. The majority of insect "zapped" are something other than mosquitoes. Other devices such as the mosquito magnet attract mosquitoes but do not generally control them. Even natural controls such as bats and dragonflies claimed to control mosquitoes is inaccurate and erroneously communicated to the public. Finally, recently marketed whole house misting systems have not been shown to be effective. In fact, the Board has issued a policy against mosquito misters because their release of pesticides is not based on current mosquito conditions or Integrated Pest Management e.g. automatic use of pesticides whether it's needed or not.

THE NATURE CONSERVANCY

NC.01 *Though the 1998 MEPA Certificate called for annual updates and additional study and research, no such materials have been submitted until now.*

See response JE.03

NC.02 *The scope should be focused on substantive information related to BMP's and demonstration of the effects of the mosquito control district activities on human health and the environment.*

The mosquito control scope of work is operational in nature. However, impairment to human health and the environment as the result mosquito control in Massachusetts has not been substantiated. In the most recent emergency aerial application, during the summer of 2006, analysis by various

state agencies indicates that there were no significant negative effects of the MCDs activities on human health and the environment. The kinds of studies and information being requested would require additional funding and resources.

NC.03 *The proposed Citizen's Advisory Committee would be more meaningful if it included technical and stakeholder representatives who are independent of the mosquito control districts*

See response MSACC.05

ALEXANDRA DAWSON

AD.01 *The districts work alters extensive areas of wetlands and rare species and is exempt from the Wetlands Protection Act.*

See Response MSACC.01

MASS AUDUBON – HEIDI RICCI

MA.HR.01 *There are also many other existing documents that should have been noted and made available with the recent GEIR update, e.g. reports on the 2006 aerial spraying, various protocols and technical analyses such as a technical memo describing why Anvil was chosen for aerial spraying.*

The technical memo described in the comment has been attached to this response titled, Choice of Anvil 10+10 for Aerial Mosquito Control dated July 28, 2006 from the Department of Public Health, Bureau of Environmental Health. Other documents such as a Report on Efficacy of Spraying produced by Arbovirus Workgroup, MDEP/ORS Memorandum on Products, Golden Pacific Laboratory Cranberry Testing Protocol, MDEP Surface Water Monitoring Protocol, MDEP Benthos Monitoring Protocol, MDPH/CEH Aerial Spray Fact Sheets (original and updated version), and Public Health Emergency Declaration by Governor on 8/21 Draft MDPH/Office of General Counsel Memorandum on legal authority for aerial spraying will be attached to future filings to MEPA.

MA.HR.02 *There are also other documents that were circulated to people involved in last year's Working Groups, e.g. protocols for monitoring mosquitoes, water supplies, and other aspects in the event of aerial spraying.*

All of these documents will be available in upcoming filings to MEPA. The Board acknowledges that these documents are important as they were vetted through the workgroups convened by the Department of Public Health and a number of them have been incorporated in the State Reclamation and Mosquito Control Board's operational plan which is attached.

MA.HR.03 *I object to the use of a definition of IPM that departs from state law. I strenuously object to the use of the SRMCB's IPM/IMM definition. Administrative policies cannot supersede law.* MA Pesticide Control Act: http://www.mass.gove/legis/laws/mgl/132b-2.htm
Furthermore, the last sentence of the SRMCBs IPM policy is not supported by evidence due to the lack of a standardized pre and post treatment monitoring program or any quantification of side effects on human health and the environment (which are also important to Massachusetts' quality of life).

There are many definitions of IPM. The IPM definition in Chapter 132B of the MGL was written specifically for the Children and Families Protection Act. There are important differences in how IPM is applied in various settings that should be accounted for in any definition. Chapter 132B of the MGL broadly describes IPM for a school setting. Where possible, the definition should be tailored to the practice such as mosquito control. Given the variable nature of pests, the practices employed to implement IPM vary widely across the spectrum of pest control activities.

Before these products are registered for use they have gone through the scrutiny of a Federal risk assessment process.

There is no language in state law that requires that the definition promulgated in Chapter 132B of the MGL must be used. Its purpose in the law is simply to provide a context for mandatory IPM, which is limited to schools and daycares. The key components of the state statute mentioned such as monitoring and minimization of the use of pesticides and selection of lowest risk pesticides when necessary are in fact part of any mosquito control IPM strategy. The concepts and strategies employed by Massachusetts Mosquito Control Projects are also consistent with CDC and EPA recommendations on IPM and mosquito control. For example, mosquito control projects perform surveillance of mosquitoes for their own regions and in collaboration with the Department of Public Health to monitor for arboviruses.

Mosquito control in Massachusetts is carried out using pesticides that have been scrutinized via regulatory programs both at the Federal and State Level. Through the labeling of these products and other regulatory requirements, an analysis is conducted to ensure that the pesticides do not represent unreasonable adverse effects to the public or environment.

In Massachusetts, pesticide use is governed solely by the Department of Agricultural Resources, Pesticide Board. Pesticides used by mosquito control projects have been approved and registered by the EPA and approved by the MA Pesticide Board. Pesticides are applied by credentialed and trained practitioners and are used according to the label. The label is the law.

MA.HR.04 *They have said they plan to post the reports on the SRMCB website so if they do that is should be simple to publish a notice of availability in the Monitor annually linking people to the website.*

The Board has posted various materials on it website. The Special Review Procedure will permit this information to be published in the Environmental Monitor.

NATURAL HERITAGE AND ENDANGERED SPECIES PROGRAM

NHESP.01 *The BMPs include a brief summary of the MESA (see 2. b) which requires clarification.*

The Board has clarified MESA adding additional language to the Freshwater Mosquito BMP.

NHESP.02 *In response to the 1998 Generic Environmental Impact Report, the Secretary of EOEA stated, "The SRMCB and, GEIR acknowledge that additional study and research work is necessary to truly document the effectiveness of mosquito control techniques and their impact on the environment, particularly as they relate to freshwater project[s]." The NHESP finds that this lack of research and study remains nine years after the GEIR was completed. It is still unclear if the proposed methods are effective at controlling mosquito populations, rather than simply mitigating nuisance issues. There continues to be a lack of effort to document the post-project to understand the actual effectiveness of the mosquito control effort nor the environmental impacts.*

The Board does agree that additional study and research work is necessary but it also disagrees that there is a lack of effort to document post-project effectiveness and environmental impact. As stated in response MSACC.04, MCDs are limited in that they are funded to carry out an operational mandate. They are not established or funded as research institutions. The methods that are employed in Massachusetts are consistent with methods used nationally. Research to improve mosquito management and reduce potential environmental impacts is ongoing and the Board welcomes and adopts such advances when practical.

The Board would welcome input and assistance from other agencies whose mandate is to perform environmental monitoring to assist in monitoring environmental impacts.

MISCELLANEOUS COMMENTS

MC.01 *It is not unusual today for "mosquito control activities" to occur where someone wants to avoid filing with a conservation commission."*

The Board believes this statement to be untrue and in fairness to the MCDs, their relationship with conservation commissions and other agencies in member municipalities are strong. This comment is unsubstantiated.

MC.02 *Widespread destruction of wetlands – draining wetlands*

The Board believes this criticism is unwarranted and not specific. MCDs have been very careful in their wetland project approaches and generally find that wetland functions are enhanced after they employ well-designed, carefully-implemented projects.

MC.03 *"Years of altering, draining, channeling and ditching of wetlands has shown little if any reduction in mosquito populations."*

Studies and MCDs post evaluations of both freshwater and OMWM projects suggest that at a minimum when properly conducted, all water management tends to be effective and as such an important component of any IPM program. The Board believes that there is no compelling evidence to suggest otherwise. Again, the Board notes that MCDs activities are operational based on many years of experience.

MC.04 *Lack of monitoring for mosquitoes "Where are the studies of locally altered wetlands and /or documentation that conclusively show these alterations work?"*

The Board agrees that the Freshwater Mosquito BMP should outline some practicable and effective monitoring protocols. However, it should be pointed out that MCDs do collect and record dip data, maintain, and develop larviciding records, or have a history of mosquito collection and control practices for each site. All of this is information is available upon request. The Board and the MCDs will continue to work towards a fiscally responsible and feasible monitoring effort that addresses environmental concerns.

MC.05 *Monitoring of treatment effectiveness*

The Board agrees. MCDs can do a better job of analyzing treatment effectiveness. The Board will work with MCDs to better document the data they collect each season and present in their annual reports.

MC.06 *No clear line between "nuisance" and "disease" vectors*.

The Board recognizes that MCDs activities serve dual purposes in that reducing the number of mosquitoes that bite people necessarily reduces quality of life impacts, and because these mosquitoes are capable of spreading disease to people, the control measures also reduce public health risks. A number of the MCDs were originally established to combat nuisance mosquitoes in places such as Cape Cod. A number of the MCDs were established to suppress arbovirus risk of Eastern Equine Encephalitis virus such as Northeast, Bristol, and Plymouth County Mosquito Control. Today, given that other arboviruses have become established (such West Nile virus) it is no longer practical to separate or make distinctions between nuisance and disease control. The Board believes it is a prudent public health measure to reduce the numbers of mosquitoes available to transmit the disease agents prior to their actual detection. However, it should be pointed out that the time of the year when mosquitoes create the greatest "nuisance" is also the time of year when viral transmission may occur.

MC.07 *Towns need to join a MCD to obtain vector surveillance.*

This is not correct. DPH maintains a statewide system of long term monitoring sites for EEEv. DPH also deploys traps statewide for detection of West Nile virus including trap sites in communities that have no membership with an organized mosquito control district. These sites are supplemented by MCD trapping sites. The MCDs bear the cost of collecting these samples if the samples from an individual MCD exceed 400 pools during the mosquito season, the MCDs will bear the cost of analyzing these samples for arboviruses.

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February 15, 2008

CERTIFICATE OF THE SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
ON THE
GENERIC ENVIRONMENTAL IMPACT REPORT

PROJECT NAME	: Mosquito Control Program
PROJECT MUNICIPALITY	: Statewide
PROJECT WATERSHED	: Statewide
EOEA NUMBER	: 5027
PROJECT PROPONENT	: Department of Agricultural Resources - State Reclamation and Mosquito Control Board
DATE NOTICED IN MONITOR	: November 26, 2007

As Secretary of Energy and Environmental Affairs, I hereby determine that this project requires programmatic review pursuant to the Massachusetts Environmental Policy Act (G.L. c.30, ss. 61-62H) and its implementing regulations (301 CMR 11.00). On November 26, 2007, the State Reclamation and Mosquito Control Board (SRMCB), submitted a Generic Environmental Impact Report Update and a request that its Mosquito Control Program's future submissions be reviewed under the Special Review Procedures, 301 CMR 11.09. As described in a separate Certificate issued today, I have established a Special Review Procedure, to replace the GEIR format, by which the SRMCB shall continue their efforts to document and submit for MEPA review its polices and management practices for mosquito control throughout the Commonwealth.

Project Description

The State Reclamation and Control Board (SRMCB) is comprised of one representative each from the Department of Environmental Protection (MassDEP), the Department of Food and Agriculture (DFA) and the Department of Environmental Management (DEM) and exercises responsibility for nine mosquito control projects in Massachusetts (Berkshire County, Bristol County, Cape Cod, Central Massachusetts, East Middlesex County, Norfolk County, Plymouth County, Suffolk County, and the North east Massachusetts Mosquito Control and Wetlands Management District (formerly Essex County MCP). The SRMCB was the designated lead agency in preparing the Mosquito Control GEIR. The last MEPA filing by the SRMCB, in 1998, was intended to provide a description of then-current data, practices and standards used to control mosquitoes statewide. The purpose of the GEIR was to gather in a single document information on the methods and environmental impacts of mosquito control and eradication in Massachusetts. The GEIR focused primarily on salt marshes, their respective pest mosquito problems and the effectiveness of related mosquito control activities. The Certificate on the GEIR reflected the SRMCB's commitment to provide annual updates, by which the SRMCB proposed to continually update and supplement the GEIR. The SRMCB submitted its first annual update on November 26, 2007, that included best management practices (BMPs) and operational guidance for mosquito control activities conducted in freshwater wetland resource areas. The GEIR Update provides important information pertaining to mosquito control activities in freshwater wetland resource areas in Massachusetts, but also serves to illustrate the need for more comprehensive information about the program's polices and activities.

In the Certificate establishing the SRP, I have directed the SRMCB to file its first "EIR Update" within six months of the date of this Certificate. The purpose of the first EIR Update will be to provide for MEPA review and public comment all policies and management practices that have been developed and implemented since the GEIR was published. In addition, the first EIR Update shall provide the outline of a proposed workplan and schedule for subsequent EIR Update filings, subject to guidance in the Scope, below. I will modify the Scope for ongoing review and establish a schedule for the review of subsequent EIR Updates based on my review of the first EIR Update and comments from agencies and the public.

SCOPE FOR FIRST EIR UPDATE

The goal of programmatic review is to identify and act upon specific recommendations for improving existing open marsh, freshwater, and chemical mosquito control activities to ensure that the public health is protected and impacts to the environment are minimized. The SRMCB should use the first EIR Update to establish a framework to achieve this overall goal. As identified in the 1998 Certificate on the GEIR and in the comments received on the GEIR Update, a key missing element of the current program is a monitoring program that can be used to modify best management practices and inform management decisions made within the integrated pest management matrix.

The first EIR Update should provide the following information:

1. A discussion of the organization and practice of mosquito control in Massachusetts, integrating materials described under #2, below;
2. Plans, analyses, policies and management practices that have been developed and implemented since the GEIR was filed;
3. A workplan and schedule for developing additional information and procedures to assess and guide SRMCB's mosquito control program. The workplan should propose measures to incorporate monitoring results to measure the effectiveness and impacts of mosquito control practices, and to provide the basis for modifying Best Management Practices. Such feedback may initially be provided by a description of the effectiveness and impacts of mosquito control projects through a review of studies done elsewhere on the same practices in similar habitats, but the workplan should also identify opportunities to develop targeted monitoring studies in conjunction with state agency, municipal, or non-governmental organization resources; and,
4. A response to comments received on the 1997 GEIR and 2007 GEIR Update. This Response to Comments section should include copies of all comment letters listed at the end of the GEIR Certificate of December 18, 1998, this GEIR Update Certificate.

The SRMCB should convene at least one meeting of relevant state agencies and parties who submitted comments on the GEIR Update to facilitate the development of the workplan and schedule. In addition, I expect that the SRMCB will coordinate closely with the state permitting and resource agencies to identify opportunities to leverage agency resources (e.g., mapping, fieldwork, wetlands ecology expertise) to ensure the development of a comprehensive and consistent program of policies and activities for mosquito control in Massachusetts.

The EIR Update should be circulated in compliance with Section 11.16 of the MEPA regulations and copies should also be sent to the list of "comments received" at the end of this Certificate and commenters listed on the October 1998 GEIR Certificate.

February 15, 2008
DATE

Ian A. Bowles, Secretary

Comments:

cc: Philip Weinberg, MassDEP/Boston

Comments received:

01/22/08	Mathew Selby, Ashland Conservation Commission
01/15/08	Carol Hurley
01/17/08	Town of Stow, Conservation Commission
01/17/08	Judith Eiseman
01/17/08	Lynn Southey
01/18/08	Mass Audubon
01/22/08	Jones River Watershed Association, Inc.
01/23/08	Green Futures
01/23/08	The Nature Conservancy
01/23/08	Alexandra Dawson
01/23/08	Mass Audubon
01/25/08	Natural Heritage and Endangered Species Program (NHESP)

IAB/DBB/ncz

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December 18, 1998

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CERTIFICATE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS ON THE GENERIC ENVIRONMENTAL IMPACT REPORT

PROJECT NAME	:	Mosquito Control Program
PROJECT MUNICIPALITY	:	Statewide
PROJECT WATERSHED	:	Statewide
EOEA NUMBER	:	5027
PROJECT PROPONENT	:	State Reclamation and Mosquito Control Board
DATE NOTICED IN MONITOR	:	October 25, 1998

As the Secretary of Environmental Affairs, I hereby determine that the Generic Environmental Impact Report (EIR) submitted on this project adequately and properly complies with the Massachusetts Environmental Policy Act (M.G.L. c. 30, ss. 61-62H) and with its implementing regulations (301 CMR 11.00).

On September 23, 1996 the Secretary of Environmental Affairs issued a Certificate on a Notice of Project Change filed by the State Reclamation and Mosquito Control Board (SRMCB)[1] requiring that a Generic Environmental Impact Report (GEIR) be completed for mosquito control in the Commonwealth. The Certificate contained an extremely detailed scope for the GEIR, developed in coordination with SRMCB. This GEIR, by responding to all of the items in that scope, provides an extremely useful summary of current data, practices, and standards for mosquito control statewide. In particular, the GEIR establishes that Open Marsh Water Management (OMWM) shall serve as the preferred practice for physical controls in salt marshes. The GEIR also highlights certain areas in which further research will be necessary, and it

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1 - The State Reclamation and Mosquito Control Board (SRMCB) is comprised of one representative each from the Departments of Environmental Management, Environmental Protection and Food and Agriculture.

proposes a system of annual updates, offering continued opportunities for review and comment on new information and proposals.

Introduction

The SRMCB oversees nine organized mosquito control projects (Berkshire County, Bristol County, Cape Cod, Central Massachusetts, East Middlesex County Norfolk County, Plymouth County, Suffolk County and the North East Massachusetts Mosquito Control and Wetlands Management District) and appoints the Board of Commissioners for each project. These mosquito control projects have a total of 157 participating communities, primarily coastal. Thus, the focus of the GEIR and this Certificate are primarily upon salt marshes and their attendant pest mosquito problems. The remaining nonparticipating communities, mostly located in the central portion of the state, either practice no mosquito control, hire private contractors or have their own community-based mosquito control operations (e.g., the local public works department or health board).

The intent of the GEIR was to gather, in a single document, information on methods of mosquito control and eradication in Massachusetts, and the environmental impacts of those methods. The GEIR has accomplished the goal of disseminating information on current mosquito control practices, and it has established the basis for viewing OMWM as the preferred control technique in salt water marshes. Comments received from the Department of Environmental Protection (DEP) and the Division of Fisheries and Wildlife (DF&W), in particular, will provide a good basis for future GEIR updates.

However, the GEIR falls short of the ambitious goal of providing the basis for all future mosquito control projects implemented by the County Mosquito Control Projects. The SRMCB and the GEIR acknowledge that additional study and research work is necessary to truly document the effectiveness of mosquito control techniques and their impact on the environment, particularly as they relate to freshwater projects. The report concludes that it will take a renewed and concerted effort, involving additional resources, to complete a mosquito control program "master guidance document" that best serves the public and protects the environment. To that end, the SRMCB plans to update the GEIR on a yearly basis as new ideas and approaches to mosquito control become known.

Saltwater Marsh Regulatory Issues and MEPA

Established mosquito control projects are generally exempt from the Massachusetts Wetlands Protection Act (MWPA). However, Section 401 of the Federal Clean Water Act requires applicants wishing to discharge dredged of fill materials to obtain a certification or waiver from their state water pollution control agency. A Section 401 water quality certification is treated as a state permit for the purposes of establishing MEPA jurisdiction. Therefore, for projects involving new ditching such as that required for Open Marsh Water Management (OMWM), the MC proponent has been obliged to file an Environmental Notification Form (ENF) for projects affecting at least 1,000 square feet (sf) of saltmarsh or 5,000 sf of bordering vegetated wetlands (BVW). The MEPA regulations require the filing of an Environmental Impact Report (EIR) for any particular work site that might require the alteration of one or more acres of saltmarsh or BVW.

In November 1995 the then-Essex County Mosquito Control Project (now the Northeast Massachusetts Mosquito Control and Wetlands Management District) filed an ENF requesting a waiver from the EIR requirement (EOEA #10567). Based on a number of "findings and conditions" discussed below, a waiver from the EIR requirement was granted in February 1996. The most significant of those findings was that the Essex County Mosquito Control Project established "Standards for Open Marsh Water Management" which were endorsed by the Environmental Protection Agency, the National Marine Fisheries Service, the Massachusetts Audubon Society and others. These standards are widely viewed as the least harmful to the environment (of the various control techniques) and most efficient non-pesticidal method for controlling saltmarsh mosquitoes. The proponent also committed to conduct a review of ten years of OMWM in Essex County to provide a basis for comparison and evaluation of mosquito control effectiveness and impact to the environment. It is generally recognized that the principal concern associated with OMWM arises from the disposal of the dredge material on the marsh and the potential for invasion of upland plants (particularly Phragmites sp.) that can occur with even slight elevation increases (i.e., 1-2 inches).

Open marsh water management (OMWM) projects are now underway in Essex (EOEA #10567), Norfolk, and Plymouth counties and are being expanded to include all problem marshes in those counties. The need to convert grid ditch systems is likely to continue and the saltmarsh alterations will likely exceed the one acre EIR threshold at several locations. Based on the success of OMWM, the establishment of "Standards for Open Marsh Water Management," the conclusions of this GEIR, and the commitment to continue to monitor the effectiveness of OMWM on the control of mosquitos and its impact on the environment, I am proposing, in a forthcoming issue of the Environmental Monitor, to publish a Draft Record of Decision that would modify the ENF and EIR thresholds for OMWM projects[2], subject, at a minimum, to the following standards and conditions:

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2 - The MEPA regulations at Section 11.01 (2)(b)(3) under "Review Thresholds" state, in part, that [t]he review thresholds do not apply to... "a project that is consistent with a Special Review Procedure review document, or other plan or document that has been prepared with the express purpose of assessing the potential environmental impacts from future Projects, has been reviewed under or approved by any Participating Agency, unless the filing of an ENF and an EIR was required by a decision of the Secretary on any such review document, plan or document."

* That the Northeast Massachusetts Mosquito Control and Wetlands Management District - "Standards for Open Marsh Water Management" be used as the statewide standard for OMWM projects.

* That the saltmarsh be inventoried for the presence of rare and endangered species as determined by the Natural Heritage and Endangered Species Program (NHESP) habitat maps. If a project falls within such an area, NHESP will then determine if the area to be altered is an actual wetland habitat for rare species.

* Compliance with Section 401 of the Federal Clean Water Act and Federal Coastal Zone Consistency.

* Improved record keeping with respect to treatment location, type, efficacy and post treatment monitoring. For example, there are old ditches which still effectively control mosquitoes therefore their effectiveness should be monitored prior to going ahead with OMWM.

MC Projects Impact on Freshwater Wetlands

Freshwater wetlands are the dominant system in which freshwater physical control take place. Typically, this work consists of maintaining (i.e., removing blockages from previously ditched areas) existing ditches designed to remove standing water from the wetland. Though reducing standing water reduces mosquito breeding, there has been little research concerning the overall effects of these alterations on the modified wetland. Therefore, increased efforts are necessary to examine the environmental effects of draining surface water from wetlands.

As stated above, most of the freshwater mosquito control projects are geared to removal of blockages, be they natural or influenced by man, in wetland areas earlier identified as significant mosquito breeding habitats. These projects usually are classified as maintenance projects and are therefore exempt from MEPA review pursuant to Section 11.01 (2)(b)(3). However, there is a significant amount of work that needs to be completed in order to determine whether such work is cost effective, and whether a specific alternative is the one least damaging to the environment. As the report acknowledges there has been no study to date of the costs and benefits of Massachusetts mosquito control programs. However, this work has been done in other states, most notably New Jersey, which should be helpful in answering the following questions raised in the GEIR:

1) Establishing substantive human annoyance thresholds[3];
2) Documenting how human activity patterns relate to Human Annoyance Thresholds (HAT) and economic factors;
3) Determining the cost/benefit of control; and,
4) Correlating densities of immature mosquito (i.e., larvae) with future levels of biting annoyance.

These issues should be addressed and reported on in future GEIR updates. EOEA is prepared to help in this regard.

Standards for Freshwater Wetland Physical Control

The GEIR indicates that the SRMCB still needs to determine the appropriate control measure standards for MC projects in freshwater wetlands (described in the report as Upland Water Management operational procedures). These standards will need to

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3 - The current provocations for execution of mosquito control techniques are generally as follows:

1. Larval Populations - by dip count (up to 20 per sampling area) and based on the population #s/10 or 5 dips then a decision is made to either use a pesticide or water management strategy.

2. Adult Populations - No adulticiding is to take place at a regularly scheduled or prescribed time or place. Instead spraying is done based on annoyances, such as five bites per night; more than one landing per minute; or two complainant calls per square mile of area.

be coordinated with the DEP's Stormwater Policy Handbook and Stormwater Technical Handbook. In addition, many physical control projects lack adequate records, both with respect to the justification of a specific project, and with respect to site plans. Therefore, the SRMCB should work toward requiring better record keeping and notification practices, as discussed in the DEP comment (and the Coastal Zone Management letter for salt marsh alterations).

Integrated Pest Management (IPM)

The GEIR indicates that the strengths of the Massachusetts mosquito control IPM include the availability of and willingness to use least-toxic materials and willingness of existing control programs to try new strategies. In addition, a successful IPM program requires strong control programs and good pretreatment monitoring. The weaknesses of the IPM have been linked to a lack of funds for research and implementation and a lack of basic ecological data on the effects of control strategies in use or being planned.

I do note that all of the pesticides (larvicides and pesticides) used by MC projects have been approved by and are registered with the US Environmental Protection Agency. Given the rigorous process to gain market approval for a pesticide as well as the evolving nature of pesticide development, I agree with the conclusions of the GEIR that, for now, advances in reducing the risk of chemical use must come from improved targeting and increased use of water management and/or biological control techniques as encouraged by the IPM technique.

Eastern Equine Encephalitis (EEE)

The Massachusetts Department of Public Health (DPH) is responsible for surveillance for EEE Virus, risk assessment, public information and education on EEE disease. DPH is also responsible for recommendations for wide aerial vector control interventions. DPH published its "Vector Control Plan to Prevent

Eastern (Equine) Encephalitis" on (August 7, 1991). That protocol will govern when the next EEE outbreak occurs. The DPH has also developed a monitoring program that should bring EEE into the IPM framework. I urge that this work continue in order to avoid the adversity that accompanied the 1990 aerial spraying.

GEIR Recommendations and Conclusions

In addition to the issues discussed above, GEIR updates should emphasize how MC programs will incorporate the IPM strategy of keeping human annoyance below specified thresholds. Standards for control methodology should favor source reduction (e.g., OMWM in salt marshes) whenever possible, and employ larvicide control only when source reduction is not effective. Projects should work closely with the DEP water quality certification program and the NHESP to improve notices and documentation, and to minimize negative impacts of source reduction.

It is clear that the SRMCB and the MC projects have a good handle on their data and research needs. The stumbling block to successful completion of the analysis appears to be primarily fiscal in nature. I am pleased with the SRMCB's commitment to provide yearly updates, and I expect that issues brought forward in this Certificate, as well as the comments from the DEP and DF&W, will be addressed in the first yearly update. The SMRCB should meet with MEPA prior to finalizing the content of the GEIR update.

December 18, 1998
Date

Jan H. Reitsma

Comments received:
Massachusetts Division of Fisheries & Wildlife (11/13/98)
Boston water and sewer Commission (11/23/98)
Massachusetts Coastal Zone Management (11/24/98)
Edward S. Syrjala (11/24/98)
Massachusetts Audubon Society (11/25/98)
City of Boston Environmental Department (11/30/98)
Massachusetts Department of Environmental Protection (12/10/98)

TC/DEV/dv

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
Department of Agricultural Resources
State Reclamation and Mosquito Control Board
251 Causeway Street, Suite 500
Boston, MA 02114-2151

Massachusetts Department of Agricultural Resources

DEVAL L. PATRICK
Governor

TIMOTHY MURRAY
Lt. Governor

IAN A. BOWLES
Secretary

DOUGLAS W. PETERSEN
Commissioner

Mark S. Buffone, Chairman
Department of Agricultural Resources
Anne Monnelly
Department of Conservation and Recreation
Gary Gonyea
Department of Environmental Protection

Alisha Bouchard
Project Administrator
Tel: (617) 626-1715
Fax:(617) 626-1850

Friday, September 26, 2008

TO ALL INTERESTED PARTIES:

The State Reclamation and Mosquito Control Board (SRMCB) through this Request for Responses (RFR), is seeking professional consultant and expert assistance to compile information and prepare a report for the Massachusetts Environmental Policy Act (MEPA). The selected contractor will compile information from the scientific literature, the SRMCB, and from Mosquito Control Districts (MCD's), as applicable, and draft a report that outlines in narrative format the organization and practice of mosquito control in Massachusetts, integrating the current mosquito control plans, policies, and practices that have been developed since the final Mosquito Generic Environmental Impact Statement (GEIR) was approved in 1998. The anticipated scope of services for this contract is outlined in the attached RFR. **However, a scoping session with the SRMCB will be required as soon as possible to insure that deliverables meet an accelerated time table.**

Any questions on the RFR must be submitted in writing via fax to: Alisha Bouchard, DAR @ 617-626-1850 and received no later than 12 PM (Noon), Wednesday, October 1, 2008

All Responses to this RFR must be submitted in the requested format to: Alisha Bouchard, DAR and received **no later than Friday, October 31, 2008.**

This RFR has been distributed electronically using the Commonwealth Procurement Access & Solicitation System (Comm-PASS). Additional copies of this RFR can be obtained at http://www.Comm-PASS.com, or by contacting Alisha Bouchard.

Sincerely,

Mark S. Buffone

Mark S. Buffone, Chairman
State Reclamation and Mosquito Control Board

RFR# SRB-REPORTING-09
STATE RECLAMATION AND MOSQUITO CONTROL BOARD

I. Background and Purpose

The State Reclamation and Mosquito Control Board (SRMCB) through this Request for Responses (RFR), is seeking professional consultant assistance to compile information and prepare a report for the Massachusetts Environmental Policy Act (MEPA). The selected contractor will compile information from the scientific literature, the SRMCB, and from Mosquito Control Districts, as applicable, and draft a report that outlines in narrative format the organization and practice of mosquito control in Massachusetts, integrating the current mosquito control plans, policies, and practices that have been developed since the final Mosquito Generic Impact Statement was approved in 1998. The anticipated scope of services for this contract is outlined below.

II. Anticipated Scope of Services

The selected the report would be formatted in various sections including but not limited to cover page, summary statement, project description, background, oversight and structure of mosquito control, current practices and changes, response to comments, references and appendices.

The Scope of Services will include the following tasks:

1) Prepare a draft final report outline for SRMCB review and approval.
2) Assist SRMCB in addressing issues raised in comment letters received by the Secretary of EOEEA as outlined in Attachments A & B of this RFR.
3) Summarize the current mosquito control organization and discuss the changes that have occurred over the past 10 years closing the knowledge gap circa 1998 – 2008.
4) Summarize policy, administrative and other steps taken by SRMCB since issuance of the 1998 GEIR.
5) Describe what and how mosquito control is being currently conducted, how it has changed, and how it has not changed highlighting any improvements and revisions. Improvements can be highlighted by incorporating existing documents maintained by the SRMCB that can be incorporated into the report or referenced as appendices such as Massachusetts state review of a common larvicide used by mosquito control projects called methoprene, the Department of Public Health State Response and Surveillance Plan, operational reports for each regional mosquito control project, and newly developed Best Management Practices (BMPs).
6) Describe the process of how decisions are made to use pesticides and/or to response to public health situations. This section should highlight and define in crystal clear fashion the use of Integrated Pest Management (IPM) and how the mosquito control projects use it to monitor results to measure the effectiveness and impacts of mosquito control practices. This section can highlight a review of studies done elsewhere on the same practices in similar habitats and cite any Massachusetts data too. This section would catalogue changes in pesticide products and inventory the current products in use now.
7) Discuss limiting factors for current mosquito control practices including but not limited to municipal finance/budget concerns to be regionally sustainable, lack of resources and personnel to conduct peer review research, and operational limitations for example spraying at dusk.
8) Provide a conclusion section that provides a work plan and schedule for developing additional information and procedures to assess and guide SRMCB's mosquito control program for the future if additional resources were available.

9) Provide and incorporate preliminary analysis of Open Marsh Water Management (OMWM) data collected by MCDs for the purpose of making conclusions along with identifying studies from other states that evaluate OMWM.

Deliverables:

Draft final report outline to include, but not be limited to:

1) **Compilation of literature reviewed.**
2) **Draft responses to Comment Letters**
3) **Summary of mosquito control organizational structure plus changes.**
4) **Analysis of OMWM mosquito larvae data to determine treatment effectiveness**
5) **Review of pesticides currently used by MCDs.**
6) **List and summarize reviews, updates, work group products as they apply to new Mosquito Control Practices.**
7) **Summary of how MCDs apply IPM approach in their operating practices.**
8) **Discussion, work plan, and schedule for developing additional information.**

Request for Responses (RFR)
STATE RECLAMATION AND MOSQUITO CONTROL BOARD

1. DESCRIPTION OR PURPOSE OF PROCUREMENT:
The State Reclamation and Mosquito Control Board (SRMCB) through this Request for Responses (RFR), is seeking professional consultant and expert assistance to compile information and prepare a report for the Massachusetts Environmental Policy Act (MEPA).

2. ACQUISITION METHOD TO BE USED FOR CONTRACT(S):
____ Outright Purchase __X__ Fee For Service ____ License ____ Tax Exempt Lease Purchase (TELP)
____ Term Lease ____ Rental (not to exceed 6 months) ____ Other (specify):

3. SINGLE OR MULTIPLE CONTRACTORS FOR CONTRACT PERFORMANCE:
__X___ Single Contractor _____ Multiple Contractors

4. SINGLE OR MULTIPLE DEPARTMENTS MAY CONTRACT UNDER THIS RFR:
__X___ Only Procuring Department May Contract Under RFR
_____ Option to Allow Other Departments\Political Subdivisions to Contract Under RFR

_____ Statewide Contract - All Departments may purchase under terms of RFR
_____ Multiple Un-identified Additional Departments may purchase under terms of RFR
_____ Multiple Identified Departments Listed in RFR may purchase under terms of RFR

5. TOTAL ANTICIPATED DURATION OF CONTRACT(S):
Initial Contract Duration:
The contract is to run until 2/28/09

Options to Renew (Indicate numbers):

___1___ Option(s) to Renew not to exceed: __6__ Month(s); ____ Year(s), each option

6. TOTAL ANTICIPATED EXPENDITURES FOR TOTAL ANTICIPATED DURATION OF CONTRACT(S):
(Amounts indicated are only estimates. Contract amounts during the period of any contract are subject to a selected Bidder's response, and may increase or decrease based upon contract negotiation, performance selected, appropriation or availability of funds.)

(Optional) Estimated Value of Procurement (Including Anticipated Renewal Options):$ _49,500________________
_____ Contract(s) will have a Maximum Obligation Amount.
_____ Contract(s) will NOT have a Maximum Obligation Amount (Rate Contract).
_____ Compensation will be Subject to Quotes by List of Qualified Contractors (Maximum Obligation or Rate Contract).

Will Federal Funds be used to fund and part of Contract(s)? __X__ NO, _____ YES (If YES, to what extent?)

7. INDICATE CONTRACT AND PERFORMANCE SPECIFICATIONS:
See attached Anticipated Scope of Services

8. INSTRUCTIONS FOR SUBMISSION OF RESPONSES: (Content Requirements for Responses, Where and How to Submit Responses, # Copies of Responses, Format Requirements)
The Respondent shall provide **one original signed and three (3) copies** of its Response prepared simply and economically, providing concise descriptions of the respondent's abilities to meet the requirements of the RFR. The Department requests that the copies be submitted on recycled paper and printed double-sided. The Respondent shall also submit an electronic copy of its response on a CD. Emphasis should be on completeness, clarity and on a straightforward description on the Respondent's qualifications to accomplish the tasks in this RFR. No credit will be given for marketing or promotional materials.

In addition to its response, as described below, Respondents must complete, sign, and return with their Response the required forms contained on the Forms and Terms tab of the Comm-Pass posting and as listed below

1. Standard Contract Form
2. Commonwealth Terms and Conditions Form;
3. Contractor Authorized Signatory Listing;

The entire Response shall be typewritten on 8.5" by 11" paper, the pages numbered, and the cover page (or letter) signed in ink by an official authorized to bind the Respondent to its provisions.

All terms, conditions, requirements and procedures included in this RFR must be met in order for a Response to be determined responsive. If a Respondent fails to meet any material term, condition, requirement or procedure, its Response may be deemed unresponsive and disqualified. The Department reserves the right to request additional information from a Respondent to clarify their response to this RFR, provided that, in the Department's view, any such opportunity to provide further information does not prejudice the interests of the other Respondents.

The Response shall include a Statement of Qualifications.

The Statement of Qualifications section shall include the following items:

1. Provide resumes for the Respondent's Key Employees including subcontractors who will have primary responsibility for project tasks and identify their educational and work history and current job description;
2. Provide three (3) references who may be contacted by Department to discuss the Respondent's including their subcontractors qualifications, work experience and ability to perform the services;
3. A narrative statement describing the Respondent's qualifications and any prior and/or current work experience in the manner described in Section IX of the RFR ("Qualifications and Related Experience"), including a description of any similar projects performed by the Bidder and any other information relevant to their ability to successfully perform the services under the contract;
4. A Company Profile or Organizational Chart;
5. A list of any subcontractors and the specific task(s) to be performed by the subcontractor.
6. A detailed budget showing how the bidder intends to expend funding
7. A timeline showing how and when the project requirements are to be met

All bids will be evaluated based up:

1. The reasonableness of the project's budget
2. The shown ability to perform the work requested
3. Likeliness that the work will be completed within the strict timeframe
4. The completeness of the proposal

REQUIRED SPECIFICATIONS
Issue Date: November 1, 2005
Refresh Date: August 13, 2007

In general, most of the required contractual stipulations are referenced in the *Standard Contract Form and Instructions* and the *Commonwealth Terms and Conditions* (either version). However, the following RFR provisions must appear in all Commonwealth competitive procurements conducted under 801 CMR 21.00:

The terms of *801 CMR 21.00: Procurement of Commodities and Services* (and *808 CMR 1.00: Compliance, Reporting and Auditing for Human and Social Services*, if applicable) are incorporated by reference into this RFR. Words used in this RFR shall have the meanings defined in 801 CMR 21.00 (and 808 CMR 1.00, if applicable). Additional definitions may also be identified in this RFR.

Unless otherwise specified in this RFR, all communications, responses, and documentation must be in English, all measurements must be provided in feet, inches, and pounds and all cost proposals or figures in U.S. currency. All responses must be submitted in accordance with the specific terms of this RFR.

Items with the text, "☞ *Required for POS Only"* specify a requirement for Purchase of Service (POS) human and social services procured under *801 CMR 21.00, Procurement of Commodities or Services, Including Human and Social Services* and *808 CMR 1.00, Compliance, Reporting and Auditing for Human and Social Service.*

Affirmative Market Program (AMP). Massachusetts Executive Order 390 established a policy to promote the award of state contracts in a manner that develops and strengthens Minority and Women Business Enterprises (M/WBEs) that resulted in the Affirmative Market Program in Public Contracting. M/WBEs are strongly encouraged to submit responses to this RFR, either as prime vendors, joint venture partners or other type of business partnerships. All bidders must follow the requirements set forth in the AMP section of the RFR, which will detail the specific requirements relating to the prime vendor's inclusion of M/WBEs. Bidders are required to develop creative initiatives to help foster new business relationships with M/WBEs within the primary industries affected by this RFR. In order to satisfy the compliance of this section and encourage bidder's participation of AMP objectives, the Affirmative Market Program (AMP) Plan for large procurements greater than $50,000 will be evaluated at 10% or more of the total evaluation. Once an AMP Plan is submitted, negotiated and approved, the agency will then monitor the contractor's performance, and use actual expenditures with SOMWBA certified contractors to fulfill their own AMP expenditure benchmarks. M/WBE participation must be incorporated into and monitored for all types of procurements regardless of size, however, submission of an AMP Plan is mandated only for large procurements over $50,000.

This RFR will contain some or all of the following components as part of the Affirmative Market Program Plan submitted by bidders:

- Sub-contracting with certified M/WBE firms as defined within the scope of the RFR,
- Growth and Development activities to increase M/WBE capacity,
- Ancillary use of certified M/WBE firms,
- Past Performance or information of past expenditures with certified M/WBEs and
- Additional incentives for bidders to commit to at least one certified MBE and WBE in the submission of AMP plans.

A Minority Business Enterprise (MBE), Woman Business Enterprise (WBE), M/Non-Profit, or W/Non-Profit, is defined as such by the State Office of Minority and Women Business Assistance (SOMWBA). All certified businesses that are included in the bidder's AMP proposal are required to submit an up to date copy of their SOMWBA certification letter. The purpose for this certification is to participate in the Commonwealth's Affirmative Market Program for public contracting. Minority- and Women-Owned firms that are not currently certified but would like to be considered as an M/WBE for the purpose of this RFR should submit their application at least two weeks prior to the RFR closing date and submit proof of documentation of application for consideration with their bid proposal. For further information on SOMWBA certification, contact their office at 1-617-973-8692 or via the Internet at mass.gov/somwba.

Affirmative Market Program Subcontracting Policies. Prior approval of the agency is required for any subcontracted service of the contract. Agencies may define required deliverables including, but not limited to, documentation necessary to verify subcontractor commitments and expenditures with Minority- or Women-Owned Business Enterprises (M/WBEs) for the purpose of monitoring and enforcing compliance of subcontracting commitments made in a bidder's Affirmative Market

Program (AMP) Plan. Contractors are responsible for the satisfactory performance and adequate oversight of its subcontractors.

Agricultural Products Preference (only applicable if this is a procurement for Agricultural Products) - Chapter 123 of the Acts of 2006 directs the State Purchasing Agent to grant a preference to products of agriculture grown or produced using locally grown products. Such locally grown or produced products shall be purchased unless the price of the goods exceeds the price of products of agriculture from outside the Commonwealth by more than 10%. For purposes of this preference, products of agriculture are defined to include any agricultural, aquacultural, floricultural or horticultural commodities, the growing and harvesting of forest products, the raising of livestock, including horses, raising of domesticated animals, bees, fur-bearing animals and any forestry or lumbering operations.

Best Value Selection and Negotiation. The Procurement Management Team (PMT) may select the response(s) which demonstrates the best value overall, including proposed alternatives that will achieve the procurement goals of the department. The PMT and a selected bidder, or a contractor, may negotiate a change in any element of contract performance or cost identified in the original RFR or the selected bidder's or contractor's response which results in lower costs or a more cost effective or better value than was presented in the selected bidder's or contractor's original response.

Bidder Communication. Bidders are prohibited from communicating directly with any employee of the procuring department or any member of the PMT regarding this RFR except as specified in this RFR, and no other individual Commonwealth employee or representative is authorized to provide any information or respond to any question or inquiry concerning this RFR. Bidders may contact the contact person for this RFR in the event this RFR is incomplete or the bidder is having trouble obtaining any required attachments electronically through Comm-PASS.

Comm-PASS. Comm-PASS is the official system of record for all procurement information which is publicly accessible at no charge at **www.comm-pass.com**. Information contained in this document and in each tab of the Solicitation, including file attachments, and information contained in the related Bidders' Forum(s), are all components of the Solicitation.

Bidders are solely responsible for obtaining all information distributed for this Solicitation via Comm-PASS, by using the free Browse and Search tools offered on each record-related tab on the main navigation bar (Solicitations and Forums). Forums support Bidder submission of written questions associated with a Solicitation and publication of official answers. All records on Comm-PASS are comprised of multiple tabs, or pages. For example, Solicitation records contain Summary, Rules, Issuer(s), Intent or Forms & Terms and Specifications, and Other Information tabs. Each tab contains data and/or file attachments provided by the Procurement Management Team. All are incorporated into the Solicitation.

It is each Bidder's responsibility to check Comm-PASS for:

- Any addenda or modifications to this Solicitation, by monitoring the "Last Change" field on the Solicitation's Summary tab, and
- Any Bidders' Forum records related to this Solicitation (see Locating a Online Bidders' Forum for information on locating these records.

The Commonwealth accepts no responsibility and will provide no accommodation to Bidders who submit a Response based on an out-of-date Solicitation or on information received from a source other than Comm-PASS.

Comm-PASS SmartBid Subscription. Bidders may elect to obtain an optional SmartBid subscription which provides value-added features, including automated email notification associated with postings and modifications to Comm-PASS records. When properly configured and managed, SmartBid provides a subscriber with:

- A secure desktop within Comm-PASS for efficient record management
- A customizable profile reflecting the subscriber's product/service areas of interest
- A customizable listing in the publicly accessible Business Directory, an online "yellow-pages" advertisement
- Full-cycle, automated email alert whenever any record of interest is posted or updated
- Access to Online Response Submission, when allowed by the Issuer, to support:

- paperless bid drafting and submission to an encrypted lock-box prior to close date
- electronic signature of OSD forms and terms; agreement to defer wet-ink signature until Contract award, if any
- withdrawal of submitted bids prior to close date
- online storage of submitted bids

Every public purchasing entity within the borders of Massachusetts may post records on Comm-PASS at no charge. Comm-PASS has the potential to become the sole site for all public entities in Massachusetts. SmartBid fees are only based on and expended for costs to operate, maintain and develop the Comm-PASS system.

Contract Expansion. If additional funds become available during the contract duration period, the department reserves the right to increase the maximum obligation to some or all contracts executed as a result of this RFR or to execute contracts with contractors not funded in the initial selection process, subject to available funding, satisfactory contract performance and service or commodity need.

Costs. Costs which are not specifically identified in the bidder's response, and accepted by a department as part of a contract, will not be compensated under any contract awarded pursuant to this RFR. The Commonwealth will not be responsible for any costs or expenses incurred by bidders responding to this RFR.

Debriefing. ☞ *Required for POS Only. This is an optional specification for non-POS RFRs.* Non-successful bidders may request a debriefing from the department. Department debriefing procedures may be found in the RFR. Non-successful POS bidders aggrieved by the decision of a department must participate in a debriefing as a prerequisite to an administrative appeal.

Debriefing/Appeals: Administrative Appeals to Departments. ☞ *Required for POS Only. Not applicable to non-POS bidders.* Non-successful bidders who participate in the debriefing process and remain aggrieved with the decision of the department may appeal that decision to the department head. Department appeal procedures may be found in the RFR.

Debriefing/Appeals: Administrative Appeals to OSD. ☞ *Required for POS Only. Not applicable to non-POS bidders.* Non-successful bidders who participate in the department appeal process and remain aggrieved by the selection decision of the department may appeal the department decision to the Operational Services Division. The basis for an appeal to OSD is limited to the following grounds:

1. The competitive procurement conducted by the department failed to comply with applicable regulations and guidelines. These would be limited to the requirements of 801 CMR 21.00 or any successor regulations, the policies in the OSD Procurement Information Center, subsequent policies and procedures issued by OSD and the specifications of the RFR; or
2. There was a fundamental unfairness in the procurement process. The allegation of unfairness or bias is one that is easier to allege than prove, consequently, the burden of proof rests with the bidder to provide sufficient and specific evidence in support of its claim. OSD will presume that departments conducted a fair procurement absent documentation to the contrary.

Requests for an appeal must be sent to the attention of the State Purchasing Agent at Room 1017, One Ashburton Place, Boston, MA 02108 and be received within fourteen (14) calendar days of the postmark of the notice of the department head's decision on appeal. Appeal requests must specify in sufficient detail the basis for the appeal. Sufficient detail requires a description of the published policy or procedure which was applied and forms the basis for the appeal and presentation of all information that supports the claim under paragraphs 1 or 2 above. OSD reserves the right to reject appeal requests based on grounds other than those stated above or those submitted without sufficient detail on the basis for the appeal.

The decision of the State Purchasing Agent shall be rendered, in writing, setting forth the grounds for the decision within sixty (60) calendar days of receipt of the appeal request. Pending appeals to the State Purchasing Agent shall not prohibit the department from proceeding with executing contracts.

Electronic Communication/Update of Bidder's/Contractor's Contact Information. It is the responsibility of the prospective bidder and awarded contractor to keep current the email address of the bidder's contact person and prospective contract manager, if awarded a contract, and to monitor that email inbox for communications from the PMT, including requests for clarification. The PMT and the Commonwealth assume no responsibility if a prospective bidder's/awarded contractor's designated email address is not current, or if technical problems, including those with the prospective bidder's/awarded contractor's computer, network or internet service provider (ISP) cause email communications sent to/from the prospective bidder/awarded contractor and the PMT to be lost or rejected by any means including email or spam filtering.

Electronic Funds Transfer (EFT). All bidders responding to this RFR must agree to participate in the Commonwealth Electronic Funds Transfer (EFT) program for receiving payments, unless the bidder can provide compelling proof that it would be unduly burdensome. EFT is a benefit to both contractors and the Commonwealth because it ensures fast, safe and reliable payment directly to contractors and saves both parties the cost of processing checks. Contractors are able to track and verify payments made electronically through the Comptroller's Vendor Web system. A link to the EFT application can be found on the OSD Forms page (www.mass.gov/osd). Additional information about EFT is available on the VendorWeb site (www.mass.gov/osc). Click on MASSfinance.

Successful bidders, upon notification of contract award, will be required to enroll in EFT as a contract requirement by completing and submitting the *Authorization for Electronic Funds Payment Form* to this department for review, approval and forwarding to the Office of the Comptroller. If the bidder is already enrolled in the program, it may so indicate in its response. Because the *Authorization for Electronic Funds Payment Form* contains banking information, this form, and all information contained on this form, shall not be considered a public record and shall not be subject to public disclosure through a public records request.

The requirement to use EFT may be waived by the PMT on a case-by-case basis if participation in the program would be unduly burdensome on the bidder. If a bidder is claiming that this requirement is a hardship or unduly burdensome, the specific reason must be documented in its response. The PMT will consider such requests on a case-by-case basis and communicate the findings with the bidder.

Environmental Response Submission Compliance. In an effort to promote greater use of recycled and environmentally preferable products and minimize waste, all responses submitted should comply with the following guidelines:

- All copies should be printed double sided.
- All submittals and copies should be printed on recycled paper with a minimum post-consumer content of 30% or on tree-free paper (i.e. paper made from raw materials other than trees, such as kenaf). To document the use of such paper, a photocopy of the ream cover/wrapper should be included with the response.
- Unless absolutely necessary, all responses and copies should minimize or eliminate use of non-recyclable or non re-usable materials such as plastic report covers, plastic dividers, vinyl sleeves and GBC binding. Three ringed binders, glued materials, paper clips and staples are acceptable.
- Bidders should submit materials in a format which allows for easy removal and recycling of paper materials.
- Bidders are encouraged to use other products which contain recycled content in their response documents. Such products may include, but are not limited to, folders, binders, paper clips,

diskettes, envelopes, boxes, etc. Where appropriate, bidders should note which products in their responses are made with recycled materials.

- Unnecessary samples, attachments or documents not specifically asked for should not be submitted.

Filing Requirements. ☞ *Required for POS Only. Not applicable to non-POS bidders.* Successful bidders must have filed their Uniform Financial Statements and Independent Auditor's Report (UFR), as required for current contractors, with the Operational Services Division via the Internet using the UFR eFiling application for the most recently completed fiscal year before a contract can be executed and services may begin. Other contractor qualification/risk management reporting requirements and non-filing consequences promulgated by secretariats or departments pursuant to 808 CMR 1.04(3) may also apply. In the event immediate services are required by a department, a contract may be executed and services may begin with the approval of OSD and the appropriate secretariat. However, unless authorized by OSD and the appropriate secretariat, the contractor will not be paid for any such services rendered until the UFR has been filed.

HIPAA: Business Associate Contractual Obligations. Bidders are notified that any department meeting the definition of a Covered Entity under the Health Insurance Portability and Accountability Act of 1996 (HIPAA) will include in the RFR and resulting contract sufficient language establishing the successful bidder's contractual obligations, if any, that the department will require in order for the department to comply with HIPAA and the privacy and security regulations promulgated thereunder (45 CFR Parts 160, 162, and 164) (the Privacy and Security Rules). For example, if the department determines that the successful bidder is a business associate performing functions or activities involving protected health information, as such terms are used in the Privacy and Security Rules, then the department will include in the RFR and resulting contract a sufficient description of business associate's contractual obligations regarding the privacy and security of the protected health information, as listed in 45 CFR 164.314 and 164.504 (e), including, but not limited to, the bidder's obligation to: implement administrative, physical, and technical safeguards that reasonably and appropriately protect the confidentiality, integrity, and availability of the protected health information (in whatever form it is maintained or used, including verbal communications); provide individuals access to their records; and strictly limit use and disclosure of the protected health information for only those purposes approved by the department. Further, the department reserves the right to add any requirement during the course of the contract that it determines it must include in the contract in order for the department to comply with the Privacy and Security Rules. Please see other sections of the RFR for any further HIPAA details, if applicable.

Minimum Bid Duration. Bidders responses/bids made in response to this RFR must remain in effect for at least 90 days from the date of bid submission.

Pricing: Federal Government Services Administration (GSA) or Veteran's Administration Supply. The Commonwealth reserves the right to request from the successful bidder(s) initial pricing schedules and periodic updates available under their GSA or other federal pricing contracts. In the absence of proprietary information being part of such contracts, compliance for submission of requested pricing information is expected within 30 days of any request. If the contractor receives a GSA or Veteran's Administration Supply contract at any time during this contract period, it must notify the Commonwealth contract manager.

Pricing: Price Limitation: The bidder must agree that no other state or public entity customer within the United States of similar size and with similar terms and conditions shall receive a lower price for the same commodity and service during the contract period, unless this same lower price is immediately effective for the Commonwealth. If the Commonwealth believes that it is not receiving this lower price as required by this language, the bidder must agree to provide current or historical pricing offered or negotiated with other state or public entities at any time during the contract period in the absence of proprietary information being part of such contracts.

Prompt Payment Discounts (PPD). All bidders responding to this procurement must agree to offer discounts through participation in the Commonwealth Prompt Payment Discount (PPD) initiative for receiving early and/or on-time payments, unless the bidder can provide compelling proof that it would be unduly burdensome. PPD benefits both contractors and the Commonwealth. Contractors benefit by increased, usable cash flow as a result of fast and efficient payments for commodities or services rendered. Participation in the Electronic Funds Transfer initiative further maximizes the benefits with payments directed to designated accounts, thus eliminating the impact of check clearance policies and traditional mail lead time or delays. The Commonwealth benefits because contractors reduce the cost of products and services through the applied discount. Payments that are processed electronically can be tracked and verified through the Comptroller's Vendor Web system. The PPD form can be found under the Forms and Terms tab of this solicitation.

Bidders must submit agreeable terms for Prompt Payment Discount using the PPD form within their proposal, unless otherwise specified by the PMT. The PMT will review, negotiate or reject the offering as deemed in the best interest of the Commonwealth.

The requirement to use PPD offerings may be waived by the PMT on a case-by-case basis if participation in the program would be unduly burdensome on the bidder. If a bidder is claiming that this requirement is a hardship or unduly burdensome, the specific reason must be documented in or attached to the PPD form.

Provider Data Management. ☞ *Required for POS Only. Not applicable to non-POS bidders.* The Executive Office of Health and Human Services (EOHHS) has established a Provider Data Management (PDM) business service that is integrated into the Virtual Gateway. PDM is accessible by providers with current POS contracts. Departments may require that bidders with current POS contracts submit certain RFR-required documents through PDM. These documents have been specified in the RFR. When submitting documents via PDM, bidders are required to print and sign a PDM Documentation Summary. PDM users should verify that all information is accurate and current in PDM. Bidders are required to include the signed PDM Documentation Summary in their RFR response.

Public Records. All responses and information submitted in response to this RFR are subject to the Massachusetts Public Records Law, M.G.L., c. 66, s. 10, and to c. 4, s. 7, ss. 26. Any statements in submitted responses that are inconsistent with these statutes shall be disregarded.

Reasonable Accommodation. Bidders with disabilities or hardships that seek reasonable accommodation, which may include the receipt of RFR information in an alternative format, must communicate such requests in writing to the contact person. Requests for accommodation will be addressed on a case by case basis. A bidder requesting accommodation must submit a written statement which describes the bidder's disability and the requested accommodation to the contact person for the RFR. The PMT reserves the right to reject unreasonable requests.

Restriction on the Use of the Commonwealth Seal. Bidders and contractors are not allowed to display the Commonwealth of Massachusetts Seal in their bid package or subsequent marketing materials if they are awarded a contract because use of the coat of arms and the Great Seal of the Commonwealth for advertising or commercial purposes is prohibited by law.

Subcontracting Policies. Prior approval of the department is required for any subcontracted service of the contract. Contractors are responsible for the satisfactory performance and adequate oversight of its subcontractors. Human and social service subcontractors are also required to meet the same state and federal financial and program reporting requirements and are held to the same reimbursable cost standards as contractors.

Massachusetts Department of Public Health

2008 MASSACHUSETTS ARBOVIRUS SURVEILLANCE AND RESPONSE PLAN

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Executive Summary

The 2008 MDPH Massachusetts Arbovirus Surveillance and Response plan provides surveillance and phased response guidance for both West Nile virus (WNV) and eastern equine encephalitis virus (EEE). The year 2007 was witness to continued West Nile virus activity across the state. In the past five years there have thirty-four cases of WNV infection reported in Massachusetts and thirteen human cases of EEE resulting in six deaths. This plan reflects a comprehensive review of surveillance activities, mosquito control efforts, public information and risk communication related to arbovirus control in Massachusetts.

The purpose of the plan is to provide guidance on operational aspects of surveillance and response by state and local agencies responsible for the prevention of mosquito-borne disease in the 2008 season. The Department of Public Health will continue to seek advice from its partners and collaborators and modify the plan, as appropriate. This document is open to continual review and evaluation. Information is provided to guide planning and actions to reduce the risk of human disease from EEE virus and WNV.

Key objectives contained in this plan provide for:

- the monitoring of trends in EEE virus and WNV activity in Massachusetts;
- the timely collection and dissemination of information on the distribution and intensity of WNV and EEE virus in the environment;
- the laboratory diagnosis of WNV and EEE cases in humans, horses and other mammals;
- the effective communication, advice and support of activities that may reduce risk of infection.

This document provides information about EEE and WNV disease and program goals, and specific guidelines for mosquito, avian, equine and human surveillance. Additionally, this document provides guidance for the dissemination of information, including routine information; media advisories of positive EEE virus and WNV findings in birds and mosquitoes, as well as public health alerts related to positive EEE and WNV human cases.

This plan describes MDPH's public outreach efforts to provide helpful and accurate communications to Massachusetts' citizens about their risk from arboviral diseases and specific actions that individuals and communities can take to reduce this risk.

Recommendations regarding the WNV phased response plan appear in Table 1 and incorporate components presented in the "Massachusetts Surveillance and Response Plan for Mosquito-Borne Disease", May 2004; as well as those presented in the Centers for Disease Control and Prevention (CDC) document, "Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance Prevention, and Control", 3rd Revision, 2003. Recommendations regarding the EEE virus phased response plan appear in Table 2 and incorporate information provided in the MDPH document, "Vector Control Plan to Prevent Eastern (Equine) Encephalitis", 1991, as well as analyses of additional surveillance data collected in Massachusetts since that time.

I. INTRODUCTION

The Massachusetts Department of Public Health (MDPH), in collaboration with regional mosquito control projects (MCPs), conducts surveillance for mosquito-borne viruses that pose a risk to human health. The Massachusetts Arbovirus Surveillance Program (MASP)

- tests mosquitoes, birds, veterinary specimens from horses and other mammals, and humans for evidence of infection; identifies areas of disease risk;
- provides information to guide decision-making to reduce the risk of disease;
- informs the public of where and when there is an increased risk of infection.

The MASP currently focuses on West Nile (WNV) and eastern equine encephalitis (EEE) viruses, which are found in the local environment and are capable of causing serious illness and death in human, horses and other mammals.

The 2008 Massachusetts Surveillance and Response Plan for mosquito-borne diseases is based on a comprehensive plan initially developed for WNV in 2001 in collaboration with local health agencies, other state agencies, academic institutions, the Centers for Disease Control and Prevention (CDC), and interested groups and individuals. It incorporates components of the state's EEE surveillance activities, which began in the 1950's and have continued since that time. The Massachusetts Arbovirus Surveillance Program (MASP) began monitoring for WNV following a 1999 outbreak of human WNV disease in the New York City area, the first known occurrence of this disease in North America. WNV was identified in birds and mosquitoes in Massachusetts during the summer of 2000 and has been found during each consecutive season.

The updated 2008 plan is the result of analyses of surveillance data collected in Massachusetts and the United States. In addition, in order to manage the complexity of the human disease risk posed by these viruses, MDPH convened four workgroups that advised MDPH and promoted collaborative efforts by multiple agencies and interest groups. The purpose of the plan is to provide guidance on operational aspects of surveillance and response by the state and local agencies with responsibilities for the prevention of mosquito-borne disease. MDPH will continue to seek advice from its partners and collaborators and modify the plan, as appropriate. This document is open to continual review and evaluation with changes made when there is opportunity for improvement.

II. **DISEASE BACKGROUND**

The two principal mosquito-borne viruses (also known as arboviruses, for **ar**thropod-**bo**rne viruses) recognized in Massachusetts and known to cause human and animal disease are eastern equine encephalitis virus with the first human cases identified in both the United States and Massachusetts in 1938, and West Nile virus, with the first human case identified in the United States in 1999, and in Massachusetts in 2001.

Eastern Equine Encephalitis Virus

Background

Eastern equine encephalitis is a serious disease with 30-50% mortality and lifelong neurological disability among many survivors, which occurs sporadically in Massachusetts. The first symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease gets worse quickly and some patients may go into coma within a week. There is no treatment for EEE. In Massachusetts, approximately half of the people identified with EEE have died from the infection. People who survive this disease will often be permanently disabled. Few people recover completely.

Historically, clusters of human cases have occurred in cycles lasting 2-3 years, with a hiatus of 10-20 years between outbreaks. In the years between outbreaks, isolated cases may occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39 (35 cases, 25 deaths), 1955-56 (16 cases, 9 deaths), 1972-74 (6 cases, 4 deaths), 1982-84 (10 cases, 3 deaths), 1990-92 (4 cases, 1 death), 2004-06 (13 cases, 6 deaths).

Massachusetts Eastern Equine Encephalitis Experience		
Year(s)	Human EEE Cases	Human EEE Deaths
1938-39	35	25
1955-56	16	9
1972-74	6	4
1982-84	10	3
1990-92	4	1
2004-06	13	6

The Massachusetts Department of Public Health, with CDC funding, initiated a field surveillance program in 1957; following a 1955-56 outbreak of EEE. The purpose of the program was to gather data to guide prevention and risk reduction of this disease.

Risk Factors for Disease Transmission

Eastern equine encephalitis virus is an alphavirus enzootic in some passerine bird species found in fresh-water swamp habitats. The virus is transmitted among wild birds in these areas primarily by *Culiseta melanura*, a mosquito species that feeds predominantly on birds. This mosquito-borne virus has a cycle of natural infection among bird populations with occasional ''incidental" symptomatic infections of humans, horses, llamas, alpacas, emus and ostriches. The prevalence of infection among birds is related to the prevalence in bird-feeding mosquitoes. When infections become more prevalent among birds, infection rates may also rise in mosquitoes that feed indiscriminately on birds and other animals. Thus, infection within these bridge vector mosquitoes seems to enhance the risk of infection to people.

Outbreaks involving two or more human infections associated temporally and spatially; occur with the convergence of several factors. A major factor that affects the risk of disease in humans is the prevalence of immunity to EEE virus in the birds that serve as the enzootic reservoir of the virus. EEE virus infection in passerine birds usually results in a mild infection. Following infection, birds become immune to the virus and will not harbor it. Following a year of increased viral transmission, the prevalence of EEE immunity in birds increases and in subsequent years, the virus may not be able to spread rapidly among these reservoir hosts due to the establishment of 'herd immunity'. Thus, elevated levels of herd immunity in birds reduce the amplification of EEE virus in the bird-mosquito-bird cycle, which in turn reduces the chance of incidental infections in humans.

The risk of infection in humans is a function of exposure to infected human-biting mosquitoes. Certain kinds of mosquitoes are highly selective as to the kind of host they will seek and feed upon. *Culiseta melanura* (*Cs. melanura*) mosquitoes feed primarily on birds and are recognized as the predominant vector of EEE virus transmission between the passerine birds that are the reservoir of the virus. Thus, the intensity of enzootic EEE virus transmission correlates with the abundance of this enzootic vector. If the herd immunity level against EEE virus of these birds is high, (i.e. few susceptible birds) due to several years of prior exposure, then there is little opportunity for the virus to perpetuate or amplify within the bird population. When herd immunity is low and there are many susceptible birds; EEE virus infections can spread more rapidly and more widely among the birds. This condition may enhance the potential for transfer of EEE virus to humans by a ‘bridge vector’ mosquito, i.e., a species that is indiscriminant and will feed on birds or humans, such as *Coquillettidia perturbans, Ochlerotatus canadensis, Aedes vexans and Culex species.*

The risk of EEE virus infection in humans varies by geographical area in Massachusetts, as well as in the United States. EEE is more prevalent in areas that support dense populations of passerine birds and have favorable breeding conditions for the enzootic vector. In Massachusetts, these areas consist mainly of large wetlands containing mature white cedar and red maple swamps that are more common in southeastern Massachusetts. The majority of EEE cases have occurred in Norfolk, Bristol, and Plymouth counties with some cases also occurring in Middlesex County, rarely in Essex County and very rarely in Worcester County or further west. Historically, Cape Cod and the Islands of Martha’s Vineyard and Nantucket have not had human cases of EEE.

Other major factors that affect the risk of EEE virus infections for humans are the abundance of specific kinds of mosquitoes at critical periods of the transmission season, groundwater levels and the timing of rainfall and flooding during the mosquito season. Participation in outdoor activities increases the risk of exposure while the use of personal protective measures (e.g., avoidance of mosquitoes, use of repellent) helps to reduce the risk of exposure.

Long-term weather patterns during the fall and winter that include high ground water levels and snow cover may enhance survival of *Cs. melanura* larval populations. The abundance of these larval populations may serve as an early indicator of the potential for human disease later in the year. Multiple factors affect the development, survival, and abundance of mosquitoes. It is not currently possible to predict either the abundance of mosquitoes or the risks of encountering an infected vector later in the season. The best control approach to reduce these vectors must consider multiple factors. One approach calls for beginning integrated pest management (IPM) control activities early in the season and targeting both the enzootic and human biting vector species.

West Nile Virus

Background

West Nile Virus (WNV) first appeared in the United States in 1999. Since its initial outbreak in New York City, the virus has spread across the US from East to West. WNV infection may be asymptomatic in some people, but it leads to morbidity and mortality in others. WNV causes sporadic disease of humans, and occasionally results in significant outbreaks. Nationally, over 3600 human cases of WNV neuroinvasive disease (West Nile meningitis and West Nile encephalitis) and WNV fever were reported to the CDC in 2007.

The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller number of people who become infected (~ 20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach and back. Less than 1% of people infected with WNV will develop severe illness, including encephalitis or meningitis. The symptoms of severe illness can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. Persons older than 50 years of age have a higher risk of developing severe illness. In Massachusetts, there were six fatal WNV human cases identified between 2001-2007, all in individuals eighty years of age or older.

Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state and federal officials, academicians and the public to develop recommendations to improve and strengthen key aspects of the state plan for mosquito-borne virus surveillance and prevention of mosquito-borne disease. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity and communication.

Risk Factors for Disease Transmission

West Nile (WN) virus is amplified by a cycle of continuous transmission between mosquito vectors and bird reservoir hosts. Infectious mosquitoes carry virus particles and infect susceptible bird species. WNV infection is often fatal in some species of birds, particularly American crows and blue jays (corvids). Confirmation of WNV in dead birds provides sentinel information useful for assessing risk of human WNV infections.

The principal mosquito vector for West Nile virus on the East coast is the Culex species. These species may be abundant in urban areas, breeding easily in artificial containers such as birdbaths, discarded tires, buckets, clogged gutters, and other standing water sources. *Culex pipiens* feeds mainly on birds and occasionally on mammals. It will bite humans, typically from dusk into the evening. *Culex restuans* feeds almost primarily on birds but has been known to bite humans on occasion. Brackish and freshwater wetlands are the preferred habitat for *Culex salinarius* which feeds on birds, mammals, and amphibians and is well known for biting humans. *Ochlerotatus japonicus* may be involved in the transmission of both WNV and EEE virus. Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is a fierce human biter.

Activity of the West Nile virus zoonotic cycle varies from year to year. When a large number of infected birds and a high rate of infected mosquitoes are found in a relatively small geographic area, the risk of transmission of virus to humans will increase.

A summary of current and historical surveillance information for EEE virus and WNV in Massachusetts is available at **www.mass.gov/dph**.

III. PROGRAM GOALS

Timely and accurate information provided by the MDPH based on surveillance information can be used to provide an indication of the level of risk of human disease from WNV and EEE. Based on this surveillance information, plans and actions to reduce risk can be developed and implemented when needed.

Specific Program Priorities

1. Test mosquitoes, birds, horses, humans and other animals to identify EEE virus and WNV infections.
2. Track trends in incidence and prevalence of EEE virus and WNV infections by geographic area.
3. Estimate viral infection rates in birds and mosquitoes.
4. Stratify risk o geographic areas as a function of their relative risk of human disease.
5. Conduct surveillance for human and equine disease.
6. Educate human and animal medical practitioners on the appropriate procedures for detecting and identifying infections and disease caused by mosquito-borne viruses.
7. Recommend measures to reduce virus transmission and disease risk.
8. Provide information to the public on mosquito-borne diseases and disease risk, and on common-sense precautions to reduce the risk of infection.
9. Participate in the national Arbovirus surveillance network coordinated by the CDC.

Roles

1. Massachusetts Department of Public Health (MDPH)
The central purpose of the Massachusetts Arbovirus Surveillance Program (MASP) is to provide information that will guide planning and actions to reduce the risk of human disease from EEE virus and WNV. To achieve this, the main objectives are to monitor trends in EEE virus and WNV in Massachusetts; provide timely information on the distribution and intensity of WNV and EEE virus in the environment; perform laboratory diagnosis of WNV and EEE cases in humans, horses and other mammals; communicate effectively with officials and the public; provide guidelines, advice and support on activities that effectively reduce risk of disease; and provide information on the safety, anticipated benefits and potential adverse effects of proposed prevention interventions.

MDPH works cooperatively with the Massachusetts State Reclamation and Mosquito Control Board (SRMCB) and with regional mosquito control projects to identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles. The application of pesticides as a means to reduce human risk is one of several methods/strategies to attain this goal.

2. State Reclamation and Mosquito Control Board (SRMCB)

The State Reclamation and Mosquito Control Board (SRMCB) oversees mosquito control in the Commonwealth of Massachusetts. The SRMCB consists of three (3) members representing the Department of Agricultural Resources (DAR), Department of Conservation and Recreation (DCR), and Department of Environmental Protection (DEP). Additionally, the SRMCB advises its respective state agency Commissioners on actions to reduce mosquito populations based on MDPH findings and characterization of risk.

The SRMCB 'Operational Response Plan to Reduce the Risk of Mosquito-Borne Disease in Massachusetts' addresses the issues related to the operational aspect of adult mosquito surveillance and control to prevent and/or reduce the risk of mosquito-borne diseases.

In 2006, the SRMCB created an SRMCB Mosquito Advisory Group (MAG). The MAG provides independent scientific advice to the SRMCB to assist them in evaluating and assessing data from both DPH and mosquito control projects

3. Mosquito Control Projects (MCP)
There are nine (9) organized mosquito control projects or districts located throughout Massachusetts. All of the mosquito control activities of these organized agencies are performed under the aegis of the State Reclamation and Mosquito Control Board (SRMCB). Mosquito Control Projects collaborate with local boards of health in their jurisdictions to control mosquitoes. These locally authorized efforts employ a variety of targeted activities for source reduction, larviciding and adulticiding that are in compliance with the SRMCB Operational Response plan.

IV. SURVEILLANCE

A. Mosquito Surveillance for West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) Virus

Surveillance of mosquitoes for arboviruses is one of the core functions of the MASP. Monitoring mosquitoes for the presence of virus provides a direct estimate of risk to humans. Massachusetts has a long-term field surveillance program that was initiated in 1957 for EEE virus and was modified in 2000 to include WNV surveillance. The extensive experience in Massachusetts with surveillance for mosquito-borne disease provides expertise and capacity to guide risk reduction efforts. The MASP uses a comprehensive and flexible strategy that modifies certain surveillance activities in response to trends in disease risk.

On an ongoing basis, MASP will continue to monitor national and regional surveillance data and current scientific literature to assess risk of newly emerging arboviruses in Massachusetts. In addition, defined subsets of mosquito pools will be evaluated by MDPH for the presence of new or emerging viruses

1. Fixed and Long-Term Trap Sites: MASP will collect mosquitoes from areas with activity during the previous year, and from long-term trap sites maintained in the EEE virus high-risk areas of southeastern and eastern Massachusetts (Figure 1). Trapping of gravid mosquitoes for testing of WNV is conducted both by mosquito control projects and MDPH staff at various locations throughout the state during the arbovirus season. At the State Laboratory Institute (SLI), samples (pools of 1- 50 specimens) of trapped mosquito collections are assayed for WNV and EEE virus. Test results from routine mosquito collections are available within 24-48 hours. Fixed and long-term trap sites provide the best available baseline information for detecting trends in mosquito abundance and virus prevalence and for estimating the relative risk of human infection from EEE virus and WNV. MDPH will monitor larvae from select sites in late fall and early spring to determine end-season and pre-season larval abundance. Monitoring of larval abundance from these sites will continue on a weekly basis during the arbovirus season.

2. Supplemental Trap Sites: When EEE virus or WNV activity, or increased WNV bird deaths, are detected in an area, additional trap sites and/or trap types will be used to obtain more information regarding the intensity of virus activity in mosquitoes. The following risk indicators may result in the implementation of more intensive mosquito trapping: 1) virus isolations in mosquitoes; 2) increasing or significant numbers of bird deaths associated with WNV; 3) emergence of large numbers of human-biting mosquitoes in an area with a high rate of virus activity and 4) human or equine cases

3. Mosquito Control Project Trap Sites: Massachusetts mosquito control projects (MCP's), are organized under the State Reclamation and Mosquito Control Board (SRMCB), located within Department of Agricultural Resources. The SRMCB is composed of three members; representing the Department of Agricultural Resources; the Department of Environmental Protection; and the Department of Conservation and Recreation. MCP's and the SRMCB communicate collaboratively with the MASP. The mosquito control projects employ comprehensive, integrated mosquito management (IMM) programs based on integrated pest management (IPM) principles.

The IMM program uses a variety of available control strategies to impact mosquito abundance. Monitoring mosquito abundance is accomplished through various surveillance methods including but not limited to larval dip counts, the use of light/ CO_2 baited traps and gravid traps.

B. Avian Surveillance: West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEE virus)

1. Dead Bird Reports: Because WNV causes death in certain species of birds, and the mortality rate from infection for the American crow is high, we expect that dead birds may be the first warning of WNV activity in an area. The association between corvid deaths and WNV activity is well established. The MASP tracks dead bird reports provided by local and state officials, and from the public. MASP will request that crows and blue jays, representing the species most likely to experience mortality due to WNV, be submitted for testing, and will provide a pickup service for designated regional repositories to assist local communities in the transport of specimens to MDPH. Most kinds of birds that are infected with EEE virus survive the viremia, making dead bird EEE virus monitoring impractical. Thus, MASP does not utilize dead bird reports for EEE virus monitoring.

MASP will record and analyze dead bird reports, which will be used to identify areas for intensified surveillance of WNV activity including bird testing, and mosquito trapping. Reports of dead birds are taken via a toll-free telephone number at MDPH (866 MASS WNV, or 866-627-7968), which may be used by local officials and the public. At the time of the report, information on the location and type of bird will be collected and entered into a surveillance database. The caller will be informed if the reported bird is to be tested, and arrangements will made for pickup and delivery if needed. Otherwise the caller will be informed of proper disposal procedures for the dead bird.

These reports are summarized daily and provided to local health agents, the public and the media via a public website (**www.mass.gov/dp**h.)

2. Laboratory Testing of Dead Wild Birds for West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEE virus): The MASP will collect and test dead birds, primarily crows and blue jays, for WNV. Routine testing is generally completed within 24-48 hours. Confirmatory testing, when necessary, may take approximately four working days**.** After WNV infection of a bird population has been established by confirmation of two WNV avian specimens within a focal area, further routine bird testing will discontinued in that area. Boston and areas defined as 'Boston neighborhoods' are considered to be one geographic focal area. Therefore, avian testing will continue until two positives are identified within this focal area. Following the finding of two WNV specimens, and in the presence of continued bird deaths, a limited sample of dead birds may be tested to confirm that additional bird deaths are the result of WNV infection. In addition, ongoing evaluation of reports of dead birds may indicate the need for increased testing of birds and/or mosquitoes to better assess virus transmission among the bird and mosquito populations at particular times throughout the season.

Most birds that are infected with EEE virus generally survive the viremia, making dead bird EEE virus monitoring impractical. MASP does not conduct routine surveillance of EEE in birds for public health surveillance purposes because it does not provide additional information useful for determining levels of human risk. Testing of individual bird specimens for EEE infection will be determined on an as-needed basis as determined by the MDPH Public Health Veterinarian and the MASP. The MDPH Pubic Health Veterinarian will determine the appropriateness of testing specimens from dead bird clusters for both for WNV and EEE infections.

3. Laboratory Testing of Live Birds: The MASP may capture, bleed and release birds during the season to collect supplemental information about virus activity in an area where infections in birds are increasing.

C. Animal Surveillance: West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) Virus

Testing for WNV and EEE virus: Specimens from horses and other domestic animals that have severe neurological disease suspected of being caused by EEE virus or WNV infection are tested at SLI. Confirmatory testing, when necessary, may take up to nine working days. Massachusetts' veterinarians, the state Department of Agricultural Resources, USDA and Tufts University School of Veterinary Medicine collaborate with the MASP to identify and report suspect animal cases. In addition, blood samples from other sources such as zoos, horse stables or wild animals may be tested. Current information on WNV and EEE virus infections in horses along with clinical specimen submission procedures are disseminated to large animal veterinarians, stable owners, and other populations as needed, through mailings and postings on the MDPH Arbovirus website at www.mass.gov/dph. Many horses are immunized against infection with WNV and EEE virus with available veterinary vaccines. This is the primary means of preventing infection in horses.

D. Human Surveillance

1. Passive surveillance: Specimens from clinical cases of encephalitis and meningo-encephalitis are submitted to MDPH and screened for possible causes of infection, including WNV and EEE virus. Confirmatory testing, when necessary, may take three to seven working days. Selected cases of other human disease, such as aseptic meningitis, may be screened, if appropriate. Current information on WNV and EEE virus infections in humans along with clinical specimen submission procedures are disseminated to physicians (infectious disease, emergency medicine and primary care), emergency room directors and hospital infection control practitioners through mailings, broadcast faxes, and postings on the MDPH Arbovirus website at www.mass.gov/dph.

2. Active surveillance: If surveillance data indicate a high risk of human disease, active surveillance may be instituted in targeted areas. Active surveillance involves regularly contacting local health care facilities to communicate current surveillance information, prevention strategies and specimen submission procedures. HHAN (Health and Homeland Alert Network) alerts are sent to local boards of health upon confirmation of EEE virus or WNV virus in any specimen; health care facilities are advised of increased risk status and the corresponding need to send specimens to SLI for testing.

3. Pesticide related surveillance: Outreach on pesticide illness reporting will be coordinated by the MDPH Bureau of Environmental Health. In the event of an aerial pesticide application, active surveillance efforts will be implemented with emergency departments and intensified outreach efforts will be made to health care providers.

V. Prevention and Control

The MASP will provide information to guide planning and actions to reduce the risk of human disease from EEE virus and WNV. MDPH works to identify and support the use of risk reduction and disease prevention methods that are specific to the causes of disease; and supports planning and practices which incorporate the most appropriate prevention methods and appropriate use of pesticides.

Communication of Information

1. Routine Information:

Prior to the beginning of the Arbovirus season, general disease information and specimen submission procedures will be provided to local boards of health via electronic messages from the Massachusetts Health and Homeland Alert Network (HHAN). General information and fact sheets are posted on the MDPH Arbovirus website and available for Mosquito Control Projects, physicians, veterinarians, animal control officers, and other agencies.

2. Positive EEE Virus and WNV Findings in Mosquitoes, Birds, Horses (and other Veterinary Specimens), and Humans:

Laboratory confirmation of a human WNV or EEE case is immediately reported by telephone to the submitting physician, and Local Board of Health (LBOH) in the town where the case resides. If the LBOH cannot be reached via telephone in a timely manner, a severe level HHAN alert will be sent.

Laboratory confirmation of a horse (or other veterinary specimen) with WNV or EEE virus infection will be immediately reported by telephone to the submitting veterinarian, the Department of Agricultural Resources- Bureau of Animal Health, Biosecurity and Dairy Services and the LBOH. As with human cases, if the LBOH cannot be reached in a timely manner, a severe level HHAN alert will be sent.

Initial positive findings in birds (WNV) and mosquitoes (WNV and EEE) from a given town will be reported to the LBOH by telephone. Adjacent towns will be notified via a moderate level HHAN alert. Any additional positive findings in birds or mosquitoes will be reported simultaneously to the town and adjacent towns via a moderate level HHAN alert.

At the time of notification, MDPH will encourage local Boards of Health to share the information with other local agencies and high-risk populations in their community as appropriate. MDPH provides local Boards of Health with sample press releases for their use. Depending on the circumstances, MDPH may also issue a public health alert. In addition, weekly summaries of results from avian samples submitted and tested will be posted as News Items on the HHAN by town.

All laboratory confirmed results for WNV and EEE virus in humans, horses, other veterinary specimens, mosquitoes and birds are provided to the regional health department representative, mosquito control projects and members of the State Reclamation and Mosquito Control Board (SRMCB) once the LBOH has been notified.

After all appropriate individuals and agencies have been sent notification, positive surveillance findings are made available to the media and general public on the MDPH Arbovirus website at www.mass.gov/dph. This website, which also includes a variety of educational materials related to preventing mosquito-borne diseases, is updated on a daily basis throughout the Arbovirus season. Results are also reported to the CDC’s Arbonet reporting system.

3. Public Health Alerts and Media Advisories: MDPH issues public health alerts through the media when surveillance information indicates an increased risk of human disease or if a significant surveillance event occurs (for example, the first arbovirus activity of the season). In general, alerts will include current surveillance information and emphasize prevention strategies. Alerts will be drafted in consultation with outside state and local agencies, as indicated.

VI. Recommendations for a Phased Response to EEE virus and WNV Surveillance Data

The recommendations provided here are based on current knowledge of risk and appropriateness of available interventions to reduce the risk for human disease. Multiple factors contribute to the risk of mosquito-transmitted human disease. Decisions on risk reduction measures should be made after consideration of all surveillance information for that area at that time.

Recommendations regarding the WNV phased response plan (Table 1) incorporate several components presented in the “Massachusetts Surveillance and Response Plan for Mosquito-Borne Disease”, May 2004, as well as those presented in the CDC document, “Epidemic/Epizootic West Nile virus in the United States: Guidelines for Surveillance Prevention, and Control”, 3rd Revision, 2003.

Recommendations regarding the EEE virus phased response plan (Table 2) incorporate information provided in the MDPH document, “Vector Control Plan to Prevent Eastern (Equine) Encephalitis”, 1991, and results of analyses of additional surveillance data collected in Massachusetts since that time.

Public awareness of what can be done to reduce risk of infection is of utmost importance. The level of EEE virus and WNV activity may occasionally present a potential for increased virus transmission to humans. Typically, risk is expected to be relatively low, and the routine precautions taken by individuals may be sufficient to reduce opportunities for infection. These guidelines take into consideration the complexity of reducing risk of human disease from EEE virus and WNV infection and form a framework for decision-making.

2. Phased response

General guidelines are provided for an array of situations that are noted in the Surveillance and Response Plan Tables that follow. Specific situations must be evaluated individually and options discussed before final decisions on specific actions are made. The assessment of risk from mosquito-borne disease is complex and many factors modify specific risk factors. MDPH works with local public health agencies, mosquito control projects, and the SRMCB to develop the most appropriate prevention activities to reduce the risk of human disease. There is no single indicator that can provide a precise measure of risk, and no single action that can assure prevention of infection.

When recommending the use of mosquito larvicides or adulticide, MDPH works collaboratively with SRMCB and with regional mosquito control projects to identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles.

A. MDPH Guidance:

The MDPH Arbovirus Program will determine human risk levels as outlined in the phased response tables of this plan. Risk levels are defined for focal areas. “Focal Areas” may incorporate multiple communities, towns or cities. Factors considered in the determination of human risk in a focal area include: mosquito habitat, prior isolations, human population densities, timing of recent isolations of virus in mosquitoes, the cyclical nature of human outbreaks (EEE), current and predicted weather and seasonal conditions needed to present risk of human disease.

If the risk of an outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB, MCP’s, and MAG to discuss the use of intensive mosquito control methods and determine whether measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of WNV or EEE human disease.

Once significant human risk has been identified in a focal area by MDPH, MDPH will coordinate with the SRMCB to determine the adulticide activities that should be considered and implemented in response. The SRMCB will provide recommendations on appropriate pesticide(s), extent, route and means of treatment, and the location of specific treatment areas.
Based on historical experience with EEE virus, MDPH has identified specific critical indicators for EEE virus and provides specific risk reduction and prevention guidance for seasons with an anticipated increased EEE risk.

3. Risk Reduction and Prevention Guidance for Seasons with Indicators of Increased EEE Risk:

a. MDPH may increase the number of public health alerts throughout the season to remind the public of the steps to take to reduce their risk of exposure to mosquitoes.

b. MCP’s may increase their source reduction activities to reduce mosquito-breeding habitats and to reduce adult mosquito abundance. This may include ground and aerial larviciding.

c. After sustained findings of positive mosquito isolates, if not already in progress, adult mosquito control efforts including targeted ground adulticiding operations should be considered. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations.

d. Other intensified efforts may be implemented following coordinated recommendations from MDPH and other agencies including DEP, MDAR, and DCR.

Table 1. Guidelines for Phased Response to WNV Surveillance Data

Risk Category	Probability of human outbreak	Definition of Risk Category for a Focal Area[1]	Recommended Response
1	Remote	All of the following conditions must be met: <u>Prior Year</u> No prior year WNV activity detected in the focal area. And <u>Current Year</u> No current surveillance findings indicating WNV activity in birds or mosquitoes in the focal area And No horse or human cases.	1. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., the elderly). 3. Routine avian surveillance activities: Dead bird reporting and recorded information via MDPH Public Health Information Line. 4. Assess mosquito populations, monitor larval and adult mosquito density. 5. Routine collection and testing of mosquitoes. 6. Initiate source reduction; use larvicides at specific sites identified by entomologic survey. In making a decision to use larvicide consider the abundance of *Culex* larvae, intensity of prior virus activity and weather. 7. Locally established, standard, adult mosquito control activities are implemented. No specific supplemental control efforts are recommended. 8. Passive human and horse surveillance. 9. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans.

[1] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in determination of human risk in a focal area include mosquito habitat, prior isolations, human population densities, timing of current isolations of virus in mosquitoes, the cyclical and seasonal conditions needed to present risk of human disease

2	Low	<u>Prior Year</u> Any WNV activity in birds or mosquitoes in the community or focal area Or <u>Current Year</u> Sporadic WNV activity in mosquitoes in the focal area. Sporadic activity is defined when 1-2 isolates are found within 1-2 weeks of routine collections; or, one WNV positive bird And No horse or human cases	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. 2. Increase larval control and source reduction measures. 3. Public health alert sent out by MDPH in response to first WNV virus positive bird and mosquito pool detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 4. Locally established standard adult mosquito control activities continue.
3	Moderate	<u>Prior Year</u> Confirmation of one or more human or horse WNV cases; or sustained WNV activity in mosquitoes and/ or birds for 2 or more weeks. Or <u>Current year</u> Sustained WNV activity for 2 or more weeks in birds* and /or mosquitoes (<15 mosquito isolates from routine collections) * Two confirmed WNV positive birds in a community or focal area And No horse or human WNV cases	Response as in category 2, plus: 1. Outreach and public health educational efforts are intensified including media alerts as needed. 2. If not already in progress, standard, locally established adult mosquito control efforts including targeted ground adulticiding operations should be considered against *Culex* mosquitoes and other potential vectors, as appropriate. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations. 3. Duly authorized local officials may request that DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 4. Supplemental mosquito trapping and testing may be performed in areas with positive WNV findings. 5. Local boards of health are contacted via phone or HHAN (Health and Homeland Alert Network) upon confirmation of WNV in any specimen. Advise health care facilities of increased risk status and corresponding needs to send specimens to SLI for testing.

4	High	<u>Current Year</u> Sustained or increasing WNV activity in mosquitoes with mosquito isolates $\geq$ 15 from routine collections in a community or focal area. Sustained elevated minimum infection rates for MDPH WNV trap sites And/or MDPH confirmation of WNV in a horse at any time And/or, MDPH confirmation of WNV in a human at any time	Response as in category 3, plus: 1. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, schools, etc.) and educate them on personal protection d. Advisory information on pesticides provided by MDPH Center for Environmental Health. e. Urge towns and schools to consider rescheduling outdoor events. 2. Intensify and expand active surveillance for human cases. 3. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito control. Town or city may request preemption of homeowner private property no-spray requests. 4. Local officials should evaluate all quantitative indicators including population density and time of year and may proceed with focal area aerial adulticiding. 5. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 6. MDPH will confer with local health officials, SRMCB and Mosquito Control Projects to determine if the risk of disease transmission threatens to cause multiple human cases and warrants classification as level 5.

5	Critical	<u>Current Year</u> More than 1 confirmed human case in a community or focal area Or More than 1 confirmed horse case in a community or focal area Multiple quantitative measures indicating critical risk of human infection (e.g. early season positive surveillance indicators, and sustained elevated field mosquito infection rates, and horse or mammal cases indicating escalating epizootic activity)	Response as in category 4, plus: 1. Continued highly intensified public outreach messages on personal protective measures. Frequent media updates and intensified community level education an outreach efforts. 2. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine if measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of WNV human disease. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by making recommendations on: A. Appropriate pesticide B. Extent, route and means of treatment C. Targeted treatment areas 3. MDPH Center for Environmental Health (CEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences. 4. MDPH will designate high-risk areas where it has issued a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. If this becomes necessary, notification will be given to the public. 5. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 6. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt sample submission from all clinically suspect cases.

Table 2. Guidelines for Phased Response to EEE virus Surveillance Data

Risk Category	Probability of human outbreak	Definition of Risk Category for a Focal Area[2]	Recommended Response
1	Remote	All of the following conditions must be met: <u>Prior Year</u> No EEE virus activity detected in a community or focal area And <u>Current Year</u> Sporadic EEE virus activity in mosquitoes after August 1. Virus activity is considered to be sporadic when 1-2 isolates in *Cs. melanura* are found within 1-2 weeks of routine collections. And No animal or human EEE cases.	1. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in Arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., the elderly). 3. Routine collection and testing of mosquitoes. 4. Assess mosquito populations, monitor larval and adult mosquito density. 5. Initiate source reduction; use larvicides at specific sites identified by entomologic survey and targeted at the likely amplifying bridge vector species. In making a decision to use larvicide consider the prevalence of Culiseta and bridge vector larvae, intensity of prior virus activity, and weather. 6. Locally established, standard, adult mosquito control activities are implemented. No specific supplemental control efforts are recommended. 7. Passive human and horse surveillance. 8. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans.

[2] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in the determination of human risk in a focal area include: mosquito habitat, prior isolations, human population densities, timing of current isolations of virus in mosquitoes, and the cyclical nature of human EEE outbreaks, current weather and seasonal conditions needed to present risk of human disease.

2	Low	<u>Prior Year</u> EEE virus activity in mosquitoes in the prior year in the focal area Or <u>Current Year</u> Sporadic EEE Cs. melanura mosquito activity in the community or focal area between July 1-July31. Virus activity is considered to be sporadic when 1-2 isolates in *Cs. melanura* are found within 1-2 weeks of routine collections And No animal or human cases.	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. 2. Increase larval control and source reduction measures. 3. Locally established standard adult mosquito control activities continue 4. Public health alert sent out by MDPH in response to first EEE mosquito isolate detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies.
3	Moderate	<u>Prior Year</u> Confirmation of one human EEE case in the community or focal area; or 1 or more EEE horse case(s); or sustained EEE virus activity in mosquitoes. Sustained activity' is defined as 2 or more positive isolations found for 2 or more weeks. Or <u>Current year</u> No animal or human EEE cases in current year And Total EEEV isolates in *Cs. melanura* found after July 1 as a result of routine collections are between 10-15 in the community or focal area Or A single EEEV isolate from mosquitoes likely to bite humans (bridge vector species) Or A single EEEV isolate in mosquitoes of any species, prior to July 1.	Response as in category 2, plus: 1. Outreach and public health educational efforts are intensified including media alerts as needed. 2. If not already in progress, standard, locally established adult mosquito control efforts including targeted ground adulticiding operations should be considered. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations. 3. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 4. Supplemental mosquito trapping and testing in areas with positive EEEV findings. Notify all boards of health of positive findings. 5. Public health alert sent out by MDPH in response to first pool of EEE virus positive mammal-biting mosquitoes detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 6. HHAN (Health and Homeland Alert Network) alerts or phone calls are provided to local boards of health upon confirmation of EEE virus in any specimen; advise health care facilities of increased risk status and corresponding needs to send specimens to SLI for testing.

4	High	<u>Current Year</u> Total EEEV mosquito isolates numbering more than 15 from routine collections with sustained or increasing activity in the community or focal area. Sustained elevated weekly mosquito minimum infection rates. Virus activity is considered to be sustained when isolates are found for 2 or more consecutive weeks. And/or Isolation of EEEV in more than 1 pool of bridge vector mosquitoes And/or Confirmation of EEE in an animal at any time And/or Confirmation of EEE in a human at any time	Response as in category 3, plus: 1. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, schools, workers employed in outdoor occupations, etc.) and educate them on personal protection d. Advisory information on pesticides provided by MDPH Center for Environmental Health. e. Urge towns and schools to consider rescheduling outdoor events. 2. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito control. Town or city may request preemption of homeowner private property no-spray requests. 3. Active surveillance for human cases is intensified. Health care facilities are advised of increased risk status and corresponding needs to send specimens to SLI for testing. 4. Local officials should evaluate all quantitative indicators including population density and time of year and may proceed with focal area aerial adulticiding. 5. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 6. MDPH will confer with local health officials, SRMCB and Mosquito Control Projects to determine if the risk of disease transmission threatens to cause multiple human cases and warrants classification as level 5.

5	Critical	<u>Current Year</u> More than 1 confirmed human EEE case Or Multiple EEE animal cases Or Multiple quantitative measures indicating critical risk of human infection (e.g. early season positive surveillance indicators, and sustained high mosquito infection rates, and horse or mammal case indicating escalating epizootic activity)	Response as in category 4, plus: 1. Continued highly intensified public outreach messages on personal protective measures. Frequent media updates and intensified community level education an outreach efforts. 2. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine the measures needed to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of EEE human disease. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by making recommendations on: A. Appropriate pesticide B. Extent, route and means of treatment C. Targeted treatment areas 3. MDPH Center for Environmental Health (CEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences. 4. MDPH will designate high-risk areas where individual no spray requests may be preempted by local and state officials based on this risk level. If this becomes necessary, notification will be given to the public. 5. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 6. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt sample submission from all clinically suspect cases.

Appendix 1: Mosquitoes Associated with Arboviral Activity in Massachusetts

Aedes vexans – Is a common nuisance mosquito. Temporary flooded areas such as woodland pools and natural depressions are the preferred larval habitat of this mosquito. It feeds on mammals and is a fierce human biter. This species is typically collected from May to October. *Ae vexans* is an epizootic vector of Eastern Equine Encephalitis (EEE) Virus.

Coquillettidia perturbans - Cattail marshes are the primary larval habitat of this mosquito. It feeds on both birds and mammals. It is a persistent human biter and one of the most common mosquitoes in Massachusetts. This species is typically collected from June to September. *Cq perturbans* is an epizootic vector of EEE Virus.

Culex pipiens – Artificial containers are the preferred larval habitat of this mosquito. It feeds mainly on birds and occasionally on mammals. It will bite humans, typically from dusk into the evening. This species is regularly collected from May to October but can be found year round as it readily overwinters in man-made structures. *Cx pipiens* has been implicated as a vector of West Nile Virus (WNV).

Culex restuans – Natural and artificial containers are the preferred larval habitat of this mosquito. It feeds almost primarily on birds but has been known to bite humans on occasion. This species is typically collected from May to October but can be found year round as it readily overwinters in man-made structures. *Cx restuans* has been implicated as a vector of WNV.

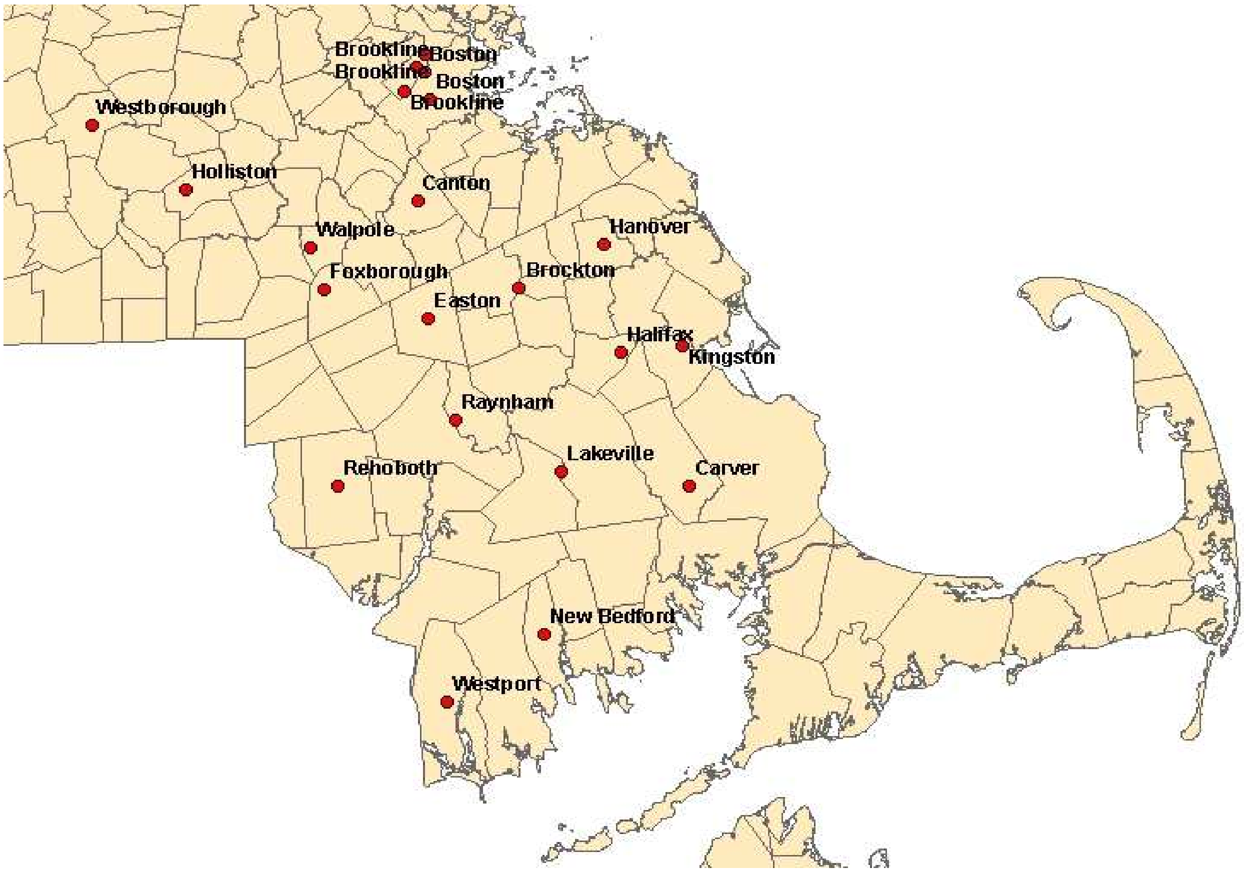
Culex salinarius – Brackish and freshwater wetlands are the preferred habitat of this mosquito. It feeds on birds, mammals, and amphibians and is well known for biting humans. This species is typically collected from May to October but can be found year round as it readily overwinters in natural and man-made structures. *Cx salinarius* may be involved in the transmission of both WNV and EEE virus.

Culiseta melanura –White Cedar and Red Maple swamps are the preferred larval habitat of this mosquito. It feeds almost exclusively on birds. This species is typically collected from May to October. *Cs melanura* is the primary enzootic vector of EEE virus.

Ochlerotatus canadensis – Shaded woodland pools are the preferred larval habitat of this mosquito. It feeds mainly on birds and mammals but is also known to take blood meals from amphibians and reptiles. This mosquito can be a fierce human biter near it larval habitat. This species is typically collected from May to October. *Oc canadensis* is an epizootic vector of EEE virus.

Ochlerotatus japonicus – Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is a fierce human biter. This species is typically collected from May to October. *Oc japonicus* may be involved in the transmission of both WNV and EEE virus.

Figure 1: Location of MDPH EEE virus Mosquito Trap Sites



The Commonwealth of Massachusetts

OPERATIONAL RESPONSE PLAN TO REDUCE THE RISK OF MOSQUITO-BORNE DISEASE IN MASSACHUSETTS

This document is open to continual review and evaluation and can be modified, if and when appropriate

Revised October 22, 2008

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TABLE OF CONTENTS

Massachusetts State Reclamation and Mosquito Control Board

OPERATIONAL RESPONSE PLAN TO REDUCE THE RISK OF MOSQUITO-BORNE DISEASE IN MASSACHUSETTS

Introduction

Mosquito-borne viruses such as Eastern Equine encephalomyelitis virus (EEEv) and West Nile virus (WNv) have been and continue to be the cause of disease outbreaks in humans and animals in Massachusetts. These viruses can cause illness and death in humans, horses, as well as diverse kinds of native, exotic, and farmed birds such as emus. Even though vaccines exist to protect horses and repellants are available to protect humans, mosquito control can be a practical and meaningful method of protecting people especially when risk levels of virus become high or critical. Efforts to reduce risk of arbovirus transmission include but are not limited to public awareness and prevention, standard mosquito control methods utilized by established mosquito control projects applied to alleviate mosquito annoyance, as well as intensified ground-based treatments (when and where feasible) and aerial adulticide applications, whether targeted or over widespread areas, to suppress populations of infectious adult mosquitoes to reduce and/or halt a mosquito-borne disease episode or epidemic.

Purpose and Scope

This document (hereafter referred to as the Plan) describes the role and activities of the State Reclamation and Mosquito Control Board (SRMCB) to counter the threat of mosquito-borne diseases in Massachusetts such as EEEv and West Nile Virus (WNv). In particular, the plan identifies and highlights the important partnership between the Massachusetts Department of Public Health (MDPH), Mosquito Control Districts (MCP's), Mosquito Advisory Group (MAG) and the Executive Office of Energy and Environmental Affairs (EOEEA), in responding to a mosquito-borne disease event or emergency. This plan is intended to serve as a companion document to the most current version of the MDPH Arbovirus Surveillance and Response Plan (See Appendix 14). Invariably, the document is open to continual review and evaluation and can be modified, if and when appropriate. Currently, this document categorizes the roles of the key agencies responsible for characterizing risk and planning operational response. Finally, it provides protocols (see appendix 3) for evaluating efficacy and environmental impact of an intervention such as aerial adulticide application.

This plan:

- Describes the respective roles of SRMCB, MDPH, MCP's, MAG and others as well as the manner by which they shall interact and collaborate to ensure a coordinated and rational response to mosquito-borne disease risk.

- Contains a response structure (see Table 1 - Summary of Operational Response Plan Responsibilities and Appendix 1 - Detailed SRMCB Response Matrix to Prevent or Reduce Mosquito-Borne Disease) that summarizes the operating characteristics and structural components needed to protect against, and respond to a mosquito-borne disease event.

- Outlines a multi-agency response when the threat of mosquito-borne illness warrants aerial application(s)

- Describes and highlights the specific activities and components that are being conducted and supervised by the SRMCB concerning any mosquito-borne incident.

Authority

The authorities of participating state and local agencies to respond to projected or current outbreaks of mosquito-borne disease and to exercise powers where necessary include:

- Chapter 252 of the Massachusetts General Laws (MGL) establishing the State Reclamation and Mosquito Control Board (SRMCB) and procedures for creating local control as well as eradicating (abating) mosquitoes in infested areas whenever it considers such activities to be necessary or useful. Under section 8 of Chapter 252, if the SRMCB concludes that certain improvements will benefit public health, the costs be paid by the Commonwealth, and the SRMCB must separately estimate that part of the expense, to be included with other estimates under MGL Chapter 29, Section 4.

- Chapter 132B of the Massachusetts General Laws (MGL), the Pesticide Control Act, designates the Department of Agricultural Resources as the lead state agency for implementing and administrating the Act and the Massachusetts pesticide program. Under this law, the DAR is responsible for registering all pesticides for use in the Commonwealth and for issuing all certifications and/or licenses in their legal use.

- Chapter 17 sections 2A of the Massachusetts General Laws states that upon declaration by the governor of a public health emergency, the Commissioner of Public Health may, subject to the approval of the governor and the public health council, take action to assure the maintenance of public health and the prevention of disease.

Roles and Responsibilities

Roles and responsibilities of key agencies involved in conducting mosquito-borne virus surveillance and response are outlined in the *Response Matrix* (*see Table 1 - Summary of Operational Response Plan Responsibilities* and *Appendix 1 - Detailed SRMCB Response Matrix to Prevent or Reduce Mosquito-Borne Disease*).

The matrix summarizes and identifies the duties of each agency, and their respective roles, as they relate to surveillance and intervention efforts. The MDPH and SRMCB are the two principal agencies responsible for the monitoring, detection, analysis, and implementation of operational interventions to protect public from mosquito-borne diseases in Massachusetts. In addition, a mosquito advisory group (MAG) has been established as a non-governmental partner to provide technical, expert advice to the SRMCB.

Massachusetts Department of Public Health (MDPH)

MDPH-SLI (State Laboratories Institute) responsibilities include performing surveillance of mosquito-borne viruses, providing risk assessments, disseminating public information relating to mosquito-borne disease, as well as providing advice to the SRMCB on appropriate risk management for these virus infections. MDPH's central responsibility is to characterize the severity of risk associated with mosquito-borne diseases such as EEEv and WNv. This characterization is based on the most current MDPH State Surveillance and Response Plan, which describe the steps and protocols for collecting and evaluating data for indications of a potential or current mosquito-related public health problem. MDPH Arbovirus staff analyzes surveillance data and issue weekly- summaries that include a current risk assessment on a dedicated MDPH website.

These arbovirus reports are also distributed to key state agency and MCP personnel via email. The SRMCB and the regional MCPs collaborate with MDPH surveillance effort by collecting additional field data for MDPH analysis.

The MDPH Bureau of Environmental Health (BEH) is responsible for addressing health concerns related to pesticide applications. If an aerial application is undertaken, the MDPH/BEH implements a surveillance system for possible pesticide related illnesses as reported by emergency departments in the area of application or the Poison Control Center, as well as by local health officials and individuals calling MDPH/BEH directly. In addition, MDPH/BEH works with MDEP and MDAR toxicology staff to develop recommendations on the choice of pesticide product for use in aerial application and develops a question and answer on health concerns related to the pesticide product used in aerial applications. This fact sheet is available on the MDPH/BEH web site

Once MDPH-SLI has characterized a situation of critical risk, justifying action to reduce transmission risk, the SRMCB weighs options and strategies for interventions. Intervention options may include source reduction, ground-or aerial delivery of larvicides, ground-or aerial application of adulticides, and public service advisories. The SRMCB would consult with MAG and after careful risk assessments based upon scrutiny of diverse ecological, epidemiological, operational, meteorological, and financial considerations, the SRMCB would advise its respective state commissioner and/or their representative of the intervention(s) that would be the most meaningful.

State Reclamation and Mosquito Control Board (SRMCB)

The State Reclamation and Mosquito Control Board is responsible for overseeing mosquito control in Massachusetts, whether in response to a public health situation or to reduce the overall annoyance caused by mosquitoes. The SRMCB provides a resource to municipalities statewide pertinent to mosquito-associated concerns, and works cooperatively with MDPH regarding all aspects of planning and response for mosquito-borne viruses that pose a risk to human health.

Pursuant to Chapter 252 of the MGL, the members of the SRMCB are appointed and represent the DAR, DCR, and DEP. The Board is based in the Department of Agricultural Resources.

The nine organized mosquito control districts or projects located throughout Massachusetts operate under the aegis of the SRMCB pursuant to the provisions of Chapter 252 of the Massachusetts General Laws and special legislation (individual and Resolves) that created them. Each MCP operates under the direction of a Commission. The SRMCB issues certificates and appoint Commissioners who carry out improvements on behalf of the SRMCB. The MCP Commissions represent the interests of the member communities of the MCP and their residents by providing oversight of MCP activities. The MCP Commissions strive to insure that the member communities receive services that are consistent with applicable laws and justified by tenets of Integrated Pest Management (IPM), public health, vector control, environmental safety, and fiscal responsibility. The MCP Commissions consider the input and respond to questions from community official and residents.

In accordance with the most current version of the MDPH Arbovirus Surveillance and Response Plan, MDPH notifies the SRMCB, MAG, and regional MCPs of surveillance data indicating increasing levels of arbovirus risk. The MDPH Arbovirus Surveillance Program (SLI) informs relevant MCP superintendents of positive isolations of EEEv and/or WNv. The MCPs, in turn, provide feedback to SRMCB and MDPH regarding abundance and developmental indices and trends for mosquito species of greatest epidemiological significance. MCPs may be directed by the SRMCB to increase or intensify ground control larvicide and/or adulticide applications when and where feasible to counter threats relevant to EEEv and/or WNv risk.

If risk of a mosquito-borne disease outbreak occurs or becomes widespread (covering multiple jurisdictions), MDPH will confer with local health agencies, SRMCB and MCPs to discuss the use of intensive mosquito control interventions beyond the standard measures employed by MCPs to reduce risk of human infection. The SRMCB will advise state agency Commissioners on interventions to reduce mosquito populations based on MDPH findings and characterization of risk. When a decision is finalized, the SRMCB’s primary role is operational regarding the implementation and supervision of any state-funded aerial adulticide intervention.

SRMCB Mosquito Advisory Group (MAG)

The SRMCB created the Mosquito Advisory Group (MAG) to provide independent, scientific advice to the SRMCB regarding the justification, timing, location and options for intervention tactics such as to prevent and/or suppress and contain infected mosquito populations that may otherwise result in an outbreak of disease in people and animals. Members of the MAG are recognized experts in their fields and provide valuable independent assessments and recommendations to the SRMCB. The MAG members were selected primarily by the SRMCB; with some input from MDPH-BEH regarding individuals with toxicological expertise. **Current MAG members are listed in Appendix 13.**

A key role of MAG is to advise SRMCB whether to conduct or intensify proactive efforts to suppress certain mosquito populations *before* the force of transmission increases to pose enhanced risk to people. Based upon evaluation of assessments from MDPH, MCPs, MAG, and other agencies, *the SRMCB will advise its respective state agency Commissioners when it concludes that an aerial intervention is justified, and the details (timing, location, method) of the proposed effort*.

The MAG monitors entomological and epidemiological communications, data, and information regarding mosquito population species activity and abundance. MAG members participate in pre-season workgroups established by MDPH or SRMCB. MDPH, DAR, DCR, and other agencies are expected to communicate relevant data as well as their concerns to SRMCB, and these data/issues will subsequently be considered by MAG.

Mosquito Control Districts (MCPs)
Regional or local Mosquito Control Projects (MCPs) serve as critical elements in the surveillance network, and in performing and facilitating intervention efforts to reduce the burden of mosquitoes and mosquito-borne diseases. MCPs cooperate effectively with MDPH –SLI by coordinating the placement of traps, collecting, and identifying and submitting mosquitoes and associated data in a timely manner to MDPH-SLI. MCPs personnel have greater knowledge of local habitats and suitable field equipment that may be rapidly deployed to reduce populations of mosquitoes, and consequently, the transmission of mosquito-borne viruses. MCPs provide weekly summaries to the SRMCB on mosquito abundance, and diversity as well as on local conditions that may be conducive to mosquito development and survival. These summary reports of local conditions shall be provided to the MDPH Arbovirus program and incorporated in SRMCB/DAR analysis summary information.

Other EOEEA agencies
Other EOEEA agencies such as DEP, DFW, and the EOEEA Secretary and Public Relations Office along with DPH (BCDC, BEH, BSL) and DAR/SRMCB will engage and contact appropriate personnel as needed to participate in planning and facilitating interventions, particularly in terms of public relations and environmental monitoring.

Multi-Agency Response When the Threat of Mosquito-Borne Illness Warrants Aerial Application(s)

- DPH (BCDC) characterizes area of risk and delineates the spray area with a GIS map based on surveillance data relevant to mosquitoes and virus;
- DPH (BEH) contacts and provides pesticide illness surveillance protocol to Emergency Rooms, Poison Control Centers, and local health departments;
- DEP, DAR, and DPH (BEH/BSL) initiate plans for pre/post-monitoring for public drinking water reservoirs, honey bees, macro-invertebrates, and cranberries in designated spray area;

- DPH/BEH and DAR determine the type of pesticide to be used and obtain any EPA waivers, if necessary, for use in aerial application;

- DAR coordinates compilation of mosquito treatment sensitive areas data layers (no-spray zones) developed by DAR, DFW, and DEP within designated DPH spray area into a final GIS data layer;

- Mosquito treatment sensitive areas data layers (i.e. recommended no - aerial spray zones) include:
    - Certified organic farms
    - Priority habitats for spray sensitive state- listed rare species
    - Surface Water Supply resource areas
    - Commercial Fish hatcheries/aquaculture

- DPH (BCDC), in consultation with SRMCB, DAR, DEP, and DFW determines if spraying in mosquito treatment sensitive areas is necessary to protect the public health;

- If spraying in DFW-designated mosquito treatment sensitive areas is necessary to adequately reduce the risk to public health, DPH/BCDC requests a permit from DFW to be issued to DAR for taking endangered, threatened, or special concern species;

- DPH/BCDC requests Commissioner of Public Health issue a Certification that Pesticide Application is Necessary to Protect Public Health;

- DAR approves any needed emergency waivers to use pesticides on school property and ensure compliance with pesticide laws;

- DAR and DPH provide public notices regarding the locations, dates, and times of aerial spraying;

- DAR/SRMCB initiates aerial spray operations using collective guidance and consensus developed through multi-agency, cross secretariat process.

<u>DPH- Department of Public Health</u>
BCDC- Bureau of Communicable Disease Control
BEH- Bureau of Environmental Health
BSL- Bureau of State Laboratories

<u>DAR- Department of Agricultural Resources</u>
SRMCB- State Reclamation and Mosquito Control Board
DFG-Department of Fish and Game
DFW- Division of Fisheries and Wildlife

Internal Communication Processes
When mosquito-borne disease is projected to be a threat or during an outbreak, each of the SRMCB members report significant findings and concerns to another official within their respective agency to ensure that important mosquito-borne disease risk information flows to Secretary of EOEEA.

Diverse information relative to disease risk and mosquito control intervention options will be efficiently and freely communicated and carried out in three steps amongst the primary agencies of MDPH, SRMCB, and the MCPs.

1. MDPH Weekly Reporting
The MDPH SLI-Arbovirus Program generates and posts weekly Arbovirus Surveillance Program Reports. These reports summarize the results of mosquito trap collections from the prior week and other pertinent data. This information is forwarded to key personnel including but not limited to members of the SRMCB, mosquito control personnel, MAG members, state Commissioners from DAR, DCR, DEP and others within EOEEA.

The weekly reports comprise current and historical data including:
1) Avian Surveillance (Dead birds reported, tested, and infected (WNv);
2) Mosquito Surveillance (Cs. melanura abundance, number of pools tested and infected (EEEv and WNv) and Cs. melanura infection rates;
3) Veterinary cases (Number of infections and death by species (horse, emus, alpaca, etc) and virus (EEEv and WNv) ;
4) Human Cases (Number of infections and deaths by virus (EEEv and WNv) ;
5) Current Risk Classifications for EEEv and WNv by town and county.

2. *SRMCB/DAR Analysis*
The DAR entomologist (state entomologist) regularly reviews each MDPH/SLI generated Arbovirus Surveillance Program Report, in concert with other data provided by MCP superintendents to assess the extent of any risk, and form an opinion regarding the justification and urgency for a response. As the mosquito season evolves and when risk levels become a concern, brief abstracts or briefing on current conditions is distributed by e-mail to key personnel by the DAR entomologist (state entomologist). These reports may be sent bi-weekly and more frequently, if and when, required. Recipients will include SRMCB, MCP personnel, MAG members, state Commissioners from DAR, DCR, DEP and others within EOEEA as well as MDPH key personnel such as the state lab director and arbovirus surveillance program manager**.**

3. *MAG / SRMCB Analysis*
If an apparent or emerging risk appears imminent based on data and analyses from MDPH-SLI State Arbovirus program, DAR entomologist, MCPs or other entities, MAG will evaluate available data sets, describe, and prioritize strategies for intervention (method, location, timing), and advise SRMCB of their recommendations. Key MDPH Arbovirus staff such as the state lab director and arbovirus surveillance program manager shall be copied on the recommendations made by the MAG to the SRMCB. SRMCB will take these recommendations under advisement, and after consultation with

MDPH, MCPs, and other officials or senior managers within their respective state agencies, will decide whether to pursue the MAG recommendations.

If and when intensified interventions such as aerial adulticiding, are deemed justified, the SRMCB shall contract with credentialed mosquito control vendors to perform the service (See Appendix 12).

It is very important to note that this decision-making process can be quite rapid, and it may only be a few days from the MAG input and MDPH's risk assessment determination to the decision to conduct an aerial spray operation. The SRMCB has developed this plan to facilitate a rapid, and response as a result of a transparent decision-making process, given the short time and many steps needed to determine and implement best management practices to reduce projected or current mosquito borne disease threats.

Public Information, Communication, and Media Notification

The SRMCB will designate a spokesperson in advance of a potential mosquito-borne disease incident. This person will be knowledgeable, credible, and have good communication skills. This individual will not, however, be responsible for overseeing, or facilitating operational details for any such incident. MCP personnel can defer questions to the designated spokesperson and/or answer questions directly pertaining to the issues taking place in their own district area. Public information developed in collaboration with MDPH and others will be used in this plan and in media kits designed to communicate timely and accurate information to the public as far as in advance as feasible or during any mosquito-borne disease incident. Finally, SRMCB/DAR will work with the EOEEA Public Relations office and the MDPH Office of Public Health Strategies and Communication to ensure a standardized framework for communications and information sharing. The framework for communication include but are not limited to a system where the major media outlets are contacted via an electronic list of facsimile numbers by region, e-mail distribution lists, and web-based resources. The framework for communication will target messages that explain to the media, BOHs, and public a description regarding the kind, location, and extent of any mosquito-borne incident, instructions to public, benefits and risks of the planned intervention, fact sheets, frequently asked questions materials and contact lists for further information.

Notification of Key Contacts

In the event of a mosquito-borne disease event or emergency, the SRMCB will contact key personnel who will assist in any operational response, including the contact of entities requiring notification such as beekeepers, growers, certified organic farms and fish farms. Accordingly, GPS coordinates for certified organic farms; commercially licensed aquaculture operations and other sites to be excluded shall be available and uploaded into aircraft operational software (Appendix 9 and 10). Because beehives are frequently relocated throughout the season, the SRMCB has established a notification tree and will request the state chief apiary inspector contact County Association Presidents concerning the timing and location of aerial application activities; these representatives will, in turn, notify their members (See Appendix 11).

Environmental Monitoring

In the event that a decision is made to conduct aerial intervention(s), specific environmental monitoring to monitor possible effects on drinking water supplies, benthic macroinvertebrates, and honeybees will be conducted. The SRMCB through the respective agency each member represents (DAR, DEP, DCR) will activate and follow through with monitoring response protocols relating to **water supplies** (*even though water supply reservoirs are specifically excluded from the spraying operation*). Also, monitoring will be conducted on **aquatic macro invertebrates (benthos)**, since potential effects on aquatic biota cannot be ruled out (See Appendix 5 discussion of potential impacts from DEP-ORS). In addition, monitoring will be conducted to assess potential effects on **honey bees.** (See Appendix 6).

The sampling protocol for water supplies will assess any potential impact of the mosquito control spraying to drinking water. Monitoring activity will seek to assess the extent, if any, pesticide-related impacts to water supplies during and following aerial application operations. The monitoring plan for water supplies (See Appendix 8) specifies that post-spray water sample sets should be coordinated with the water supply sampling activities.

The sampling of surface waters and biota as outlined in the monitoring plan for pesticides/benthos should be conducted in conjunction with aerial application (See Appendix 7 Biomonitoring Protocol).

Finally, in addition to the above, MDPH (BEH-SLI) will conduct pre and post aerial adulticide application monitoring of cranberries in designated spray areas.

Certified Organic Farms

DAR will exclude all certified organic farms from aerial applications of adulticides, even under a declared emergency. DAR has worked with certifying organizations to identify certified organic farms, and to map these farms. Mapping is being done statewide. Mapping of all certified organic farms is an ongoing process and update annually.

The USDA National Organic Program (NOP) does not prohibit the application of pesticides for a public health emergency on certified organic farms. However, the NOP does require revocation of certification for 1 year should detectable residues be found after such a spray event.

DAR believes that this exclusion will have an insignificant impact on the efficacy of the spray operation. Certified organic farms are not prime habitat for adult mosquitoes and represent an extremely small area of land. Exclusion is necessary to protect the certification of the farm. As such, the risk benefit analysis favors exclusion.

There is no need to exclude transitional farms (Tfs) from spraying under the NOP. However, those Tfs that make known their status may be excluded. Transitional farms are those farms undergoing the process of becoming certified as organic. Under the NOP, when applications are done for public health purposes, there is no impact on the status of transitional farms or the timeline under which they become certified.

Creation of the Geographic Data for Aerial Adulticide Spray Operations

The MDPH SLI will make available a GIS polygon indicating the geographic area where human risk of EEEv or WNv is high to all agencies that are involved with the Commonwealth's mosquito control efforts. This GIS polygon will be circulated via email within 5 hours of its definition. Concurrently, hard-copy maps of the polygon will also be reviewed by MDPH/SEI using standard departmental cartographic templates and language and posted at the MDPH website.

The development, maintenance, sharing, and general stewardship of potential GIS data layers that demarcate areas that are sensitive to aerial spray operations, is the responsibility of the GIS staff in the agencies with respective authority for the these aerial spray sensitive areas. For example, the MDEP is responsible for the maintenance and provision of open water polygons that have been identified as spray sensitive areas. Similarly, certified organic farms and commercial aquaculture facilities are the responsibility of the MDAR GIS as are priority habitats the responsibility of the DFG NHES program. In anticipation of the mosquito season, agencies will create and maintain thematic GIS layers of areas that are sensitive to aerial adulticide spray operations and keep these layers up to date.

The release by MDPH of the GIS polygon indicating areas of high human risk of EEEv will be followed by the inclusion of aerial spray sensitive data layers from each agency within the designated polygon. The MDPH polygon and spray sensitive areas will be compiled by a GIS point person at DAR and re-circulated to DEP and DFG within 24 hours. Each agency must approve in writing (e.g., via email) to the GIS point of contact at DAR as to the accuracy of the delineation of the areas of high human risk and spray sensitive areas. With agreement from all agencies, DAR will send the final geographic data to the aerial applicator for conversion to appropriate navigational formats.

Mosquito Response Plan Funding and Costs

The cost of an emergency aerial intervention will be dependent on conditions identified as the mosquito season progresses, which includes but is not limited to the number of acres needing treatment, the amount of chemical necessary to cover the area of risk, calibrating and characterization of delivery apparatus of aircraft, environmental monitoring expenses, aircraft software (AGNAV) and Mapping Tech support, post-spray analysis, personnel expenses, and established contingency contracts for aerial application services.

Table 1: Summary of Operational Response Plan Responsibilities

MDPH Risk Category	MDPH	SRMCB
1- Remote	1. Standard surveillance activities. 2. Provide educational materials to the general public on personal prevention steps and emphasizing residential source reduction 3. Emphasize need for schools to comply with MA requirements for filing outdoor IPM plans 4. Conventional collection and testing of mosquitoes. 5. Passive human and horse surveillance 6. MDPH Epidemiological staff provide educational materials and clinical specimen submission protocols to targeted groups involved in arbovirus surveillance (including local boards of health, physicians, veterinarians, animal control officers, stable owners, etc.	Standard mosquito practices for monitoring and surveillance. Carry out Best Management Practices (BMPs) such as Integrated Mosquito Management (IMM) to reduce immature and adult mosquitoes. Maintain larvicide applications (where necessary) at designated sites; and adulticide applications based on Mosquito GEIR, MCPs surveillance, and other relevant data.
2- Low	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction.	Maintain larval control (where necessary when surveys or monitoring indicates need. Maintain adulticide applications based on Mosquito GEIR, MCPs surveillance, and other relevant data.
3- Moderate	Response as in category 2, plus: 1. Supplemental mosquito trapping and testing in areas with positive EEEV findings. Notify all boards of health of positive findings. 2. Public health alert sent out by MDPH in response to first pool of EEE virus positive mammal-biting mosquitoes detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 3. HHAN (Health and Homeland Alert Network) alerts are sent to local boards of health upon confirmation of EEE virus in any specimen; health care facilities are advised of increased risk status and corresponding need to send specimens to SLI for testing.	Target Larviciding (if feasible) and adulticiding (where needed) at local municipal level including but not limited to multiple treatments via ground based truck mounted Ultra-Low-Volume (ULV) equipment depending on mosquito abundance and weather conditions.

<table>
<tr><th>MDPH Risk Category</th><th>MDPH</th><th>SRMCB</th></tr>
<tr><td>4- High</td><td>Response as in category 3, plus:

1. Intensify and expand active surveillance for human cases.

2. Local officials should evaluate all quantitative indicators mosquito including population density and time of year and may proceed with focal area aerial adulticiding.

3. MDPH will confer with local health officials, SRMCB and Mosquito Control Projects to determine if the risk of disease transmission threatens to cause multiple human cases and warrant classification as level 5.

4. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction.

a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles or cable channel interviews, etc

b. Encourage local boards of health to actively seek out high-risk populations in their own communities (nursing homes, schools, etc.) and educate them on personal protection

c. Increased advisory information on pesticides provided by MDPH- BEH

d. Urge towns/schools consider rescheduling outdoor events.</td><td>Continue response as in Category 3 and expand or intensify where needed or around positive virus findings, location of residents near positive findings, type(s) of wetland habitat to target where treatment would be most effective.

MCP's/BOH may proceed with focal area aerial adulticiding as approved by the SRMCB in order to suppress risk in these areas. The SRMCB considers "focal area" to include but not be limited to a multiple mile radius circle or larger around positive virus findings that could incorporate multiple communities, towns or cities. The delineation of a focal area at risk depends on a number of factors such as prior year isolations, timing of current virus isolations as well as the species of mosquitoes where virus is confirmed, location and density of residents near positive findings, type(s) of wetland habitat to target where treatment would be most effective, general mosquito habitat, and the cyclical and seasonal conditions that represent conditions conducive to risk of human disease

Confer with MDPH and local health officials and determine if classification 5 is warranted.

If high health risk is declared, advise respective agency commissioners of appropriate pesticide, extent and route of treatment and targeted treatment areas and advise commissioners whether a more aggressive approach such as aerial application is necessary. When State Commissioners of DAR, DEP, and DCR agree that aerial adulticide is necessary, DAR Commissioner notifies Secretary of EOEEA.</td></tr>
</table>

MDPH Risk Category	MDPH	SRMCB
5- Critical	Response as in category 4, plus: 1. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine if measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of EEE human disease. 2. MDPH Bureau of Environmental Health (BEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences. 3. MDPH will designate high-risk areas where individual no spray requests may be preempted by local and state officials based on this risk level. Aerial adulticiding will override no-spray requests. If this becomes necessary, notification will be given to the public including those who have opted out. 4. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 5. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt reporting of all suspect cases.	Continue response as in Category 4. If critical health risk is characterized by MDPH notify respective agency officials of appropriate pesticide, extent and route of treatment, targeted treatment areas and advise commissioners whether full scale adulticide aerial spraying is necessary. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by providing advice relative to: A. Appropriate pesticide B. Extent and route of treatment C. Targeted treatment areas State Commissioners of DAR, DEP, DCR agree that aerial adulticide is necessary and DAR Commissioner notifies Secretary of EOEEA. EOEEA Secretary and HHS/MDPH jointly notify Governor. Governor considers advisement to approve declaration of emergency to protect public health risk.

Conclusion

The overall goal of reducing and/or halting the transmission risk of mosquito-borne diseases to Massachusetts citizens during any mosquito season is ultimately achieved by having contracts in place such as aerial application service and insecticide vendor contracts, as well as essential personnel contact lists, and operations plan ready prior to a projected or current mosquito-borne disease outbreak or emergency. These contracts, contact lists, and plan ensure that aircraft, personnel, product, and other supports are available for a rapid and timely response.

This plan assures that the Commonwealth is ready to provide appropriate and as, quickly as practical, the most meaningful response based on entomological, epidemiological, meteorological, and ecological data backed up by both practical and scientific evaluation of this data by the MDPH-SLI, MDPH-BEH, SRMCB, MAG, and other state agencies such DAR, DCR, DEP, and DF & W.

Appendices

- Appendix 1: SRMCB Response Matrix to Prevent or Suppress Mosquito-Borne Disease
- Appendix 2: Chain Of Command Flow Chart
- Appendix 3: SRMCB Massachusetts Mosquito Control Surveillance Protocol For Evaluation of Efficacy of Aerial Adulticide Application(s) Regarding Mosquito-Borne Disease
- Appendix 4: Aerial Application and Insecticide ANVIL 10+10 Information Sheet
- Appendix 5: Water Quality Sampling for Mosquito Control Aerial Chemical Application
- Appendix 6: Honeybee Monitoring Protocol for Aerial Mosquito Adulticide Application
- Appendix 7: Biomonitoring Plan: Pesticide-Related Impacts to Macroinvertebrates (Benthos) Following Aerial Application
- Appendix 8: Water Supply Monitoring Plan to Assess Potential Impact of Mosquito Control Spraying During Any Public Health Emergency To Drinking Water
- Appendix 9: Certified Organic Farms List
- Appendix 10: Commercial Freshwater Fish Farm List
- Appendix 11: Bee Keeper Association Notification Tree Contact List
- Appendix 12: Contacts for Conducting Control of Adult Mosquitoes (Vector Species)
- Appendix 13: 2008 Mosquito Advisory Group (MAG) Members
- Appendix 14: 2008 Massachusetts Arbovirus Surveillance and Response Plan

Appendix 1: SRMCB Response Matrix to Prevent or Suppress Mosquito-Borne Disease[1]

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
Conduct surveillance (*Avian such as dead birds, native, exotic, and farmed birds such as emus, mosquitoes, veterinary such as horses, ponies, alpaca etc., and human*)	MDPH-SLI	- To trap, sort, and identify mosquitoes in the field at long-term sites; - To test submitted Dead Birds from Cities/Towns; - To obtain Data from Veterinarians; and - To obtain Clinical Data from Physicians/Hospitals.	June 1 through October 15th
Conduct standard or supplemental surveillance (m*osquitoes*)	MCPs/SRMCB	- To collect and submit mosquito pools to MDPH-SLI for virus detection from non MDPH-SLI sites; - To monitor and report on abundance or trends for both immature and adult mosquito population in local geographic area; - To monitor local climate and weather data; and - To provide weekly trap data.	June 1 through October 15th
Process and report laboratory analyses results	MDPH-SLI	- To perform screening and confirmatory testing of collected specimens (dead birds, mosquitoes, horse, humans etc.); - To maintain and transmit laboratory results via an Arbovirus software system to MCPs; - To distribute weekly arbovirus report regarding laboratory results and confirm positive isolations of EEEv and/or WNv to SRMCB and MCPs; and - To notify Boards of Health using the Health and Homeland Alert network (HHAN) to report Bird and mosquito results.	June 1 through October 15th
Characterize severity of human risk	MDPH-SLI	- To evaluate **current level of risk** geographically based on triggers outlined in the **MA Surveillance and Response Plan.**	June 1 through October 15th
Communicate severity of human risk to public	MDPH Office of Public Health Strategies and Communication	-To provide Guidance and Alerts to BOHs, general public, and media on ways to reduce risks.	June 1 through October 15th
Analyze, evaluate, and scrutinize all available data from MDPH-SLI and MCPs	MAG	- To advise SRMCB concerning mosquito control intervention(s) necessary to prevent or reduce human risk ***before*** it becomes significant or spreads.	Ongoing – May 15th to October 15th

[1] See Agency Key on Page 36.

NOTE: Due to the complexity of operations to prevent or suppress mosquito-borne disease, actions outlined in this matrix may be implemented concurrently or simultaneously in order to achieve the objectives. Moreover, the actions outlined, responsibilities, and associated time-lines may be subject to change without notice.

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
Submit summary report(s)	SRMCB/DAR	- To inform and advise SRMCB respective state agencies commissioners and EOEEA key personnel of arbovirus risk status and mosquito control response intervention being taken (if any).	Beginning when virus is first confirmed and Bi-weekly from July 15st-September 30th
Advise respective state agency stakeholders when necessary	SRMCB, MAG, and DAR	- To determine what mosquito control intervention will be most effective to **prevent or suppress** potential for human risk including but not limited to maintain standard mosquito and virus surveillance activities, increase mosquito and virus surveillance activities, intensify and increase localized control of immature (where practical) and/or adult mosquitoes, and/or accelerate, expand, and target control of adult mosquitoes in larger geographical areas.	Ongoing – May 15th to October 15th Or when virus is confirmed
Review, select and approve insecticide or product of choice	MDPH BEH, DEP, DAR including SRMCB	- To prepare and collaborate to select and approve the specific pesticide product to be used; and - To file and obtain Federal authorization to use a pesticide not registered for use over crops.	Ongoing-January 1st to December 31st
File application to EPA for public health emergency exemption (if required)	DAR/ SRMCB	- To file and obtain Federal authorization to use a pesticide not registered for use over crops.	Ongoing-January 1st to December 31st
Direct MCPs to respond locally	SRMCB	- To adjust, increase, or maintain standard mosquito surveillance and control activities to **prevent or suppress** potential for human risk.	Ongoing – May 15th to October 15th Or when virus is confirmed
Classify risk as Level 5 or (Critical)	MDPH-SLI	. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB, and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine if measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of EEE human disease. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by providing advice relative to: A. Appropriate pesticide B. Extent and route of treatment C. Targeted treatment areas MDPH- (BEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences	June 1 through October 15th

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
Notify respective state agency Commissioners of Level 5 (Critical) classification	SRMCB and DAR	- To advise SRMCB respective state agencies commissioners. DAR Commissioner notifies EOEEA Secretary when highest level of risk has been characterized by MDPH-SLI for purpose of considering the most effective interventions to **prevent or suppress** human risk including but not limited accelerating, expanding, and targeting adult mosquitoes in larger geographical areas such as aerial application.	Concurrent with virus characterization and mosquito control advice
Classify risk as Level 5 or (Critical) cont'd.	MDPH-SLI, MDPH-BEH, DAR, SRMCB, MAG, and DF& W	- To initiate emergency conference calls and meetings with multiple state agency stakeholders including but not limited to MDPH-SLI, MDPH-BEH, DAR, SRMCB, MAG, DF&W in order to reach consensus on most effective way to **prevent or suppress** human risk including but not limited accelerating, expanding, and targeting adult mosquito control in larger geographical areas such as aerial spray. SRMCB will notify respective their state agencies commissioners. DAR Commissioner notifies EOEEA Secretary regarding emergency conference call(s) and meeting consensus; and To invite Aerial Applicator Vendor, Insecticide vendor, BOHs to participate.	Concurrent with virus characterization and mosquito control advice
Contact emergency aerial applicator and insecticide contractor	SRMCB	- To facilitate the timely deployment of aircraft and pesticides required for an aerial intervention.	Immediately upon multiple stakeholder consensus and before declaration of Public Health Emergency
Notify and advise executive level administrators within State government	MDPH Commissioner's Office and EOEEA Secretariat Office	- To inform and advise of critical mosquito-borne risk level.	Concurrent with virus characterization and mosquito control advice
Notify and advise Governor	MDPH Commissioner's Office and EOEEA Secretariat Office	- To provide joint notification and advisement by MDPH Commissioner, EOEEA Secretary, EHHS Secretary, in order for Governor to consider declaration of public health emergency.	Concurrent with virus characterization and mosquito control advice
IMPLEMENT OPERATION **Send formal authorization to aerial applicator and pesticide contractor**	SRMCB and DAR	To confirm and formalize communications that authorize both aerial applicator and insecticide contractor to proceed for the purpose of making an aerial mosquito adulticide application over the populated areas identified in specified geographic portions of Massachusetts in response to increased mosquito populations and infection rates of EEEv and WNv on behalf of the Commonwealth of MA and State Reclamation and Mosquito Control Board.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Confirm federal authorization of pesticide product to be used for aerial intervention**	DAR	- To ensure compliance with state and federal pesticide laws.	Immediately and concurrently with declaration of public health emergency

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
IMPLEMENT OPERATION (Cont'd) **Notify the Federal Aviation Administration (FAA)**	SRMCB	- To complete notification of the FAA that an aerial intervention will be performed; and - To obtain approval to apply insecticides for mosquito control over Congested Areas (CAP) citing geographic area and beginning and end dates of treatments.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT **OPERATION (Cont'd)** **Notify the Massachusetts Aeronautics Commission (MAC)**	SRMCB	- To obtain the certificate of waiver from the Massachusetts Aeronautics Commission (MAC) pursuant to 702 CMR 4.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Forward all approval documents from FAA and MAC to aerial applicator**	SRMCB	- To assure compliance with state and federal aviation rules and regulations.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Notify pre-designated airport for conducting operations**	SRMCB and DAR	- To obtain approval to use facility as operational site as pre-designated; and - To insure secure site for aircraft and pesticide inventory at airport during operations.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Request Massachusetts Environmental Police Detail**	SRMCB and DAR	- To provide security for the aerial application operation at the airport.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Establish base of operations**	SRMCB and DAR	- To supervise the operation and facilitate the communication and decision-making in accord with the operational plans.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Calibrate and characterized spray delivery apparatus**	SRMCB/DAR and Contractor	- To ensure calibration and characterization of spray delivery equipment in compliance with product labeling and other operational parameters.	Concurrent with time of anticipated treatment
IMPLEMENT OPERATION (Cont'd) **Notify DF&W and DMF in accordance with Fish Impact MOU**	SRMCB and DEP and DAR	- To follow State Fish Impact Memorandum of Understanding (MOU).	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Notify MPAL that samples will be delivered**	SRMCB and DAR	- To arrange with the University of Massachusetts Pesticide Analysis Laboratory (MPAL) for the analyses of all samples collected pre- and post-application.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Implement Water Quality Sampling and other Environmental Monitoring Protocols**	SRMCB and DEP and DAR	- To carry out established Water Quality Sampling and other environmental monitoring protocols.	Immediately and concurrently with declaration of public health emergency

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
IMPLEMENT OPERATION (Cont'd) **Activate notification protocols for bee keepers, aquaculture facilities, and certified organic farmers, and honey bees**	SRMCB and DAR	- To activate the Bee Keeper Association Notification Tree and facilitate communication and provide information on the specific pesticide application operational details to the following previously identified agricultural parties: o Beekeepers; o Aquaculture Facilities; and o Certified Organic Farmers.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Assign MCPs personnel to observe and note aerial application characteristics and weather.**	SRMCB and DAR	- To have MCPs personnel observe flight paths, pesticide applications, conduct pre and post application sampling of mosquitoes to determine efficacy and evaluate/document weather conditions including wind and temperatures during the applications.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Activate SRMCB efficacy trapping protocol and convene meeting of efficacy-evaluation workgroup**	SRMCB, MDPH-SLI, MAG, and MCPs	- To have **efficacy-evaluation workgroup** confirm trap type, trap placement; target species; and distance from spray perimeter in accordance with the SRMCB Efficacy protocol and review the GIS maps representing the geographic area and habitats encompassed by the spray zone to determine specific trap sites that will be included in the IN/OUT to measure for efficacy evaluation	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Establish integrated communication strategy.**	SRMCB and DAR	- To ensure interoperability of communication equipment such as cell phones, radios, etc. such that all divisions within the operation maintain communication with each other and provide necessary and otherwise important information in a timely manner.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Designate official(s) who will communicate with the aerial pilot.**	SRMCB and DAR	- To designate state official(s) who will supervise the aerial spray operation and communicate with pilot(s) prior to, during, and after spraying operations	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Assign state personnel for on site inspection and monitoring**	SRMCB and DAR	- To designate state officials, in addition to contractor personnel, to inspect airplanes and spray equipment, monitor calibration and characterization of droplets, monitor pesticides being loaded into the aircraft.	Immediately and with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Notify and coordinate activities of Public Relations Office of EOEEA, EHHS, MDPH Office of Public Health Strategies and Communications**	DAR, MDPH Office of Public Health Strategies and Communications and Contractor PR services	- To insure coordination between Public Relations Office of respective state agency secretariat responsible to conduct media campaign for dissemination of public health risk communication information regarding specific areas that will be treated, timing of application, choice of pesticide, and information to mitigate personal and environmental risks through media outlet electronic fax notification system called BLAST and other means.	Immediately and with declaration of public health emergency

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
IMPLEMENT OPERATION (Cont'd) **Notify media relative to treatment areas**	MDPH Office of Public Health Strategies and Communications and DAR/SRMCB	- To provide the media with maps detailing treatment areas; - To provide the media with public health risk communication information; - To provide the media with information relative to the choice of pesticide to be used, the time of applications, and information to help mitigate environmental health risks in the specific towns to be treated; and - To make the above information also available via the state websites maintained by MDPH and DAR.	Immediately and with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Notify local Police Departments in treatment areas**	SRMCB and MCPs	- To help prepare local Police Departments in treatment areas; such that, they are aware of the spray operation to occur in their community and are able to direct individuals calling them to the State's informational resources via established informational hotlines, websites, etc.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Notify Local Boards of Health in designated treatment areas**	MDPH-SLI	- To notify Local Boards of Health in designated treatment areas utilizing the Health and Homeland Alert Network (HHAN); such that, they are aware of the spray operation to occur in their community and are able to direct individuals calling them to the State's informational resources via established informational hotlines, websites, etc.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Develop and Send final GIS mapping shape file data to SRMCB**	DAR	- To compile and develop the final comprehensive GIS maps with all exclusion zones delineated to EOEEA agencies such as DAR/SRMCB, DFW, DEP and DCR for consensus and approval; and - To allow for the SRMCB to provide the GIS maps to the aerial applicator/contractor no later than 48 hours prior the commencement of operation for navigation software preparation.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Follow up to Ensure that GIS maps for aerial intervention are complete for operations**	SRMCB	- To ensure final GIS shape file maps with the required exclusion zones and buffer zones for the specified treatment areas have been forwarded to aerial application service vendor in order to ensure pilot/aircraft navigation systems via AGNAV software uploaded in timely manner.	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Obtain additional assistance from CDC to assist in aircraft and insecticide set up if necessary**	SRMCB	- To obtain additional assistance from CDC to assist in aircraft and insecticide set up **(if necessary).**	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Implement active surveillance of potential health effects in area of treatment**	MDPH-BEH	- To activate and implement active surveillance of potential health effects in area of treatment	Immediately and concurrently with declaration of public health emergency
IMPLEMENT OPERATION (Cont'd) **Identify media Public Information Office (PIO)**	MDPH Office of Public Health Strategies and Communications and DAR/SRMCB	- To identify media Public Information Office (PIO), establish media center, and disseminate pre-prepared media kits	Immediately and concurrently with declaration of public health emergency

ACTION	RESPONSIBLE AGENCY	OBJECTIVE	TIME-FRAME
IMPLEMENT OPERATION (Cont'd) **Activate SRMCB surveillance protocol to evaluate efficacy**	SRMCB and DAR	- To activate surveillance protocol surveys in addition to MCP tasks within spray areas and in areas outside of the sprayed area for comparison purposes.	Upon completion of all other necessary logistical steps and cooperation of conditions supporting applications.
IMPLEMENT OPERATION (Cont'd) **Commence Aerial Spraying Operation weather dependent**	SRMCB and Contractors	- To commence Aerial Spraying Operation	Upon completion of all necessary logistical and operational preparatory steps and cooperation of conditions supporting applications.
ASSESS OPERATION	SRMCB	Provide 1-2 page summary report to respective state agency commissioners and other key state agency stakeholders Provide report of Intervention including but not limited to final number of acres treated, per cent efficacy results, environmental impairment sampling results, complaints, etc.	Complete Brief Summary Report within two weeks or as soon after operation as practical Complete final report within six months of receipt of all documentation and data analysis from operation.

Key to Massachusetts Agency Names:

BOH = (Local) Boards of Health;

EOEEA =Executive Office of Energy and Environmental Affairs;

EHHS = Executive Office of Health and Human Services;

DF&W = Division Fish and Wildlife;

DMF = Division of Marine Fisheries;

MAG = SRMCB Mosquito Advisory Group;

MCPs = Mosquito Control Projects;

DAR = Department of Agricultural Resources;

MDPH-BEH = Massachusetts Department of Public Health, Bureau of Environment Health;

MDPH-BCDC = Massachusetts Department of Public Health, Bureau of Communicable Disease Control;

MDPH-SLI = Massachusetts Department of Public Health, State Laboratory Institute;

SRMCB = State Reclamation and Mosquito Control Board.

Appendix 2: Decision-Making Flow Chart

The Response Matrix or operational response is activated when MDPH issues a finding that there is a risk to the public health from mosquito arbovirus (level IV or V according to most current MDPH's Arbovirus State Surveillance and Response Plan) and when MDPH along with the MAG advise for risk reduction interventions. At that point, depending on the location(s) and extent of the problem, the type of virus involved and a number of other variables, a decision will be made by the SRMCB and the individual MCPs as to what specific measures will be implemented. As noted above, the Mosquito Advisory Group (MAG) will be asked for scientific advice based on specific current conditions. Because at any time, there are many data under review and there are many individuals and organizations that must be involved during a short time period to protect the public health, this appendix outlines the key components and responsible agency in the decision-making process expectations.

Ongoing seasonal mosquito data collection and monitoring (MDPH-SLI and SRMCB and MCPs)

↓

MCPs under aegis of SRMCB standard, locally established mosquito control efforts including targeted ground adulticiding operations based on Mosquito GEIR, MCPs surveillance data and MDPH (SLI) trapping data when risk classification is low to moderate.

Ongoing seasonal analysis and evaluation of long-term trapping data (MDPH-SLI)

↓

MDPH (BCDC) will characterize human risk severity level and delineate the spray area with a GIS map based on arbovirus surveillance data

↓

MDPH (BCDC) requests permit from DFW for treatment of priority habitat to be issued to DAR

↓

DAR coordinates multi-agency GIS mapping and develops final shape files for SRMCB

↓

MAG will review and evaluate MDPH long-term trapping data along with other data such as MCPs data and provide advice to SRMCB

↓

SRMCB will advise its respective state Commissioners representing DAR, DEP, & DCR who notify EOEEA officials on most meaningful intervention action to protect public health from mosquito-borne disease

↓

Spray Decision certified for public health purpose by MDPH Commissioner and/or Governor's Office declares public health emergency

↓

Commence and Supervise Aerial Adulticide Operation (SRMCB/ MCPs/DAR)

↓

Feedback/Assessment of operation (MCP, SRMCB, MDPH and MAG)

Appendix 3: SRMCB Massachusetts Mosquito Control Surveillance Protocol for Evaluation of Efficacy of Aerial Adulticide Application(s) Regarding Mosquito-Borne Disease

INTRODUCTION

Eastern Equine Encephalitis (EEEv) and West Nile Virus (WNv) are the most significant mosquito-borne public health threats in Massachusetts. In Massachusetts and elsewhere in the United States, established regional mosquito surveillance and control programs operate utilizing principles of, and components comprising, Integrated Pest Management (IPM), or more specifically, Integrated Mosquito Management (IMM). A basic tenet of IPM and IMM is that action thresholds and intervention decisions are based on surveillance.

Mosquito-Borne disease surveillance demands proper pest recognition and quantification as it attempts to define the local epidemiology of the disease: the presence, distribution, and prevalence of the causal agents and vectors. Surveillance of these populations, along with careful scrutiny of environmental influences, seasonal variations, facilitates the process of assessing risk of mosquito-borne disease, and provides a basis for intervention decisions.

In Massachusetts, the State Reclamation and Mosquito Control Board (SRMCB) and the mosquito control districts/projects (MCPs) it oversees collaborate with the Massachusetts Department of Public Health (MDPH) Arbovirus program to monitor ecological and epidemiological parameters, and to dynamically assign risk levels pertaining to EEEv and WNv transmission throughout any mosquito season.

PURPOSE

This document establishes a standardized protocol for use by SRMCB, MCPs and MDPH personnel to assess the efficacy of an aerially applied adulticide for the goal of reducing risk of EEEv and/or WNv transmission to the public. In pursing the goal previously stated, the overarching purpose of this protocol is to ensure the trapping of mosquito populations that have not been impacted by aerially applied adulticides in order to achieve a better interpretation and apply correctly conclusion(s) regarding the efficacy of the adulticide to reduce the threat of mosquito-borne disease. Finally, this particular document will address and place more emphasis on quantitatively measuring efficacy of interventions such as aerial adulticide application for purpose of suppressing EEEv.

Although the protocol places emphasis on EEEv, there is an established surveillance system for WNv using specific traps such as gravid traps to collect mosquitoes statewide for submission to the MDPH Arbovirus Laboratory in Jamaica Plains. The gravid trap is very effective in collecting live specimens of these species for virus analysis and could be used to quantitatively measuring efficacy of interventions such as aerial adulticide application. The MDPH in cooperation with the MCPs, boards of health and various state/local agencies have established a trapping protocol for deployment of traps (gravid traps) specific for the purpose of determining the presence of WNv in geographically specific mosquito populations. During the mosquito season, MCPs deploy traps at predetermined locations for season long collection of primarily *Culex pipiens* and *Culex restuans*. The *Culex pipiens/restuans* complex of mosquitoes has been implicated in the transmission of the West Nile virus from bird-to-bird and bird-to-human during years of increased virus activity. Trapping protocols for deployment of these traps has evolved over time resulting in an elaborate network of traps covering many areas of the state. In concert with the long-term trapping sites, MDPH, in cooperation with the MCPs, has developed a rapid deployment trap protocol which is activated and geographically focused based on certain environmental parameters such as clusters of WNv positive birds and/or human cases.

LESSONS LEARNED IN 2006

The task of measuring efficacy is straightforward in terms of looking at the abundance of mosquitoes before a spray event and directly after to determine if the intervention such as an aerial adulticide intervention was successful. Data indicating decreases in numbers or abundance can support a conclusion that the intervention was successful where the spray was actually deployed and lead to conclusions that risk of arbovirus was reduced too. The analysis of the numbers or abundance would include areas outside of the treated areas or areas not sprayed and an intervention would be deemed successful if the data reflect a lesser reduction occurred or mosquito numbers rose. Although increases in mosquito density can occur after the intervention, this does not automatically mean the intervention was a failure since increases can be due to either/both immigration from outside the spray zone and/or emergence of new mosquitoes on a daily basis. However, one lesson learned in 2006 is that no resources were available to determine the parity or age of these mosquitoes in order to gain information that would help provide a clearer picture of the overall efficacy. In addition, although minimum infection rates (MIR) had increased in those mosquitoes being sampled, the MIR was evaluated within the context of the ranges of reductions in overall abundance and by species observed after the aerial adulticide intervention in 2006. Finally, the measuring of efficacy for future evaluations need to include the review of ongoing data collected each week beyond 24 hour post intervention period in order to gauge the results of the intervention.

During the 2006 mosquito season, surveillance data overwhelmingly indicated that the use of aerial adulticiding to parts of Southeastern Massachusetts would be a prudent intervention to reduce the emerging mosquito-borne threat of EEEv. In response to this emergency event, figuring out when and where to trap posed a significant challenge and difficult task in order to quantify the efficacy of the aerial adulticide intervention. The discrepancies and variability of the measured reductions seen in 2006 were attributable to differing methods of analysis as well as confounding factors such as weather changes between pre and post collections, terrain, locations and kinds of traps utilized, and mosquito species.

Another lesson learned was the need for a stronger protocol incorporating as much standardization to the extent feasible that could address as many of the aforementioned variables and complexities inherent in the sampling of adult mosquitoes. These inherent complexities include but are not limited to flight range of the target mosquitoes being sampled, location of traps and distance traps are placed outside treatment areas to access efficacy. One way to strengthen the current protocol is to identify and select sites where specific trapping devices could be set prior to any decision to deploy an intervention such as an aerial application. As a result, the actual trap placements can be coordinated to insure placement within similar habitat to insure analysis uniformity.

Also, there are no additional or supplemental resources that can be utilized to run efficacy measures for a specific intervention. The same MCPs personnel responsible for several tasks including standard surveillance and data collection efforts are used to set additional traps in order to measure efficacy for a situation such as an emergency aerial adulticide intervention.

Another lesson learned was that there was no clear operational pre-assignment of the appropriate personnel from each MCP that would be responsible for sampling efforts. There was no established timeline between SRMCB, MCPs, and MDPH regarding the turnaround time pertaining to efficacy analysis, interpretation, and results reports. In this protocol, the SRMCB shall coordinate with its member MCP's and MDPH, the number of traps, acceptable trap type, and acceptable ranges for placement within and outside of spray zone perimeter. Once relevant data on these collections has been provided, the SRMCB shall determine the final efficacy measures for reporting purposes.

Due to the nature of the emergency conditions, changing weather conditions, and logistical uncertainties such as knowing in advance the number of aircraft that would be available as well as the size of the spray zone, communication challenges included less than desirable notification to all parties regarding fundamental changes to the proposed spray areas as the operation proceeded as well as delayed reports on the progress of the aerial spray. A standard sampling protocol will go a long way in improving the experience gained in 2006 especially communication between SRMCB, MCPs, and MDPH and ultimately result in better interpretation and application of the data derived from sampling efforts to assess efficacy of an aerial application intervention.

SPECIFIC SPECIES OF MOSQUITOES

More than 150 species of mosquitoes have been identified in the U.S.; of these, 51 are known to occur in Massachusetts. Whereas all mosquitoes require water in which their immature stages develop, each species of mosquito exploits a characteristic kind of habitat (e.g. fresh water wetland, salt marsh, cedar swamp, tree hole, etc), produces as few as one or as many as several generations each year, is active during a defined season, and quests for blood during defined intervals (e.g. daytime, nighttime or during dawn/dusk periods). Furthermore, mosquitoes of certain species feed predominately on one kind of host (e.g. birds or mammals), whereas others are less discriminating and feed on a number of different ones. Because of these and yet other differences, certain kinds of mosquitoes are better able to acquire, maintain and transmit disease-causing viruses between their vertebrate hosts. Accordingly, just a few kinds of mosquitoes are of particular concern to public health authorities and the mosquito control practitioner in Massachusetts. For EEEv, these include the maintenance vector *(Culiseta melanura*), and the likely bridge vectors (mainly *Aedes vexans, Ochlerotatus canadensis, and Coquilletidia perturbans).* For WNv virus, these include the maintenance vector *(Culex pipiens)*, and a long list of potential bridge vectors.

QUANTITATIVE MEASUREMENT FOR EFFICACY OF AERIAL APPLICATION OF PESTICIDES

Traps used for assessing the efficacy of an adulticidal application generally should be selected and deployed to maximize the sampling of mosquitoes of the target species. The larger the sample size, and the greater the proportion of the sample being composed of the target species, the greater the return on investment of time and labor.

The efficacy of an adulticiding effort can be assessed by noting a change in the

Local abundance of the target mosquito (es),
Age structure of that/those population(s), and
Proportion of vectors harboring the virus.

Traditionally, measurements have been limited to recording changes in abundance and infection rates. Whereas the abundance of a vector is most readily assessed, this parameter is of only limited significance as a component contributing to the transmission risk posed by that vector. For many kinds of mosquitoes, adults may emerge daily during the season. In these cases, the vast majority of adults will be just one or a few days of age. Thus, if a significant proportion of the adult population is killed by application of an adulticide, and if that same fraction of the population is soon replaced, in whole or part, by newly emergent adults, then the reduction might not be apparent simply by measuring vector abundance. The abundance of the vector population should be measured, but data is most valuable if considered along with other parameters that together better relate to risk.

Mosquitoes of any age may acquire EEEv and WNv infection from viremic vertebrate hosts. The virus survives and reproduces within, and may be transmitted by only certain kinds of mosquitoes. With few exceptions, such virus-competent mosquitoes can transmit infection to new hosts only after incubating the virus for a period of days or weeks. Young mosquitoes, even if infected, pose relatively little immediate threat. It is the aging mosquito population, composed in part of adults that may have acquired and incubated EEEv and WNv that pose risk of virus transmission. Thus, interventions based upon use of adulticides may reduce the abundance of vectors that may yet acquire virus as well as those that may already be infected or infectious. In the former case, the intervention may reduce risk of transmission for days or weeks. In the latter case, the intervention may have immediate effects on reducing transmission risk.

TRAP TYPE

Diverse kinds of traps exist for the surveillance of adult mosquitoes. Each kind of trap has attributes that make it more or less useful than other kinds for sampling certain kinds of mosquitoes.

In Massachusetts, the traps used most often for surveillance of adult mosquitoes include the *CDC light trap, the gravid trap, the New Jersey Light trap and the resting box.*

The *CDC Trap* was first designed in the late 1950's by the Centers for Disease Control. The trap is compact and portable, is powered by a battery, and can maintain sampled mosquitoes alive for the purpose of species identification and viral assay. A small incandescent lamp disorients flying insects, and a fan draws these into a collection chamber. The light may be augmented or replaced by a carbon dioxide (CO_2) source. Several modifications to the basic design are available; each configuration changes the attractiveness of the trap to different kinds of mosquitoes. Modified versions in use in Massachusetts include the American BioPhysics (ABC) trap (used by the Plymouth County Mosquito Control Project), and the UV light trap (used by MDPH), which is fitted with a blue-black light rather than the standard incandescent lamp.

Carbon dioxide ($CO_{2)}$ may be provided by a mass of sublimating dry ice, or as a metered flow from a pressurized cylinder. Standard use of a calibrated metered flow aids in comparing results between trap collections. This trap, baited with a CO_2 source, attracts the widest cross section of an existing, host seeking population. Generally, mosquitoes represent the largest fraction of insects collected within CDC traps. The primary enzootic vectors of EEEv (*Culiseta melanura)* and WNv (*Culex species*) are readily sampled with these devices. **Currently, the CDC Trap (even with the modified versions mentioned above augmented with CO2) is the most efficient or best standard surveillance device for assessing the efficacy of an aerial application because of its relatively low cost, portability, widespread use, and tendency to maintain captured insects alive and in good condition.**

The *Gravid Trap* is used almost exclusively to collect female *Culex pipiens and Cu. restuans* that have already taken a blood meal and are seeking a site to deposit eggs. These portable battery-operated traps are particularly useful for surveillance of virus-infected mosquitoes because they tend to collect the older (and thus infected) portion of the vector populations, and maintain the captured mosquitoes alive and in good condition for laboratory assay. **Gravid traps, therefore, are valuable for WNv monitoring efforts.**

The *New Jersey Light Trap* is a large, robust device powered by 120V AC. Consequently, these are best deployed as permanent installations. **Because they are not as portable as CDC traps, they are less suitable for rapid deployment in temporary sites.**

The *Resting Box* is used almost exclusively to sample adult *Culiseta melanura, particularly those that have already blood fed*. Because few other kinds of mosquitoes or insects visit such boxes, this surveillance device tends to be a selective and sensitive indicator of EEEv transmission in the immediate area. Resting Boxes, however, demand more time and labor for monitoring than do CDC traps. Arrays of resting boxes are operated in focal areas by some MCPs. Because resting boxes generally tend to sample relatively few mosquitoes, the sample sizes may not be sufficiently robust for statistical analyses. **Accordingly, they will not routinely be relied upon for evaluating efficacy of aerial applications of pesticides.**

Each kind (species) of mosquito exhibits its own specific host seeking preferences. These preferences relate to, amongst other characteristics, the kind of hosts attacked, the habitats where they are most abundant, their vertical distribution (for questing, resting and ovipositing), the seasonality of their population dynamics, and their photoperiodicity (for questing and ovipositing). For instance, females of *Ochlerotatus trivittatus* tend to feed under tree canopies, whereas those of many tidal wetland *Ochlerotatus* species seek hosts in open fields. Vertical stratification of host-seeking behavior has been demonstrated, with several species (*Culiseta melanura*, *Culex restuans*) most frequently feeding high in the tree canopies. **To assure standardization of trap placement in emergency efficacy evaluations, traps shall be suspended at a height of about 4 feet off the ground.**

MOSQUITO IDENTIFICATION AND AGE ASSESSMENT

Correct identification of mosquito vectors is paramount to disease risk assessment and for justifying intervention efforts.

Published 'keys' to assist in identifying mosquitoes include:

1.Connecticut Key: (Andreadis, T.G., Thomas, M. C., Shepard, J. J., Identification Guide to the Mosquitoes of Connecticut 2005, New Haven, CT: The Connecticut Agricultural Experiment Station. 173p.)

2. Midwestern Key: (Siverly, R. E. (1972). Mosquitoes of Indiana. Indianapolis, Ind, Indiana State Board of Health)

3. New York Key: (Means, R. G. (1979). Mosquitoes of New York: Part I. The genus Aedes Meigen, with identification keys to genera of Culicidae. Albany, NY, The University of the State of New York, State Education Dept. State Science Service, New York State Museum and Means, R. G. (1987). Mosquitoes of New York: Part II, Genera of Culicidae other than Aedes occurring in New York. Albany, NY, University of the State of New York, State Education Dept.)

4. Northeastern Key: (Stojanovich, C. J. (1961). Illustrated Key to Common Mosquitoes of Northeastern North America, Stojanovich, Chester J., 750 East McGlincey Lane, Campbell, California 95008).

5. North American Key: (Darsie, R. F., Ward, Ronald A., Chang, Chien C. (1981). Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. Fresno, Calif, Fresno, Calif.: American Mosquito Control Association**:** 313p and Darsie, R. F., Ward, Ronald A. (2005). Identification and Geographical Distribution of the Mosquitoes of North America, North of Mexico. Gainesville, FL, University Press of Florida.)

In Massachusetts, regional MCPs and MDPH employ entomologists to sort and identify sampled mosquitoes.

SURVEILLANCE CRITERIA

Trap Type

CDC light trap baited with CO_2. The CO_2 will be delivered either via a calibrated metered flow of 250-500cc/min from a secured pressurized cylinder, or as a non-metered flow from sublimating dry ice (2 lbs / trap/night)
UV Traps can be deployed as a non-CO_2 option, if these traps are arrayed in a manner in which meaningful comparisons can be made using the same kind of trap. Thus, collection data derived from UV traps operating in treated areas should be compared to data from UV traps operated in non-treated areas. The use of the UV trap to analyze efficacy for the purpose of this protocol is not recommended since the numbers of mammal biting mosquitoes may be under represented by lack of CO2 bait.

II. Trap Activation and Sample Collection

Traps:
Should ideally be installed at the surveillance site no later than one hour before astronomical sunset, or set to activate automatically at the assigned time if the location is a secure. **Note: Traps should be set so that collection period is no less than one full trapping night.**
Should be removed the following calendar day, ideally no earlier than 30 minutes after astronomical sunrise, or set to automatically stop collecting (and retain the sample).
Must be removed (or completely covered) during adulticide applications so that insecticide does not contaminate the trap and collecting vessel.

III. Trap Deployment

Traps:
Should be installed away from competing light sources and obstructions such as buildings.
should be located along the intersection of differing habitats to maximize local diversity
will be sited at geocoded locations, and be further identified by the name of the community, street address (if relevant) or other physical or ecological indicator.
used to compare treated and non-treated areas will be placed in similar habitats to the extent possible as coordinated by pre-planning efforts prior to an aerial adulticide intervention.
IV. Trap Density

Each treatment and comparison block will be monitored by not be less than two, and not more than four traps
Traps should be deployed so that, to the extent possible, their samples are representative of the density of adults of target species in geographically distinct areas.
Important Note: The number of traps described in the above passage should be adequate to meet the objective of evaluating treatment efficacy and exceeds the density typically required by FEMA, (24 hour windows pre and post trap within the spray block or area).
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V. Mosquito Identification

Female mosquitoes from traps will be identified to species.
Female mosquitoes will be counted, including damaged individuals, and reported on standard collection forms.
Trap contents will be subjected to aliquot reduction when sample size exceeds 400 mosquitoes / trap / night.
Collections should be stored chilled, and sorted on a chill table or on ice. Samples of female mosquitoes of target species should be assayed for virus as soon as possible, and other samples should be ideally deep-frozen (-20 degrees C or –4 degrees F) for subsequent dissection to assess parity rates for the purpose of obtaining additional data on the physiological age of collected mosquitoes. ***Note:*** *Mosquitoes should be knocked down with CO2 into tight tubes, frozen quickly, held in a freezer for months to be processed at a later time or in the case of analysis for mosquitoes collected pre and post intervention, thawed minutes before dissection for aging.*

CONCLUSION

For the purpose of moving toward uniformity in establishing meaningful measures to determine efficacy of interventions such as aerial adulticide applications, the best protocol will contain challenges and limitations when measuring impacts to biological organisms such as mosquitoes. During any given aerial adulticiding application, adult mosquitoes can be resting, digesting blood meals, or seeking hosts at varied times and may escape control. As outlined, various trap types can bias toward specific mosquito behavior such as the resting box which sample *Culiseta melanura* mosquitoes that have already blood fed. Similarly, gravid traps sample or collect mosquitoes that are ready to oviposit (lay eggs). These conditions may allow these mosquitoes to escape the impact of any single aerial adulticide application (only reducing those mosquitoes on the wing). Those mosquitoes escaping treatment will continue to be collected by sampling devices and effect meaningful comparisons. As a result, trap placement is critical to this protocols objective. Therefore, the emphasis of this protocol aims to achieve the proper placement of the least bias sampling device such as the CDC light trap baited with CO2 well within the spray zone at least 24 hours prior to the intervention and 24 hours after the intervention to assess impact on the target population.

Appendix 4: Aerial Application Service and Insecticide ANVIL 10+10 ULV Information Sheet

Aerial Application Service

Dynamic Aviation Group, Inc.
Post Office Box 7
1402 Airport Road
Bridgewater, VA 22812-0007

Aircraft Type: Specially Equipped Twin Engine, Turbine Powered King Air 90.
Speed of Aircraft: 150-knots/170 mph.
Altitude or height of aircraft: 300 feet AGL (Above Ground Level).
Swath Width: 750-1,000 ft.
Aircraft Capacity for Pesticide: 90 gallons per load when using Anvil 10+10 equating to covering 42,000 acres. *Note 640 acres equals 1 square mile*
Aircraft Contractor: Dynamic Aviation Group, Inc., Post Office Box 7, 1402 Airport Road, Bridgewater, VA 22812-0007, Telephone: (540) 828-2600,FAX: (540) 828-4031.
Aircraft Contract minimum acreage range: 5,000 to 24,999 acres.
Aircraft Contract maximum acreage range: 25,000 to 500,000 acres and greater.
Application Window: The “optimum” spray window depends upon the target species of mosquito, and the hours during which that species is most active. A “typical” spray window would begin approximately sunset and conclude after midnight.
Aircraft Flight Path: Flying at 170 MPH and assuming a 1,000-foot swath width, the King Air 90 is able to cover 343 acres per minute. *Note 640 acres equals 1 square mile. It would take approximately 2 minutes to treat a 1 square mile area*
Distinct Application System: Rotary or flat fan nozzles set up to provide optimized spray pattern for adult mosquito control.
Aircraft Noise: The twin turbine King Air is exceptionally quiet, and will likely be overhead and gone before most people hear it coming.
Aircraft Spray Visibility: The actual spray that comes out of the nozzles often is visible during daylight/dusk hours. However, if spraying takes place at night, it is unlikely that the spray would be visible.
Aircraft Operational Efficiency: The fewer blocks or zones that need to be excluded as “no spray” the more operational efficiency can be expected.
For More Information: Website: http://www.dynamicaviation.com/index.html

Insecticide Contractor

Clarke Mosquito Control Products, Inc.
P.O. Box 72197
159 N. Garden Avenue
Roselle, Il 60172

Pesticide of Choice: ANVIL 10 + 10 ULV
EPA Registration #: 1021-1688-8329
Active Ingredient: sumithrin 10.00% and Piperonyl Butoxide 10.00%
Note: This product is a synthetic pyrethroid in the Anvil formulation that replicates the mosquito fighting properties of pyrethrum, an extract of the chrysanthemum flower. Sumithrin is synergized with piperonyl butoxide (PBO) providing a fast knockdown of adult mosquitoes.
Signal Word: Caution
EPA Classification: Non-restricted or General Use
Target: Adult Mosquitoes
Use: Outdoor Residential and Recreational areas, woodlands, swamps, marshes, overgrown areas, and golf courses
Manufacturer: Clarke Mosquito Control Products, Inc., 159 N. Garden Avenue, Roselle, Illinois 60172, Phone: (630) 671-3128, Phone: (800) 323-5727, Fax: (800) 832-9344, Email: info@clarkemosquito.com
Max Rate of Application: 0.62 fluid ounces per acre
Dosage Rate: 0.0036 pounds of active ingredient per acre
Equipment: Ultra Low Volume (ULV) technology
Droplet Sizes: Volume Median Diameter produced is less than 60 microns and that 90% of the spray are contained in droplets smaller than 100 microns
Period droplets are airborne: Depending on environmental conditions, treatment block size, spray droplets should move through the target area 30-60 minutes after application is completed.
Optimum Ground Application Wind Speed: No greater than 10 MPH
Optimum Application Temperature Range: 65 degrees or greater but range of temperatures between 65 and 57 are acceptable.
For more information: Website: http://www.clarkemosquito.com/

TO: Gary Gonyea, BRP/WW

CC: Dave Terry, Director DWP, BRP
Robert Nuzzo, BRP

Signed original on file in ORS

THROUGH: Carol Rowan West, Director, ORS
FROM: Michael Hutcheson and Diane Manganaro, ORS
DATE: March 7, 2006
SUBJECT: Water Quality Sampling for Mosquito Control Aerial Chemical Application

This memo is in response to your e-mail dated Tuesday, February 28, 2006 to Michael Hutcheson, in which you requested the opinion of the Office of Research and Standards (ORS) regarding if and how environmental monitoring recommendations would change if malathion were to be used for aerial spraying of mosquitoes instead of sumithrin to control the spread of Eastern Equine Encephalitis (EEE) virus or West Nile Virus (WNV). The monitoring plan that was developed in conjunction with proposed spraying of sumithrin, entitled "Water Supply Monitoring Plan to Assess Potential Impact of Mosquito Control Spraying During Any Public Health Emergency To Drinking Water", provides a protocol for sampling drinking water reservoirs and finished waters in order to evaluate potential public health effects as well as benthos and water chemistry in order to evaluate potential ecological effects. We reviewed this plan in light of the information we have on Malathion to determine whether it could be adapted to spraying with Malathion. Our recommendations regarding the extent of monitoring to be conducted to address human health and ecological concerns are presented below.

Recommendations:

1. Based on the discussions provided below, an evaluation of potential drinking water impacts indicates that neither sumithrin nor Malathion applied aerially would likely pose a threat to public health via ingestion of drinking water. An extensive water-monitoring program, such as detailed in the Monitoring Plan under the Design Protocol, may not be needed. However, confirmatory sampling of representative water supply areas and finished waters would nevertheless be a worthwhile endeavor for both informational purposes and to provide reassurance to the public that aerial spraying of either pesticide did not pose a threat to public health via contamination of drinking water. The Drinking Water Program is in the best position to determine the scale of such a sampling program with regard to how many and which water supplies should be sampled. We also note that the sampling intensity presently described is not needed. As a cost-cutting measure, sampling could be reduced from the three sampling points described in the protocol to two, including the intake water prior to treatment and the finished water. Sampling of untreated surface water seems unnecessary in this case since the intake water closer to the treatment/distribution facility is being sampled concurrently. Finished water need only be analyzed if the intake samples test positive for the insecticide. Samples need only be collected twice, once shortly after spray operations take place and approximately twenty-four hours later.

2. Based on the discussions below pertaining to potential ecological effects, an evaluation of potential effects on aquatic biota cannot be ruled out for either pesticide. It is our opinion that sampling of surface waters and biota as outlined in the monitoring plan for pesticides/benthos of August 2005 should be conducted in conjunction with aerial application of either pesticide. The monitoring plan specifies that pre-and post-spray water sample sets should be coordinated with the water supply sampling activities; however, it is unclear as to the timing of this sampling relative to other water and benthos sampling. We question the necessity of post-application water sampling for sumithrin to accompany post-spray benthos sampling one week after application. Predicted maximum sumithrin concentrations from aerial application are so low (near the method detection limit of 0.1 g/L) and the degradation so relatively rapid (half-life on order of a couple of days) that coupled with dilution over one week, there would seem to be no chance of detecting any residual sumithrin that far after application. Similar arguments would apply to Malathion, which has a similar half-life and higher predicted initial maximum surface water concentrations. Rather, we suggest that surface water be sampled shortly after spray operations takes place (i.e., 1-3 hours), as it is during this time that pesticide concentrations at the water surface would be at their highest and have the most potential to impact aquatic life. It is our opinion that the monitoring protocol discussed above that was originally developed in conjunction with a sumithrin application can be adapted for a Malathion application.

3. Given that aerial dispersion of pesticides is of particular concern to aquatic organisms; it is recommended that, if possible, measures be taken to minimize exposure of these organisms during pesticide application. For example, fish typically feed at the surface of the water during the early mornings and evenings. When they are not feeding, there is a lower probability that they will be at the surface of the water, thus a lower probability that they will be exposed to pesticide that has been deposited to the surface of the water, which would be at a higher, undiluted concentration. We therefore recommend that the pesticide application be made in the nighttime hours, utilizing night-vision technology if necessary. A night application would also reduce potential dermal and inhalation exposures to humans, as there would be a lower probability that people would be outside during this time.

4. The proposed spraying protocol calls for an 800-foot buffer from surface water bodies. Although some drift within the 800-foot margin will likely occur, this setback is designed to minimize the amount of pesticide that will reach surface waters. One presumed rationale for employing this approach is to minimize possible effects on surface waters used for drinking water purposes. However, if direct aerial applications of these pesticides were to occur, we predict that water concentrations of the chemicals would be so far below drinking water guideline values that setbacks would not be needed. Mosquitoes tend to preferentially breed near sources of water. The margins of surface water bodies would be among these preferred breeding locations. By using a large setback distance from all surface water bodies, the area-wide application is essentially being riddled with large “holes” around surface waters, which may contain potential EEE virus-carrying mosquito populations. A smaller or zero setback distance would permit more comprehensive vector eradication with the tradeoff of a more certain risk to aquatic organisms, especially those in more shallow waters. Other measures could be taken to reduce exposures such as the one discussed in item #3 above. We recognize that making a decision on the most appropriate setback to use has its tradeoffs and is ultimately a management decision where improved mosquito control for

public health protection must be balanced against public perception issues associated with direct application of these insecticides near surface waters used as drinking water sources.

Discussion:

The above recommendations are made based on our evaluation of available information that we have compiled to date on sumithrin and malathion relative to potential impacts to public health via drinking water and to aquatic organisms. This information is summarized below.

1. Potential for Sumithrin Application to Impact Human Health via Drinking Water

An evaluation of potential human health risks posed by sumithrin exposure through drinking water surface water sources sprayed during pesticide application was presented in Hutcheson (2005). The memo concluded that any human exposure via drinking water to sumithrin aerially deposited to surface water during spraying would not pose a public health threat since concentrations would be well below any concentrations of toxicological and public health concern. This conclusion assumes that aerial spraying takes place in accordance with specified operational plans and that application rates do not exceed the application rate for the product provided to us for our evaluation.

> **Carcinogenicity** - Since the Hutcheson (2005) memo was written, the U.S. Environmental Protection Agency (EPA) Cancer Assessment Review Committee has designated resmethrin (another pyrethroid insecticide, having a similar mechanism of action as sumithrin) "likely to be carcinogenic to humans". There has been some suggestive evidence of an increased incidence of liver tumors in rodents as well as a potential for sumithrin to increase expression of a gene involved in the proliferation of mammary tissue leading to the development of breast cancer (Cox et al., 1987 as cited in WHO, 2002; SCDHS, 2005; Kasat et al., 2002 as cited in SCDHS, 2005; Cox, 2003). The EPA has not yet evaluated sumithrin for carcinogenicity and any information is still speculative. However, even if we assumed that sumithrin is also likely to be carcinogenic to humans, our calculations indicate that predicted concentrations of sumithrin in the field are not expected to exceed the recommended benchmark RfDs and drinking water levels determined for this chemical. The Department's policy with regard to developing a drinking water guideline for a possible carcinogen for which there is no quantitative potency information, is to apply an uncertainty factor of 10 to the drinking water guideline, thereby numerically reducing the value by 10. Given that ORS' evaluation indicated that drinking water guidance for sumithrin is several orders of magnitude greater than predicted field concentrations, an additional factor of 10 will not change the conclusion reached above that a public health or ecological threat would not be expected from an application of sumithrin at maximum application rates.

2. Potential for Malathion Application to Impact Human Health via Drinking Water

– Massachusetts conducted an aerial application of Malathion in the late summer of 1990. In conjunction with this application, ORS conducted an evaluation of potential human health and ecological risks posed as a result of exposure to Malathion. As presented in two memos (Hutcheson, 1990a; Hutcheson, 1990b), ORS concluded that drinking water should not be adversely affected by spraying conducted under the assumed spraying conditions. The evaluation concluded that after direct spraying (if that inadvertently were to have occurred) field concentrations of Malathion in surface waters should have been an order of magnitude lower than the drinking water guideline for Malathion. In practice, measured field concentrations of Malathion immediately after spraying using a 300-foot buffer in most lakes sampled agreed closely with predicted concentrations.

Assuming that spraying methodology and insecticide application rate of malathion are the same as those assumed for the 1990 application, potential future applications of malathion are also not expected to pose a public health threat from exposure to malathion in drinking water.

3. Potential for Sumithrin Application to Impact Non-Target Organisms – ORS has not conducted a formal evaluation of the potential for an aerial application of sumithrin to impact biota in the area of application. However, as indicated in Hutcheson and Manganaro (2005), our review of sumithrin has indicated that it has high non-target toxicity potential to aquatic life, particularly fish. The sumithrin product, Anvil 10+10, has a label warning against use directly on water or near surface water. In addition, sumithrin formulated products are typically mixed with the synergist piperonyl butoxide (PBO), which enhances toxicity by inhibiting metabolism of the insecticide. Thus, the potential for ecological effects resulting from an aerial sumithrin application cannot be ruled out should drift occur.

4. Potential for Malathion Application to Impact Non-target Organisms – An evaluation for potential ecological effects was also conducted for the 1990 Malathion application. This application conservatively assumed that Malathion would be deposited directly over a body of water. The evaluation concluded that, based on the estimated concentrations of malathion in surface water, toxicity to invertebrates (aquatic insects and crustaceans) would be likely under this scenario. In addition, while the evaluation found that most fish should not be affected by the surface water concentrations of Malathion that would result from an aerial application; there are several species that would likely be affected. In general, those species that inhabit shallow waters or that remain near the water's surface would most likely be exposed to the highest concentrations of Malathion and would thus be most adversely affected. In practice, there were a number of fish kills that occurred along flight paths shortly after Malathion application.

Again, assuming that spraying methodology and the insecticide application rate of malathion are the same as those used for the 1990 application, it can be concluded that the potential for ecological effects resulting from an aerial malathion application cannot be ruled out should drift occur.

References:

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Hutcheson, M. September 29, 2005. Evaluation of potential human health risks from sumithrin exposure through drinking water from surface water sources inadvertently sprayed during mosquito control operations. Memorandum to Dave Terry, DWP from Michael Hutcheson, ORS. Department of Environmental Protection. Office of Research and Standards. Boston, MA.

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Appendix 6: Honeybee Monitoring Protocol for Aerial Mosquito Adulticide Application

Introduction

Honey bees and other insect pollinators generally forage when temperatures are above 55-60 degrees Fahrenheit during daylight hours. Honey bees, bumble bees, and solitary bees do not forage at night or during very cool weather. Insecticides applied during the day at optimal temperatures inadvertently to melliferous (honey bearing) bloom will cause severe pollinator losses. Treatments made during the night and very early morning in the proximity of desirable flowering nectar and pollen sources are the safest for pollinators.

Mosquito Adulticide Applications and Honeybees

Mosquito adulticiding can progress from sun set to sunrise with little honey bee mortality because of honey bee flight inactivity and the short half-life of sumithrin. None-the-less, the Department of Agricultural Resources (DAR) will carryout the following protocol as a part of any SRMCB supervised aerial mosquito adulticide operation.

Protocol to Monitor Honeybees

In the event aerial adulticiding is necessary, DAR will monitor selected honeybee hives in proximity of proposed application areas to evaluate hive health prior to Anvil 10+10 ULV application for potential impacts on domestic bees. Approximately 10-15 hives will be inspected inside the spray area, and 10-15 will be inspected outside the spray area as a control group. Hives registered with DAR will be chosen at random. Contacts with the appropriate and area specific beekeeper associations (e.g. Bristol and Plymouth County Beekeepers Associations) have been made.

Pre-Spray Inspections

Pre-spray inspections will be made as close to the spray event as possible, although if time does not permit, DAR may rely on data from inspections made earlier in the season.

Post-Spray Inspections

Post-spray inspections will occur at two time periods to evaluate acute and delayed impacts on colonies. Post spray evaluations will occur at the following intervals:
Days 1-3 Post-Spray
Day’s 7-10 post

Reporting of Results

DAR will issue a report between 21 and 30 days after the spray operation ceases. This will be posted on the DAR website (http://www.mass.gov/agr/).

Appendix 7: Biomonitoring Plan: Pesticide-Related Impacts to Macroinvertebrates (Benthos) Following Aerial Application.

For purposes of monitoring the non-target effects of aerial insecticide application to control the mosquito vectors of EEEv and WNv, MassDEP's Division of Watershed Management (DWM) will sample lentic water bodies within the designated spray zone(s). The included waterbodies may be lake littoral zones, emergent vegetation areas of depressional wetlands, or the wet margins of streams where there is emergent vegetation and unidirectional flow is not evident. The following protocol is intended to detect acute reductions in the richness and impairment of ecological integrity of the aquatic macroinvertebrate community.

Sample Procedure

Sample collections will be made within days of the announced date for aerial spraying and again after aerial spraying to provide a basis for before/after comparisons (Before-After-Control-Impact or BACI). Samples will be collected by sweeping with a kick-net in areas of less than 1 m depth. Two to three sweeps will be performed by reaching forward approximately 1 m and vigorously pulling the net through the vegetation and water column toward the sampler's body while bouncing the net along the sediment surface without penetrating it. The contents of the net will be emptied into a basin or deep tray along with a small amount of water. This procedure will be completed at three to five points within the waterbody.

Sample Processing

Macroinvertebrates will be extracted from the sample while on-site. Picking through the sample will continue until no new taxa are being detected provided the sample has been searched for a minimum of 30 minutes. The taxa present will be recorded and vouchers will be placed in labeled vials and preserved in 70% EtOH. The frequency a taxon is encountered in the sample will be characterized as "rare," "common," or "hyperabundant." Voucher specimens will be brought back to the lab for examination under a microscope to verify the taxonomic determinations made in the field.

Results and Reporting

Taxa lists generated from the collections will be compared between pre- and post-spray events using statistical analysis of the BACI results. The before and after pairs will be examined for changes in taxonomic make up as well as changes in trophic relationships. The conditions that will be regarded as indicative of serious impacts if absent in the control waterbodies are:

1. A reduction in richness of 20% or greater;
2. A reduction in a population sufficient to change its status from "hyperabundant" or "common" to "rare";
3. Loss of the top invertebrate predator;
4. A significant change in the proportions of the various functional feeding groups.

If none of these conditions is met the macroinvertebrate community in the waterbody will be considered to have “no acute response” to the aerial insecticide application.

Water Chemistry

In addition to the benthos sampling, a water quality grab sample will be collected by DEP Regional or DAR staff the morning after an aerial spray event from all biomonitoring stations in the spray area. DEP/DAR staff will also collect surface water quality samples from up to six additional stations within the spray zone. These surface water samples will be collected in acid-washed, 1L brown, Teflon capped, wide-mouth glass bottles, kept on ice and transported to DEP Regional office for shipment to UMASS PAL. The surface water samples will be analyzed for both pesticides and PBO by UMASS PAL. The results of this analysis will provide useful information for discussing the biological monitoring results and putting these results in perspective.

BIOMONITORING PLAN SUMMARY

1) DWM personnel will conduct reconnaissance within and near the expected spray path to identify potential study sites and control sites; aquatic macroinvertebrate samples will be collected prior to commencement of aerial spraying and again at least one week after the completion of spray operations.

2) DWM personnel will use the results to assess impacts from the aerial spray application on the aquatic macroinvertebrate communities.

3) DWM personnel will collect pre and post application sediment samples from the macroinvertebrate sampling sites.

4) DEP Regional or DAR personnel will collect water samples at the selected benthos monitoring sites, coordinated with sampling in water supplies; all water samples to be delivered to the coordinator of the water-sampling program (water supplies).

Nuzzo, R.M. 2003. Standard operating procedures: Water quality monitoring in streams using aquatic macroinvertebrates. Massachusetts Department of Environmental Protection, Division of Watershed Management. Worcester, MA. 36 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: Benthic macroinvertebrates and fish. U.S. Environmental Protection Agency. Washington, D.C. EPA/444/4-89-001. 162 pp.

Appendix 8: Water Supply Monitoring Plan to Assess Potential Impact of Mosquito Control Spraying During Any Public Health Emergency to Drinking Water

INTRODUCTION

In the event of a public health emergency as determined or declared by the Department of Public Health (MDPH) regarding mosquito-borne disease potential, the area(s) identified by MDPH for coordinated mosquito control efforts under the direction of the State Reclamation and Mosquito Control Board will be sampled to assess potential impact. The following protocol will be utilized to insure successful operational outcomes and avoidance of environmental impacts.

Coordination Of Water Supply Monitoring Will Involve The Following Programs And Staff:

AGENCIES: Department of Environmental Protection (DEP)
- Bureau of Resource Protection (BRP)
- Drinking Water Program (DWP)
- Division of Watershed Management (DWM)
- Northeast Regional Office (NERO)
- Southeast Regional Office (SERO)
- Central Regional Office (CERO)
- Western Regional Office (WERO)

Department of Agricultural Resources (DAR)
State Reclamation and Mosquito Control Board (SRMCB)
Massachusetts Pesticide Analytical Laboratory (MPAL)
Division of Fisheries and Wildlife (DFW)

STAFF:	Gary Gonyea, BRP	617-556-1152
	David Terry, DWP Boston	617-292-5529
	Kathy Romero, DWP Boston	617-292-5727
	Richard Rondeau, DWP SERO	508-946-2816
	Jim Dillon, DWP NERO	617- 654-6622
	Marielle Stone, DWP CERO	508-767-2733
	Deirdre Cabral, DWP WERO	413-755-2148
	Robert Nuzzo, DWM	508-767-2809
	John Fiorentino, DWM	508- 767-2862
	Taryn LaScola, DAR Pesticide Bureau	617-828-3793
	Mike McClean, DAR Pesticide Bureau	617-828-3792
	Mark Buffone, SRMCB, DAR	617-626-1777
	Ray Putnam, MPAL	413-545-4369

DESIGN PROTOCOL FOR COLLECTION, STORAGE, AND TRANSPORT OF WATER SAMPLES:

Post spray water samples will be collected from: the raw water sample at the tap of the intake (prior to treatment) to the treatment/ distribution facility; and the finished water sample following all treatment/filtration steps and prior to the first consumer intake.

Public Water Systems will each collect two 1-liter water samples:

1) From both the raw and finished water taps twelve to twenty-four hours (12 to 24) before the spray operation;
2) From both the raw and finished water taps within three (3) hours of the end of the spray operation;
3) From both the raw and finished water taps eighteen to twenty-four hours (18 to 24) after the spray operation.

Comment: Both raw, untreated surface water and finished treated water samples will be collected and analyzed to assess the success of the water treatment facilities to remove residues.

DEP staff will:

1) Ensure acid-washed sample collection bottles (1L brown, Teflon capped *wide-mouth* glass bottles) are available in timely fashion to DWP Regional Office staff (via DEP courier delivery) for pickup/and or delivery to water systems, and for collection of surface water samples at benthos monitoring sites;

2) Contact water systems, coordinate distribution of sample collection bottles, and coordinate collection of water samples;

3) Ensure that ice chest(s) and ice/cold packs are available for use by each DEP Regional Office for transportation and storage of water samples;

4) Identify available staff from either the Pesticide Bureau (Boston Office) or DEP offices that will be responsible for water sample pickups from the DEP Regional Offices and delivering them to the Massachusetts Pesticide Analysis Laboratory (MPAL) at the University of Massachusetts (UMASS) Amherst, for analysis;

5) Will pickup ice chests at 11 A.M. for transport to UMASS each morning, if more than one day of spraying is planned. DAR staff may substitute;

Laboratory analyses of water samples will be conducted by UMASS MPAL using standard QA/QC procedures with analytical costs assessed to both DAR and DEP.

1) Samples will be analyzed using gas chromatography (GC) at a limit of detection of 0.1 ug/L (micrograms/liter) (parts per billion). The detection of the chemical with GC will be reconfirmed using GC/mass spectroscopy (GC/Mass Spec). If pyrethroid pesticide is used the samples will also be analyzed for PBO (Piperonyl butoxide) at a limit of detection of 0.1 ug/L (micrograms/liter) (parts per billion)

HEIRARCHY OF DECISION MAKING FOR SAMPLING, COLLECTION, STORAGE, AND TRANSPORTATION

1. Gary Gonyea (SRMCB; DEP Boston) contacts Glenn Haas and David Terry then Gary Gonyea calls:

   A. DEP Regional Offices and the DEP/DWM with information on what will be sprayed, along with the how, when and where. Gary Gonyea will also call DFW and DWM to alert fisheries biologists.

   B. Pesticide Enforcement personnel (DAR) prior to spraying to make sure both agencies have an adequate supply of sample bottles on hand or in case bottles need to be ordered; to have sample bottles shipped to SERO and/or NERO via DEP courier at the appropriate time.

   C. Pesticide Enforcement personnel (DAR) to work and coordinate with the DEP Regions for the collection and transport of sample bottles between the DEP Regions and the UMASS-Amherst Pesticide Analytical Laboratory.

2. Richard Rondeau & Michael Quink (DWP/SERO), James Dillon (DWP/NERO), Marielle Stone (DWP/CERO), and Deirdre Cabral (DWP/WERO):

   A. Establishes standardized sample identification for samples collected from the program (use DEP/DWP source IDs and, if available, established sample location IDs);

   B. Coordinates and educates water systems on the sampling, labeling and transportation procedures;

   C. Contacts all surface water systems at least a week prior to any spraying to have them pick up the bottles and to prepare them for collecting water samples.

   D. Informs water systems within two days of spraying to be ready to collect (1) two POST SPRAY samples: 0- 3 hours, and 18-24 hours. Pass along sample number scheme to DAR.

   E. Contacts the DAR Pesticide Bureau person or DEP staff responsible to make sure that sample are picked up each morning at 11 A.M. for transport to the Pesticide Lab at UMASS Amherst.

   F. Informs water systems on the standard way of filling out the chain of custody and bottle labels (Date/Time of Collection/location of sample/Name of Surface Water Source Water; PWS ID number).

   G. Identifies a central location for the ice chest and provides ice for storing sample bottles after they have been delivered to DEP.

   H. Contacts DAR, and the water systems about any matters related to the sample-bottle pickup and delivery logistics during pre and post spraying activities;

3. Mark Buffone (DAR) and Gary Gonyea (DEP/BRP) will:

   A. Make the necessary arrangements with the UMASS Pesticide Laboratory (MPAL) to provide the analytical testing with costs borne by participating agencies or paid from emergency funding.

   B. Provide the chain of custody paperwork for shipping all water samples;

   C. Ensure that MPAL performs the appropriate QA/QCs on the analytical results, including recovery results on spiked samples.

   D. Report the results of water analyses to SRMCB within 1 Business Day of reports received by DAR/DEP. **Note: Anticipated turnaround time for test results is three days.**

EPA APPROVED SAMPLING METHODOLOGY

Sample Collection, Preservation, and Handling

Grab Sample Bottle: One liter or 1 quart wide mouth, amber glass, fitted with a screw cap lined with Teflon. The bottle and cap liner must be acid-washed, rinsed with acetone or methylene chloride, and dried before use to minimize contamination.

Grab samples must be collected in glass containers, labeled, and kept on ice for transport to DEP Regional Office and MPAL.

Appendix 9: Certified Organic Farms List

FARM NAME	CITY
Allen Farms	Westport
Apex Orchards	Shelburne
Astarte Farm	Hadley
Atlas Farm	S. Deerfield
Bagdon Brothers Farm	Sunderland
Bay End Farm	Buzzards Bay
Bear Mountain Farm	Charlemont
Blue Heron Farm	Charlemont
Belkin Family Lookout Farm and Market	Natick
Blue Heron Organic Farm	Lincoln
Blue Heron Organic Farm	Charlemont
Butter Brook Farm	Acton
Cape Cod Organic Farm	Barnstable
Cape Farm Supply and Cranberry Co.	N. Harwich
Chamutka Farm	Whately
Chang Farm	Whately
Chase Hill Farm	Warwick
Collins Bog	Waquoit
Colrain Dairy Farm	Colrain
Couch Brook Farm	Bernardston
Crabapple Farm	Chesterfield
Cranberry Acres - Vineyard Open Land Foundation	Vineyard Haven
Cranberry Hill	Plymouth
Delta Organic Farm	Amherst
Enterprise Farm	South Deerfield
Eva's Garden	South Dartmouth
Farm School Apprentice Program at Maggie's Farm	Orange
Full Bloom Market Garden LLC	Whately
Golden Rule Farm	Plymouth
Goshen Hill Garlic Farm	Carlisle
Great Oak Farm	Berlin
Green Meadow Farm	S. Hamilton
Harvest Moon Organics	Southwick
Heaven's Harvest Farm	New Braintree
Heirloom Harvest CSA	Westborough
Holly Hill Farm	Cohasset
Hutchins Farm	Concord
Kelly Farm	Cummaquid
Kettle Pond Farm	Berkley
Lakeside Organic	Hadley
Left Field Farm	Middlefield
Lifeforce Growers	Waltham
Lindentree Farm	Lincoln
Long Plain Organics	Acushnet
Lucky Field Organics	New Bedford
Maiewski Farm	Whately
Many Hands Organic Farm	Barre
Maribett Farm/Colchester Neighborhood Farm	Kingston

Misty Brook Farm	Hardwick
Morning Sun Farm	Rehoboth
Nantucket Conservation Foundation, Inc.	Nantucket
Natick Community Organic Farm	Natick
New England Wild Edibles	Colrain
Old Friends Farm	Amherst
Old Frog Pond Farm	Harvard
Old Town Organics	Newbury
Orcranics	Buzzards Bay
Out of the Woods Farm	Hardwick
Plainville Farm	Hadley
Plato's Harvest	Middleboro
Pleasant Lake Farm LLC	Harwich
Prospect Hill Farm	Plympton
Raehurst Farm	Belchertown
Red Fire Farm	Granby
River Rock Farm	Westport
Riverland Farm	Sunderland
Robinson Farm	Hardwick
Russell's Garden Center	Wayland
Savory Farm	Plymouth
Serving Ourselves Farm	Boston
Shaw Farm Dairy	Dracut
Sidehill Farm	Ashfield
Silferleaf Farm	Concord
Silverbrook Farm	Dartmouth
Simple Gifts Farm	Belchertown
Sloan Farm	Orleans
Spencer Brook Farm	Concord
Squanit Bog	E. Freetown
Standish Farms	Duxbury
Stannard Farms	Vineyard Haven
Stillman Farm	New Braintree
Sweet Earth Farm	Belchertown
Sweet Water Farm	Pertersham
The Clover Path Garden	Acushnet
The Farm	Winchester
The HERB FARMacy	Salisbury
Tripp Farm	Westport
Upinngil	Gill
Web of Life Farm	Carver
West Branch Farm Products	Chester
Wise Acre Farm	Sunderland
Wolfe Springs Farm	Sheffield

Appendix 10: Commercial Freshwater Fish Farm List

FIRSTNAME	LASTNAME	ORGANIZATION	COUNTY	CITY	DISTRICT
PETER A.	UHLMAN	Owner	PLYMOUTH	BRIDGEWATER	SE
BRADFORD	MORSE	DOUBLE M CRANBERRY	PLYMOUTH	ROCHESTER	SE
ROBERT J.	HANSON	HANSON FARM, INC.	PLYMOUTH	BRIDGEWATER	SE
WAYNE A.	MILLER	BLUE STREAM HATCHERY, INC.	CAPE	WEST BARNSTABLE	SE
GERALD G.	ANCTIL	Owner	BRISTOL	BERKLEY	SE
PATRICK	ZECCO	Owner	CENTRAL	NORTHBORO	CE
PHILLIP S.	CRONIN II	NOOK FARM FISHERIES	PLYMOUTH	PLYMOUTH	SE
ROBERT	LAHTI	Owner	CENTRAL	LUNENBURG	CE
ROBERT	MCGRATH	Owner	PLYMOUTH	CARVER	SE
WATIE	AKINS	ROBBINS TROUT FARM	PLYMOUTH	WAREHAM	SE
WILLIAM A.	CHOUINARD	SPRINGBORN SMITHERS LABS, INC.	PLYMOUTH	WAREHAM	SE
JOHN R.	NICKERSON	GILBERT TROUT HATCHERY	PLYMOUTH	PLYMOUTH	SE
RODMAN E.	NICKERSON	BREWSTER HATCHERY	PLYMOUTH	PLYMOUTH	SE
LELIO	MARINO	LOOKOUT FARM	CENTRAL	SOUTH NATICK	NE
EDWARDC	OSMUN, SR.	E & T FARMS, INC.	CAPE	WEST BARNSTABLE	SE

Appendix 11: Bee Keeper Association Notification Tree Contact List

County Association	**President**	**Secretary**
Barnstable	Marte Ayers	Claire Desilets
Bristol	Greg Boyd	Bill Russell
Essex	Pete Delaney	Candace Levy
Franklin	Dan Conlon	
Hampden	Jim Stefanik	Pam Rys
Hampshire	No President	Dan Conlon
Middlesex	Rick Reault	
Norfolk	Ray Hennessey	Tony Lulek
No Berkshire	Tom Stefanik	
Plymouth	Chuck Marchewka	
Worcester	Bob DeBoer	
Massachusetts Beekeeper Association	Dan Conlon	Paul Desilets

Appendix 12: Contacts for Conducting Control of Adult Mosquitoes (Vector Species)

Contact Aerial Applicator Service (Dynamic Aviation Group, Inc.)
The decision to conduct an aerial spraying operation will trigger the immediate contacting of the aerial applicator, Dynamic Aviation, to implement emergency and/or area-wide vector control services for the purpose of preventing significant human risk or expansion of disease to other areas. The decision will be based upon thresholds or risk factors outlined in the 2007 State Surveillance and Response Plan and recommendations by the Mosquito Advisory Group (MAG).

Dynamic Aviation has the capacity to meet the needs of any aerial intervention recommended whether it is smaller targeted acreage at a minimum of 5,000 acres or larger wide-area adulticide treatments upwards to 500,000 acres. The SRMCB has renewed the approved state contract with Dynamic Aviation with options to renew this contract through May 31, 2016.

Dynamic Aviation will employ twin-engine turbine aircraft - King Air-65-A90 - that typically fly at an altitude of 300 feet at a speed of 170 mph carrying 90 gallons of the approved product of choice, Anvil 10+10 (sumithrin) delivering a swath width of 750 –1,000 feet. These aircraft are configured for nighttime operation, and applications will take place in the late evening – early nighttime hours when most mosquito species are active and treatment efficacy will be enhanced (see Appendix 4).

Contact by SRMCB will begin deployment and mobilization of aircraft including determining how many aircraft would be required, when the aircraft will arrive, and when operations will commence and be completed. Aerial adulticiding may take one or more evenings depending on weather conditions, the number of acres needing treatment, the number of aircraft, and an approved multi-hour spray window (i.e. approximately sunset through shortly after sunrise) to treat large spray blocks. If weather is not acceptable or deteriorates after the spraying has begun or should the blocks be small or scattered due to exclusions, or if a 6-hour spray window (minimum) is not available, applications will take more than one evening to complete the operation.

Contact Insecticide Contractor (Clarke Mosquito Control Products, Inc.)
The decision to conduct an aerial spraying operation also will trigger the immediate SRMCB contacting of the company approved on the current state contract for mosquito control insecticide, renewed recently to insure the delivery of insecticides for emergency wide-area adulticide operations. The product of choice for any operational response will be Anvil 10+10 distributed by Clarke Mosquito Control Products, Inc.

Identification and Pre-designation of Base of Operations for Various Locations
Base of Operations have been cleared with the following airports and established for aerial application treatments. These bases of operation are located in Essex, Norfolk, and Plymouth counties where EEE infection has historically occurred.

If aerial adulticiding operations are necessary in Essex County, the SRMCB through its regional mosquito control district (Northeast Mosquito Management and Wetlands District) has pre-designated the Lawrence Airport as a base of operation. A Memorandum of Understanding is being developed for both these airports addressing the specific needs and requirements of the Northeast Mosquito Control District and the Airport. The SRMCB would contact both the Director of the Northeast Mosquito Control District and the Airport Managers depending on suitability of location of operation.

The only functioning airport in Norfolk County is the Norfolk Municipal Airport and if needed, the SRMCB would contact the Airport Manager.

The SRMCB has identified through Norfolk County Mosquito Control Project several sites that can be used for landing zones for helicopters that are town owned, mostly old dumps, which can be utilized if necessary (See Appendix 4).

If aerial adulticiding operations are necessary in Plymouth County, the SRMCB through its regional mosquito control district (Plymouth County Mosquito Control Project) has pre-designated the Plymouth Airport as a base of operation. The Plymouth County Mosquito Control Project Headquarters would be used for equipment and insecticide delivery.

Appendix 13: 2008 Mosquito Advisory Group (MAG) Members

The five-member Mosquito and Mosquito-Borne Disease Advisory Group are comprised of the following independent experts:

1. Dr. Asim Ahmed specializing in Pediatric Infectious Disease at Children's Hospital-Boston

Asim A. Ahmed, MD
Division of Pediatric Infectious Diseases
Children's Hospital Boston
Department of Microbiology and Molecular Genetics
Harvard Medical School

2. Mr. Jere Downing, Executive Director of the Cranberry Institute who has exceptional experience in mosquito control and arbovirus issues;

Jere Downing, Executive Director
Cranberry Institute
3203-B Cranberry Highway
East Wareham, Massachusetts 02538

3. Dr. Anthony Kiszewski an epidemiologist at Bentley College;

Anthony (Tony) Kiszewski
Department of Natural and Applied Sciences
Bentley College
175 Forest Street
Waltham, MA 02452

4. Mr. James Leach, Research Scientist for the New York State Health Department, Bureau of Toxic Substance Assessment

James Leach, Research Scientist IV
New York State Department of Health
Bureau of Toxic Substance Assessment
Flanigan Square, 547 River Street, Room 330
Troy, NY 12180-2216

5. Dr. Richard Pollack who is a research associate in the Department of Immunology and Infectious Disease at the Harvard School of Public Health.

Richard Pollack
Research Associate
Department of Immunology and Infectious Diseases
Harvard School of Public Health
665 Huntington Avenue
Boston MA 02115

Appendix 14: 2008 Massachusetts Arbovirus Surveillance and Response Plan [1]

Massachusetts Department of Public Health

Mary Gilchrist, Ph.D.
Director, William A. Hinton State Laboratory Institute
Massachusetts Department of Public Health

Alfred DeMaria, M.D.
State Epidemiologist
Massachusetts Department of Public Health

Executive Summary

The 2008 MDPH Massachusetts Arbovirus Surveillance and Response plan provides surveillance and phased response guidance for both West Nile virus (WNV) and eastern equine encephalitis virus (EEE). The year 2007 was witness to continued West Nile virus activity across the state. In the past five years there have thirty-four cases of WNV infection reported in Massachusetts and thirteen human cases of EEE resulting in six deaths. This plan reflects a comprehensive review of surveillance activities, mosquito control efforts, public information and risk communication related to arbovirus control in Massachusetts.

The purpose of the plan is to provide guidance on operational aspects of surveillance and response by state and local agencies responsible for the prevention of mosquito-borne disease in the 2008 season. The Department of Public Health will continue to seek advice from its partners and collaborators and modify the plan, as appropriate. This document is open to continual review and evaluation. Information is provided to guide planning and actions to reduce the risk of human disease from EEE virus and WNV.

Key objectives contained in this plan provide for:

- the monitoring of trends in EEE virus and WNV activity in Massachusetts;
- the timely collection and dissemination of information on the distribution and intensity of WNV and EEE virus in the environment;
- the laboratory diagnosis of WNV and EEE cases in humans, horses and other mammals;
- the effective communication, advice and support of activities that may reduce risk of infection.

This document provides information about EEE and WNV disease and program goals, and specific guidelines for mosquito, avian, equine and human surveillance. Additionally, this document provides guidance for the dissemination of information, including routine information; media advisories of positive EEE virus and WNV findings in birds and mosquitoes, as well as public health alerts related to positive EEE and WNV human cases.

This plan describes MDPH's public outreach efforts to provide helpful and accurate communications to Massachusetts' citizens about their risk from arboviral diseases and specific actions that individuals and communities can take to reduce this risk.

Recommendations regarding the WNV phased response plan appear in Table 1 and incorporate components presented in the "Massachusetts Surveillance and Response Plan for Mosquito-Borne Disease", May 2004; as well as those presented in the Centers for Disease Control and Prevention (CDC) document, "Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance Prevention, and Control", 3rd Revision, 2003. Recommendations regarding the EEE virus phased response plan appear in Table 2 and incorporate information provided in the MDPH document, "Vector Control Plan to Prevent Eastern (Equine) Encephalitis", 1991, as well as analyses of additional surveillance data collected in Massachusetts since that time.

1 – Most recent DPH surveillance and response plan can be found at:
http://www.mass.gov/Eeohhs2/docs/dph/cdc/arbovirus/arbovirus_surveillance_plan.pdf

I. INTRODUCTION

The Massachusetts Department of Public Health (MDPH), in collaboration with regional mosquito control projects (MCPs), conducts surveillance for mosquito-borne viruses that pose a risk to human health. The Massachusetts Arbovirus Surveillance Program (MASP)

- tests mosquitoes, birds, veterinary specimens from horses and other mammals, and humans for evidence of infection; identifies areas of disease risk;
- provides information to guide decision-making to reduce the risk of disease;
- informs the public of where and when there is an increased risk of infection.

The MASP currently focuses on West Nile (WNV) and eastern equine encephalitis (EEE) viruses, which are found in the local environment and are capable of causing serious illness and death in human, horses and other mammals.

The 2008 Massachusetts Surveillance and Response Plan for mosquito-borne diseases is based on a comprehensive plan initially developed for WNV in 2001 in collaboration with local health agencies, other state agencies, academic institutions, the Centers for Disease Control and Prevention (CDC), and interested groups and individuals. It incorporates components of the state's EEE surveillance activities, which began in the 1950's and have continued since that time. The Massachusetts Arbovirus Surveillance Program (MASP) began monitoring for WNV following a 1999 outbreak of human WNV disease in the New York City area, the first known occurrence of this disease in North America. WNV was identified in birds and mosquitoes in Massachusetts during the summer of 2000 and has been found during each consecutive season.

The updated 2008 plan is the result of analyses of surveillance data collected in Massachusetts and the United States. In addition, in order to manage the complexity of the human disease risk posed by these viruses, MDPH convened four workgroups that advised MDPH and promoted collaborative efforts by multiple agencies and interest groups. The purpose of the plan is to provide guidance on operational aspects of surveillance and response by the state and local agencies with responsibilities for the prevention of mosquito-borne disease. MDPH will continue to seek advice from its partners and collaborators and modify the plan, as appropriate. This document is open to continual review and evaluation with changes made when there is opportunity for improvement.

II. **DISEASE BACKGROUND**

The two principal mosquito-borne viruses (also known as arboviruses, for **ar**thropod-**bo**rne viruses) recognized in Massachusetts and known to cause human and animal disease are eastern equine encephalitis virus with the first human cases identified in both the United States and Massachusetts in 1938, and West Nile virus, with the first human case identified in the United States in 1999, and in Massachusetts in 2001.

Eastern Equine Encephalitis Virus

Background

Eastern equine encephalitis is a serious disease with 30-50% mortality and lifelong neurological disability among many survivors, which occurs sporadically in Massachusetts. The first symptoms of EEE are fever (often 103º to106ºF), stiff neck, headache, and lack of energy. These symptoms show up three to ten days after a bite from an infected mosquito. Inflammation and swelling of the brain, called encephalitis, is the most dangerous and frequent serious complication. The disease gets worse quickly and some patients may go into coma within a week. There is no treatment for EEE. In Massachusetts, approximately half of the people identified with EEE have died from the infection. People who survive this disease will often be permanently disabled. Few people recover completely.

Historically, clusters of human cases have occurred in cycles lasting 2-3 years, with a hiatus of 10-20 years between outbreaks. In the years between outbreaks, isolated cases may occur. Outbreaks of human EEE disease in Massachusetts occurred in 1938-39 (35 cases, 25 deaths), 1955-56 (16 cases, 9 deaths), 1972-74 (6 cases, 4 deaths), 1982-84 (10 cases, 3 deaths), 1990-92 (4 cases, 1 death), 2004-06 (13 cases, 6 deaths).

Massachusetts Eastern Equine Encephalitis Experience		
Year(s)	Human EEE Cases	Human EEE Deaths
1938-39	35	25
1955-56	16	9
1972-74	6	4
1982-84	10	3
1990-92	4	1
2004-06	13	6

The Massachusetts Department of Public Health, with CDC funding, initiated a field surveillance program in 1957; following a 1955-56 outbreak of EEE. The purpose of the program was to gather data to guide prevention and risk reduction of this disease.

Risk Factors for Disease Transmission

Eastern equine encephalitis virus is an alphavirus enzootic in some passerine bird species found in fresh-water swamp habitats. The virus is transmitted among wild birds in these areas primarily by *Culiseta melanura*, a mosquito species that feeds predominantly on birds. This mosquito-borne virus has a cycle of natural infection among bird populations with occasional ‘‘incidental” symptomatic infections of humans, horses, llamas, alpacas, emus and ostriches. The prevalence of infection among birds is related to the prevalence in bird-feeding mosquitoes. When infections become more prevalent among birds, infection rates may also rise in mosquitoes that feed indiscriminately on birds and other animals. Thus, infection within these bridge vector mosquitoes seems to enhance the risk of infection to people.

Outbreaks involving two or more human infections associated temporally and spatially; occur with the convergence of several factors. A major factor that affects the risk of disease in humans is the prevalence of immunity to EEE virus in the birds that serve as the enzootic reservoir of the virus. EEE virus infection in passerine birds usually results in a mild infection. Following infection, birds become immune to the virus and will not harbor it. Following a year of increased viral transmission, the prevalence of EEE immunity in birds increases and in subsequent years, the virus may not be able to spread rapidly among these reservoir hosts due to the establishment of ‘herd immunity’. Thus, elevated levels of herd immunity in birds reduce the amplification of EEE virus in the bird-mosquito-bird cycle, which in turn reduces the chance of incidental infections in humans.

The risk of infection in humans is a function of exposure to infected human-biting mosquitoes. Certain kinds of mosquitoes are highly selective as to the kind of host they will seek and feed upon. *Culiseta melanura* (*Cs. melanura*) mosquitoes feed primarily on birds and are recognized as the predominant vector of EEE virus transmission between the passerine birds that are the reservoir of the virus. Thus, the intensity of enzootic EEE virus transmission correlates with the abundance of this enzootic vector. If the herd immunity level against EEE virus of these birds is high, (i.e. few susceptible birds) due to several years of prior exposure, then there is little opportunity for the virus to perpetuate or amplify within the bird population. When herd immunity is low and there are many susceptible birds; EEE virus infections can spread more rapidly and more widely among the birds. This condition may enhance the potential for transfer of EEE virus to humans by a ‘bridge vector’ mosquito, i.e., a species that is indiscriminant and will feed on birds or humans, such as *Coquillettidia perturbans, Ochlerotatus canadensis, Aedes vexans and Culex species.*

The risk of EEE virus infection in humans varies by geographical area in Massachusetts, as well as in the United States. EEE is more prevalent in areas that support dense populations of passerine birds and have favorable breeding conditions for the enzootic vector. In Massachusetts, these areas consist mainly of large wetlands containing mature white cedar and red maple swamps that are more common in southeastern Massachusetts. The majority of EEE cases have occurred in Norfolk, Bristol, and Plymouth counties with some cases also occurring in Middlesex County, rarely in Essex County and very rarely in Worcester County or further west. Historically, Cape Cod and the Islands of Martha's Vineyard and Nantucket have not had human cases of EEE.

Other major factors that affect the risk of EEE virus infections for humans are the abundance of specific kinds of mosquitoes at critical periods of the transmission season, groundwater levels and the timing of rainfall and flooding during the mosquito season. Participation in outdoor activities increases the risk of exposure while the use of personal protective measures (e.g., avoidance of mosquitoes, use of repellent) helps to reduce the risk of exposure.

Long-term weather patterns during the fall and winter that include high ground water levels and snow cover may enhance survival of *Cs. melanura* larval populations. The abundance of these larval populations may serve as an early indicator of the potential for human disease later in the year. Multiple factors affect the development, survival, and abundance of mosquitoes. It is not currently possible to predict either the abundance of mosquitoes or the risks of encountering an infected vector later in the season. The best control approach to reduce these vectors must consider multiple factors. One approach calls for beginning integrated pest management (IPM) control activities early in the season and targeting both the enzootic and human biting vector species.

West Nile Virus

Background

West Nile Virus (WNV) first appeared in the United States in 1999. Since its initial outbreak in New York City, the virus has spread across the US from East to West. WNV infection may be asymptomatic in some people, but it leads to morbidity and mortality in others. WNV causes sporadic disease of humans, and occasionally results in significant outbreaks. Nationally, over 3600 human cases of WNV neuroinvasive disease (West Nile meningitis and West Nile encephalitis) and WNV fever were reported to the CDC in 2007.

The majority of people who are infected with WNV (approximately 80%) will have no symptoms. A smaller number of people who become infected (~ 20%) will have symptoms such as fever, headache, body aches, nausea, vomiting, and sometimes swollen lymph glands. They may also develop a skin rash on the chest, stomach and back. Less than 1% of people infected with WNV will develop severe illness, including encephalitis or meningitis. The symptoms of severe illness can include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. Persons older than 50 years of age have a higher risk of developing severe illness. In Massachusetts, there were six fatal WNV human cases identified between 2001-2007, all in individuals eighty years of age or older.

Following the identification of WNV in birds and mosquitoes in Massachusetts during the summer of 2000, MDPH arranged meetings between local, state and federal officials, academicians and the public to develop recommendations to improve and strengthen key aspects of the state plan for mosquito-borne virus surveillance and prevention of mosquito-borne disease. Four workgroups addressed the issues of surveillance, risk reduction interventions, pesticide toxicity and communication.

Risk Factors for Disease Transmission
West Nile (WN) virus is amplified by a cycle of continuous transmission between mosquito vectors and bird reservoir hosts. Infectious mosquitoes carry virus particles and infect susceptible bird species. WNV infection is often fatal in some species of birds, particularly American crows and blue jays (corvids). Confirmation of WNV in dead birds provides sentinel information useful for assessing risk of human WNV infections.

The principal mosquito vector for West Nile virus on the East coast is the Culex species. These species may be abundant in urban areas, breeding easily in artificial containers such as birdbaths, discarded tires, buckets, clogged gutters, and other standing water sources. *Culex pipiens* feeds mainly on birds and occasionally on mammals. It will bite humans, typically from dusk into the evening. *Culex restuans* feeds almost primarily on birds but has been known to bite humans on occasion. Brackish and freshwater wetlands are the preferred habitat for *Culex salinarius* which feeds on birds, mammals, and amphibians and is well known for biting humans. *Ochlerotatus japonicus* may be involved in the transmission of both WNV and EEE virus. Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is a fierce human biter.

Activity of the West Nile virus zoonotic cycle varies from year to year. When a large number of infected birds and a high rate of infected mosquitoes are found in a relatively small geographic area, the risk of transmission of virus to humans will increase.

A summary of current and historical surveillance information for EEE virus and WNV in Massachusetts is available at **www.mass.gov/dph**.

III. PROGRAM GOALS

Timely and accurate information provided by the MDPH based on surveillance information can be used to provide an indication of the level of risk of human disease from WNV and EEE. Based on this surveillance information, plans and actions to reduce risk can be developed and implemented when needed.

Specific Program Priorities

1. Test mosquitoes, birds, horses, humans and other animals to identify EEE virus and WNV infections.
2. Track trends in incidence and prevalence of EEE virus and WNV infections by geographic area.
3. Estimate viral infection rates in birds and mosquitoes.
4. Stratify risk o geographic areas as a function of their relative risk of human disease.
5. Conduct surveillance for human and equine disease.
6. Educate human and animal medical practitioners on the appropriate procedures for detecting and identifying infections and disease caused by mosquito-borne viruses.
7. Recommend measures to reduce virus transmission and disease risk.
8. Provide information to the public on mosquito-borne diseases and disease risk, and on common-sense precautions to reduce the risk of infection.
9. Participate in the national Arbovirus surveillance network coordinated by the CDC.

Roles

1. Massachusetts Department of Public Health (MDPH)

The central purpose of the Massachusetts Arbovirus Surveillance Program (MASP) is to provide information that will guide planning and actions to reduce the risk of human disease from EEE virus and WNV. To achieve this, the main objectives are to monitor trends in EEE virus and WNV in Massachusetts; provide timely information on the distribution and intensity of WNV and EEE virus in the environment; perform laboratory diagnosis of WNV and EEE cases in humans, horses and other mammals; communicate effectively with officials and the public; provide guidelines, advice and support on activities that effectively reduce risk of disease; and provide information on the safety, anticipated benefits and potential adverse effects of proposed prevention interventions.

MDPH works cooperatively with the Massachusetts State Reclamation and Mosquito Control Board (SRMCB) and with regional mosquito control projects to identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles. The application of pesticides as a means to reduce human risk is one of several methods/strategies to attain this goal.

2. State Reclamation and Mosquito Control Board (SRMCB)

The State Reclamation and Mosquito Control Board (SRMCB) oversee mosquito control in the Commonwealth of Massachusetts. The SRMCB consists of three (3) members representing the Department of Agricultural Resources (DAR), Department of Conservation and Recreation (DCR), and Department of Environmental Protection (DEP). Additionally, the SRMCB advises its respective state agency Commissioners on actions to reduce mosquito populations based on MDPH findings and characterization of risk.

The SRMCB 'Operational Response Plan to Reduce the Risk of Mosquito-Borne Disease in Massachusetts' addresses the issues related to the operational aspect of adult mosquito surveillance and control to prevent and/or reduce the risk of mosquito-borne diseases.

In 2006, the SRMCB created an SRMCB Mosquito Advisory Group (MAG). The MAG provides independent scientific advice to the SRMCB to assist them in evaluating and assessing data from both DPH and mosquito control projects

3. Mosquito Control Projects (MCP)

There are nine (9) organized mosquito control projects or districts located throughout Massachusetts. All of the mosquito control activities of these organized agencies are performed under the aegis of the State Reclamation and Mosquito Control Board (SRMCB). Mosquito Control Projects collaborate with local boards of health in their jurisdictions to control mosquitoes. These locally authorized efforts employ a variety of targeted activities for source reduction, larviciding and adulticiding that are in compliance with the SRMCB Operational Response plan.

IV. SURVEILLANCE

A. Mosquito Surveillance for West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) Virus

Surveillance of mosquitoes for arboviruses is one of the core functions of the MASP. Monitoring mosquitoes for the presence of virus provides a direct estimate of risk to humans. Massachusetts has a long-term field surveillance program that was initiated in 1957 for EEE virus and was modified in 2000 to include WNV surveillance. The extensive experience in Massachusetts with surveillance for mosquito-borne disease provides expertise and capacity to guide risk reduction efforts. The MASP uses a comprehensive and flexible strategy that modifies certain surveillance activities in response to trends in disease risk.

On an ongoing basis, MASP will continue to monitor national and regional surveillance data and current scientific literature to assess risk of newly emerging arboviruses in Massachusetts. In addition, defined subsets of mosquito pools will be evaluated by MDPH for the presence of new or emerging viruses

1. Fixed and Long-Term Trap Sites: MASP will collect mosquitoes from areas with activity during the previous year, and from long-term trap sites maintained in the EEE virus high-risk areas of southeastern and eastern Massachusetts (Figure 1). Trapping of gravid mosquitoes for testing of WNV is conducted both by mosquito control projects and MDPH staff at various locations throughout the state during the arbovirus season. At the State Laboratory Institute (SLI), samples (pools of 1- 50 specimens) of trapped mosquito collections are assayed for WNV and EEE virus. Test results from routine mosquito collections are available within 24-48 hours. Fixed and long-term trap sites provide the best available baseline information for detecting trends in mosquito abundance and virus prevalence and for estimating the relative risk of human infection from EEE virus and WNV. MDPH will monitor larvae from select sites in late fall and early spring to determine end-season and pre-season larval abundance. Monitoring of larval abundance from these sites will continue on a weekly basis during the arbovirus season.

2. Supplemental Trap Sites: When EEE virus or WNV activity, or increased WNV bird deaths, are detected in an area, additional trap sites and/or trap types will be used to obtain more information regarding the intensity of virus activity in mosquitoes. The following risk indicators may result in the implementation of more intensive mosquito trapping: 1) virus isolations in mosquitoes; 2) increasing or significant numbers of bird deaths associated with WNV; 3) emergence of large numbers of human-biting mosquitoes in an area with a high rate of virus activity and 4) human or equine cases

3. Mosquito Control Project Trap Sites: Massachusetts mosquito control projects (MCP's), are organized under the State Reclamation and Mosquito Control Board (SRMCB), located within Department of Agricultural Resources. The SRMCB is composed of three members; representing the Department of Agricultural Resources; the Department of Environmental Protection; and the Department of Conservation and Recreation. MCP's and the SRMCB communicate collaboratively with the MASP. The mosquito control projects employ comprehensive, integrated mosquito management (IMM) programs based on integrated pest management (IPM) principles.

The IMM program uses a variety of available control strategies to impact mosquito abundance. Monitoring mosquito abundance is accomplished through various surveillance methods including but not limited to larval dip counts, the use of light/ CO_2 baited traps and gravid traps.

B. Avian Surveillance: West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEE virus)

1. Dead Bird Reports: Because WNV causes death in certain species of birds, and the mortality rate from infection for the American crow is high, we expect that dead birds may be the first warning of WNV activity in an area. The association between corvid deaths and WNV activity is well established. The MASP tracks dead bird reports provided by local and state officials, and from the public. MASP will request that crows and blue jays, representing the species most likely to experience mortality due to WNV, be submitted for testing, and will provide a pickup service for designated regional repositories to assist local communities in the transport of specimens to MDPH. Most kinds of birds that are infected with EEE virus survive the viremia, making dead bird EEE virus monitoring impractical. Thus, MASP does not utilize dead bird reports for EEE virus monitoring.

MASP will record and analyze dead bird reports, which will be used to identify areas for intensified surveillance of WNV activity including bird testing, and mosquito trapping. Reports of dead birds are taken via a toll-free telephone number at MDPH (866 MASS WNV, or 866-627-7968), which may be used by local officials and the public. At the time of the report, information on the location and type of bird will be collected and entered into a surveillance database. The caller will be informed if the reported bird is to be tested, and arrangements will make for pickup and delivery if needed. Otherwise the caller will be informed of proper disposal procedures for the dead bird.

These reports are summarized daily and provided to local health agents, the public and the media via a public website (**www.mass.gov/dp**h.)

2. Laboratory Testing of Dead Wild Birds for West Nile Virus (WNV) and Eastern Equine Encephalitis Virus (EEE virus): The MASP will collect and test dead birds, primarily crows and blue jays, for WNV. Routine testing is generally completed within 24-48 hours. Confirmatory testing, when necessary, may take approximately four working days**.** After WNV infection of a bird population has been established by confirmation of two WNV avian specimens within a focal area, further routine bird testing will discontinued in that area. Boston and areas defined as 'Boston neighborhoods' are considered to be one geographic focal area. Therefore, avian testing will continue until two positives are identified within this focal area. Following the finding of two WNV specimens, and in the presence of continued bird deaths, a limited sample of dead birds may be tested to confirm that additional bird deaths are the result of WNV infection. In addition, ongoing evaluation of reports of dead birds may indicate the need for increased testing of birds and/or mosquitoes to better assess virus transmission among the bird and mosquito populations at particular times throughout the season.

Most birds that are infected with EEE virus generally survive the viremia, making dead bird EEE virus monitoring impractical. MASP does not conduct routine surveillance of EEE in birds for public health surveillance purposes because it does not provide additional information useful for determining levels of human risk. Testing of individual bird specimens for EEE infection will be determined on an as-needed basis as determined by the MDPH Public Health Veterinarian and the MASP. The MDPH Pubic Health Veterinarian will determine the appropriateness of testing specimens from dead bird clusters for both for WNV and EEE infections.

3. Laboratory Testing of Live Birds: The MASP may capture, bleed and release birds during the season to collect supplemental information about virus activity in an area where infections in birds are increasing.

C. Animal Surveillance: West Nile Virus (WNV) and Eastern Equine Encephalitis (EEE) Virus

Testing for WNV and EEE virus: Specimens from horses and other domestic animals that have severe neurological disease suspected of being caused by EEE virus or WNV infection are tested at SLI. Confirmatory testing, when necessary, may take up to nine working days. Massachusetts' veterinarians, the state Department of Agricultural Resources, USDA and Tufts University School of Veterinary Medicine collaborate with the MASP to identify and report suspect animal cases. In addition, blood samples from other sources such as zoos, horse stables or wild animals may be tested. Current information on WNV and EEE virus infections in horses along with clinical specimen submission procedures are disseminated to large animal veterinarians, stable owners, and other populations as needed, through mailings and postings on the MDPH Arbovirus website at www.mass.gov/dph. Many horses are immunized against infection with WNV and EEE virus with available veterinary vaccines. This is the primary means of preventing infection in horses.

D. Human Surveillance

1. Passive surveillance: Specimens from clinical cases of encephalitis and meningo-encephalitis are submitted to MDPH and screened for possible causes of infection, including WNV and EEE virus. Confirmatory testing, when necessary, may take three to seven working days. Selected cases of other human disease, such as aseptic meningitis, may be screened, if appropriate. Current information on WNV and EEE virus infections in humans along with clinical specimen submission procedures are disseminated to physicians (infectious disease, emergency medicine and primary care), emergency room directors and hospital infection control practitioners through mailings, broadcast faxes, and postings on the MDPH Arbovirus website at www.mass.gov/dph.

2. Active surveillance: If surveillance data indicate a high risk of human disease, active surveillance may be instituted in targeted areas. Active surveillance involves regularly contacting local health care facilities to communicate current surveillance information, prevention strategies and specimen submission procedures. HHAN (Health and Homeland Alert Network) alerts are sent to local boards of health upon confirmation of EEE virus or WNV virus in any specimen; health care facilities are advised of increased risk status and the corresponding need to send specimens to SLI for testing.

3. Pesticide related surveillance: Outreach on pesticide illness reporting will be coordinated by the MDPH Bureau of Environmental Health. In the event of an aerial pesticide application, active surveillance efforts will be implemented with emergency departments and intensified outreach efforts will be made to health care providers.

V. Prevention and Control

The MASP will provide information to guide planning and actions to reduce the risk of human disease from EEE virus and WNV. MDPH works to identify and support the use of risk reduction and disease prevention methods that are specific to the causes of disease; and supports planning and practices which incorporate the most appropriate prevention methods and appropriate use of pesticides.

Communication of Information

1. Routine Information:

Prior to the beginning of the Arbovirus season, general disease information and specimen submission procedures will be provided to local boards of health via electronic messages from the Massachusetts Health and Homeland Alert Network (HHAN). General information and fact sheets are posted on the MDPH Arbovirus website and available for Mosquito Control Projects, physicians, veterinarians, animal control officers, and other agencies.

2. Positive EEE Virus and WNV Findings in Mosquitoes, Birds, Horses (and other Veterinary Specimens), and Humans:

Laboratory confirmation of a human WNV or EEE case is immediately reported by telephone to the submitting physician, and Local Board of Health (LBOH) in the town where the case resides. If the LBOH cannot be reached via telephone in a timely manner, a severe level HHAN alert will be sent.

Laboratory confirmation of a horse (or other veterinary specimen) with WNV or EEE virus infection will be immediately reported by telephone to the submitting veterinarian, the Department of Agricultural Resources- Bureau of Animal Health, Biosecurity and Dairy Services and the LBOH. As with human cases, if the LBOH cannot be reached in a timely manner, a severe level HHAN alert will be sent.

Initial positive findings in birds (WNV) and mosquitoes (WNV and EEE) from a given town will be reported to the LBOH by telephone. Adjacent towns will be notified via a moderate level HHAN alert. Any additional positive findings in birds or mosquitoes will be reported simultaneously to the town and adjacent towns via a moderate level HHAN alert.

At the time of notification, MDPH will encourage local Boards of Health to share the information with other local agencies and high-risk populations in their community as appropriate. MDPH provides local Boards of Health with sample press releases for their use. Depending on the circumstances, MDPH may also issue a public health alert. In addition, weekly summaries of results from avian samples submitted and tested will be posted as News Items on the HHAN by town.

All laboratory confirmed results for WNV and EEE virus in humans, horses, other veterinary specimens, mosquitoes and birds are provided to the regional health department representative, mosquito control projects and members of the State Reclamation and Mosquito Control Board (SRMCB) once the LBOH has been notified.

After all appropriate individuals and agencies have been sent notification, positive surveillance findings are made available to the media and general public on the MDPH Arbovirus website at www.mass.gov/dph. This website, which also includes a variety of educational materials related to preventing mosquito-borne diseases, is updated on a daily basis throughout the Arbovirus season. Results are also reported to the CDC's Arbonet reporting system.

3. Public Health Alerts and Media Advisories: MDPH issues public health alerts through the media when surveillance information indicates an increased risk of human disease or if a significant surveillance event occurs (for example, the first arbovirus activity of the season). In general, alerts will include current surveillance information and emphasize prevention strategies. Alerts will be drafted in consultation with outside state and local agencies, as indicated.

VI. Recommendations for a Phased Response to EEE virus and WNV Surveillance Data

The recommendations provided here are based on current knowledge of risk and appropriateness of available interventions to reduce the risk for human disease. Multiple factors contribute to the risk of mosquito-transmitted human disease. Decisions on risk reduction measures should be made after consideration of all surveillance information for that area at that time.

Recommendations regarding the WNV phased response plan (Table 1) incorporate several components presented in the "Massachusetts Surveillance and Response Plan for Mosquito-Borne Disease", May 2004, as well as those presented in the CDC document, "Epidemic/Epizootic West Nile virus in the United States: Guidelines for Surveillance Prevention, and Control", 3rd Revision, 2003.

Recommendations regarding the EEE virus phased response plan (Table 2) incorporate information provided in the MDPH document, "Vector Control Plan to Prevent Eastern (Equine) Encephalitis", 1991, and results of analyses of additional surveillance data collected in Massachusetts since that time.

Public awareness of what can be done to reduce risk of infection is of utmost importance. The level of EEE virus and WNV activity may occasionally present a potential for increased virus transmission to humans. Typically, risk is expected to be relatively low, and the routine precautions taken by individuals may be sufficient to reduce opportunities for infection. These guidelines take into consideration the complexity of reducing risk of human disease from EEE virus and WNV infection and form a framework for decision-making.

2. Phased response

General guidelines are provided for an array of situations that are noted in the Surveillance and Response Plan Tables that follow. Specific situations must be evaluated individually and options discussed before final decisions on specific actions are made. The assessment of risk from mosquito-borne disease is complex and many factors modify specific risk factors. MDPH works with local public health agencies, mosquito control projects, and the SRMCB to develop the most appropriate prevention activities to reduce the risk of human disease. There is no single indicator that can provide a precise measure of risk, and no single action that can assure prevention of infection.

When recommending the use of mosquito larvicides or adulticide, MDPH works collaboratively with SRMCB and with regional mosquito control projects to identify and support the use of safe and effective mosquito control measures based on integrated pest management (IPM) principles.

A. MDPH Guidance:

The MDPH Arbovirus Program will determine human risk levels as outlined in the phased response tables of this plan. Risk levels are defined for focal areas. “Focal Areas” may incorporate multiple communities, towns or cities. Factors considered in the determination of human risk in a focal area include: mosquito habitat, prior isolations, human population densities, timing of recent isolations of virus in mosquitoes, the cyclical nature of human outbreaks (EEE), current and predicted weather and seasonal conditions needed to present risk of human disease.

If the risk of an outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB, MCP’s, and MAG to discuss the use of intensive mosquito control methods and determine whether measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of WNV or EEE human disease.

Once significant human risk has been identified in a focal area by MDPH, MDPH will coordinate with the SRMCB to determine the adulticide activities that should be considered and implemented in response. The SRMCB will provide recommendations on appropriate pesticide(s), extent, route and means of treatment, and the location of specific treatment areas.
Based on historical experience with EEE virus, MDPH has identified specific critical indicators for EEE virus and provides specific risk reduction and prevention guidance for seasons with an anticipated increased EEE risk.

3. Risk Reduction and Prevention Guidance for Seasons with Indicators of Increased EEE Risk:

a. MDPH may increase the number of public health alerts throughout the season to remind the public of the steps to take to reduce their risk of exposure to mosquitoes.

b. MCP’s may increase their source reduction activities to reduce mosquito-breeding habitats and to reduce adult mosquito abundance. This may include ground and aerial larviciding.

c. After sustained findings of positive mosquito isolates, if not already in progress, adult mosquito control efforts including targeted ground adulticiding operations should be considered. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations.

d. Other intensified efforts may be implemented following coordinated recommendations from MDPH and other agencies including DEP, MDAR, and DCR.

Table 1. Guidelines for Phased Response to WNV Surveillance Data

Risk Category	Probability of human outbreak	Definition of Risk Category for a Focal Area[2]	Recommended Response
1	Remote	All of the following conditions must be met: <u>Prior Year</u> No prior year WNV activity detected in the focal area. And <u>Current Year</u> No current surveillance findings indicating WNV activity in birds or mosquitoes in the focal area And No horse or human cases.	1. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., the elderly). 3. Routine avian surveillance activities: Dead bird reporting and recorded information via MDPH Public Health Information Line. 4. Assess mosquito populations, monitor larval and adult mosquito density. 5. Routine collection and testing of mosquitoes. 6. Initiate source reduction; use larvicides at specific sites identified by entomologic survey. In making a decision to use larvicide consider the abundance of *Culex* larvae, intensity of prior virus activity and weather. 7. Locally established, standard, adult mosquito control activities are implemented. No specific supplemental control efforts are recommended. 8. Passive human and horse surveillance. 9. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans.
2	Low	<u>Prior Year</u> Any WNV activity in birds or mosquitoes in the community or focal area Or Current Year Sporadic WNV activity in mosquitoes in the focal area. Sporadic activity is defined when 1-2 isolates are found within 1-2 weeks of routine	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. 2. Increase larval control and source reduction measures. 3. Public health alert sent out by MDPH in response to first WNV virus positive bird and mosquito pool detected during the season. The alert will summarize current surveillance information and emphasize

[2] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in determination of human risk in a focal area include mosquito habitat, prior isolations, human population densities, timing of current isolations of virus in mosquitoes, the cyclical and seasonal conditions needed to present risk of human disease

		collections; or, one WNV positive bird And No horse or human cases	personal prevention strategies. 4. Locally established standard adult mosquito control activities continue.
3	Moderate	**Prior Year** **Confirmation of one or more human or horse WNV cases; or sustained WNV activity in mosquitoes and/ or birds for 2 or more weeks.** Or Current year Sustained WNV activity for 2 or more weeks in birds* and /or mosquitoes (<15 mosquito isolates from routine collections) * Two confirmed WNV positive birds in a community or focal area And No horse or human WNV cases	Response as in category 2, plus: 1. Outreach and public health educational efforts are intensified including media alerts as needed. 2. If not already in progress, standard, locally established adult mosquito control efforts including targeted ground adulticiding operations should be considered against *Culex* mosquitoes and other potential vectors, as appropriate. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations. 3. Duly authorized local officials may request that DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 4. Supplemental mosquito trapping and testing may be performed in areas with positive WNV findings. 5. Local boards of health are contacted via phone or HHAN (Health and Homeland Alert Network) upon confirmation of WNV in any specimen. Advise health care facilities of increased risk status and corresponding needs to send specimens to SLI for testing.

4	High	Current Year Sustained or increasing WNV activity in mosquitoes with mosquito isolates $\geq$ 15 from routine collections in a community or focal area. Sustained elevated minimum infection rates for MDPH WNV trap sites And/or MDPH confirmation of WNV in a horse at any time And/or, MDPH confirmation of WNV in a human at any time	Response as in category 3, plus: 1. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing, using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, schools, etc.) and educate them on personal protection d. Advisory information on pesticides provided by MDPH Center for Environmental Health. e. Urge towns and schools to consider rescheduling outdoor events. 2. Intensify and expand active surveillance for human cases. 3. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito control. Town or city may request preemption of homeowner private property no-spray requests. 4. Local officials should evaluate all quantitative indicators including population density and time of year and may proceed with focal area aerial adulticiding. 5. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 6. MDPH will confer with local health officials, SRMCB and Mosquito Control Projects to determine if the risk of disease transmission threatens to cause multiple human cases and warrants classification as level 5.
5	Critical	Current Year More than 1 confirmed human case in a community or focal area Or More than 1 confirmed horse case in a community or focal area Multiple quantitative measures indicating critical risk of human infection (e.g. early season positive surveillance indicators, and sustained elevated field mosquito infection rates, and horse or mammal cases indicating escalating epizootic activity)	Response as in category 4, plus: 1. Continued highly intensified public outreach messages on personal protective measures. Frequent media updates and intensified community level education an outreach efforts. 2. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine if measures need to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide. Factors to be considered in making this decision

			include the cyclical, seasonal and biological conditions needed to present a continuing high risk of WNV human disease. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by making recommendations on: A. Appropriate pesticide B. Extent, route and means of treatment C. Targeted treatment areas 3. MDPH Center for Environmental Health (CEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences. 4. MDPH will designate high-risk areas where it has issued a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. If this becomes necessary, notification will be given to the public. 5. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 6. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt sample submission from all clinically suspect cases.

Table 2. Guidelines for Phased Response to EEE virus Surveillance Data

Risk Category	Probability of human outbreak	Definition of Risk Category for a Focal Area[3]	*Recommended Response*
1	Remote	All of the following conditions must be met: Prior Year No EEE virus activity detected in a community or focal area And Current Year Sporadic EEE virus activity in mosquitoes after August 1. Virus activity is considered to be sporadic when 1-2 isolates in *Cs. melanura* are found within 1-2 weeks of routine collections. And No animal or human EEE cases.	1. MDPH staff provides educational materials and clinical specimen submission protocols to targeted groups involved in Arbovirus surveillance, including, but not limited to, local boards of health, physicians, veterinarians, animal control officers, and stable owners. 2. Educational efforts directed to the general public on personal prevention steps and source reduction, particularly to those populations at higher risk for severe disease (e.g., the elderly). 3. Routine collection and testing of mosquitoes. 4. Assess mosquito populations, monitor larval and adult mosquito density. 5. Initiate source reduction; use larvicides at specific sites identified by entomologic survey and targeted at the likely amplifying bridge vector species. In making a decision to use larvicide consider the prevalence of Culiseta and bridge vector larvae, intensity of prior virus activity, and weather. 6. Locally established, standard, adult mosquito control activities are implemented. No specific supplemental control efforts are recommended. 7. Passive human and horse surveillance. 8. Emphasize the need for schools to comply with MA requirements for filing outdoor IPM plans.

[3] Focal Area- May incorporate multiple communities, towns or cities. Factors considered in the determination of human risk in a focal area include: mosquito habitat, prior isolations, human population densities, timing of current isolations of virus in mosquitoes, and the cyclical nature of human EEE outbreaks, current weather and seasonal conditions needed to present risk of human disease.

2	Low	<u>Prior Year</u> EEE virus activity in mosquitoes in the prior year in the focal area Or <u>Current Year</u> Sporadic EEE Cs. melanura mosquito activity in the community or focal area between July 1-July31. Virus activity is considered to be sporadic when 1-2 isolates in *Cs. melanura* are found within 1-2 weeks of routine collections And No animal or human cases.	Response as in category 1, plus: 1. Expand community outreach and public education programs, particularly among high-risk populations, focused on risk potential and personal protection, emphasizing source reduction. 2. Increase larval control and source reduction measures. 3. Locally established standard adult mosquito control activities continue 4. Public health alert sent out by MDPH in response to first EEE mosquito isolate detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies.
3	Moderate	**<u>Prior Year</u>** **Confirmation of one human EEE case in the community or focal area; or 1 or more EEE horse case(s); or sustained EEE virus activity in mosquitoes. Sustained activity' is defined as 2 or more positive isolations found for 2 or more weeks.** Or <u>Current year</u> No animal or human EEE cases in current year And Total EEEV isolates in *Cs. melanura* found after July 1 as a result of routine collections are between 10-15 in the community or focal area Or A single EEEV isolate from mosquitoes likely to bite humans (bridge vector species) Or A single EEEV isolate in mosquitoes of any species, prior to July 1.	Response as in category 2, plus: 1. Outreach and public health educational efforts are intensified including media alerts as needed. 2. If not already in progress, standard, locally established adult mosquito control efforts including targeted ground adulticiding operations should be considered. The decision to use ground-based adult mosquito control will depend on critical modifying variables including the time of year, mosquito population abundance and proximity of virus activity to at-risk populations. 3. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. 4. Supplemental mosquito trapping and testing in areas with positive EEEV findings. Notify all boards of health of positive findings. 5. Public health alert sent out by MDPH in response to first pool of EEE virus positive mammal-biting mosquitoes detected during the season. The alert will summarize current surveillance information and emphasize personal prevention strategies. 6. HHAN (Health and Homeland Alert Network) alerts or phone calls are provided to local boards of health upon confirmation of EEE virus in any specimen; advise health care facilities of increased risk status and corresponding needs to send specimens to SLI for testing.
4	High	<u>Current Year</u> Total EEEV mosquito isolates numbering more than 15 from routine collections with sustained or increasing activity in the community or focal	Response as in category 3, plus: 1. Intensify public education on personal protection measures including avoiding outdoor activity during peak mosquito hours, wearing appropriate clothing,

		area. Sustained elevated weekly mosquito minimum infection rates. Virus activity is considered to be sustained when isolates are found for 2 or more consecutive weeks. And/or Isolation of EEEV in more than 1 pool of bridge vector mosquitoes And/or Confirmation of EEE in an animal at any time And/or Confirmation of EEE in a human at any time	using repellents and source reduction. a. Utilize multimedia messages including public health alerts from MDPH, press releases from local boards of health, local newspaper articles, cable channel interviews, etc. b. Encourage local boards of health to actively seek out high-risk populations in their communities (nursing homes, schools, workers employed in outdoor occupations, etc.) and educate them on personal protection d. Advisory information on pesticides provided by MDPH Center for Environmental Health. e. Urge towns and schools to consider rescheduling outdoor events. 2. Intensify larviciding and/or adulticiding control measures where surveillance indicates human risk. Local, ground- based ULV applications of adulticide may be repeated as necessary to achieve adequate mosquito control. Town or city may request preemption of homeowner private property no-spray requests. 3. Active surveillance for human cases is intensified. Health care facilities are advised of increased risk status and corresponding needs to send specimens to SLI for testing. 4. Local officials should evaluate all quantitative indicators including population density and time of year and may proceed with focal area aerial adulticiding. 5. Duly authorized local officials may request that the DPH Commissioner issue a certification that pesticide application is necessary to protect public health in order to preempt homeowner private property no-spray requests. **6. MDPH will confer with local health officials, SRMCB and Mosquito Control Projects to determine if the risk of disease transmission threatens to cause multiple human cases and warrants classification as level 5.**
5	Critical	Current Year More than 1 confirmed human EEE case Or Multiple EEE animal cases Or Multiple quantitative measures indicating critical risk of human infection (e.g. early season positive surveillance indicators, and sustained high mosquito infection rates, and horse or mammal case indicating escalating epizootic activity)	Response as in category 4, plus: 1. Continued highly intensified public outreach messages on personal protective measures. Frequent media updates and intensified community level education an outreach efforts. 2. The MDPH Arbovirus Program will determine human risk levels as outlined in this plan. If risk of outbreak is widespread and covers multiple jurisdictions, MDPH will confer with local health agencies, SRMCB and Mosquito Control Projects to discuss the use of intensive mosquito control methods and determine the measures needed to be taken by the agencies to allow for and assure that the most appropriate mosquito control interventions are applied to reduce risk of human infection. These interventions may include state-funded aerial application of mosquito adulticide.

			Factors to be considered in making this decision include the cyclical, seasonal and biological conditions needed to present a continuing high risk of EEE human disease. Once critical human risk has been identified, the SRMCB will determine the adulticide activities that should be implemented in response to identified risk by making recommendations on: A. Appropriate pesticide B. Extent, route and means of treatment C. Targeted treatment areas 3. MDPH Center for Environmental Health (CEH) will initiate active surveillance via emergency departments and with health care provides only if aerial spraying commences. 4. MDPH will designate high-risk areas where individual no spray requests may be preempted by local and state officials based on this risk level. If this becomes necessary, notification will be given to the public. 5. MDPH recommends restriction of group outdoor activities, during peak mosquito activity hours, in areas of intensive virus activity. 6. MDPH will communicate with health care providers in the affected area regarding surveillance findings and encourage prompt sample submission from all clinically suspect cases.

Appendix 1: Mosquitoes Associated with Arboviral Activity in Massachusetts

Aedes vexans – Is a common nuisance mosquito. Temporary flooded areas such as woodland pools and natural depressions are the preferred larval habitat of this mosquito. It feeds on mammals and is a fierce human biter. This species is typically collected from May to October. *Ae vexans* is an epizootic vector of Eastern Equine Encephalitis (EEE) Virus.

Coquillettidia perturbans - Cattail marshes are the primary larval habitat of this mosquito. It feeds on both birds and mammals. It is a persistent human biter and one of the most common mosquitoes in Massachusetts. This species is typically collected from June to September. *Cq perturbans* is an epizootic vector of EEE Virus.

Culex pipiens – Artificial containers are the preferred larval habitat of this mosquito. It feeds mainly on birds and occasionally on mammals. It will bite humans, typically from dusk into the evening. This species is regularly collected from May to October but can be found year round as it readily overwinters in man-made structures. *Cx pipiens* has been implicated as a vector of West Nile Virus (WNV).

Culex restuans – Natural and artificial containers are the preferred larval habitat of this mosquito. It feeds almost primarily on birds but has been known to bite humans on occasion. This species is typically collected from May to October but can be found year round as it readily overwinters in man-made structures. *Cx restuans* has been implicated as a vector of WNV.

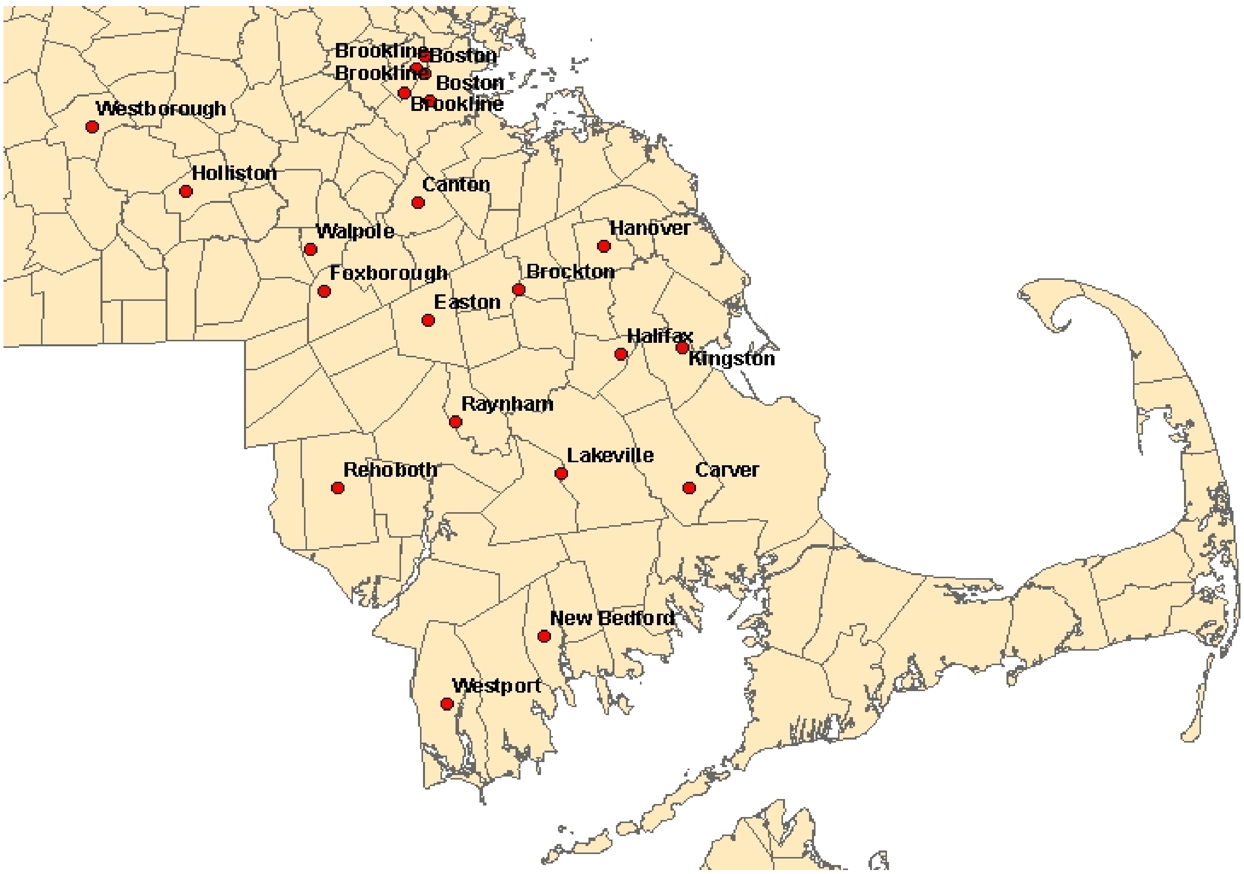
Culex salinarius – Brackish and freshwater wetlands are the preferred habitat of this mosquito. It feeds on birds, mammals, and amphibians and is well known for biting humans. This species is typically collected from May to October but can be found year round as it readily overwinters in natural and man-made structures. *Cx salinarius* may be involved in the transmission of both WNV and EEE virus.

Culiseta melanura –White Cedar and Red Maple swamps are the preferred larval habitat of this mosquito. It feeds almost exclusively on birds. This species is typically collected from May to October. *Cs melanura* is the primary enzootic vector of EEE virus.

Ochlerotatus canadensis – Shaded woodland pools are the preferred larval habitat of this mosquito. It feeds mainly on birds and mammals but is also known to take blood meals from amphibians and reptiles. This mosquito can be a fierce human biter near it larval habitat. This species is typically collected from May to October. *Oc canadensis* is an epizootic vector of EEE virus.

Ochlerotatus japonicus – Natural and artificial containers such as tires, catch basins, and rock pools are the preferred larval habitat of this mosquito. It feeds mainly on mammals and is a fierce human biter. This species is typically collected from May to October. *Oc japonicus* may be involved in the transmission of both WNV and EEE virus.

Figure 1: Location of MDPH EEE virus Mosquito Trap Sites



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TO: Commissioner Douglas P. Gillespie (DAR)
Commissioner Stephen Burrington (DCR)
Secretary and Commissioner Robert W. Golledge Jr. (EOEA and DEP)

FROM: State Reclamation and Mosquito Control Board (SRMCB)

DATE: August 18, 2006

RE: EEE AERIAL SPRAY

As outlined in the State Reclamation and Mosquito Control Board (SRMCB) Mosquito-Borne Disease Response Plan, the Board hereby submits a summary report regarding the aerial spray operation that took place on the evening of Tuesday, August 8th, commencing at 7:55 PM and ending on the morning of Wednesday, August 9, 2006 at 1:54 AM. This activity was performed in response to a declaration of Public Health Emergency by the Governor regarding an outbreak of mosquito-borne Eastern Equine Encephalitis virus (EEEv) in the region.

Calibration and characterization of the spray delivery apparatus took place on Monday, August 7th and was completed on the morning of Tuesday August 8th. Calibrations and characterization was conducted by Clarke Mosquito Control and Dynamic Aviation staff and overseen by Fran Krenick, National Technical Service Manager, of Clarke Mosquito Control in the presence of Gary Gonyea (a member of the SRMCB and representing the Massachusetts Department of Environmental Protection (DEP)), John Kenney of MDAR and former Chair of the SRMCB, and personnel from the Plymouth County Mosquito Control Project (PCMCP) and Northeastern Massachusetts Mosquito and Wetlands Management District (NMMWMD). The details and documentation of this procedure will be reported in a final post spray report.

The SRMCB and Department of Agricultural Resources (DAR) supervised the aerial spraying that covered an area approximately 140, 994.3 acres, as calculated by the navigational flight system of the aircraft. The area treated encompassed the municipalities of Middleboro, Lakeville, Carver, Kingston and Plympton, plus parts of the communities of New Bedford, Taunton, Raynham, Freetown, Duxbury, Halifax, Plymouth, Rochester and Acushnet (see map on page 6).

Two (2) -twin turbine Beechcraft King Air, Model A90 aircraft were deployed from Dynamic Aviation Company in Virginia. Based on the area treated and the rate of application 0.62 oz/acre (the maximum allowable amount permitted by the pesticide product label), the aircraft dispensed approximately 683 gallons of Anvil 10 +10 ULV EPA # 1021-1688-8329, (a Clarke Mosquito Control product) at a height of 300 feet above the ground and average airspeed of 172.5 mph and a swath width of the aerosol of 1,000 feet. Additionally, 32 gallons of Anvil 10 +10 ULV was used in the droplet size characterization equipment testing prior to the operation.

Weather conditions during the aerial application appeared optimal for Anvil 10+10 ULV. All weather parameters remained with in ranges compatible with the product label. Temperatures ranged from the low 70's at the beginning of the applications down to the low 60's at the end of the application. Wind was calm to light and variable during the application window. Dew points reflected dry conditions. These weather conditions also reflected conditions favorable to mosquito activity during the application window.

The results of the operation were remarkable. Mosquito populations in the treated areas were dramatically reduced, and overall risk to the general public was lessened. Bristol and Plymouth County Mosquito Control Projects staff reported large reductions in mosquito abundance in areas that had been so treated. Overall, Bristol and Plymouth Counties reported reductions of 82.8% and 85.5%, respectively, in mosquito abundance. These reductions included mosquitoes of species that are important as maintenance vectors of EEEv amongst birds and those that are aggressive human biters and suspected to be the bridge vectors of EEEv to people. In addition, the staff of the MDPH State Laboratories Institute reported overall reductions of 59.8 % with noted reductions of mosquito species of concern such as *Ae. vexans* and *Cq. perturbans.* The discrepancies and variability of the measured reductions are attributable to differing methods of analysis as well as confounding factors such as weather changes between pre and post collections, terrain, and mosquito species. More details of efficacy results can be found on page 4 and 5.

Fran Krenick (National Technical Service Manager for Clarke Mosquito Control) stated in part "Operationally … the bridge vector populations have been significantly reduced thereby reducing the potential for human involvement by a much greater margin. Dr. Roger Nasci of Centers for Disease Control and Prevention (CDC) stated that the risk for transmission and amplification has been greatly reduced. Overall, it looks like good reductions in all species."

After evaluation of trap collection data from Bristol and Plymouth County Mosquito Control Projects, and Massachusetts Department of Public Health (DPH) preliminary data on the Cs. melanura minimum infection rate (MIR) for the 4 trap sites located within the spray zone, Dr. Roger S. Nasci, Ph.D. Chief, Arboviral Diseases Branch Division of Vector-Borne Infectious Diseases National Center for Zoonotic, Vector-Borne and Enteric Diseases Centers for Disease Control and Prevention stated that the percent reduction of mosquitoes due to the application of Anvil 10+10 ULV in certain parts of Southeast Massachusetts was impressive.

Such an aerial application should result in decreased risk (i.e., the density of infected mosquitoes is reduced) and should impact amplification (i.e., fewer infected adult mosquitoes to infect birds and fewer uninfected adult mosquitoes to acquire virus and become infected/infectious). Since the risk of infection (for a bird, horse, or human) is directly related to the likelihood of being bitten by an infected/infectious mosquito, this equates to a meaningful reduction in the likelihood of that happening. Such reductions in risk seem to have been accomplished in the treated areas.

Significant impacts to the environment have not been observed as a result of the aerial application. Water sampling analysis by the Massachusetts Pesticide Analytical Laboratory (MPAL) indicate there were no detectable residues of d-phenothrin or sumithrin (pyrethroid active ingredient in Anvil 10+10) in surface water and drinking water supplies tested. The levels of the synergist Piperonyl Butoxide (PBO) were very low and were below the expected environmental concentrations (EEC) as estimated by the Environmental Protection Agency (EPA). The EPA has not established a maximum contaminant level or MCL for residues of PBO in drinking water. The levels found do not violate any federal law. Additionally, there have been no reported unintended effects regarding fish, birds, and or bees. However, no quantitative assessment was performed for these non-targets. Verbal reports from the Center for Environmental Health indicate only a few human illness reports (n=8) being investigated as a result of the aerial application. No objective findings have been reported of any alleged adverse effects to the environment to date. The details and documentation of this analysis will be reported in a final post spray report.

Operationally, the only significant problems of the aerial application of August 8th and 9th 2006 related to GIS mapping for areas to be treated and those to be excluded in the operation. The final maps that were sent from DPH to SRMCB/DAR staff, including the buffer zones, were not correct, and hence, the only buffer zone was the 400 ft buffer zone to the fish hatcheries. Finally, SRMCB/DAR did not receive the final maps until late Friday evening, when spraying was scheduled for Monday. One area designated as priority habitat and to be excluded from spraying appears to have been sprayed. A water body of similar size and shape adjoined the no-spray zone. The pilot assumed that there was mapping error. He apparently excluded the water body but sprayed part of the priority habitat.

One other important concern in terms of operational effectiveness is the fact that a number of locations or areas excluded from application overlap with, or were in very close proximity to, “hot spots” where EEEv has been currently and/or historically found. This occurred where Division of Fish and Game had excluded priority habitat areas, even though the Governor has signed a declaration of public health emergency. The SRMCB and DAR being responsible for controlling mosquitoes have significant concerns about the ability to reduce and/or prevent the risk of infection when such areas are excluded.

The above issues are being addressed in order to make the necessary refinements to improve the process and function of any future aerial applications. These refinements include but are not limited to better coordination and communication between all agencies responsible in developing mapping for aerial application such as exclusion areas. The objective being to ensure that the final maps be completed and reviewed by all agencies in a timely fashion before being sent to the aerial applicators. In addition, SRMCB/DAR will brief the pilot(s) prior to take off to further ensure that excluded areas will not be treated. Finally, it is imperative that a balance be struck between minimizing risks to endangered and threatened species of concern in priority habitat and reducing risk of infection to humans of EEEv. To accomplish this goal, it is critical that each of the agencies with interests in mosquito control and priority habitat must communicate effectively and cooperate to devise a balanced approach that protects human health and the environment. A unilateral decision by a single agency with a limited interest fails to protect public interests, especially in light of a declaration of a public health emergency.

Although the aerial application operation during August 8 and 9th of 2006 to fight EEEv is far more advanced technologically than in 1990 (the last time aerial application occurred over Southeast Massachusetts), the operation is still somewhat imprecise due to the scope and complexity of the project, meteorological variables, human pilots, and incredibly small droplet sizes. However, the operation is a standard practice in combating mosquito-borne diseases wherever they occur in the United States, and provides the most meaningful option that ultimately results in positive public health outcomes.

Aerial Intervention August 8-9, 2006 Efficacy Results

Reported by, Wayne Andrews, Superintendent
Bristol County Mosquito Control Project
Taunton, Massachusetts

Trapping results for 24-hour post-adulticide:

Outside Spray: Central Taunton, North Taunton, Dighton
Inside Spray: Freetown, New Bedford, East Taunton

Overall: 82.8%
Cq. perturbans: 87.1%
Oc. canadensis 72.0%
Cs. melanura 97.1%
Ae. vexans 77.2%

CDC traps with 200cc CO_2 per minute. Three traps in each area. The day before and the day after collection were used in the calculations.

****

Aerial Intervention August 8-9, 2006 Efficacy Results

Reported by: Ellen Bidlack, Entomologist
Plymouth County Mosquito Control Project

I am finally satisfied with my calculations for the efficacy of the aerial adulticing. I have used the same method for calculating the efficacy as Wayne Andrews did, so that you can compare results. Below you will find my calculations for those traps where the collection was made 24hrs post treatment. I had 4 traps in each area and I have attached a map so you can see where these traps were located.

Overall: 85.5% control
Cq. perturbans: 91.9% control
Oc. canadensis: no control
Cs. melanura: 79.2% control
Ae. vexans: 100% control
Culex (sp): 69.9% control

I am still working on the calculations for 48 and 72 hrs post treatment. These numbers don't look that great at least in part because I had two sites in the treatment where the numbers either stayed the same or increased where as all the controls decreased. On the map I have attached you will see the sites that will be used to calculate the 48 and 72 hr post treatment.

Some other things you should know:

1. I dropped from all calculations the trap sites that are located south of the treatment area. I did this because Fran Krenick recommended it. She said that the wind was blowing out of the north – west and that those sites may have been too close to the treatment area.
2. For the pre-treatment collections all but one collection (Old Center St, Middleboro) was made on the 5-6 Aug 06. Old Center St. had to be run twice and the collection used was made 7-8 Aug 06.

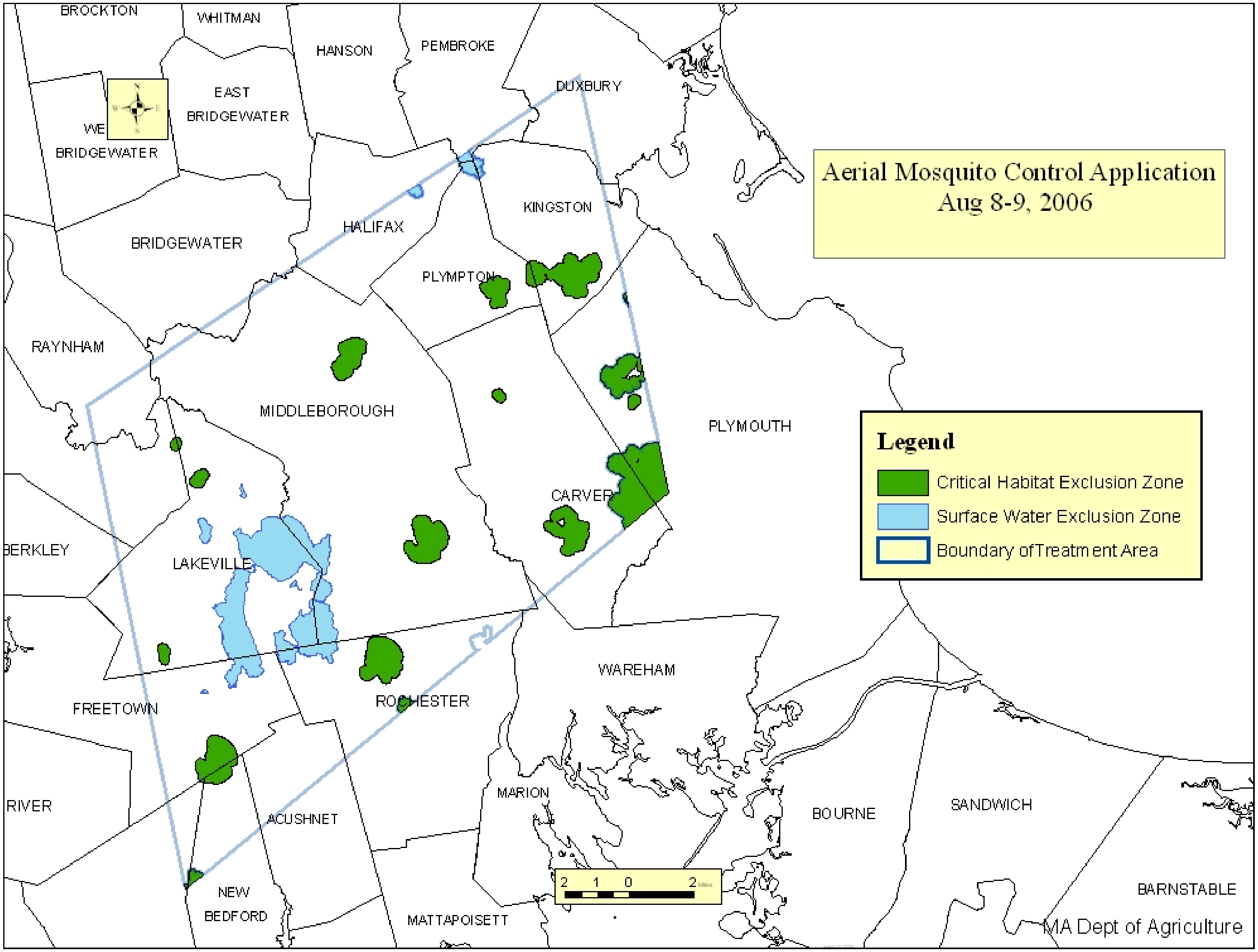
Please forward to anyone I you think I forgot.

****

<u>Aerial Intervention August 8-9, 2006 Efficacy Results</u>

Reported by Matthew Osborne
State Laboratories

Overall: 59.8% control
Cq. perturbans: 35% control
Oc. canadensis: no control
Cs. melanura: 70.1% control
Ae. vexans: 65.2% control


Aerial Mosquito Control Application
Aug 8-9, 2006
Legend
Critical Habitat Exclusion Zone
Surface Water Exclusion Zone
Boundary of Treatment Area
BROCKTON
WHITMAN
HANSON
PEMBROKE
DUXBURY
EAST
BRIDGEWATER
WE
BRIDGEWATER
BRIDGEWATER
HALIFAX
KINGSTON
PLYMPTON
RAYNHAM
MIDDLEBOROUGH
PLYMOUTH
CARVER
BERKLEY
LAKEVILLE
WAREHAM
FREETOWN
ROCHESTER
MARION
RIVER
ACUSHNET
BOURNE
SANDWICH
NEW
BEDFORD
MATTAPOISETT
BARNSTABLE
MA Dept of Agriculture
2 1 0 2

The Commonwealth of Massachusetts

Department of Food and Agriculture

State Reclamation and Mosquito Control Board

100 Cambridge Street, Boston 02202

J.Kenney DFA Chairman
G.Gonyea DEP
C.Burnham DEM

Margaret Havey, Secretary
617-727-3000 X 137

October 14, 1998

Enclosed is the "final" Generic Environmental Impact Report (GEIR) for the Massachusetts Mosquito Control Projects. The use of quotation marks around "final" denotes the Board's intention that there never will be an actual final version of this report. It is our goal to update this document on a yearly basis as new ideas and approaches to mosquito control become known, new pesticides or equipment come on the market or improved techniques are made available.

This GEIR will become a living document, which will change and improve over the years, rather than be a static report becoming outdated in a few short years. As these improvements come to the Board's attention, and are reviewed and found to be valid and useful, addendum will be issued in order to continually update the report.

Yours truly,

John Kenney
Chairman

TABLE OF CONTENTS

CERTIFICATE OF THE SECRETARY OF ENVIRONMENTAL AFFAIRS ON THE GENERIC ENVIRONMENTAL IMPACT REPORT

PROJECT NAME	Mosquito Control Program
PROJECT MUNICIPALITY	Statewide
PROJECT WATERSHED	Statewide
EOEA NUMBER	5027
PROJECT PROPONENT	State Reclamation & Mosquito Control Board

DATE NOTICED IN MONITOR: October 25, 1998

As the Secretary of Environmental Affairs, I hereby determine that the Generic Environmental Impact Report (EIR) submitted on this project adequately and properly complies with the Massachusetts Environmental Policy Act (M.G.L. c. 30, ss. 61- 62H) and with its implementing regulations (301 CMR 11.00).

On September 23, 1996 the Secretary of Environmental Affairs issued a Certificate on a Notice of Project Change filed by the State Reclamation and Mosquito Control Board (SRMCB) requiring that a Generic Environmental Impact Report (GEIR) be completed, for mosquito control in the Commonwealth. The Certificate contained an extremely detailed scope for the GEIR, developed in coordination with SRMCB. This GEIR, by responding to all of the items in that scope, provides an extremely useful summary of' current data, practices, and standards for mosquito control statewide. In particular, the GEIR establishes that Open Marsh Water Management (OMWM) shall serve as the preferred practice for physical controls in salt marshes. The GEIR also highlights certain areas in which further research will be necessary, and it.

1 - The State Reclamation and Mosquito. Control Board (SRMCB) is comprised of one representative each from the Departments of Environmental Management, Environmental Protection and Food and Agriculture proposes a system of annual updates, offering continued opportunities for review and comment on new information and proposals.

<u>Introduction</u>

The SRMCB oversees nine organized mosquito control projects (Berkshire County, Bristol County, Cape Cod, Central Massachusetts, East Middlesex County' Norfolk County, Plymouth County, Suffolk County and the North East Massachusetts Mosquito Control and Wetlands Management District) and appoints the Board of Commissioners for each project. These mosquito control projects have a total of 157 participating communities, primarily coastal. Thus, the focus of the GEIR and this Certificate are primarily upon salt marshes and their attendant pest mosquito problems. The remaining nonparticipating communities, mostly located in the central portion of the state practice no mosquito control, hire private contractors or have their own community-based mosquito control operations (e.g., the local public works department or health board).

The intent of the GEIR was to gather, in single document information on methods of mosquito control and eradication in Massachusetts, and the environmental impacts of those methods. The GEIR has accomplished the goal of disseminating information on current mosquito control practices, and it has established the basis for viewing OMWM as the preferred control technique in salt-water marshes.

Comments received from the Department of Environmental Protection (DEP) and the Division of Fisheries and Wildlife (DF&W), in particular, will provide a good basis for future GEIR updates.

However, the GEIR falls short of the ambitious goal of providing the basis for all future mosquito control projects implemented by the County Mosquito Control Projects. The SRMCB and, the GEIR acknowledge that additional study and research work is necessary to truly document ~he effectiveness of mosquito control techniques and their impact on the environment, particularly as they relate to freshwater projects. The report concludes that it will take a renewed and concerted effort, involving additional resources, to complete a mosquito control program "master guidance document" that best serves the public and protects the environment. To that end, the SRMCB plans to update the GEIR on a yearly basis as new ideas and approaches to mosquito control become known.

Saltwater Marsh Regulation Issues and MEPA

Established mosquito control projects are generally exempt from the Massachusetts Wetlands Protection Act (MWPA). However, Section 401 *of* the Federal Clean Water Act requires applicants wishing to discharge dredged *of* fill materials to obtain a certification or waiver from their state water pollution control agency. A Section 401 water quality certification is treated as a state permit for the purposes of establishing MEPA jurisdiction. Therefore, for projects involving new ditching such as that required for Open Marsh Water Management (OMWM), the MC proponent has been obliged to file an Environmental Notification Form (ENF) for, projects affecting at least 1,000 square feet of salt marsh or 5,600-sf- *of* bordering-vegetated wetlands (BVW). The MEPA regulations require the filing *of* an Environmental Impact Report (EIR) for any particular work site that might require the alteration of one or more acres of salt marsh or BVW.

In November 1995 the then-Essex County Mosquito Control Project (now the Northeast Massachusetts Mosquito Control and Wetlands Management District) filed an ENF requesting a waiver from the EIR requirement- (EOEA #10567). Based on a number *of* "findings and conditions" discussed below, a waiver from the EIR requirement was granted in February 1996. The most significant of those findings .was that the Essex County Mosquito Control Project established "Standards for Open Marsh Water Management" which were endorsed by the Environmental Protection Agency, the National Marine Fisheries Service, the Massachusetts Audubon Society and others. These standards are widely viewed as the least harmful to the environment (of the various control techniques) and most efficient non-pesticide method for controlling salt marsh mosquitoes. The-proponent also committed-' to conduct a review of ten years of OMWM in Essex County to provide a basis for comparison and evaluation of mosquito control effectiveness and impact to the environment. It is generally recognized that the principal concern associated with OMWM arises" from the disposal of the dredge material on the marsh and the potential for invasion of upland plants (particularly <u>Phragmites</u>) that can occur with even slight elevation increases (i.e." 1-2 inches).

Open marsh water management (OMWM) projects are now underway in Essex (EOEA #10567), Norfolk, and Plymouth counties and are being expanded to include all problem marshes in those counties. The need to convert grid ditch systems is likely to continue and the salt marsh alterations will likely exceed the one-acre EIR threshold at several locations. Based on the success of OMWM,

The establishment of "Standards for Open Marsh Water Management," the conclusions of this GEIR, - and the commitment to continue to monitor the effectiveness of OMWM on the control of mosquitoes and, its impact on the environment, I am proposing, in a -forthcoming issue of the Environmental Monitor, to publish a Draft Record of Decision that would modify" the ENF and EIR thresholds for OMWM projects2, subject, at a minimum, to the following standards and conditions:

2 The MEPA regulations at Section 11.01 (2) (b)"(3) under" Review Thresholds" state, in part, that the review thresholds do not apply to..." a project that is consistent with a Special Review Procedure review document, or other plan or document that has been prepared with the express purpose of assessing the potential environmental impacts from future Projects, has been reviewed under or approved by any Participating Agency, unless the' filing of an ENF and an EIR was required by a decision of the secretary on any such review document, plan or document."

* That the Northeast Massachusetts Mosquito Control and Wetlands Management District "Standards for Open Marsh Water Management" be used as the statewide standard for OMWM projects.

* That the salt marsh be inventoried for the presence of rare and endangered species as determined by the Natural Heritage and Endangered Species Program (NHESP) habitat maps. If a project falls within such an area, NHESP will then determine if the area to be altered is an actual wetland habitat for rare species.

* Compliance with Section 401 of the Federal Clean Water Act and Federal Coastal Zone Consistency.

* Improved record keeping with respect to treatment location, type, efficacy and post treatment monitoring. For example, there are old ditches that still effectively control mosquitoes therefore their effectiveness should be monitored prior to going ahead with OMWM.

<u>MC Projects Impact on Freshwater Wetlands</u>

Freshwater wetlands are the dominant system in which freshwater physical control take place. Typically, this work consists of maintaining (i.e., moving blockages from previously ditched areas) existing ditches designed to remove standing water from the wetland. Though reducing standing water reduces mosquito breeding, there has been little research concerning the overall effects of these alterations on the modified wetland. Therefore, increased efforts are necessary to examine the environmental effects of draining surface water from wetlands.

As stated above, most of the freshwater mosquito control projects are geared to removal of blockages, be they natural or influenced by man, in wetland areas earlier identified as significant mosquito breeding habitats. These projects usually are classified as maintenance projects and are therefore exempt from MEPA review pursuant to Section 11.01 (2) (b) (3). However, there is a significant amount of work that needs to be completed in order to determine whether such work is cost effective, and whether a specific alternative is the *one* least damaging to the environment. As the report acknowledges there has been no study to date of the costs and benefits of Massachusetts mosquito control programs. However, this work has been done in other states, most notably New Jersey, which should be helpful in answering the following questions raised in the GEIR:

1) Establishing substantive human annoyance thresholds

2) Documenting how human activity patterns relate to Human Annoyance Thresholds (HAT) and economic factors; 3) Determining the cost/benefit of control; and

4) Correlating densities of immature mosquito (i.e., larvae) with future levels of biting annoyance.

These issues should be addressed and reported *on* in future GEIR updates. EOEA is prepared to help in this regard.

Standards for Freshwater Wetland Physical Control

The GEIR indicates that the SRMCB still needs to determine the appropriate control measure standards for MC projects in freshwater wetlands (described in the report as Upland Water Management operational procedures). These standards will need to

The current provocations *for* execution of mosquito control techniques are generally as follows:

1. Larval populations - by dip count (up to 20 per sampling area) and based *on* the population #s/10 or 5 dips then a decision is made to either use a pesticide or water management strategy.

2. Adult populations - No adulticiding is to take place at a regularly scheduled or prescribed time or place. Instead spraying is done based *on* annoyances, such as *five* bites per night; more than *one* landing per minute; *or* two complainant calls per square mile of area be coordinated with the DEP's Storm water Policy Handbook and Storm water Technical Handbook. In addition, many physical control projects lack adequate records, both with respect to the justification of a specific project, and with respect to site plans. Therefore, the SRMCB should work toward requiring better record keeping and notification practices, as discussed in the DEP comment (and the Coastal Zone Management letter for salt marsh alterations).

Integrated Pest Management (IPM)

The GEIR indicates that the strengths of the Massachusetts mosquito control IPM include the availability of and willingness to use least-toxic materials and willingness of existing control programs to try new strategies. In addition, a successful IPM program requires strong control programs and good pretreatment monitoring. The weaknesses of the IPM have been linked to a lack of funds for research and implementation and a lack of basic ecological data on the effects of control strategies in use or being planned. I do note that all of the pesticides -(larvicides and pesticides) used by MC projects have been approved by and are registered with the US Environmental Protection Agency. Given the rigorous process to gain market approval for a pesticide as well as the evolving nature of pesticide development, I agree with the conclusions of the GEIR that, for now, advances in reducing the risk of chemical use must come from improved targeting and increased use of water management and/or biological control techniques as encouraged by the IPM technique.

Eastern Equine Encephalitis (EEE)

The Massachusetts Department of Public Health (DPH) is responsible for surveillance for EEE Virus, risk assessment, public information and education on EEE disease. DPH is also responsible for recommendations for wide aerial vector control, interventions. DPH published its "Vector Control Plan to Prevent Eastern (Equine) Encephalitis" on (August 7, 1991). That protocol will govern when the next EEE outbreak occurs. The DPH has also developed a monitoring program that should bring EEE into the IPM framework. I urge that this work continue in order to avoid the adversity that accompanied the 1990 aerial spraying.

GEIR Recommendations and Conclusions

In addition to the issues discussed above, GEIR updates should emphasize how MC programs will incorporate the IPM strategy of keeping human annoyance below specified thresholds. Standards for control methodology should favor source reduction (e.g., OMWM in salt marshes) whenever possible, and employ larvicide control only when source reduction is not effective. Projects should work closely with the DEP water quality certification program and the NHESP to improve notices and documentation, and to minimize negative impacts of source reduction.

It is clear that the SRMCB and the MC projects have a good handle on their data and research needs. The stumbling block to successful completion of the analysis appears to be primarily fiscal in nature. I am pleased with the SRMCB's commitment to provide yearly updates, and I expect that issues brought forward in this Certificate, as well as the comments from the DEP and DF&W, will be addressed in the first yearly update. The SMRCB should meet with MEPA prior to finalizing the content of the GEIR update.

State of Massachusetts

Generic Environmental Impact Report on Mosquito Control

Executive Summary

I. Introduction

A Generic Environmental Impact Report (GEIR), covering mosquito control activities within the State of Massachusetts, was mandated under the provision of Massachusetts General Laws Chapter 30A Section 61 by the Massachusetts Environmental Policy Act (MEPA) Regulation 301 CMR 10.32(5)(b) adopted on January 25, 1979. The State Reclamation and Mosquito Control Board (SRMCB), the state agency that oversees all local and regional mosquito control programs in Massachusetts, administers the GEIR. The SRMCB consists of one representative each from the Departments of Environmental Management, Environmental Protection, and Food and Agriculture. The latter member presently serves as the Chairman of the Board.

This GEIR serves five purposes:

1. It provides a historic summary of all public activities in Massachusetts related to mosquito control, including an account of how mosquito control in Massachusetts has rapidly evolved over the past ten years.
2. It describes and quantifies Massachusetts mosquito problems and assesses the effectiveness of past and current control programs.
3. It assesses the real and potential environmental impacts of past and current control practices and describes and evaluates alternative strategies.
4. It gives an IPM framework for mosquito control in Massachusetts and provides a series of operational standards for mosquito control practices.
5. It makes recommendations relative to the future organization and practice of mosquito control in Massachusetts.

II. History, Organization and Practice Of Mosquito Control In Massachusetts

A. Legislation and Regulation

1. State Laws

The first Act of major importance is Chapter 252 of the Massachusetts General Laws (MGL), which establishes the State Reclamation and Mosquito Control Board (SRMCB) and procedures for creating local control projects. As now amended, 252 includes the important earlier provisions of Chapters 199 and 699 of the Acts of 1960. The word improvement (of wetlands) as frequently used in the narrative for this Act is misleading. Modification or alteration would have been a more appropriate and objective term to describe wetland drainage and filling activities.

The second Act is the Wetlands Protection Act (Chapter 131 of MGL) which regulates activities in the aquatic and brackish habitats where most mosquitoes breed. However, organized mosquito control is generally exempt from the provisions of this State Law. Hence, the Federal Clean Water Act as administered by the U. S. Corps of Engineers, is the principal regulating mechanism for mosquito-control alterations in wetlands. Regardless of the general exemption, mosquito control is not exempt from checking for the presence of rare and endangered species through the Massachusetts Natural Heritage Atlas, which lists estimated habitat maps for all rare and endangered species as developed by the Natural Heritage Endangered Species Program (NHESP).

The third Act which influences mosquito control in the Endangered Species Act (Chapter 131A of MGL) which prohibits the “taking” of rare and endangered species. It also protects “significant habitats,’ requiring a permit request for any work done in such areas.

The fourth Act of importance to mosquito control activities is the Pesticide Control Act (Chapter 132B of MGL) which regulates pesticide use by mosquito control practitioners.

Three additional Acts have the potential to impact mosquito control. M.G.L., Chap. 91. Sections 1-63 -- Waterways does not deal specifically with mosquito control but it does cover variety of activities associated with wetlands. Mosquito control is specifically exempted from the provisions of Sections 19A, 59 and 59A of this law but not from other provisions. M.G.L., Chapter 40. Section 5 - Boards of Health and Supervision, contains clauses that address the issue of appropriating money at the municipal level for mosquito abatement. M.G.L., Chapter 132A. Sections 13-16, 18 -- Ocean and Coastal Sanctuaries Act, Section 14, is designed to is to protect designated ocean sanctuary from any "...exploitation, development, or activity that would seriously alter or otherwise endanger the ecology or the appearance of the ocean, the seabed, or the subsoil (of the sanctuaries), or the Cape Cod National Seashore." Mosquito control does not take place in these sanctuaries.

2. Federal Laws

Federal laws which directly impact on mosquito control activities are Sections 401 and 404 of the Clean Water Act and the Endangered Species Act. All other federal restrictions governing wetlands and pesticides are covered by Massachusetts laws which impose restrictions and requirements that are equal to or greater than those in comparable federal law. The exception in the case of Section 404 arises because the state laws governing the ditching of wetlands exempt mosquito control but the Federal Clean Water Act does not.

Section 401 (Clean Water Act: Water Quality Certification) requires applicants wishing to discharge dredged or fill materials to obtain a certification or waiver from their state water pollution control agency (Massachusetts Bureau of Resource Protection, Division of Wetlands and Waterways). The U. S. Army Corps of Engineers will not permit a mosquito-control project that does not have a water quality certification.

Section 404 of the Clean Water Act (1972), calls for a system of permitting to be carried out by the U.S. Army Corps of Engineers with a review of al! permit applications by appropriate state and federal agencies. The activities that involve mosquito control which require a permit under Section 404 are cutting or clearing new mosquito ditches in tidal areas below mean high water and/or placing material excavated from existing or new ditches on salt marshes or freshwater wetlands.

The Endangered Species Act is designed to protect threatened and endangered species as listed on the Natural Heritage Atlas. To date, several programs have had to modify their control effort to take into account endangered species.

B. Current Mosquito Control Programs in Massachusetts

1. Formal Mosquito Control Projects

Of the 351 Towns in Massachusetts, 157 (or 44.7%) currently belong to the 9 organized mosquito control projects. Each project is managed by a superintendent who is hired and supervised by a Board of Commissioners representing the towns included in the project. Board members are appointed by the Board of Reclamation for designated terms (usually 3-5 years). Boards generally meet once or twice monthly to authorize major expenditures and to review policy and program progress.

The SRMCB is made up of three members, one each from the Departments of Food and Agriculture, Environmental Management and Environmental Protection, and exercises responsibility over all 9 projects. All projects have a Board of Commissioners appointed by the SRMCB. They represent the various towns within each project and exercise general control over the project.

The Nine Mosquito Control Projects of Massachusetts are Berkshire County, Bristol County, Cape Cod, Central Massachusetts, East Middlesex County, Norfolk County, Plymouth County and Suffolk County Mosquito Control Projects and the North East Massachusetts Mosquito Control and Wetlands Management District (formerly Essex County MCP). Nantucket conducts saltmarsh mosquito control including larviciding and open marsh water management.

2. Other State Agencies

The State Division of Forests and Parks discontinued its own mosquito control program in. The North East Massachusetts Mosquito Control and Wetlands Restoration District (NEMMCWRD) adulticides Salisbury Beach State Park and Bradley Palmer State Park in Hamilton as the need arises.

The Massachusetts DPH is responsible for surveillance for EEE Virus, risk assessment, public information and education on EEE disease, as well as providing advice to the State Reclamation and Mosquito Control Board on appropriate risk management for EEE. DPH is also responsible for recommendations for wide area aerial vector control interventions in the event of an EEE Public Health Emergency.

3. Federal Property

No mosquito control is carried out by the U.S. Department of Interior on any government-owned land in Massachusetts. The Cape Cod National Seashore is perhaps the U.S. Park Service property with the most significant mosquito populations. Park Service biologists have conducted their own studies on the environmental impact of Cape Cod mosquito control activities (Portnoy 1983, 1984a, 1984b) in adjacent estuaries and have lobbied against certain ditch cleaning practices on environmental grounds.

The East Middlesex MCP has been controlling mosquitoes in Great Meadows National Wildlife Refuge since 1987. Annual aerial Bti applications targeted against spring *Aedes* species began in 1987 and applications to control *Aedes vexans* began in 1990. The National Park Service reservation area (Paul Revere's Ride) in East Middlesex County has been declared off limits to any mosquito control activity (by East Middlesex MC project) except for ditch cleaning.

The NEMMCWRD has completed OMWM projects on the Parker River Wildlife Refuge.

C. Overview of Mosquito Control Practices in Massachusetts

Development and tourism along the Massachusetts coast is predicated on an ability to control the hoards of saltmarsh mosquitoes. Massive hand-ditching projects in East Coast marshes that took place during the WPA programs of the great depression. These ditching schemes, while quite effective in reducing saltmarsh mosquitoes, were engineered to make work rather than for optimum biological efficiency.

Early saltmarsh mosquito control projects, such as the one on Cape Cod in the 1930's, were organized prior to the availability of synthetic pesticides following World War II and these projects expanded and maintained the WPA-dug ditch system as their main strategy for mosquito control. After DDT, BHC, and other organochlorine pesticides became available, they were used to both supplement larval control and, for the first time, to conduct residual spraying for adults. Aerial application of these pesticides became commonplace in the 1950's and early 60's. The commercial mosquito control oil, Flit ML0, was introduced and widely used during the 70's.

Chemical control in freshwater marshes followed a similar pattern to that in salt marshes. Treatment of catch basins, first with oils followed by organochlorines and organophosphates, dates back to the beginning of most Massachusetts projects.

Physical control was limited to drainage maintenance and expansion in both salt marshes and freshwater areas. Biological control was not conducted.

By the early 1980s, concerns over pesticide use and wetlands loss began to encroach on mosquito control. Grid ditching for larvae and malathion for adults was no longer a desirable one-two punch. Control trends during the eighties and early nineties included: changing from traditional chemicals, such as Abate and Flit MLO, to Bti and methoprene for larval control, changing from malathion to permethrin or resmethrin for adult control, and changing from open tidal ditching to open marsh water management for saltmarsh mosquito control.

Source reduction remained a mainstay of the projects during this time period. Coastal communities shifted away from ditch maintenance towards open marsh water management. An emerging difficulty for control programs is the rise in wet basins mandated by stormwater runoff regulations.

The evaluation of control effectiveness by projects remained a combination of public complaints, adult counts, larval counts, and cases of human disease.

Chemical control, including *Bacillus* products and IGRs, and source reduction, including open marsh water management, now dominate mosquito control in Massachusetts. Aerial applications of larvicide have been used by several programs and are increasing. Biological control has not been emphasized except to the extent that OMWM creates conditions under which biological control operates. Public education is a minor component of most programs.

Saltmarsh mosquitoes are the primary target of coastal programs, whereas inland programs target spring-brood and summer-reflood *Aedes*. *Coquillettidea perturbans* is restricted by larval habitat to areas near cattail marshes but is a big problem in those areas. It complicates control efforts because controlling the larval stage with methoprene is expensive and adulticiding provides only short-term control.

Vector mosquitoes are not the primary targets of Massachusetts control programs, though projects can respond to requests for aid from DPH in times of EEE emergencies. *Culiseta melanura* larval populations may be incidentally reduced by treatment programs that target swamp areas.

At present, policy issues revolve around wetlands protection, water quality preservation, and endangered species. A chronic source of discussion is mosquito control's exemption from many of the state-level wetlands protection acts, making the Federal Section 401 Water Quality Certification (administered at the state level) and the state and federal Endangered Species Acts the primary means of "controlling" source-reduction work. Stormwater runoff regulations have increased the number of wet basins (retention, wet detention) in many areas, on occasion creating breeding habitat

The EEE outbreak in 1990 highlighted a need for stronger DPH policies regarding emergency mosquito control. As a result, the Massachusetts Department of Public Health published "Vector Control Plan to Prevent Eastern (Equine) Encephalitis" (August 7, 1991) and implemented an extensive Public Education Program in 1991.

The combination of large, affluent human population (both permanent residents and visitors) and prolific pest mosquito populations near Massachusetts coastal marshes suggests that the public may always demand control programs to deal with this problem.

Open Marsh Water Management (OMWM) projects now underway in Essex, Norfolk, and Plymouth counties are being expanded to include essentially all problem marshes in those counties. The trend to convert grid-ditch systems to OMWM is likely to continue.

There are certain salt marshes where old ditches are effectively controlling mosquito production and perhaps where new OMWM activities might actually disrupt the marsh more than maintaining the status quo. Thus, OMWM plans should not be automatically prescribed for every saltmarsh without first examining this issue. Larviciding is still carried out in salt marshes.

Inadequate budgets, the inability to conduct more source reduction work and a lack of applied research into more environmentally sound mosquito-control practices continue to restrict the actions and effectiveness of mosquito control programs in Massachusetts.

III. Current Abatement Strategies and Their Impacts

A. Chemical Control

Twenty-six different insecticide formulation distributed among fifteen product lines were used for mosquito control in Massachusetts between 1993 and 1995 (Table 1). Eight of these formulations used Bti as the active ingredient, five were methoprene-based, three were resmethrin-based, two each were pyrethin-based or malathion-based, and there were one each of temephos, isoctedecanol, and mineral oil. Of these, Acrobe (Bti) and Vectobac AS (replaced by 12AS) are no longer produced. Arosurf-MSF (Isoctadecanol) was off the market for several years but is now available under the name Agnique MMF. Abate 4E was not used in either 1994 or 1995 and both the Malathion 10EC and the Resmethrin product (EPA reg. # 4-339-53853) were used in small amounts only

Of the insecticides used, all of the larvicides were classed as Category IV (Category I is the most toxic, Category IV the least) materials by EPA. Bonide Mosquito Larvicide, available but not used, is border line between Category III and IV. VectoLex CG, a new *Bacillus sphaericus* product, is Category IV. All adulticides are in Category III, with permethrin and resmethrin having essentially replaced malathion.

Chemical impacts include acute, direct impacts to target and non-target organisms, and chronic or indirect effects to target and non-target organisms. In general, acute toxicity effects are generally easiest to measure and avoid, particularly when the organism is large and the effect is death. However, less visible acute toxicity, such as

Table 1. Chemicals used in Massachusetts mosquito control, 1993 through 1995

Trade Name	EPA Registration Number	Active Ingredient(s)	% Active Ingredient	Toxicity Class	Other Warning Statements
LARVICIDES					
Abate 4E	241-132	Temephos	43	IV	
Acrobe[a]	62637-1-241	Bti[b]		IV	
Arosurf-MSF[c]	42943-8	Isooctadecanol	100	III	
Altosid					
Briquets	2724-375-64833	Methoprene	7.9	IV	
XR Briquets	2724-421-64833	Methoprene	1.8	IV	
Pellets	2724-448-64833	Methoprene	4.0	IV	
Bactimos					
Briquets	43382-3	Bti	10	IV	
Granules	37100-43-2217	Bti	0.2	IV	
Pellets	37100-42-2217	Bti	0.4	IV	
GB-1111	8898-16	Petroleum Hydrocarbons			
GB-1356	8898-16				
Teknar HP-D	2724-365-64833	Bti	0.8	IV	
Vectobac					
AS	275-52	Bti		IV	
12AS	275-66	Bti	1.2	IV	
Granular	275-50	Bti	0.2	IV	
ADULTICIDES					
Malathion 8EC	34704-119	Malathion	8	III	
Permanone 10EC	4816-688	Permethrin	10	III	
Permanone 31-66	4816-740	Permethrin	31	III	
Resmethrin	4-339-53853	Resmethrin		III	
Scourge 4+12	432-716	Resmethrin	4	III	RESTRICTED USE
		PBO	12		CLASSIFICATION
Scourge 18+54	432-667	Resmethrin	18	III	Due to acute fish toxicity
		PBO	54		Retail sale to and use only by
					Certified Applicators or
					persons under their direct
					supervision and only for those
					uses covered by the Certified
					Applicators Certificate
MATERIALS REGISTERED BUT NOT USED - LARVICIDES					
Altosid					
Liquid	2724-392-64833	Methoprene	5	IV	
Liquid Con	2724-446-64833	Methoprene	20	IV	
Bonide Mosquito					
Larvicide	4-195	Mineral Oil	98	III-IV	
VectoLex CG	275-77	*B. sphaericus*	50[d]	IV	
MATERIALS REGISTERED BUT NOT USED - ADULTICIDE					
Fyfanon ULV	4787-8	Malathion	95	III	

[a]No longer marketed
[b]*Bacillus thuringiensis* var. *israelensis*
[c]Now marketed as Agnique MMF

methoprene toxicity to Chironomid larvae in duck-breeding habitat (SPRP 1996), may cause harm in the short term, and, since it often goes unnoticed, may be harmful in the long run as well. Mosquito Control Programs have limited, but not removed, the threat of acute impacts to non-targets by using pesticides that are more specific to the target, less toxic to non-targets, and/or have a shorter persistence in the environment. The amount of pesticide used, as in the case of ultra-low-volume sprays versus mist sprays, has also been reduced.

Chronic effects that may occur include the long-term effect of the chemical on targets (development of resistance to the chemical) and non-targets (reduced reproductive success), and long-term effects caused by a change in the ecosystem brought about by removal of the target organism. The current assumption is that the mosquitoes controlled are those which have escaped the food web and which, therefore, may be eliminated without undue risk to the food web itself. That mosquitoes are remarkably productive cannot be denied. That removing millions of larvae from the food web of a salt marsh by the application of Bti has no effect on that ecosystem deserves additional study, as does the role of mosquitoes in the ecosystem, and the effect of mosquito control on that ecosystem.

Control personnel should take care to avoid chemical applications where mosquito larvae are not present or are present in very small numbers, should use control measures that do not harm existing predator complexes, and should limit control to areas where control is necessary, allowing natural cycles to continue in areas where human activity and the risk of disease transmission is slight. One argument made in favor of Altosid is that it does not kill the young larvae, leaving them available as food for the existing predator complex.

Barring the discovery of new materials, both adulticiding and larviciding are presently be conducted with the least risk imposing materials available for the foreseeable future. Advances in reducing the risk of chemical use must therefore come from improved targeting and increased use of water management and/or biological control techniques.

B. Biological Control.

Biological control includes attacks on the pest species by other species and manipulation of the pest species itself. Only the former has been used in Massachusetts. Note that, for the purposes of this GEIR, Bti, *Bacillus sphaericus* and methoprene are classified as chemical controls and open marsh water management is classified as a physical control. A case can be made for classifying each of these strategies as a type of biological control.

Biological control agents are grouped into three categories: predators, parasites and pathogens. Predators include both vertebrates and invertebrates and may attack both adult and immature stages of mosquitoes. In general, biological control is much more feasible in managing permanent water mosquitoes than temporary water forms.

There are three basic strategies for utilizing all biological control agents: 1) increasing existing natural enemy populations by habitat improvement, 2) one-time introduction of sustainable exotic agents from other regions or habitats, and 3) augmentation of natural or exotic enemy populations by repeatedly releasing non-sustainable, lab-reared (or field collected) organisms. To date only the first, increasing fish habitat through OMWM, has been used in Massachusetts. Bti could arguably be classified as a biological control agent but its application technique and mode of action functioning as a stomach poison more closely resemble a pesticide than a biological control agent *per se*. *Bacillus sphaericus* may more closely fit the model of repeatedly releasing non-sustainable lab-reared organisms as there is evidence to suggest that it recycles within the environment.

There are important reasons why biocontrol is not more widely used against mosquitoes. First, the differences in biology of the various species of mosquitoes make it unlikely that any one control agent will operate across a wide range of species. Second, mosquito breeding is wide spread, making it difficult for a biological control agent to find, or be placed in, all breeding areas. Third, predators such as bats and purple martins, may eat mosquitoes but prefer to eat other, larger insects. Finally, there is a high cost associated with sustained releases of a biological control agent and there are not, at this time, control agents available that require a single, or a few, releases to become established.

The impacts on biological control have not received much attention because biological control has not been exercised to any great degree in Massachusetts. However, one of the primary reasons *Gambusia* are not being used in Massachusetts is the fear that they might displace native species of fish, thus altering the natural biota, not by predation but by competition for the same resource.

C. Habitat Modification (Physical Control)

1. Salt Marshes. Open Marsh Water Management was originally developed for New Jersey salt marshes (Ferrigno 1970, Ferrigno and Jobbins 1968, Ferrigno et al. 1969), this strategy basically attempts to overcome the limitations of ditching by incorporating other water management strategies. Reservoirs (which permanently hold water and sustain larvivorous fish) are created in selected tidal pools or large shallow pans and are connected via small shallow ditches to surrounding mosquito breeding depressions. This customized

approach to marsh management represents the least deleterious and most efficient non-pesticidal method for controlling saltmarsh mosquitoes.

New England coastal wetlands have been heavily impacted by man (Shisler 1990). However, evidence concerning the negative impact of saltmarsh ditch maintenance activity is mixed. The principal concern is with disposal of the spoil on the marsh and the alleged invasion of upland plants that can occur with even slight elevation increases (i.e. 1-2 inches). OMWM effects are apparently limited (Wolfe 1996) but all alterations must be designed so that raised patches of marsh elder and other boundary plants are not created.

2. Freshwater Wetlands (exclusive of Vernal Pools). Palustrine wetlands, including emergent, scrub-shrub and forested wetlands, are the dominant system in which Massachusetts freshwater physical control take place. Typically, this work consists of maintaining existing ditching designed to remove standing water from the wetland, thereby reducing mosquito-breeding habitat. For most MCPs, this type of work (source reduction) makes up a large percentage of their control effort. Though reducing standing water certainly reduces mosquito breeding, there has been little research concerning the overall effects of these alterations on the modified wetland. Ditch systems can become problems in their own right, producing mosquitoes if left unmaintained. Most of these systems were never designed specifically for mosquito control and their other, primary function, such as removing runoff from large parking lots, may cause considerable damage to the ecosystem, leaving the MCP to clean up, or at least deal with, someone else's mess.

The majority of drainage systems currently maintained by MCPs were not initially constructed for mosquito control and the effort of MCPs today is almost entirely restricted to removing blockages to existing flows, rather than enlarging or straightening channels to increase flow. Road sand and yard waste represent two of the most common obstructions MCPs are called upon to remove from existing drainage networks. New developments also can cause dramatic changes in the sediment load in streams, despite regulations designed to prevent such problems. Road sand, yard waste and increased sediment load from development can all have impacts on a stream that are as greater or greater than regular ditch maintenance. Because MCPs are often involved in removing manmade sediments from streams, a system under appropriate ditch maintenance may function more closely to a natural system than one in which manmade wastes are allowed to accumulate unabated.

The three broad categories of wetlands alteration are outright loss, changes in the abiotic system and changes in the biotic community. Filling and/or draining wetlands to convert them to upland is a mosquito-control practice that has been all but eliminated in Massachusetts. There is no indication that MCPs are intentionally reducing wetland acreage in order to control mosquitoes. However, the fact that the wetlands boundary remains essentially unmoved by a mosquito-control alteration does not mean that changes to the ecosystem have not occurred.

Changes in the abiotic system and biotic community are deeply intertwined, though physical control most often causes abiotic changes which then cause biotic changes. For channels changes in flow rates, microhabitats, sediment load, sedimentation, and groundwater interactions can all occur. For wetlands (outside of channels) changes can include lost water-storage capacity, increased sedimentation and pollutant load, changes in water depth, and changes in groundwater hydrology.

When a stream is altered to improve water flow for the purpose of removing standing water, either within the stream or from adjacent wetlands, a number of changes may take place. By definition, improving water flow increases runoff. This, in turn, may decrease the surface-water storage capacity of the wetland system and decrease the capability of the wetland to retain load (suspended solids). This may increase the load of the water moving through the stream (Brown 1988). Increasing runoff into a given stream tends also to increase erosion, which further increases load (Williams & Feltmantle 1992). Not only may total flow be increased, but alteration tends to increase peak flow, which is associated with reductions in faunal diversity (Hynes 1972). Increased peak flow may also lead to faster drying in intermittent streams.

Maintenance for the purpose of reducing mosquito breeding also includes removing obstructions within streams. Tree branches and fallen trees are a particularly important part of the stream environment, providing food, living space, concealment from predators, protection from abiotic conditions and emergence sites (Ward 1992). Removing these obstructions diminishes the variability of the stream ecosystem.

The hyporheic zone, the interstitial space between the substrate particles in a stream bed, is an important part of the habitat for many stream species (Williams & Feltmantle 1992). Excessive drying can reduce the viability of the hyporheic zone.

Sedimentation, both within stream beds and in wetlands into which streams flow, is a problem because it can alter the stream bed composition, thereby altering the fauna, and can clog interstitial spaces, thereby reducing the hyporheic zone and/or reducing groundwater recharge. Sediments can also increase exposure to pollutants as they provide additional sites for pollutant binding while suspended, and then carry the pollutants to the benthic fauna. Sedimentation, however, results most often from sources other than mosquito-control activities, and it is the primary cause of maintenance work.

When new channels are constructed, they are typically designed to change standing-water wetlands to soil-saturated wetlands (New Jersey DEP 1997). Though this reduces mosquito breeding it can also adversely affect other organisms that require standing water for periods other than peak flow.

Increased drainage also has an effect on groundwater. Precipitation and inflow determine the amount of water initially available to a wetland for ground water recharge (Todd 1972). Increasing the amount of water removed from the wetland and/or stream prior to percolation downwards may decrease groundwater recharge.

What is most needed is a comprehensive understanding of the true ecological costs of physical alterations for mosquito control. This is particularly important because, although the environmental effects of pesticides receive the lion's share of concern, it is likely that the long-term effects of physical controls have a more profound effect on the environment than does pesticide use (Buchsbaum 1994). This may be especially true today with the switch from broad-spectrum, more-persistent pesticides to methoprene and Bti.

3. Vernal Pools. Vernal pools form in contained depressions in which water stands for a period of several months, generally from mid- to late winter through the spring. Water either comes in the form of snow melt or spring precipitation or can be a result of a rising water table. Some pools dry down within two or three months, others may only dry when the water table is lower than normal, resulting in a pool that is semi-permanent. Regardless, a key feature of vernal pools is that they undergo periods of dry down. Vernal pools may have permanent inlets but do not have permanent outlets (Kenney 1995). There are numerous obligate species for vernal pools, the most visible of which include fairy shrimp, the wood frog (*Rana sylvatica*) and several species of salamander (*Ambystoma* spp.).

Mosquito species such as *Ae. canadensis* and *Ae. excrucians* also use vernal pools for breeding. From a control perspective, vernal pools are important because, due to increasing protection, vernal pool habitat is often left undeveloped while the land adjacent to the pool is built up. As a result, many new developments surround known breeding sites. Regardless of the wisdom of developing so close to vernal pools, mosquito-control personnel are charged with controlling the mosquitoes coming from the pool.

4. Rare and Endangered Species. Operating under the assumption that it is rare and endangered species which are most likely to be lost from a wetlands system first, then reductions in habitat

diversity, alterations from the natural state, and frequent disturbances will all work against these species. Channelization of streams reduces diversity by removing obstructions, straightening the channel and increasing flood levels. Wetlands changed from standing-water to saturated-soil regimes have been drastically changed from their natural state. Maintenance is ongoing, as is the disturbance it causes.

However, to what extent does mosquito control contribute to the these problems? First, Massachusetts MCPs do not channelize streams, as their certification manual calls for following the existing meanders. Second, MCPs work neither in historically undisturbed, nor currently undisturbed streams. There is good reason to argue that there is no specific "natural" state that can be assigned a ditch dug by man and intermittently filled with road sand and grass clippings. Even with natural streams, the "natural" habitat in which they flow has long been altered and continues to be altered.

The Natural Heritage and Endangered Species Program (NHESP) was created in order to conserve and protect those plants and animals not hunted, fished, trapped or commercially harvested in the state. The program's highest priority is to inventory rare and endangered species and to develop conservation plans through research, management and habitat protection for those species

The NHESP also reviews proposed alterations to wetlands habitats under the Wetlands Protection Act (M.G.L. c. 131, s. 40 and regulations 310 CMR 10.00). NHESP has produced a series of estimated habitat maps for rare and endangered species (Massachusetts Natural Heritage Atlas) which proponents of a given alteration are required to check. Should a project fall within an estimated habitat, NHESP will then determine if the area to be altered is actual wetland habitat for a state-listed species. The results of the NHESP determination are given to the inquiring MCP.

In Massachusetts, the species that have caused modifications in mosquito control practices are the Blue-spotted salamander (*Ambystoma laterale*), Mystic Valley amphipod (*Crangonyx aberrans*), and banded bog skimmer (*Williamsonia lintneri*). In addition, ditch maintenance in vernal pond areas has been curtailed to protect this type of habitat. Other animals for which concerns have been raised are the yellow-spotted turtle and osprey.

Under the current system mosquito-control maintenance activities are exempt from the Massachusetts Wetland Protection Act, leaving the federal 401 Water Quality Certification Act and both the Massachusetts and Federal Endangered Species Acts as a method for regulating maintenance. Unfortunately, water quality, while important, does not address the issue of changing habitat and the presence or absence of a rare or endangered species has little to do with the merits of a given drainage project. Again, a more comprehensive understanding of the true ecological effects of mosquito control is required to better determine the cost/benefit ratio for different types of mosquito control, including their effect on rare and endangered species.

Physical control by water management may increase predation, as in OMWM, or may eliminate predator and prey as when wetlands are drained to soil saturation. Mosquito breeding must be thoroughly documented before new work is done. Because disturbances may displace some species, and because predator species tend to rebound more slowly than their prey, maintenance work should be conducted only when necessary.

D. No Program

Many communities in Massachusetts have chosen to forego mosquito control. These town are usually outside of the enzootic EEE zone so the risk of human diseases transmitted by mosquitoes is viewed as practically nil by these communities.   In addition, they are not located near salt marshes and their attendant pest mosquito problems. The mid-section of Massachusetts, where most no-control communities occur, also has a more rural character, less wetland , lower human populations, and a lower mean family income than most eastern areas with organized MCPs.

In addition to risk-benefit considerations, other criteria for weighing the control/no control option are 1) the feasibility of successfully reducing annoyance below the human annoyance threshold, and 2) the adequacy of community resources for reducing annoyance to acceptable levels.

It is difficult to measure the impact of choosing the no control option. The example of towns that have left, and later rejoined, mosquito control projects is perhaps the only available basis for estimating public opinion concerning such impact. However, no documentation of annoyance levels, cases of disease, recreational dollars spent, etc., was ever attempted in these towns when they had mosquito control versus when they did not.

The number of towns in MCPs declined in the late eighty's. Economic factors, not environmental concerns, were the dominant reason given for withdrawal. This trend has reversed itself significantly in the last several years. The 1990 EEE problem is probably one reason, coupled with the fact that several coastal programs tried the no-control option and found mosquito numbers rose quickly.

IV. IPM as it Relates to Mosquito Control.

A. Definition of IPM

At its most basic IPM is:

A system designed to reduce the negative impact of a pest species to an acceptable level while avoiding unnecessary additional problems (Virginia Cooperative Extension Service 1987).

For mosquito control in general the negative impacts of mosquitoes are reduction in outdoor use, particularly recreational, and disease transmission. These negative impacts are all ongoing in Massachusetts. Problems that have developed in the past are loss/degradation of valuable habitat, exposure of non-target organisms to pesticides, creation of new, sometimes worse, breeding habitat, and resistance of mosquitoes to pesticides in use. Other than exposure of non-targets to pesticides (unavoidable) none of these problems have been documented in Massachusetts.

Before an IPM program can be put in place, a strong organization must be in place. The organization must be adequately funded, adequately trained and provided with the materials to do the job correctly. At a minimum expertise in mosquito biology, wetlands ecology, and program administration are required.

Adequate staffing and resources are only the first steps in creating an IPM program. The main step is in creating the analytical process whereby control decisions are made, evaluated and modified. This process can be divided into four steps: 1) Surveillance and Monitoring, 2) establishing Thresholds for Action, 3) Prevention and Control, and 4) Evaluation.

1. Surveillance and Monitoring. For mosquitoes, adult populations are monitored for their direct impact on people whereas larval populations are monitored for their potential impact after they emerge as adults. For adult populations, monitoring is used to determine if adulticiding is required and to identify the species of mosquito in a given area so that future larval control efforts can be directed at the appropriate breeding sites. Larval populations are monitored to determine if larviciding is required and/or if physical or biological controls are working.

The habitats in which breeding occurs or in which the adult mosquitoes are most numerous must also be identified. Wetlands should be mapped as should drainage basins.

A third component of monitoring is to classify the area in which control is to take place by human usage. Unless funding is not a constraint, the goal of surveillance and monitoring should be to produce a site list prioritized by the level of mosquito breeding and its proximity to humans.

2. Establishing Thresholds for Action. The goal of IPM is to keep pest levels below the

Economic Injury Level (EIL). This is the level where the economic loss from pest damage exceeds the cost of control. In mosquito control, this is the Human Annoyance (or Disease) Threshold (HAT) and represents the highest biting density (or Disease Incidence) that most citizens in a community find tolerable. Intolerance is usually exemplified by people moving indoors, putting on repellent, leaving a campground etc.. HAT is generally the biting level above which most people prefer to pay to have the level reduced than put up with the annoyance. This level will vary from community to community and may be influenced by the species biting (Sjogren, 1977), the time of day when annoyance occurs, and the duration of the period when HAT is exceeded.

The choice of control measures to use, and the extent to which a given control measure is used, is determined by the pest species and population, the environment in which the pest population is located, and human factors expressed in political and economic terms. Determining which control options are available and how much funding will be allocated to each, coupled with an understanding of the pest population, should allow action thresholds to be created.

3. Prevention and Control. Prevention refers to maintaining a pest population below the action threshold for control, whereas control refers to bringing a pest population back under the threshold for control. Source reduction is the primary prevention technique for mosquito control in that it directly reduces the area in which mosquitoes can breed. Maintaining water flow through drainage networks is the primary freshwater mosquito control technique while ditching used to be the primary prevention in salt marshes. Programs that do not stress source reduction cannot make long-term reductions in mosquito populations.

Public education is a second vital component of prevention. An educated public should be more willing to cooperate in eliminating man-made breeding habitats, should better understand the trade-offs between the various available control techniques, and should be more willing to fund more expensive approaches if the expense can be justified by a better long-term benefit.

Control, in the sense of killing mosquitoes, is dominated by chemical use for adult mosquito control. For larvae a combination of chemical control and OMWM (biological/physical control) is used.

Thresholds are vital to the control process because only through thresholds can a rational response be made to unusual circumstances. A quality IPM program cannot “fail” in the strict sense because it has control techniques available for each step in pest population increase (or, in the case of a disease threat, each increase in the risk of contracting the disease).

4. Evaluation. Each control step is evaluated for efficacy and future actions modified to improve control or reduce negative impacts. Field evaluation will generally use the same monitoring techniques described above and the important criteria will be changes in the mosquito population and/or environment. Over time, a steady state should develop where realistic thresholds trigger effective responses.

B. IPM for Mosquitoes as it is Currently Practiced in Massachusetts.

The strategy of IPM as developed for agricultural ecosystems is an ecologically-based concept (Axtell 1979). It has yet to be fully applied to mosquito management programs. IPM is a strategy for managing insect populations not a method for controlling them. It is more than integrated control which is simply the combining of several control methods. Mosquito control has a long history of integrating different control methods.

The general feeling among most MC practitioners is that any significant larval population within flight range of residential areas will probably result in some human annoyance and therefore should be controlled. No Project in Massachusetts has undertaken such an effort.

Although many MC programs regularly monitor adult population levels (with light traps and landing counts) they do it to evaluate larval control effectiveness and the need for adulticiding; not to determine when immediate larval control is needed as in the case of agricultural IPM programs. However, light trap counts, landing rates and complaint calls are used to create a general picture of the need for mosquito control and projects with long-term experience develop larviciding plans based on this historical data.

There is no study to date of the costs and benefits of Massachusetts mosquito control programs. There is good reason to believe, even if such studies were done, that the results would reflect local, current thought, as opposed to some underlying “true” cost/benefit for mosquito control. Regardless of the underlying variability of any cost/benefit analysis, working towards an understanding of the costs and benefits of mosquito control is desirable. The following information would aid in such work:

1) Establish human annoyance thresholds (HAT)
2) Document how human activity patterns relate to HAT and economic factors
3) Determine cost/benefit analysis of control (willingness to pay)
4) Correlate HAT with a standard non-biting sampling method (e.g. light trap)
5) Correlate densities of immatures with future levels of biting annoyance.

The cost/benefit of various control options (e.g., permanent vs. temporary control) also has been evaluated

(Ofiara & Allison 1986a, 1986b) but this should not be confused with the cost/benefit of control programs.

One major advance already underway is vastly improved mapping through Geographic Information Systems (GIS). GIS wetlands mapping can both aid mosquito control agencies in determining control priorities but can be used by mosquito control agencies to integrate their work with other land-use agencies (Guthe 1993). Very detailed maps can also be made when planning water management projects (Gettman 1995).

Overall, Massachusetts mosquito-control IPM strengths include, strong control programs, good pre-treatment monitoring, the availability of and willingness to use least-toxic materials and a willingness of existing control programs to try new control strategies. Weaknesses include a lack of funds for research into new strategies, a lack of funds to implement new strategies and a lack of basic ecological data on the effects of control strategies in use or being planned. A final wildcard is EEE which dramatically increases the stakes when attempting to determine the correct response. DPH has developed a monitoring program that should bring EEE into the IPM framework.

V. Standards For Mosquito Control

A. Standards for Monitoring and Control. Pesticide applications in an IPM program require monitoring insect populations and comparing data with pre-established thresholds for treatment. In addition, post-treatment evaluation is required to ensure the treatment worked as planned and did not have unintended side-effects.

1. Larval Populations: The primary technique for larval population counts is the dip count. It is hard to standardize dipping technique but, for the purposes of this document, it is assumed that dips are taken in undisturbed pools (the field person is aware that disturbing the water and/or casting a shadow over the water will cause mosquitoes to dive, thereby lowering counts) known by the field personnel to be typical of the breeding area being monitored. For large-scale work, dipping will be done at permanent, marked (or easily located) dip stations. For small sites such as drainage basins and woodland pools, dips will be taken at random throughout the site. Up to twenty dips per site will be taken unless the count for treatment and/or water management is exceeded with a smaller number of dips. Specifics for various types of work are given in Table 2.

Table 2. Specifics for monitoring larval (& pupal) populations of mosquitoes for determining control.

	No Treatment	Pesticide Application	Water management	# Sites for large-scale work
Salt Marsh	<1 per 10 dips	1+ per 10 dips	5+ per dip[a]	1 dip station per 250 acres

Freshwater				
Ground	<1 per 5 dips	1+ per 5 dips	Variable	Not applicable
Aerial	<1 per 10 dips	1+ per 10 dips	Not applicable	1 dip station per 250 acres

[a]Numerous additional factors go into determining water management options for OMWM.

Projects have an obligation to ensure that all alterations function as intended without adverse effects on the environment. Post-alteration work for water management will also monitor vegetative re-growth, changes in fauna and notes on whether or not the hydrology of the site is as intended. When projects have historical data that establishes a pattern of breeding at a given site, they may conduct pre-treatment work.

2. Adult Populations. No adulticiding program will be conducted on a routine, pre-scheduled basis (i.e. once per week, regardless).

a. Monitoring for Adulticiding

Table 3. Adult mosquito monitoring techniques and thresholds for adulticiding.

Monitoring Mechanism	Rate to trigger adulticiding
Light traps	Human-biting mosquito counts exceed five per night
Landing counts	Landing count rates exceed one per minute
Complaint calls	When complaint calls exceed two per geographical area (this area will vary but assume approximately one square mile)

Projects should increase their efforts to understand the impact of adulticiding on mosquitoes. Projects should cross-reference complaint calls with adulticide applications and record the number of calls coming in the week before an application and in the following week (this work may be done during the winter for the previous season). In addition, projects should conduct before and after landing counts and/or light-trap counts for ten percent of their adulticide applications. Landing counts should be taken within 48 hours pre- and post-application at the same location both times. Light trap samples should be from the same trap and for the same time period before and after treatment. Where possible, non-treated areas similar to the treated area should be checked to determine population trends outside the spray zone.

B. Standards for Physical Control. Altering or eliminating mosquito breeding sites range from proper disposal of tires through analyzing drainage systems to creating entire new open marsh water management systems. Physical Control refers specifically to alterations to breeding habitat to prevent mosquitoes from maturing to adulthood. Physical Control is divided further into three types:

Source Elimination: Completely eliminating the breeding site not just the mosquito breeding. Source elimination is generally limited to breeding habitats created by humans in non-wetland areas.

Source Maintenance: Maintaining potential breeding sources in such a way that mosquitoes cannot become a problem.

Source Reduction: Reducing the ability of an area to breed mosquitoes. It differs from source maintenance in that the existing habitat is breeding mosquitoes whereas, if a maintenance program is running as designed, mosquito breeding should not occur. Once a source reduction project is completed, it will, in most cases, require at least some source maintenance in order not to return to being a mosquito-breeding habitat.

The Massachusetts DEP has recently (March 1997) issued a Stormwater Policy Handbook and a Stormwater Technical Handbook. These provide guidelines for stormwater management and should be used to determine appropriate control measures that MCPs should implement. Currently, the primary causes for concern regarding physical control is that there aren't always adequate records of the reasons for a specific maintenance project nor are there also adequate site plans by which it can be determined that increases in ditch cross-section and/or length are not occurring.

C. Standards for Chemical Control.

Projects must comply with regulations for aerial applications of pesticides.

For truck-mounted adulticiding, projects should notify the public through the print media, between March 1st and May 1st of each year, as to the areas that may be treated, the pesticide to be used and a number to contact for more information or to request exclusion from treatment.

As education is a primary aspect of an IPM program, projects are encouraged to develop educational flyers covering such aspects of their work as pesticide use, water management, and property-owner mosquito control. Flyers may either be developed in-house or be obtained from the state or other agencies. Aside from the pesticide applicator recertification requirements, programs are urged to provide opportunities for staff to increase their knowledge about mosquitoes, wetland, and mosquito control.

D. Standard Operating Procedures during EEE problem.

When surveillance data points to increasing levels of EEE risk, DPH notifies the SRMCB and regional MCP superintendents. The EEE Surveillance Program informs MCP superintendents of isolations of EEE in their districts and the districts, in turn, provide feedback to DPH regarding population and life stage indices for critical mosquito species. At certain defined interim levels of risk as outlined in the "Vector Control Plan," MCPs may be asked to increase their ground control larvicide and/or adulticide applications in response to increased EEE virus activity. The SRMCB is responsible for contracting with appropriate mosquito control applicators in the event that aerial EEE vector control is recommended by DPH.

VI. Recommendations

A. Legal, Organizational and Fiscal Aspects of Massachusetts Mosquito Control

The organizational structure and funding for Massachusetts mosquito control programs, be they regional or town based, rests predominately at the level of town government, although the state legislative bodies have a direct influences over eight of the nine MCPs' annual budgets (only East Middlesex is not so affected). In contrast, the overseer of mosquito-control activity in Massachusetts is the State Reclamation and Mosquito Control Board. This is a loose arrangement for delivering a public service that is best applied at a regional level. Lack of control effort in one town can greatly effect the efficiency of control efforts in neighboring towns.

Enabling legislation has been written in a patchwork manner so that there is currently little consistency from project to project. For example, towns in Barnstable County (and formerly in Berkshire) are all members of their respective regional MC project and no individual community may withdraw from the program without changing the legislation as did Chap. 119 of the Acts of 1982 in the case of Berkshire County. This provides an assurance of fiscal and organizational stability that is lacking in other programs. For example, the Essex County and Central Massachusetts projects both went through considerable upheavals in membership between 1988 and 1993. Fortunately, the other projects have remained remarkably stable over the past decade. Maintaining and improving stability, both in membership and funding, is a desirable goal.

This uncertain fiscal picture is further compounded by the fact that all MC projects in Massachusetts are seriously under-funded. In other states, with progressive MC programs, the per capita expenditure varies from $2 upward. In Massachusetts, it averages about $0.50 (based on $2 per household of 4 people). In addition, many other states provide supplemental state funds to encourage non-chemical control efforts and for supportive research and educational activities. No such state support exists in Massachusetts. When supplemental state support has come, it has been for chemical adulticiding in the wake of EEE threats.

To a large extent, funding dictates the control approaches that can be pursued. IPM, source reduction, 1arval control, and adult control represent the four major options in their order of decreasing cost and efficiency.

Thus, poorly funded programs are forced into more reliance on less efficient and more controversial techniques. Larger, better-funded, and stable regional projects can invest in better paid and trained employees, better surveillance and public education programs, and expensive equipment such as helicopters which can broaden the options for safer and more efficient larval control (e.g., granular larviciding with Bti and methoprene).

Given the fact that several different state agencies are concerned with mosquito control activities, the current system of interagency responsibility for overseeing MC activities (i.e., State Reclamation and Mosquito Control Board representing 3 different state agencies) is perhaps the best compromise arrangement. On the other hand, the level of general support services that projects and towns receive from this Board seems to be inadequate.

Recommendations

That new and comprehensive enabling legislation be drafted, reviewed, appropriately revised, and passed into law, which will bring all MC control activity in Massachusetts under the same organizational, fiscal and operational guidelines. This legislation should provide for the following:

1. The State Reclamation and Mosquito Control should have the following personnel:
    a. An Executive Director @ approximately $45,000 per year
    b. An Engineer @ approximately $35,000 per year
    c. An Entomologist @ approximately $35,000 per year

    Not only would this staffing permit the state to conduct research into mosquito control, it would provide a team for rapid response to EEE threats in communities that are not members of established MCPs. This staff would also provide services such as incorporating DEP stormwater management guidelines into Massachusetts MCP Upland Water management operational procedures.
2. An operations budget, above and beyond the normal needs of the SRCMB, for research and development. A minimum of $50,000 per year is suggested.
3. A competitive grant fund (funded by the state, administered by the Executive Director of SRMCB and advised by an ad hoc panel of outside experts) to support IPM related research and delivery programs within the state mosquito control enterprise. This should provide support for studies such as: cost/benefit analysis of mosquito-control programs; development of human annoyance thresholds (HAT); improved methods for monitoring and predicting mosquito population levels;

development, evaluation, and implementation o£ new, non-chemical mosquito management techniques (e.g., open marsh management and biological control); management of pesticide resistance, drift and other use exposures; impact of MC activities on surface and ground water, and on non-target organisms; and the biology and role of selected species in disease transmission.

4. The SRMCB should establish a committee to work with their staff to develop best management practices (BMPs) for all aspects of mosquito control, the results of their work being used to update the GEIR on a regular basis. The committee should include four mosquito-control superintendents, four representatives of environmental agencies (federal, state or private) and one at-large member to serve as chairperson. Their first order of business should be to develop a set of BMPs for freshwater drainage maintenance for mosquito control. These BMPs should establish strict definitions for projects in which the mosquito control exemption from the Wetlands Protection Act may be applied.

5. MCPs must have the authority to deny requests for maintenance work that does not have a mosquito-control component. Because these requests are often made by the same persons or municipalities which provide funding to the MCPs, the SRMCB must be willing to act as an appeals board, to which a request for work may be sent by an applicant in the event the mosquito control program denies the request.

6. Limit mosquito control activity to regionally based regional mosquito control programs which can be organized by the appropriate public vote. The SRMCB should organize the regional based mosquito control programs and appoint project or district commissioners. The SRMCB should select Commissioners from candidates proposed by authorized Boards/individuals from the cities and towns of the mosquito control projects or districts.

7. A flexible and appropriate system of tax assessment which allows for budgets that are adequate to provide for the implementation of the most contemporary and least risky strategies for controlling mosquitoes.

8. A legal system whereby all major zoning and construction plans in the Commonwealth are reviewed by the executive director of SRMCB and the appropriate county MC director for their potential impact on mosquito populations and human health.

B. Operational Aspects of Massachusetts Mosquito Control

Operational programs in Massachusetts could legally be using chemicals (approved by EPA and the Massachusetts Pesticide Board) that are significantly more hazardous than those used in current practice. This suggests that knowledge and sensitivity for the environment and human safety are generally being considered by the existing control programs. As already indicated, funding levels seldom allow projects to follow the optimum operational course. Despite these fiscal constraints, projects have significantly changed their operational methods in recent years toward more source reduction work such as the Open Marsh Water Management projects in Essex, Norfolk and Plymouth Counties. Most projects also use more selective and environmentally compatible larvicides such as Bti and methoprene.

The operational recommendations that follow are predicated on additional and adequate funding being available for implementation.

Recommendations

1. All MC Projects should build their programs around the IPM strategy of keeping human annoyance below threshold levels as given in the Standards of this GEIR.
2. Control methodology should be source reduction whenever possible and larvicidal control when it is not. Projects should work closely with the DEP water quality certification program and the Natural Heritage Endangered Species Program to minimize negative impacts of source reduction to wetland habitat and/or rare or endangered species. The most target-selective and environmentally compatible larvicides (e.g., Bti, methoprene) should be used whenever possible regardless of cost considerations.
3. Saltmarsh mosquito control efforts should emphasize OMWM. All OMWM proposals should include plans for filling many of the old grid ditches in Massachusetts salt marshes which do not function in a productive way and which must regularly be cleaned in order to prevent breeding in the ditches themselves. This will gradually eliminate the controversy over the continuing need to clean these ditches and the problem of what to do with the resulting spoil that is created.
4. Document location, length, and cross-section(s) of all drainage systems maintained by the project and have that information available in an easily understood format for public inspection.

Exemption from the permitting process extents only to those drainage systems for which adequate historical records of maintenance work exist.

5. The SRMCB should create a list of pesticides approved for mosquito control in Massachusetts. Adulticides should be from Categories III and IV and larvicides should be from Category IV.

6. Adulticiding should only be carried out in emergency situations involving disease threats or pest densities which consistently exceed the human annoyance threshold.

7. For large-scale adulticiding, only ULV-cold fogging should be used. For spot treatment around recreation areas or other areas where public events are to be held, portable mistblowers using permethrin as a residual pesticide can be used.

8. Aerial applications should be restricted to granular formulations in areas where drift could be a significant problem. Sometimes some drift is desirable so as to reduce the chance of gaps between application swathes. In such cases a liquid formulation may be a better choice. At this time liquid formulations are also significantly cheaper, making larger applications, and more effective control, easier. Increased use of helicopters for aerial larviciding in coordination with the use of drift-suppression agents and technologies should be encouraged (particularly for enhanced larval control in inaccessible habitats such as salt marshes, wooded swamps, vernal pools, etc.).

9. Projects should file a post-treatment report for aerial applications with the Pesticide Bureau which gives location and acreage actually treated. The pre-application forms do not always accurately represent what actually happened.

10. Chemical-use reporting needs to be monitored to ensure uniformity and accuracy in reporting. Previous reports contained such problems as no units are given on the 1993 through 1995 Cape Cod report for Bactimos (BTI), two different EPA registration numbers for Bactimos are given in the 1993 Cape Cod and Central Massachusetts MCPs reports, and briquets are variously reported in terms of number of briquets, pounds of briquets or pounds of active ingredient. The Pesticide Bureau should insist that yearly chemical-use reports be filled out according to standardized procedures. Reports should be checked as they come in to ensure that standardized reporting procedures are followed.

11. All pesticide storage areas should be equipped with smoke, fire and security systems. A standard procedure should be developed for the disposal of all insecticidal materials used in Massachusetts for mosquito control. The State Pesticide Board should encourage manufacturers of such products to market reusable containers. A standard procedure should be developed for the clean-up of accidental spills of insecticides. Proper use of absorbent materials and the disposal of such materials are necessary. Proper attire during formulation and application of insecticides should be made mandatory for all individuals involved in these processes.

C. Research Needs

There is a need in the mosquito control process in Massachusetts for a strong, operationally focused, research effort in freshwater wetlands, exclusive of chemical application techniques. This is not to condemn current research efforts, for we know more about EEE mosquitoes than ever before, have improved saltmarsh mosquito control dramatically, and have made improvements in both chemicals used and methods of chemical use over the past decade. But there is a need for research to assess the environmental impacts and efficacy of the current MCP programs relative to the freshwater environment.

Additional research on topics such as long-term effects of OMWM, economically viable control of *Cq. perturbans*, and mosquito control in endangered species habitats also require attention.

<u>Recommendations</u>

1. For water management practices, monitor impacts on animals on a case-by-case basis, depending on the site and establish vegetation transects to document changes in wetland vegetation.
2. Develop a unified data base that documents mosquito populations on an ongoing basis from regular monitoring sites. Establish state standards for monitoring mosquitoes and provide training to mosquito control project staff in data collection and management.
3. Conduct comparative studies with different management approaches (e.g. pesticide applications vs. water management).
4. Develop a Geographic Information System (GIS) with known breeding sites and areas of historical water management activities.
5. Qualify sites on the basis of need for control, based on breeding (potential or actual), mosquito

species, proximity to human activity, level and type of human activity, and type of wetland habitat affected.

6. Create an ongoing research partnership with NHESP to document wetland types, etc.. Mosquito Control Projects have knowledge and expertise about wetlands that could be invaluable to NHESP.

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II. INTRODUCTION

A Generic Environmental Impact Report (GEIR), covering mosquito control activities within the State of Massachusetts, was mandated under the provision of Massachusetts General Laws Chapter 30A Section 61 by the Massachusetts Environmental Policy Act (MEPA) Regulation 301 CMR 10.32(5)(b) adopted on January 25, 1979. The State Reclamation and Mosquito Control Board (SRMCB), the state agency that oversees all local and regional mosquito control programs in Massachusetts, administers the GEIR. The SRMCB consists of one representative each from the Departments of Environmental Management, Environmental Protection, and Food and Agriculture. The latter presently serves as the Chairman of the Board.

A special committee designated as the Citizen's Advisory Committee (CAC) was established under MEPA Regulation 301 CMR 10.10(3) to assist the SRMCB and the MEPA office in developing a scope of what should be included in the GEIR. Following the committee's preparation of the GEIR scope and SRMCB approval of this document, potential GEIR contractors were invited to submit proposals in 1985. A subcommittee of the CAC was appointed to screen GEIR proposals and make recommendations on the awarding of the contract. A contract agreement with the University of Massachusetts (Dr. J. D. Edman) was signed in September of 1985, and the initial Draft GEIR was prepared.

The CAC received comments on the initial Draft GEIR but no action was taken on the comments nor was a Final GEIR published. In 1995 this situation was brought to the attention of the Executive Office of Environmental Affairs and the SRMCB was instructed to complete the GEIR. Due to the substantial time lag between the original Draft GEIR and the renewal of the process, a Notice of Project Change was filed with the Massachusetts Environmental Policy Act Unit in July, and the revised Scope (Section I above) was approved September 23rd of the same year. Mr. George Christie, a private mosquito-control consultant, was hired by the SRMCB committee to rewrite the GEIR to conform with the new scope.

This GEIR serves five purposes:

1. It provides a historic summary of all public activities in Massachusetts related to mosquito control, including a account of how mosquito control in Massachusetts has rapidly evolved over the past ten years.
2. It describes and quantifies Massachusetts mosquito problems and assesses the effectiveness of

past and current control programs.

3. It assesses the real and potential environmental impacts of past and current control practices and describes and evaluates alternative strategies.

4. It gives an IPM framework for mosquito control in Massachusetts and provides a series of operational standards for mosquito control practices.

5. It makes recommendations relative to the future organization and practice of mosquito control in Massachusetts. The recommendations were formed in collaboration with the CAC and the SRMCB and were based on a joint review of the background information summarized Sections III through VII of this report.

III. HISTORY AND CURRENT ORGANIZATION AND PRACTICE OF MOSQUITO CONTROL IN MASSACHUSETTS

A. Legislation and Regulation

1. Overview

There are four basic legislative Acts which regulate mosquito control activities in Massachusetts. Often associated with each of these Acts are regulations (or CMR), which are developed by the state agency charged with administering the provisions of the legislative acts. These serve as the rules or policy used in the day-to-day enforcement of the Acts.

The first Act of major importance is Chapter 252 of the Massachusetts General Laws (MGL), which establishes the State Reclamation and Mosquito Control Board (SRCMB) and procedures for creating local control projects. As now amended, 252 includes the important earlier provisions of Chapters 199 and 699 of the Acts of 1960. The word improvement (of wetlands) as frequently used in the narrative for this Act is misleading. Modification or alteration would have been a more appropriate and objective term to describe wetland drainage and filling activities. Although the word "improvement" will be used in this report, in order to maintain continuity with the Act, the reader should be aware that "modification" would be a more accurate description.

The second Act is the Wetlands Protection Act (Chapter 131 of MGL) which regulates activities in the aquatic and brackish habitats where most mosquitoes breed. However, organized mosquito control is generally exempt from the provisions of this State Law. Hence, the Federal Wetlands Protection Act as administered by the U. S. Corps of Engineers, is the principal regulating mechanism for mosquito-control alterations in wetlands. Regardless of the general exemption, mosquito control is not exempt from checking for the presence of rare and endangered species through the Massachusetts Natural Heritage Atlas, which lists estimated habitat maps for all rare and endangered species as developed by the Natural Heritage Endangered Species Program (NHESP). NHESP also overseeing vernal pool certification, not by actively certifying pools itself, but by certifying pools brought to its attention by individuals or organizations such as the Vernal Pool Association.

The third Act which influences mosquito control in the Endangered Species Act (Chapter 131A of MGL) which prohibits the "taking" of rare and endangered species. It also protects "significant habitats,' requiring a permit request for any work done in such areas.

The fourth State Act of importance to mosquito control activities is the Pesticide Control Act (Chapter 132B of MGL) which regulates pesticide use by mosquito control practitioners. Except as already mentioned, Federal Laws do not generally influence local mosquito control practices except where Federal lands are involved. This is true because Massachusetts State Laws are generally more restrictive than their Federal counterparts.

What follows is a brief summary of State and Federal Laws and regulations which may relate to mosquito control activities.

2. State Laws

a. MGL Chap. 252 <u>as currently amended</u> - Improvement of Lowlands. it should be noted that there are ongoing efforts to modify this law, one in particular is designed to require IPM practices in mosquito control.

Sections 1-4. The State Reclamation and Mosquito Control Board (SRMCB) consists of 3 members representing the Departments of Food & Agriculture (DFA), Environmental Management (DEM), and Environmental Protection (DEP). The SRMCB is housed in the Department of Food & Agriculture. Members of the SRMCB (appointed by the commissioners of their respective departments) receive no additional compensation for their service on the SRMCB, but are entitled to any expenses incurred in the performance of their duties. Although not required by this statute, the SRMCB elects one member to serve as Chairman. The SRMCB has the authority, under this chapter, to (1) drain or flow (flood) a lowland with multiple ownerships, (2) remove obstructions in rivers or streams leading to low lands, or (3) eradicate (abate) mosquitoes in infested areas whenever it considers such activities to be necessary or useful. This chapter requires that the SRMCB make an annual report. Employees (engineers, assistants, agents, etc.) may be hired by the SRMCB to carry out the provisions in this chapter. These parties are empowered to enter any private land which the SRMCB wishes to examine or survey.

Section 4A. The Commonwealth, acting through a State department or the Metropolitan District Commission, and any municipality, may, in its proprietary capacity, take part in lowland improvements described in this chapter. In their governmental capacity, these agencies/municipalities may take such action when the public health, safety, or convenience will be promoted by lowland improvements. The improvements made must be in accordance with Section 5A of this chapter. A petition by proprietors for lowland improvement does not require a majority rule. The governing bodies of the agencies/municipalities must act on the petition. Notice of a hearing before the SRMCB will be given to all petitioners, governing bodies, and to all known proprietors whose land would be affected by such improvements. Municipalities are authorized to raise and appropriate money for the improvements.

Section 5. The majority (in either value or area) of proprietors of any area, may petition the SRMCB to improve the area. Upon receipt of the petition and appropriate fees, the SRMCB will investigate and survey the land to determine the practicability and advisability of the proposed improvements. If the improvements are deemed practicable and advisable, the SRMCB will give public notice of the petition in a regional newspaper and by registered mail to each known owner, stating the date of a hearing to be held by the SRMCB. After the hearing and upon the SRMCB's approval of the proposed improvements, the SRMCB will determine whether a reclamation district is necessary.

If a district is recommended, the SRMCB will appoint 3, 5, or 7 district commissioners to form a reclamation district. Commissioners will receive no more than ten dollars for each day of actual service plus compensation for expenses incurred in the performance of their duties. The district is responsible for paying such compensation and expenses, as well as the actual cost of improvements. The district must reimburse the SRMCB's contributors the money that was expended for improvements. However, this does not include any money that was given to the district for improvements, but returned to the SRMCB because it was not needed or used. The SRMCB may fire and hire commissioners for cause.

Section 5A. The SRMCB may determine that although improvements should be made, a reclamation district need not be formed. When the SRMCB is petitioned by an agency/municipality (as described in Section 4A), it will notify the petitioners of the estimated expense of the proposed improvements. Once money is received to cover the expense, the SRMCB will designate a name under which improvements will be made and sends the money to the State Treasurer who holds it in a special fund. When needed, the money may be disbursed on warrants drawn by the SRMCB. The SRMCB will appoint one or more commissioners to oversee the improvements. The commissioner(s) receive a compensation (fixed by the SRMCB), plus expenses incurred in the performance of their duties. The SRMCB has the authority to hire and fire commissioners for cause. Any excess funds are returned to the contributors (in proportion to their contributions). If funds contributed are insufficient to complete the improvements, the SRMCB will notify the contributors of their shares of the additional cost. Improvements will not continue until these additional funds are received by the SRMCB. In order to carry out the improvements, the SRMCB will have the powers conferred under Sections 2, 3, 4, 5 (except reimbursement of expenses), and 8. Commissioners have the powers conferred under Sections 12 and 13 (provided any property taken by eminent domain is taken in the name of the municipality, and the municipality (1) authorizes the taking, (2) assumes liability for damages, and (3) has complied with all laws concerning land taking). Money for which the municipality is liable may be contributed by persons benefited by the improvements, in proportion to their respective benefits, or otherwise. Any municipality which has withdrawn from a mosquito control project may, with approval of the board and upon such conditions as the board my prescribe, rejoin by public vote.

Section 5B. Local Boards of Health (in areas not in mosquito control districts), and mosquito control district commissioners may determine a mosquito breeding area to be a public nuisance. They may give the owner of the area a written notice stating that a mosquito breeding area exists on their land, causing a public nuisance. The notice should also give treatment methods and set a deadline for abatement. If the owner refuses to abate, the Board of Health or the mosquito control district commissioners may abate the nuisance (in a manner approved by the SRMCB). In doing so, they may hire all necessary assistants who may enter upon the land for abatement purposes.

Section 6. For the purpose of organizing a mosquito control district, the district commissioners will call a meeting of the proprietors of the lands to be improved. A majority in interest (in either property value or area) must be present at the meeting, otherwise the meeting will have no power to act. At the meeting, a temporary clerk and a moderator are elected. The moderator submits the question of organizing a reclamation district (under the provisions of this chapter) to the proprietors. If accepted by a majority vote, the proprietors will then elect, by ballot, a district clerk and treasurer (one year terms), as well as 3-member prudential committee (three years terms; one member is replaced every year). At each annual meeting, elections will be held to replace the clerk, the treasurer, and one member of the prudential committee. At meetings, the district may borrow money for necessary expenses, and may issue notes, payable in not more than two years. These notes are subject to the provisions of Section 10 and MGL Chapter 44. The proceeds will be held by the district treasurer.

Subsequent meetings will be called by the clerk at the request of the commissioners or at least two proprietors. If the clerk neglects or refuses to call the meeting, the meeting may be called upon a warrant from a justice of the peace. Notices of meetings must be posted in two or more public places or should be mailed to each proprietor 7 days before the meeting. Vacancies in the office of clerk, treasurer, or member of the prudential committee may be filled at any legal meeting. If necessary, the prudential committee may appoint a person to temporarily fill a position until an election can be held or until the officer is no longer disabled.

The prudential committee is in charge of expenditures for maintenance of the improvements, and exercises the authority conferred upon the district by law.

The treasurer receives the district's money (except as otherwise specified in Sections 6 to 14A). He/she makes payments under the direction of the district or the prudential committee, in accordance with the requirements of Sections 1 to 14B and MGL Chapter 44.

By-laws may be adopted by a district formed under this section. These by-laws are subject to the approval of the SRMCB. The district has the rights and powers authorized to it under Section 14A for carrying out and maintaining improvements. The members of the district are the owners of land lying within its limits.

A district will not be dissolved without authorization by the General Court. This authorization will not be given until a provision has been made for payment of the obligations of the district.

Section 6A. Any district established under this chapter may buy the following insurance coverages:

(1) liability for bodily injuries and damage to property;

(2) liability for workmen's compensation;

(3) fire insurance (covering, among other things, loss by destruction or damage to buildings or personal property);

and (4) motor vehicle collision insurance.

Section 7. Once a district is organized, the commissioners will make surveys and investigations and will prepare a plan delineating district boundaries and proposed improvements. They will determine the total expense of the proposed improvements, along with the percentage to be paid by each proprietor (determined by estimating the benefits less any damages caused by the improvements. The proprietor will be awarded any damages in excess of the benefits. The commissioners will report their plan and estimates to the SRMCB who will approve, disapprove or modify them.

The commissioners must also submit a copy of their determination to each proprietor (hand-delivered or by registered mail). A proprietor has 15 days in which to file any objections with the SRMCB. The SRMCB will notify all proprietors of the receipt of any objections within 30 days; and at least 7 days after this notice is given, the SRMCB will hold a meeting to consider the objections and to make a decision. If the proprietors are not satisfied with this decision, they may petition the County Superior Court.

Once the percentages to be paid by each proprietor have been determined, the SRMCB will record in the

Registry of Deeds (1) a description of the area to be improved; (2) a copy of a plan; and (3) an estimate of the amount to be assessed from each parcel.

Section 8. If the SRMCB feels that certain improvements will benefit public health as a whole and should, therefore, be paid by the Commonwealth, the SRMCB must separately estimate that part of the expense, to be included with other estimates under MGL Chapter 29, Section 4.

Section 9. After recording the description, plan and estimate (from Section 7), the commissioners will call a meeting to decide on the method of financing (options are included in Sections 10 and 11). Approval of proposed expenditures requires a majority vote of a body of proprietors representing a majority interest in both acreage and value of the district's area.

The district commissioners may petition the county commissioners to vote to pay for the first expenditures involved in making improvements. Upon approval, the county treasurer may issue bonds or notes, payable within 25 years to defray expenses. Payment of principal and interest will be made by the county and repaid to the county by the district.

Section 10. The district may vote to adopt any of three methods of financing. It may raise money, by assessment or contribution, and deposit the funds required to cover the estimated expenses with the State Treasurer (payments are made as provided in Section 14). The district may take out a temporary loan in anticipation of assessments from district members and, thereby, pay for the improvements as the work is performed. The district may issue notes or bonds, payable for the amount of the estimated expense, on condition that the initial payment is made within 5 years of the issue date, and that the entire amount is paid within 25 years.

Indebtedness is subject to MGL Chapter 44 and other MGL's applicable to notes and bonds of districts. Money received from the sale of notes and bonds will be deposited with the State Treasurer. The State Treasurer will credit the district account for any district expenses that benefit the public health of the Commonwealth. Money remaining after payment of the total expenses will be paid to the district treasurer to redeem outstanding notes and bonds.

Section 11. The district clerk will certify to the assessors the amount of money voted to be raised and paid annually (on account of the interest and principal due) along with the amount to be paid by each proprietor. A copy of this certification must be filed with the SRMCB. The certified amount will be assessed from the land of the proprietors and will be committed to the local tax collectors. Each week, the tax collectors will remit the money collected from the assessments to the district treasurer. Assessments will be considered a financial obligation under law, upon the recording of the description, plan and estimate (under Section 7), and will continue for two years as of July 1 of the year of assessment (i.e., reassessments are made every 2 years).

Section 12. If Sections 1-7 have been complied with, and payments for expenses have been arranged, the commissioners will carry out the improvements, as approved by the SRMCB. The commissioners may hire persons to perform the work under their direction. If improvements are for public use, the commissioners may take lands, easements, and rights in lands (under MGL Chapter 79), and may purchase and convey property within and beyond the limits of the Commonwealth if necessary. Any person damaged in his property (by an action under this and the following section), may recover damages from the district (as provided in MGL Chapter 79). These damages will constitute a part of the total expense of the improvements.

If the commissioners find it necessary to regulate water levels by operating floodgates or dams on the land of a person not a party to the proceedings (e.g., a person outside the district), the commissioners must give reasonable notice to the proprietor. The proprietor may appeal this work by petitioning the County Superior Court within 30 days after receipt of the notice. Until the appeal is determined, the commissioners must suspend the work.

The commissioners are required to submit to the SRMCB the bills incurred in meeting the cost of required improvements (under Section 14B), on a monthly basis. Once inspected and approved by the SRMCB, these bills will be rewarded to the County or State Treasurer who will make payment from available funds. The SRMCB must also approve bills for maintenance or further improvements reported by the prudential committee and the commissioners (as provided in Section 14A). Once approved, payment will be made by the district treasurer.

Section 14A. A reclamation district organized under this chapter may vote to undertake further improvements, and to incur debt (as provided in Section 10). Original improvements must be completed before this vote is passed. The district may also vote to request the SRMCB to appoint commissioners to carry out these further improvements (as provided in Section 5). Or, the district may authorize its prudential committee to carry out. these further improvements. In either case, both the prudential committee and the commissioners acting under this section will have the same powers as authorized under Section 5. The district will notify the SRMCB of their vote and the prudential committee/commissioners will submit to the SRMCB its/their plans for carrying out the improvements. Assessments from district members to pay for the improvements (modifications) will be made in the manner provided in Section 11.

Section 14B. No person obtaining additional water power or water by the work contemplated in Section 1 - 14B will gain the right to its use, nor may a person be entitled to compensation if the additional water is reclaimed. No water power may be developed by a district under this chapter except by vote of the district and approval of the SRMCB.

Anyone who obstructs or injures any structure constructed under the provisions of Sections 1 - 14B will be fined not less than ten dollars. In addition, the SRMCB may attempt to recover from the perpetrator any damages incurred. The provisions in Section 5A will govern the disposition of money recovered.

The mayor and aldermen or selectmen will receive two dollars for each day of service. The city or town clerk will receive (for recording the petition), the fee provided by Clause (68) of Section 34 of MGL Chapter 262.

Any party aggrieved by the mayor's and aldermen's or selectmen's refusal to make such an order, may petition the county commissioners. The county commissioners will proceed as if the petition had been originally filed with them.

Section 24. Greenhead fly control projects may be established, with the approval of the SRMCB, in any town or city along the seacoast, by vote of the city council/selectmen. By the same vote, any two or more adjoining cities or towns may form a district within their combined areas.

For these areas, the SRMCB will appoint 3 district commissioners. They will be paid a fixed compensation, not exceeding five dollars per day, along with other expenses incurred in the performance of their duties. Compensation and expenses will be paid by the district. The SRMCB may fire and hire Commissioners for cause. The duties of the commissioners will be established by the SRMCB.

Votes to form a district are binding for five years. Any city or town may vote to withdraw from the district within 60 days, but not less than 10 days, of any "anniversary date" of its original vote. They must notify the SRMCB within this time frame, as well.

Any city or town may vote to join an existing district, with the approval of the SRMCB.

Each project will determine its maximum annual budget, and will report its determination to the SRMCB. In the case of districts, the commissioners will make this determination. The SRMCB will, in turn, determine the proportionate share of the budget that each member municipality is to be held accounted for. The SRMCB will then report its determination to the treasurer of each member municipality.

One third of the budget will be paid by the member municipalities within a district in proportion to the salt marsh area within its boundaries. Another third will be paid by the Commonwealth. The final third will be paid by the member towns/cities within a district in proportion to their respective taxable valuations. A project consisting of a single municipality is not entitled to subsidy by the Commonwealth.

Payments of each municipality's share of the budget will be made to the State Treasurer. Towns/cities may also raise money in advance to anticipate its liability. These funds would be held by the State Treasurer, as well, and would be credited against the municipality's liability.

Projects will be allocated funds annually from the State Treasury to eliminate or control Greenhead flies in accordance with the predetermined control strategy (prepared and devised by the SRMCB to effect the greatest measure of relief). Such work must be performed under the direction and control of the SRMCB. Additional control efforts may be carried out as long as additional funding is provided, such as funds voluntarily deposited with the State Treasurer for such purposes.

b. MGL Chap. 132B -- Pesticide Control Act (From the Code of Massachusetts Regulations 333 CMR 2.00 -10.00)

General Information

The Massachusetts Pesticide Control Act was inserted as MGL Chap. 132B of the Acts of 1978 (Chapter 3) as an emergency law and took effect immediately. The purpose of the Act is to have the laws of the Commonwealth conform with federal requirements on registration and certification of pesticides as set forth in the Federal Insecticide, Fungicide, and Rodenticide Act, Public Law 92-516, as amended, (FIFRA), and the federal regulations thereunder. To this end, the Massachusetts Pesticide Control Act creates administrative mechanisms to regulate the labeling distribution, sale, storage, transportation, use and application and disposal of pesticides. The Massachusetts Act also establishes standards and sets forth prohibitions with regard to each regulatory function. The responsibility for implementing the commands of the Massachusetts Pesticide Control Act is distributed by the Act among three governmental bodies:

i. Department of Food and Agriculture (DFA). The DFA has been designated as the state lead agency for implementation and administration of the Act and the Massachusetts pesticide program.

The Act charges the DFA with a wide range of specific regulatory functions and empowers it to promulgate and adopt regulations, standards and forms as are necessary for implementation and administration. Among the duties assigned to the DFA by the Act are:

a. Entering into cooperative agreements and contracts in matters related to the Act and FIFRA.

b. Taking actions necessary to secure for the Commonwealth the benefits of FIFRA and other federal legislation.

c. Establishing advisory councils.

d. Declaring pests and devices to be subject to the provisions of the Act.

e. Establishing the fee and preparing and accepting the applications for experimental use permits.

f. Establishing requirements for licensing and supervising pesticide dealers.

g. Establishing requirements for certifying, licensing and supervising various categories of pesticide applicators.

h. Controlling both storage and disposal of pesticides.

i. Issuing administrative orders to prevent unreasonable adverse effects on the environment or violations under the Act.

j. Right of entry and inspection as needed to administer the Act. Within the DFA, the pesticide regulatory functions shall be under the administrative supervision of a Pesticides Program Director.

ii. Pesticide Board. The Act creates within the DFA a Massachusetts Pesticide Board.

The Board's responsibilities entail advising the Commissioner of Food and Agriculture with respect to the implementation and administration of the Act The Board also hears appeals of those aggrieved by the actions or decisions of the DFA or the Subcommittee of the Pesticide Board. The Act, additionally, assigns the Board the responsibility for approving a variety of departmental actions within the DFA. Among the actions requiring Board approval are:

a. All regulations, standards and forms proposed by the DFA to implement and administer the Act.

b. Appointment of the Pesticides Program Director.

c. Cooperative agreements and contracts with respect to the Act and FIFRA.

d. Establishment of advisory councils.

e. Declarations of pests and devices to be subject to the provisions of the Act.

The Commissioner of Food and Agriculture or his designee serves as the Chairman of the Pesticide Board. Other members include the Commissioner of Environmental Protection or his designee, the Commissioner of Fisheries, Wildlife and Recreational Vehicles or his designee, the Commissioner of Environmental Management or his designee, the Commissioner of Public Health or his designee, the Director of the Division of Food and Drugs or his designee and the seven persons appointed by the Governor, one of whom has been engaged in the commercial production of a plant-related agricultural commodity for at least the preceding five years on land owned or rented by him, one of whom has been an active commercial applicator of pesticides for at least the preceding five years, one of whom has expertise in the health effects of pesticide use, one of whom is a physician, one of whom is experienced in the conservation and protection of the environment, and two of whom represent the public at large. Each member is appointed for a period of four years, except for persons appointed to fill vacancies, who serve for the unexpired term.

The appointive members of the Board receive fifty dollars for each day or portion thereof spent in the discharge of their official duties and are reimbursed for their necessary expenses incurred in the discharge of their official duties.

iii. Subcommittee of the Pesticide Board. The Act creates a subcommittee within the Pesticide Board of the DFA.

The subcommittee is responsible for registering all pesticides for use in the Commonwealth and for issuing all experimental use permits.

The Director of the Division of Food and Drugs serves as the Chairman of the Subcommittee. Other members include the Commissioner of Food and Agriculture or his designee, the Commissioner of Environmental Management or his designee, and the Commissioner of Public Health or his designee, and one person appointed by the Governor, who has been actively engaged in commercial application of pesticides for at least the preceding five years who is a member of the Pesticide Board.

c. 333 CMR 10.03 (21-23) - Amendments of 1983.

Amendment (21) to the Pesticide Regulations provides a list of conditions that must be met prior to all non-agricultural pesticide applications by aircraft. It calls for public notification of abutting Landowners 2-10 days before the application as well as notification of the Department of Food and Agriculture and the contractor. Application sites must be recorded on U.S.G.S topographical maps and records kept for 2 years. Amendment (22) deals with the right of exclusion from pesticide applications of property owners and their tenants. Methods are outlined for requesting exclusion and for properly marking the boundaries of property to be excluded. Exclusion requests are not honored if public health or agricultural threats exist or if a recently introduced pest is being contained.

Amendment (23) requires a permit from the Department of Food and Agricultural for all private applications of pesticide by aircraft. Aerial applications for mosquito control are specifically exempted from this provision along with a few other classes of applications.

d. M.G.L., Chap. 91. Sections 1-63 -- Waterways

This law does not deal specifically with mosquito control but it does cover variety of activities associated with wetlands. Mosquito control is specifically exempted from the provisions of Sections 19A, 59 and 59A of this law but not from other provisions. As amended by Chap. 373 of the Acts of 1969, the Act makes provisions so that the use of oil for mosquito control in any lakes rivers, or tidal waters or flats under MGL 252 is exempt from the provisions of Section 59 and 59A of Chapter 91, provided it conforms to the rules and regulations and of the State Pesticide Board.

e. M.G.L., Chapter 40. Section 5 - Boards of Health and Supervision.

Clause (36) and (36C) have MGL Chapter 40 Section 5 refers to the appropriation of money by towns for mosquito abatement:

(Clause 36). At any town meeting, a town, whether or not a member of a mosquito control project, may appropriate money for lowland improvement (modification) and mosquito abatement. Outside agencies may be contracted by the Board of Health to carry out mosquito control, provided the SRMCB is notified. This outside agency is responsible for filing a detailed annual report of their mosquito control program with the SRMCB.

(Clause 36C). A town or city that is a member of a mosquito control project may appropriate money in addition to the amount assessed by the project for mosquito abatement. The abatement activities must, however, be carried out under the supervision and control of the mosquito control project.

f. M.G.L., Chapter 131. Section 40 - Wetlands Protection Act.

The Wetlands Protection Act controls the use of freshwater and coastal wetlands by establishing a public review and decision-making process through which certain activities affecting wetlands may be regulated. The Act is administered by local conservation commissions (or the mayor or selectmen of towns without conservation commissions), and the Department of Environmental Protection (DEP). Any proposed project that may affect a wetland area must be approved by the local conservation commission. The proponent must apply for a permit with the conservation commission and the DEP, who will evaluate the proposed project to determine whether any land is subject to the jurisdiction of the Act. The Act is complemented by 310 CMR 10.00, which provides the conservation commission, and DEP with standard definitions and procedures by which to implement the Act. Proposed alterations to wetland habitats of rare wildlife must also be reviewed by the Natural history & Endangered Species Program (see Endangered Species Act below).

Mosquito control activities are exempt from the provisions of the Wetlands Protection Act, provided that the activities are carried out in compliance with Clause (36) of Section 5 of MGL Chapter 40, MGL Chapter 252, or of any special act. Nonetheless, there is still some debate concerning whether the exemption applies only to the maintenance of existing structures or also includes new structures. (see page 25)

g. Section 40A of Chapter 131. Inland Wetlands Restriction Act. Section 105 of Chapter 130. Coastal Wetlands Restriction Act.

The Inland Wetlands Restriction Act, together with the Coastal Wetlands Restriction Act makes up the statutory basis of the Massachusetts Wetlands Restriction Program. The objective of both Acts is to promote and protect the public safety, property, wildlife, fisheries, water resources, flood plain areas, and agriculture by restricting or prohibiting the altering or polluting of inland and coastal wetlands. Although the areas and interests protected are basically the same as those protected by the Wetlands Protection Act, the Wetlands Restriction Acts set forth a planning program that is not dependent on a proponent's initiative to apply for a permit. Through the Massachusetts Wetlands Restoration Program, inland and coastal wetlands are mapped out in each city and town. After a public hearing, a Restriction Order is issued by the administering agency, which prohibits certain activities in the wetland areas. The Order is then recorded in the Registry of Deeds and is binding to all present and future owners of the property.

Two regulations, which correspond to the Acts, are 302 CMR 4 and 6. These regulations contain the rules for adopting coastal and inland wetland orders. The Department of Environmental Management is the legal authority for both Restriction Acts. However, the administrative responsibility has been taken on in recent years by the DEP. A statutory transfer of the Massachusetts Wetlands Restriction Program is pending.

Mosquito control, as authorized by MGL Chapter 252, is exempt from the Wetlands Restriction Act.

h. M.G.L., Chapter 131A. Massachusetts Endangered Species Act.

This Act prohibits the "taking" of rare plants or animals. This includes all plants or animals listed as Endangered, Threatened, or Special Concern by the Massachusetts Division of Fisheries and Wildlife. Fines and jail terms may be imposed for illegally taking a rare species. This Act also protects "significant habitats," which can be so designated after a public hearing process. Permits must be issued for any work in significant habitats.

The primary agency for determining rare species status and significant habitats is the Massachusetts Natural History & Endangered Species Program (NHESP) run from the office of the Division of Fisheries & Wildlife. NHESP has developed a series of Estimated Habitat Maps for state-listed rare species (contained in the Massachusetts Natural Heritage Atlas), which assist mosquito-control programs in determining the presence or absence of rare or endangered species.

Mosquito control activities are not exempt from the Endangered Species Act and care must be taken to ensure programs are in compliance with the Act. Both pesticide applications and storm water drainage are considered alterations and require permitting.

i. M.G.L., Chapter 132A. Sections 13-16, 18 -- Ocean and Coastal Sanctuaries Act

The following areas in Massachusetts are protected under the Act: the Cape Cod Ocean Sanctuary, the Cape Cod Bay Ocean Sanctuary, the Cape and Islands Ocean Sanctuary, the North Shore Ocean Sanctuary, and the South Essex Ocean Sanctuary. Section 13 of the Act demarcates the ocean sanctuaries, all of which extend approximately three miles seaward from a point on the mean low water line. The purpose of the Act, as described in Section 14, is to protect each ocean sanctuary from any "...exploitation, development, or activity that would seriously alter or otherwise endanger the ecology or the appearance of the ocean, the seabed, or the subsoil (of the sanctuaries), or the Cape Cod National Seashore."

The Ocean Sanctuaries Act does not require the issuance of permits other than those already required by law. In consequence, the Department of Environmental Management, the State agency authorized to oversee the Act, serves as a trustee rather than as a permitting agency. All other State and local permitting agencies are responsible for conducting their activities in conformation with the Act. Regulation 302 CMR 5.00 complements the Act.

Although not specifically exempted from the provisions of the Act, mosquito control activities are not performed within the boundaries of the ocean sanctuaries.

j. Acts of Enabling Legislation Establishing Mosquito Control Projects

Except for Cape Cod, all 10 current and disbanded MC Projects in Massachusetts were established after World War II when mosquito control first appeared both technically and economically feasible on a wide scale. The most recent were the Central Massachusetts and Suffolk County projects formed in 1973/74. Almost without exception, these projects were created as a result of lobbying efforts by local citizen groups who were concerned about both outbreaks of mosquito-borne disease (i.e. EEE) and biting annoyance created by high densities of mosquitoes. Local legislators and city selectmen or boards of health played roles in shepherding through the necessary legislation. The Cape Cod Chamber of Commerce was instrumental in the creation of the MC Project on the Cape. The Board of Reclamation often assisted local citizens and legislature with their efforts. especially in the case of the more recently established projects.

The East Middlesex and South Shore (disbanded in 1981) projects were formed under Chapter 252 of the General Laws. The remaining eight were created by special legislation (individual project descriptions below). An important change in the entering and leaving procedure was made in 1991 when state legislation required towns, upon joining a project, to commit to a minimum of a five-year membership. This provides both stability of funding to the projects and enables a more comprehensive pest management plan to be put in place (single-year memberships place emphasis on immediate results; multi-year memberships place emphasis on long-term results).

3. Federal Laws

Federal laws, which directly impact on mosquito control activities, are Sections 401 and 404 of the Clean Water Act and the Endangered Species Act. All other federal restrictions governing wetlands and pesticides are covered by Massachusetts's laws, which impose restrictions, and requirements that are equal to or greater than those in comparable federal law. The exception in the case of Section 404 arises because the state laws governing the ditching of wetlands exempt mosquito control but the Federal Clean Water Act does not.

a. Section 401. Clean Water Act: Water Quality Certification.

This section requires applicants wishing to discharge dredged or fill materials to obtain a certification or waiver from their state water pollution control agency (Massachusetts Bureau of Resource Protection, Division of Wetlands and Waterways). Section 401 is a federal mandate that is implemented by the state, resulting in some friction over precisely what does and does not require a water quality certificate and what issues the certification can and cannot address. The issue is rendered moot for mosquito control, however, as the U. S. Army Corps of Engineers will not permit a mosquito-control project that does not have a water quality certification. Section 401 provides DWW with the power to influence permit applications in two ways: by denial of the required water quality certification, and by issuing the water quality certification with limitations attached. To date, obtaining water quality certifications has not been particularly difficult for Massachusetts mosquito control programs.

b. Section 404. Clean Water Act (1972).

This Federal Act calls for a system of permitting to be carried out by the U. S. Army Corps of Engineers with a review of all permit applications by appropriate state and federal agencies. The mosquito-control activities, which require a permit under Section 404, are as follows:

a) Cutting or clearing new mosquito ditches in tidal areas below mean high water.

b) Placing material excavated from existing or new ditches on salt marshes or freshwater wetlands.

The Corps developed a draft plan in the early 1980's outlining procedures for issuing general permits for maintenance work (i.e. ditch cleaning) in existing mosquito ditches in each MC project. This plan was eventually shelved pending the preparation of a GEIR to serve as a guide. According to 1986 correspondence to the Norfolk County MCP from the Section Chief of the Regulatory Branch of the Operations Division, the Corps does not require a permit under Section 404 for ditch cleaning provided the spoil is scattered at a depth of no more than 3 inches.

The question of permit requirements for new construction in Massachusetts's salt marshes, such as the OMWM projects in Essex and Plymouth Counties, remains an ambiguous issue. The Audubon OMWM Manual (p. 2-2) indicates that, in addition to the Corps permit, permits are required from the Division of Waterways, Office of Environmental Affairs and a Letter of Consistency from the Office of Coastal Zone Management. Interagency correspondence suggests that even agency heads are unclear about the legality of any of these requirements when mosquito source reduction work is involved. However, in current practice the Corps is not issuing permits for OMWM projects without these two documents.

c. Endangered Species Act.

This act is designed to protect threatened and endangered species as listed on the National Historic Register Suffolk County has had to use Bti instead of Altosid in areas where the Blue-spotted salamander (*Ambystoma laterale)* and the banded bog skimmer (*Williamsonia lintneri*). Other projects, such as Bristol County MCP, have requested advice on osprey (Horseneck Beach in Westport) and the yellow-spotted turtle but have not had to modify their proposed work because of these animals. In both cases Bristol County was doing ditch maintenance. Should the project have been proposing larviciding or more extensive source reduction work, there is a chance that their request would have been denied.

With the Suffolk County larviciding program, the issue of the effects of Altosid, an insect hormone mimic, on reproduction in amphibians has been the driving force behind the decision to not allow its use. The scientific claims for such effects are limited and more research in this area is required.

In Plymouth County, proposed drainage maintenance was halted by the local conservation commission because they felt that the drainage threatened the pools themselves, regardless of the presence of endangered species. Whether or not all vernal pools deserve complete protection remains a matter for research and debate.

The net effect of the Endangered species act on mosquito control has been small, but has provided another means of analyzing the environmental effects of mosquito control. research on the effects of source reduction on non-targets is lacking and this lack should be addressed.

B. Current Mosquito Control Programs in Massachusetts

1. Formal Mosquito Control Projects

Of the 351 Towns in Massachusetts, 158 (or 45%) currently belong to the 9 organized MC. These projects and the towns included in each are illustrated topographically in Fig. 1. Each project is managed by a superintendent who is hired and supervised by a Board of Commissioners representing the towns included in the project. Board members are appointed by the Board of Reclamation for designated terms (usually 3-5 years). Members are unpaid except for up to $75 per meeting in expenses. Boards generally meet once or twice monthly to authorize major expenditures and to review policy and program progress.

Questionnaires were sent to each MC Project in both 1985 and in 1996 (copies in Appendix 1). The projects' responses to the questionnaire formed the basis for the following summaries.

The State Reclamation and Mosquito Control Board exercises responsibility over all 9 projects. This responsibility includes, but is not necessarily limit to, the following:

1. Review and approve budgets
2. Administer project funds (payroll, process purchases, etc.)
3. Review program plans
4. Appoint commissioners
5. Issue control policies and recommendations

6. Administer emergency control funds provided to projects from the governor's or legislators emergency funds
7. Provide advice and guidance when requested by projects or towns
8. Moderate disputes
9. Assist towns seeking to join or organize a formal project or to withdraw from an existing project
10. Serve as a liaison between projects and other state and federal agencies and in legislative matters

Most projects indicated satisfaction with the administrative arrangement and the current functioning of the SRMCB. Suggestions for improvement centered around the Board providing more comprehensive services to the projects (this would require more staff) and more efficient and responsive staff for dealing with project budgets. More formal meetings with all projects to foster better communication and occasional attendance of Board representatives at project commission meetings were a common theme.

All projects have a Board of Commissioners appointed by the SRMCB. They represent the various towns within each project and exercise general control over the project. Their specific role involves, but is not necessarily limited to the following:

1. Appoint the project superintendent
2. Approve the appointment of all permanent project personnel
3. Approve payroll and sign all invoices prior to processing by the SRMCB
4. Review and set policy
5. Review budgets and salaries
6. Serve as liaison between the project and the towns they represent
7. Provide advice to project superintendent
8. Moderate disputes

The projects find this administrative structure to be responsive and appropriate. The wide range of expertise represented by the commission membership brings a broad information base to bear on important financial and operational issues. The superintendents make all day-to-day operational decisions concerning when and where to institute control and what methods to use.

The Nine Mosquito Control Projects of Massachusetts (see Tables 1 and 2 for budget figures presented in descriptions):

Berkshire County Mosquito Control Project

Created under:	Chapter 456 of the Acts of 1945
Area included:	The towns of Becket, Hinsdale, Lanesboro, Otis, Richmond, and Sheffield and Stockbridge.
Annual Assessment:	35 cents on each one thousand dollars of taxable valuations; sums so expended in proportion to their respective valuations.
Amendment to Assessment:	Chapter 459 of the Acts of 1970--20 cents on each one thousand dollars of the equalized valuations; sums so expended in proportion to their said valuations.

Formed in post-War 1945 under the leadership of the State Senator from Pittsfield. This countywide project originally had 32 member towns. All except 8 of these towns withdrew in the early 80's after the passage of Proposition 2 1/2 and considerable negative publicity. One additional town left later on. Since 1985, four towns have joined the project and four have withdrawn. Of these one (Hinsdale) withdrew and then rejoined and another (Pittsfield) joined and then withdrew. The reasons for withdrawing centered on cost, while the reasons for joining centered on municipalities responding to resident complaints.

Spring hatch *Aedes* are the major problem experienced in this mountainous terrain. Some reflood *Aedes* and *Cq. perturbans* problems also exist. In 1985 approximately 70% of the budget was devoted to source reduction through hand cleaning of ditches. By 1996, approximately 70% of the budget is devoted to larviciding and adulticiding. The program is evaluated by all four standard monitoring methods.

Over the past decade increasing citizen concern regarding pesticide use has been the most important change faced by the project. At present, providing the desired control services under very tight funding is given as the most important challenge facing the project.

Bristol County Mosquito Control Project

Created under:	Chapter 506 of the Acts of 1956
Area included:	All the cities & towns comprising Bristol County
Annual Assessment:	15 cents on each one thousand dollars of taxable valuations; sums so expended in proportion to their respective valuations.
Amendment to Assessment:	Chapter 638 of the Acts of 1970--8 cents on each one thousand dollars of the equalized valuations; sums so expended in proportion to their said valuations.

All twenty towns in Bristol County make up this control project, which was formed in 1959 during a period of high pest densities and threat from EEE. Senator Parker of Taunton played a key role in organizing the project. Only one town (Dartmouth) subsequently withdrew from the project following negative publicity. It rejoined several years later during another EEE active period.

There are approximately 67,000 acres of fresh water swampland in Bristol County. As in the case of Norfolk and Plymouth Counties, this presents some unique problems. It has resulted in a large source reduction effort (78% of budget in 1995) and adulticiding (19%) over larviciding. Salt marsh mosquitoes have become an increasingly important part of the control program.   Spring *Aedes* and *Cq. perturbans* are major pest problems and concern with EEE transmission is ever present. Light trap counts and cases of human/animal disease are used to evaluate the effectiveness of the program.

Over the past decade Bristol MCP has been faced with the double squeeze of increasing concern over wetlands alterations and increasing concerns over pesticide use. With source reduction and adulticiding being the two primary control techniques used by Bristol MCP, such concerns go to the heart of the project's effectiveness. As an example, Bristol MCP switched from malathion to resmethrin for adulticiding due to public pressure to end the use of malathion. However, resmethrin is more costly, which brings to the fore the continuing difficulties of budgets. Bristol MCP, like many other projects, faces difficulties in implementing newer control strategies due to tight budgets.

Cape Cod Mosquito Control Project

Created under:	Chapter 379 of the Acts of 1930
Area included:	The town comprising Barnstable County
Annual Assessment:	25 cents on each one thousand dollars of their respective valuations.
Amendment to Assessment:	Chapter 209 of the Acts of 1975--9 cents on each one thousand dollars of the equalized valuations; sums so expended in proportion to their said valuations.

The Cape Cod project was organized through the efforts of the Cape Cod Chamber of Commerce, beginning in 1928. Their motivation was the enhancement of the recreational resources of the Cape. All 15 towns in Barnstable County have belonged to the project continuously since its formal creation in 1930. There are approximately 20,500 acres of salt marsh and 2,600 acres of freshwater wetlands on the Cape capable of supporting mosquito development.

The Cape Cod project has chosen not to use adulticides as part of their program. Larviciding and source reduction (maintenance on existing water systems) form the backbone of the project. The Cape project is currently conducting research into the use of native fish as biological control agents for mosquitoes. While larval surveys and larvicide applications are conducted during half of the year, the other half of the year is spent maintaining the current ditch systems (including work on pipes, culverts and sluiceways). Many towns' DPWs and Conservation Commissions utilize the project's expertise to help keep drainage systems open and running properly. Further, the Cape Cod project's work is recognized by the National Flood Insurance Program's Community Rating System as meeting the flood-plain maintenance requirements for towns to obtain lower flood insurance rates.

The Cape Cod project utilizes a Geographical Information System (GIS) that includes maps of all potential larval habitat, documentation of work done including larvicide application, and data from adult and larval surveys conducted at all mosquito development sites. Information from this system is used to write an annual report and is made available to the member towns.

This project also runs a greenhead fly control program. Over 600 blue box traps are placed on the salt marshes of Barnstable County every spring. Research was conducted by the project in the summers of 1992-1995 to determine the effectiveness of adding Octenol, an olfactory attractant to these traps. Success with that research has resulted in this project and others incorporating octenol into their greenhead fly trapping programs.

As an indication of the stability of the Cape Cod Project, all eighteen employees have over 4 years of experience with 50% of the employees having worked in mosquito control for over 15 years

Central Massachusetts Mosquito Control Project

Created under:	Chapter 583 of the Acts of 1973
Area included:	The area in Middlesex and Worcester Counties including the cities of Fitchburg, Leominster, and Marlborough and the towns of Ashland, Ayer, Berlin, Billerica, Blackstone, Boxborough, Chelmsford, Clinton, Dracut, Holliston, Hopedale, Hudson, Littleton, Lunenburg, Milford, Natick, Northborough, Sherborn, Shrewsbury, Southborough, Stow, Tewksbury, Westborough, Westford, and Wilmington.
Annual Assessment:	8 cents on each one thousand dollars of the cities' and towns' equalized valuations; sums so expended one quarter in proportion to their valuations and three quarters in proportion to their respective areas.

Twenty-eight towns make up this large project. It was organized in 1973 through the efforts of several town boards of health and concerned citizen groups. The Project has experienced significant turnover in membership. Two towns withdrew from the project early on but then rejoined. Seven other towns withdrew permanently prior to 1986, primarily as a result of Proposition 2 1/2 fiscal constraints and concern over pesticide use, though concerns about mosquitoes coming into the town from areas not being treated played a role in Hopkinton's decision to withdraw. However, Fitchburg, Lunenburg, and Leominster were joining during the same period, in each case due to a desire to be a part of a regional approach to mosquito control. Since 1986, an additional seven towns have withdrawn (Harvard, Lancaster, Boylston, Grafton, Groton, Northbridge and Shirley). The towns left for budgetary reasons and environmental concerns. Five towns have joined the project since 1989, two (Wilmington and Natick) because town programs were abandoned, one (Blackstone) because of bad mosquito problems, one (Dracut) because of positive feedback from member towns, and the fifth (Stow) because they liked the environmentally responsible control techniques of the Project. Towns can withdraw or rejoin by a vote at town meeting but joining towns also must be approved by the SRMCB, which may impose special stipulations.

Up to 10,000 acres of mixed, freshwater wetlands and a large number of catch basins and tires are treated with larvicide's (35% of total budget) and/or have source reduction work done (40% of budget). Spring hatch and reflood *Aedes*, and *Cq. perturbans* account for the bulk of the pest problems in this project. All standard monitoring methods are used to evaluate program effectiveness.

Central Mass has assembled an impressive staff, with six staff members holding BS or BA degrees and several personnel having more than 15 years of mosquito-control experience.

Over the past decade the Project has worked to reduce its use of adulticides and increased its applications of larvicides such as Bti. Water management has been geared towards maintenance but wetlands restoration is playing an increasing role. Given that many towns have withdrawn from the project due to budget constraints, developing a modern, cost-effective control program is the highest challenge currently facing the Project.

East Middlesex Mosquito Control Project

Created under:	MCL Chapter 252, section 5A in 1945. There is no specific Massachusetts Law or Act which names the East Middlesex Control Project.
Area included:	Twenty cities and towns in Middlesex and Norfolk Counties including Arlington, Bedford, Belmont, Brookline, Burlington, Cambridge, Framingham, Lexington, Lincoln, Melrose, Newton, North Reading, Reading, Sudbury, Wakefield, Waltham, Watertown, Wayland, Wellesley, and Weston.
Annual assessment:	Cities and towns voluntarily appropriate funding each year for mosquito-control services. Funding is carried over from one fiscal year to the next.

This project was organized in 1945 as a trust agency to provide mosquito control for 6 cities and towns. The original goals for the Project cited by the representatives of the 6 municipalities were to form a cooperative mosquito control program under the auspices of the State Reclamation Board. Policies for the Project were set by the Commission that would be comprised of representatives, appointed by the State Reclamation board, from each municipality. The primary reasons cited in 1945 for organizing the Project were the vector potential and nuisance caused by mosquitoes.

Currently the Project has 20 members. The newest municipalities to join the project have been North Reading (1991) and Melrose (1997). The twenty-member commission meets twice a year. Five Commissioners serve on the Executive Committee, which meets regularly. Funding is derived through voluntary appropriations. The Commission has a policy, which allows municipalities flexibility in choosing control methods. The Project recommends a control program for each municipality. The municipality then has control over which services it chooses to fund. Although this process has resulted in stable growth since 1983, the Project has historically had funding limitations because 33% of its area is urban with relatively minor mosquito pest problems.

Spring *Aedes* species, *Ae. vexans*, and *Cq. perturbans* are the major concerns in the district. *Culex* in urban areas are also a concern. Aerial larviciding against spring *Aedes* and *Aedes vexans* is the largest program in the district. Other programs include larviciding with a truck-mounted hydraulic sprayer and portable sprayers, catch basin larviciding in urban areas and adulticiding with truck-mounted ULV aerosol sprayers and portable aerosol and backpack mistblowers. Beginning in 1994, the Project entered into a cooperative agreement with the Essex County Mosquito Control project to use a backhoe and operator for East Middlesex ditch-maintenance operations. The Project continues to maintain ditches by hand in woodland areas. The Project maintains an extensive surveillance operation, which includes monitoring adult mosquitoes at 50 locations. The Project records extensive larval survey data to support it's larval control program. Beginning in 1995 the Project augmented its surveillance and record keeping programs by adding GIS mapping software.

North East Massachusetts Mosquito Control and Wetlands Management District
formerly Essex County Mosquito Control Project

Created under:	Chapter 516 of the Acts of 1958
Area included:	The area in Essex County not including any city or town already a member of an organized mosquito control project.
Annual Assessment:	15 cents on each one thousand dollars of taxable valuations; sums so expended one quarter in proportion to their valuations and three quarters in proportion to their respective areas.
Amendment of Assessment:	Chapter 679 of the Acts of 1970 -- eight cents on each thousand dollars of equalized valuation; on quarter in proportion to there said valuations and three quarters in proportion to their respective areas.

This seventeen-town project was established in 1965 after lobbying efforts by citizen groups who were concerned about pest mosquitoes. Prior to 1986 four towns (Essex, Merrimac, North Reading, Lynnfield) subsequently withdrew from the project by town meeting vote due to fiscal constraints and some negative publicity. One of these towns (Lynnfield) rejoined the following year due to a perceived increase in pest densities and threats to public health. Ten towns withdrew from the project in the late 'eighties, primarily because of budget constraints. Four towns (Ipswich, Newburyport, Salisbury and Amesbury) have since rejoined, all because of public demand following the halt of control activity (length of time out of project varied from one to three years).

A high proportion of the Essex County MCP budget is devoted to salt marsh mosquito problems (60%) and this project has taken the lead in working with environmental interests to develop OMWM plans and studies in some of its marshes. Catch basins are treated with Altosid briquettes and all other larviciding is carried out with the bacterial toxin Bti. This is mostly in woodland vernal pools in the spring and in unmanaged salt marshes. The project does little adulticiding. It also administers a greenhead fly control program using box traps in several coastal towns. All monitoring methods (i.e., complaints, and light emergence traps, and landing/larval counts) are used to evaluate the effectiveness of the program and for daily decision-making.

Essex County has been a leading project in developing Open Marsh Water Management as a mosquito-control and marsh-restoration technique in the Northeast, and has pushed to develop a set of standards for mosquito control in such areas as uplands ditch maintenance that will both standardize control throughout New England and provide a better framework for the permitting process.

Not surprisingly for a Project with a forward thinking approach, Essex County's program, over the past decade, has reduced adulticiding while implementing OMWM and increasing its ties with environmental agencies and groups. The loss of several towns has required a change in strategy from a regional to a municipal approach, a change not particularly desirable for area-wide control problems like mosquitoes. However, the challenge of revising the Project's strategies and techniques has been met and its most important challenge today is meeting the demand for marsh restoration work while continuing to maintain a high standard for mosquito control.

Essex County MCP changed its name in 1996 to the North East Massachusetts Mosquito Control and Wetlands Management District, but it will be referred to as Essex County in this report as the name is new and may not be recognized by readers at this time.

Norfolk County Mosquito Control Project

Created under: Chapter 341 of the Acts of 1956
Area included: The area in Norfolk County not including any city or town already a member of an organized mosquito control project.
Annual Assessment: 20 cents on each one thousand dollars of taxable valuations; sums so e expended on half in proportion to their valuations and one half in proportion to their respective areas.
Amendment of Assessment: Chapter 496 of the Acts of 1975--8 cents on each thousand dollars of equalized valuations; sums so expended one quarter in proportion to their valuations and three quarters in proportion to their respective areas OR three quarters in proportion to their valuations and one quarter in proportion to their respective areas, WHICHEVER IS THE LESSER AMOUNT.

Twenty-two towns formed this project in 1956 and three more joined in the early 80's after the South Shore project disbanded. Two towns (Milton and Norfolk) later withdrew by a vote at town meeting or city council. Norfolk rejoined just one year later only to withdraw and rejoin again about 10 years later. Withdrawal votes were fueled by environmental concerns over pesticide use and negative publicity. Efforts to rejoin were precipitated by public health threats, biting complaints, and ineffective in-house control programs. Norfolk did not lose towns during the late eighties, so has had stable membership for more than a decade.

Over half of the project budget is spent on source reduction work. In the ‘80’s adulticiding was stressed over larviciding but this has changed and now larviciding, including aerial applications, far exceeds adulticiding. It is estimated that there are over 30,000 acres of freshwater swampland in Norfolk County, which can breed mosquitoes, but only 1,087 acres are treated for spring-hatch and 523 acres (there may be overlap) for summer reflood mosquitoes. Thirty-eight acres of salt marsh are under active control. All 4 standard surveillance methods are used to evaluate program effectiveness.

Over the past decade the project has faced increasing pressure from the public concerning pesticide use. The project has responded by providing a more localized response to fogging requests (no more town-wide applications are done), by increasing larval monitoring to better target larvicide applications, and by using Bti and IGR formulations for larviciding. In 1996, the Project purchased a third excavator for source-reduction work, went from five to nine field staff positions, hired two seasonal employees to improve their database information on wetlands and purchased computer mapping equipment to better target their control efforts.

These changes, while desirable environmentally, have their cost, and funding remains a primary concern.

In addition, environmental regulations likewise cause concerns, specifically when fueled less by scientific reason and more by emotional appeal.

<u>Plymouth County Mosquito Control Project</u>

Created under:	Chapter 514 of the Acts of 1957
Area included:	The area in Plymouth County not including any city or town already a member of an organized mosquito control project.
Annual Assessment:	25 cents on each one thousand dollars of taxable valuations; sums so expended on half in proportion to their valuations and one half in proportion to their respective areas.
Amendment of assessment:	Chap. 544 of Acts of 1970 -- 13 cents on each thousand dollars of equalized valuations; one-half in proportion to said valuation and one-half in proportion to their respective areas.

Twenty-one towns formed this project in 1958 during a period of major EEE threat. The Plymouth County Selectman's Association and local legislators led this movement to organize. Seven additional towns joined the project in the early 1980's when the South Shore project disbanded. Four of the original member towns withdrew by town meeting vote in the mid-sixties. Towns must have been a member for at least 3 years before they can vote to leave the project. Towns that withdrew did so primarily over concern for the impact of the wide-scale aerial spraying that the project was carrying out in the mid-sixties. The town of Halifax rejoined the project in 1985 after they determined that the Plymouth County project was more environmentally sound than the in-house program they had developed. Since that time, Abington, Hanover, Kingston, and Whitman have also rejoined. Bridgewater withdrew in 1990, due to budgetary concerns.

About 20% of the concern of this Project is with salt marshes. Water management, including OMWM efforts, is used to control most salt marsh *Aedes*. Spring and reflood Aedes receive a substantial amount of attention. *Cq. perturbans*, the cattail mosquito, causes a very significant problem but there are no recommended larvicides for this species at present. Although several projects contract for some aerial larviciding (and adulticiding in emergencies), Plymouth County is the only project, which owns fixed winged aircraft for doing its own aerial work. Ground adulticiding with resmethrin is still an important control strategy in this project because of inability to control the cattail mosquito, and other species developing in large woodland swamps, with larvicides. Up to 7,860 acres of Plymouth County's large acreage of swampland are treated with larvicide’s (Bti), targeted mainly against spring *Aedes*. The project evaluates its control effectiveness from complaints, landing counts, and larval counts.

The past decade has clearly been one of change at Plymouth. Malathion for adulticiding gave way to resmethrin and the larvicide Temephos was replaced by Bti. There has also been an increase in the number of member towns and increased service requests. Dr. Ludlam further notes that the State Reclamation Board has become stronger and there have been improved ties with the Massachusetts Department of Public Health. The most important challenge facing Plymouth today is the continued lack of a control strategy for *Cq. pertubans* in the larval stages.

<u>Suffolk County Mosquito Control Project</u>

Created under:	Chapter 606 of the Acts of 1973
Area included:	The area of Suffolk County comprising the cities of Boston and Chelsea.
Annual Assessment:	5 cents of each one thousand dollars of equalized valuations; sums so expended one quarter in proportion to their valuations and three quarters in proportion to their respective areas.

The Suffolk County project is the smallest in land area and encompasses Boston and Chelsea. The two other towns in Suffolk County, Revere and Winthrop, are members of the Essex County project, which predates this project. The project was organized in 1974 with strong leadership from legislators who were residents of the district and felt that a pest problem existed. Member town can withdraw from the project through a majority vote of the city council and mayor. Prior to the organization of the project, the Department of Housing Inspection contracted with a private applicator to do aerial spraying of salt marshes and the Parks Department did adulticiding with mistblowers.

About 30% of the mosquito problem is associated with salt marsh *Aedes* but no marsh management activities are carried out in the project's 200 acres of breeding salt marsh. Control is done with larvicide's. Another 130 acres of freshwater wetland breeding sites are also treated with larvicides, as are storm sewer catch basins. About 40% of the projects budget is devoted to adulticiding, the highest percentage of all the projects, but down for the 1980s. Program effectiveness is evaluated by complain levels, light traps, landing rates, and larval counts are used to evaluate the effectiveness of the program.

Over the past decade the project has used more Altosid for larviciding and reduced malathion use for adulticiding. Public pressure, both for increased spraying (to eliminate mosquitoes) and decreased spraying (to protect the environment) plays a strong role in the day-by-day operation of this populous project. There are also two MDC Reservations in which mosquito-breeding areas overlap endangered species habitat. Currently the project can use Bti in these areas but would prefer to switch to Altosid. Permission to make this switch has not been granted.

Budgets

Budgets for all projects for 1993 and 1994 fiscal years are provided in Tables 1 and 2. The standard break down by category as used by the SRCMB is adopted in these Tables. The data used in these Tables were provided by the projects themselves.

2. Non-Member Communities.

For the initial GEIR, all Massachusetts Town Boards of Health were sent a concerning their town's mosquito control activities and 326 (93%) eventually responded. Fifty-seven towns (about 38% of those responding) indicated they do some mosquito control: 34 carry out the control work themselves using town personnel and 23 contracts with private applicators. Nineteen (83%) of the 23 towns with contracted control provided detailed information on costs and pesticides used; 23 (68%) of the 34 town-operated programs provided this information.

The decision by non-member towns to do mosquito control work (which in almost all cases was temporary, chemical control) is made by a variety of authorities: 68% by the BOH, selectmen, mayor or other town officials, and 32% by a public vote. Citizen complaints and a perceived health threat both weighed heavily in decisions to do control work. Approximately 1/4 of the towns had some mosquito survey information available as an aid in the decision-making process. The major criteria used to assess the effectiveness of the control work undertaken was the post-treatment level of citizen complaints (95% of all towns). Other considerations were, in order of importance: larval counts, light trap counts, level of disease, and human landing counts.

Table 1. Budgets for Mosquito Control Projects for Fiscal Years starting in 1993 and 1994.

Budget Item	1993	1994
Berkshire County MCP		
Administration		
a. Personnel (wages & benefits)	30,000	30,000
b. Other (office supplies, travel, etc.)	500	500
Field Operations		
a. Personnel (wages & benefits)	10,700	10,700

b.	Pesticides	5,792	0
c.	New equipment	0	0
d.	Other (gas, supplies, etc.)	20,000	25,792
TOTAL		$66,992	$66,992

Bristol County MCP

Administration			
a.	Personnel (wages & benefits)	75,370	75,518
b.	Other (office supplies, travel, etc.)	46,918	47,888
Field Operations			
a.	Personnel (wages & benefits)	260,615	255,550
b.	Pesticides	34,377	31,610
c.	New equipment	6,125	17,412
d.	Other (gas, supplies, etc.)	24,121	20,162
TOTAL		$447,526	$448,140

Table 1. Budgets for Mosquito Control Projects for Fiscal Years starting in 1993 and 1994 (continued).

Budget Item		1993	1994
Cape Cod MCP			
Administration			
a.	Personnel (wages & benefits)	585,000	585,000
b.	Other (office supplies, travel, etc.)	5,000	5,000
Field Operations			
a.	Personnel (wages & benefits)	204,495	204,495
b.	Pesticides	38,000	38,000
c.	New equipment	35,000	35,000
d.	Other (gas, supplies, etc.)		
TOTAL		$918,511	$918,511
Central Mssachusetts MCP			
Administration			
a.	Personnel (wages & benefits)	123,201	125,817
b.	Other (office supplies, travel, etc.)	36,546	17,241
Field Operations			
a.	Personnel (wages & benefits)	286,348	286,144
b.	Pesticides	15,000	37,527
c.	New equipment	18,154	18,970
d.	Other (gas, supplies, etc.)	84,181	77,731
TOTAL		$563,430	$563,430
East Middlesex MCP[a]			
Administration			
a.	Personnel (wages & benefits)	64.190	64,995
b.	Other (office supplies, travel, etc.)	27,507	24,804
Field Operations			
a.	Personnel (wages & benefits)	119,156	116,734
b.	Pesticides	18,422	21,508
c.	New equipment	0	11,927
d.	Other (gas, supplies, etc.)	18,843	23,159
TOTAL		$248,118	$263,126
[a]Rounded to the nearest dollar from reported figures.			
Essex County MCP			
Administration			
a.	Personnel (wages & benefits)	47,320	53,000
b.	Other (office supplies, travel, etc.)	7,000	7,000
Field Operations			
a.	Personnel (wages & benefits)	188,105	188,737
b.	Pesticides	10,000	28,000
c.	New equipment	0	13,000
d.	Other (gas, supplies, etc.)	25,685	37,231
TOTAL		$278,110	$326,968

Table 1. Budgets for Mosquito Control Projects for Fiscal Years starting in 1993 and 1994 (continued).

Budget Item		1993	1994
Norfolk County MCP			
Administration			
a.	Personnel (wages & benefits)	184,427	161,640
b.	Other (office supplies, travel, etc.)	60,482	60,472
Field Operations			
a.	Personnel (wages & benefits)	79,040	121,939
b.	Pesticides	4,617	186
c.	New equipment	19,520	26,369
d.	Other (gas, supplies, etc.)	57,331	45,556
TOTAL		$405,417	$416,162
Plymouth County MCP			
Administration			
a.	Personnel (wages & benefits)	127,217	144,700
b.	Other (office supplies, travel, etc.)	37,388	40,000
Field Operations			
a.	Personnel (wages & benefits)	243,318	256,514
b.	Pesticides	30,590	31,500
c.	New equipment	54,625	32,100
d.	Other (gas, supplies, etc.)	71,311	59,635
TOTAL		$564,449	$564,449
Suffolk County MCP			
Administration			
a.	Personnel (wages & benefits)	No Figures supplied	
b.	Other (office supplies, travel, etc.)		
Field Operations			
a.	Personnel (wages & benefits)		
b.	Pesticides		
c.	New equipment		
d.	Other (gas, supplies, etc.)		
TOTAL			

Table 2. Total Budgets for the nine MCPs.

County	1993	1994
Berkshire County	66,992	66,992
Bristol County	447,526	448,140
Cape Cod	918,511	918,511
Central Massachusetts	563,430	563,430
East Middlesex	248,118	263,126
Essex County	278,110	326,968
Norfolk County	405,417	416,162
Plymouth County	564,449	564,449
Suffolk County	No Figures Supplied	
TOTAL	$3,492,553	$3,567,778

The choice of control strategy to be used was generally made by the town BOH or town personnel directly responsible for control activities. About 1/4 of the towns left this decision to the private applicator contracted to do the control work. One-third consulted outside public advisor such as the Board of Reclamation or neighboring MC project superintendents. About 1/6 sought advice from private sources such as pesticide salespersons. A similar breakdown of sources was used by towns to make decisions concerning when, where and how to apply the prescribed pesticides, except in the case of public and private consultants who were used less (only by 1/4 and 1/10 of the towns respectively). The choice of chemical to be used for control was based largely on its safety to the environment. Two-thirds of the towns predicated their decision on this consideration. Other concerns such as cost, effectiveness, and ease/safety of application were much less important. None of these criteria were used in selecting pesticides by more than 10 of responding towns. Decisions on when and how often to apply larvicides were based on larval sampling in about 2/3 of the towns and on a calendar spray schedule in 1/3 of the towns. Adulticide applications were mainly based on public complaints or pre-established calendar schedules, but a little over 50% of towns were prepared to modify their application schedules depending on weather conditions. Twenty-nine percent of towns indicated that scheduled pesticide treatments had actually been canceled due to adverse weather or for other reasons.

Most towns (ca. 80%) rely on newspaper and TV/radio announcements to inform the public of pending pesticide treatments. Twelve percent make no effort to inform the public at all. Fifty-three percent keep a list of beekeepers whose hives should be avoided but only 3% personally notify beekeepers of pending spray schedules. In most towns, beekeepers must rely on the same information provided to the general public, which means that 9-12% of towns provide beekeepers with no warning whatsoever. In contrast, 94% of towns polled make some provisions for people to request that their property not be sprayed.

Nantucket is one town that has started a program in the time period between the first draft GEIR and this draft. The program has included aerial and ground applications of Altosid, and extensive Open Marsh Water Management. Activity and expense peaked in 1992 and 1993 when the OMWM system was dug. Since then the town has conducted small amounts of larviciding in salt marshes. No work is done in freshwater areas and no adulticiding is done.

3. Other Programs

a. Department of Environmental Management

The Division of Forests and Parks discontinued its own mosquito control program in 1978 at the suggestion of the MEPA office pending the completion of an Environmental Impact Report of statewide mosquito control. From 1966-77, their mosquito control program consisted of adulticide treatments of state parks twice each summer coinciding with the heavy use periods of Memorial Day and July 4th. Applications were made with a mist blower and a mixture of methoxychlor (9 gal of 25% EC), malathion (1 gal of 57% EC) and water (40 gal). There was no attempt to evaluate the effectiveness of these applications, which were presumably carried out at night.

The Essex County Mosquito Control Program adulticides as required at the Salisbury Beach State Park and at the Bradley Palmer State Park in Hamilton.

b. Department of Public Health

The Massachusetts DPH is responsible for surveillance for EEE Virus, risk assessment, public information and education on EEE disease, as well as providing advice to the State Reclamation and Mosquito Control Board on appropriate risk management for EEE. DPH is also responsible for recommendations for wide area aerial vector control interventions in the event of an EEE Public Health Emergency. The Process for Risk Assessment and Management of EEE is outlined in the "Vector Control Plan to Prevent EEE" (See Appendix B, Vector Control Plan: Risk Assessment Section VI).

Every year DPH's Eastern Equine Encephalitis Surveillance Program (EEESP) collects data to assess the risk of EEE. This is an on-going program, which is carried out at the State laboratory Institute in Jamaica Plain. Key variables used to determine the risk of EEE include precipitation levels, mosquito population abundance, and presence of EEE virus in mosquitoes, horses, and humans. The purpose of the DPH EEE surveillance effort is to assess risk and use this information to advise the SRMCB and the public of the relative risk of EEE in any given season. In addition, the DPH chairs the Pesticide Review Board, which regulates pesticide use in the state.

In 1956 the EEESP was established in southeastern Massachusetts by the U. S. Public Health Service (CDC), in cooperation with the Massachusetts DPH, for the study of EEE. A surveillance program has continued since 1957 to the present, with funding solely from DPH beginning in 1970. Surveillance for EEE consists of monitoring mosquitoes to determine population levels in relation to previous years' levels, especially *Cs. melanura, Ae. vexans, Ae. canadensis, Cq. perturbans,* and *Ae. sollicitans,* testing samples of mosquito populations for the presence of EEE and Highland J (HJ) virus (HJ is an arbovirus which does not cause human disease but which is an indicator of arboviral activity in the bird population), testing suspected EEE horse cases and screening suspected human cases of encephalitis, meningoencephalitis or other cases of clinical disease that may mimic symptoms of EEE virus infection. Information is also compiled on precipitation, groundwater levels, and surveillance data from other sites. The surveillance program keeps abreast of new developments in the study of EEE and has expanded its trapping effort in response to these developments.

In recent years DPH has funded studies in collaboration with local universities aimed at furthering our understanding of EEE. These have included an assessment of the focality of EEE transmissions; *Cs. melanura* host preferences studies and research aimed at identification of the principal avian reservoir host species for the amplification and perpetuation of the EEE virus. In 1997, mosquito trapping was expanded to include several bird roost studies postulated to be critical foci for amplification of EEE virus (Komar et al., unpublished).

Each year the EEESP prepares a summary of the past season's surveillance activities in November, and provides an early prediction of the next season with regard to the likelihood of the presence of EEE virus in the environment and the potential for transmission to humans based on key variables of precipitation, mosquito populations and prior years' EEE activity in mosquitoes, birds, horses and humans. This information is provided to the SRMCB, EOEA agencies, the State Legislature, Boards of Health and the general public. Vector control meetings are held as needed with eastern Massachusetts Mosquito Control District Superintendents and the SRMCB throughout the season.

Surveillance provides an early warning of the presence of EEE in the environment. The EEE Surveillance Program begins no later than the first week in June and continues through early October, unless a killing frost brings the mosquito season to an end earlier. This is a continuing program with an objective to provide epidemiological information on EEE virus and potential vectors of this disease to guide public health actions. EEE surveillance reports are issued weekly throughout the trapping season and provide a summary of weekly laboratory analyses for mosquitoes, horses and humans.

When EEE is found in trapped mosquitoes, supplemental surveillance activities are initiated. These may include increased trapping of bridge vector species (species that transmit the disease from birds to horses or humans) utilizing a variety of trapping methods, estimation of vector species larval abundance, and age structure determinations. Isolation of EEE also may trigger health alerts and advisories when appropriate.

The first emergency effort to control mosquitoes during a disease outbreak occurred in 1956 when $90,000 was made available from the governor's emergency fund for aerial adulticiding. In this effort 150,000 acres were sprayed with DDT. The EEE disease outbreak of 1973 led to an aerial ULV application of malathion in the late summer, when approximately 1.7 million acres in eastern Massachusetts were treated. In 1974 and 1975 approximately 82,000 acres were aerially treated. The cost of the 1973-75 vector control interventions was over $700,000. In the EEE outbreak of 1982-84, no state-funded aerial application was conducted, however, $150,000 was allocated from the governor's emergency fund to support intensified ground spraying. In 1990 another emergency aerial ULV malathion application occurred over the southeastern part of Massachusetts. In this intervention 524,096 acres were treated at a cost of approximately $800,000. All interventions were based upon the likelihood of multiple human cases of EEE. While the cost of EEE vector control interventions may appear high, the lifelong costs associated with just one residual case of EEE have been estimated at $3 million dollars (Villari et al. 1995).

c. Federal Lands

In general, states have no jurisdiction over federal property. Any mosquito control activity on U. S. government property in Massachusetts is only subject to federal laws and not to the laws of the commonwealth. Thus, the following description will be brief and informational only.

i. Parks, monuments, refuges, etc.

No mosquito control is carried out by the U. S. Department of Interior on any government-owned land in Massachusetts. The current philosophy of the U. S. Park Service and U. S. Fish and Wildlife Service seems to be adverse toward the initiation of pest control except in unusual circumstances, e.g., the campground in Everglades National Park, the Island Wildlife Refuge, etc. The Cape Cod National Seashore is perhaps the U. S. Park Service property with the most significant mosquito populations. Park Service biologists have conducted their own studies on the environmental impact of Cape Cod mosquito control activities (Portnoy 1983, 1984a, 1984b) in adjacent estuaries and have lobbied against certain ditch cleaning practices on environmental grounds.

The East Middlesex MCP has been controlling mosquitoes in Great Meadows National Wildlife Refuge since 1987. Annual aerial Bti applications targeted against spring *Aedes* species began in 1987 and applications to control *Aedes vexans* began in 1990. Prior to each application, the Eat Middlesex MCP submits data on pre-application larval populations. Following receipt of the data each year, Great Meadows National Wildlife Refuge issues a permit for the aerial application. The National Park Service reservation area (Paul Revere's Ride) in East Middlesex County has been declared off limits to any mosquito control activity (by East Middlesex MCP) except for ditch cleaning.

The Essex County MCP has completed OMWM projects on the Parker River Wildlife Refuge.

ii. Military Bases.

All U. S. Military bases have a pest control section, which often engage in some mosquito surveillance and control activity. In Massachusetts, Fort Devens has routinely carried out both larval and adult control. In the 1980s this has consisted of mist blowing with Malathion for adult control and Altosid briquettes for larval control. Hanscom Air Force Base joined the East Middlesex MC project in 1985 but still assists with surveillance and some control activities. None of the other military bases in Massachusetts (i.e., Barnes in Westfield, Westover in Chicopee, and Otis on the Cape) reported mosquito control activities in recent years.

d. Private Reserves.

There are several private reserves and estates in Massachusetts (e.g., Cranes Beach), which are frequently used by the public in one capacity or another. There is no indication that mosquito control is regularly practiced on any of these properties. It seems unlikely; therefore, that this represents a significant category of undocumented pesticide use or habitat modification for mosquito control, past or present. Certain MCPs include, by request, some reservation properties in their overall program but those activities are included in their program summaries.

C. Historical Overview of Mosquito Control Practices in Massachusetts

1. Practices prior to 1980

Development along the Eastern Seaboard, especially for tourism, was predicated on an ability to control the hoards of salt marsh mosquitoes. The earliest experimental work took place in New Jersey salt marshes in the late teens and early 1920's. These successes encouraged the massive hand-ditching projects in East Coast marshes that took place during the WPA programs of the great depression, with some 3,000 miles of ditching being dug in Massachusetts's salt marshes alone. These ditching schemes, while quite effective in reducing salt marsh mosquitoes, were engineered to make work rather than for optimum biological efficiency. Moreover, the value of estuarine ecosystems was unrecognized at the time.

Early salt marsh mosquito control projects, such as the one on Cape Cod in the 1930's, were organized prior to the availability of synthetic pesticides following World War II and these projects expanded and maintained the WPA-dug ditch system as their main strategy for mosquito control. After DDT, BHC, and other organochlorine pesticides became available, they were used to both supplement larval control and, for the first time, to conduct residual spraying for adults. Aerial application of these pesticides became commonplace in the 1950's and early 60's. However, coastal projects that were organized after the introduction of these modern pesticides still relied heavily on source reduction to manage salt marsh mosquitoes. Paris Green (an arsenical) and petroleum oils were developed as mosquito larvicide's for malaria control during World War II and also became popular in the U. S. after the war. Waste crank case oil was not infrequently used in mosquito control despite the fact that thin oils (e.g., diesel fuel) with a spreading agent provide for the greatest and most effective surface coverage. The commercial mosquito control oil, Flit MLO, was introduced and widely used during the 70's, but was taken off the market in the mid-80's. Arosurf-MSF, a monomolecular surface film was available for several years, starting in the mid-80, but was taken off the market. It is now (1997) being returned to the market as Agnique MMF (Henley, personal communication).

Abate (temephos), one of the few organophosphates registered for aquatic use, was introduced a few years later and shared the larvicide market with surface oils. The first new generation pesticide introduced for mosquito control was the growth regulator Altosid (methoprene), a juvenile hormone mimic. It has been widely used in mosquito control since the mid-l970's. Projects in the Northeast were slow to switch to this highly selective material, perhaps due to its delayed response and narrow window for control.

The choice of which larvicide to use is based equally on effectiveness and safety to the applicator and to the environment. Adulticiding is often predicated on public complaints. Weather conditions and field surveys also play a role in deciding when to schedule applications in most projects.

Chemical control in freshwater marshes followed a similar pattern to that in salt marshes. Treatment of catch basins, first with oils followed by organochlorines and organophosphates, dates back to the beginning of most Massachusetts projects.

Physical control was limited to drainage maintenance and expansion in both salt marshes and freshwater areas. Biological control was not conducted.

Controlling *Cs. melanura* larvae in large white cedar/red maple swamps was generally considered an impossibility so aerial adulticiding was adopted as the strategy of choice for vector control during epidemic threats. Projects within the main focus of EEE in southeastern Massachusetts were the only ones to routinely do aerial spraying. This work was gradually discontinued in the 1970's due to environmental concern over aerial adulticiding.

Projects have intermittently had the support service of a SMRCB entomologist. During 1976-81, a period when the projects had no entomological support from the SMRCB, an extension biting-fly specialist was available through a cooperative agreement with the University of Massachusetts. Each project contributed 0.5% of their annual operating budget as their share of support for this position, which was jointly funded by Massachusetts Cooperative Extension. The specialist developed control recommendations, evaluated new control methods, set up a statewide light trap surveillance program, and carried out other support services to the projects. Some controversy developed among projects, particularly over the control recommendations made by the specialist. Following his resignation, the SMRCB again hired an entomologist and the University position was discontinued.

2. Transitioning: from 1980 to 1995.

By the early 1980s, concerns over pesticide use and wetlands loss began to encroach on mosquito control. Grid ditching for larvae and malathion for adults was no longer a desirable one-two punch. Control trends during the eighties and early nineties include:

- Changing from traditional chemicals, such as Abate and Flit MLO, to Bti and methoprene for larval control (Table 3).

- Changing from malathion to permethrin or resmethrin for adult control (Table 3).
- Changing from open tidal ditching to open marsh water management for salt marsh mosquito control.
- Reduction in the number of towns belonging to Projects in the late 1980s. This trend has reversed in the past several years.

Table 3. A comparison, between the early 1980's and the mid-1990's of chemicals used by Massachusetts MCPs.

Active Ingredient	Toxicity Class	Used Between[a]	
		1981-1985	1993-1995
AS LARVICIDES			
Bacillus thuringiensis var. *israelensis*	IV	+	+++
Fenthion	II	-	N
Isooctadecanol[b]			
Malathion	III	+	N
Methoprene	IV	o	++
Methoxychlor	IV	++	N
Mineral Oil	III-IV	+++	o
Permethrin	III	-	N
Temephos	IV	+	-
AS ADULTICIDES			
Dibrom	II	+	N
Fenthion	II	o	N
Malathion	III	+++	-
Methoxychlor	IV	+	N
Permethrin	III	N	++
Resmethrin	III	-	+++

[a]+++ = Primary pesticide used
++ = Significant use
+ = Common but minor use
o = Infrequent use
- = Rarely used
N = Never used
[b]Discontinued product (Arosurf)

Altosid had come onto the market but acceptance was slow, both because it was hard to monitor the efficacy (larvae do not die for some time) and because of restrictions on the label against using in fish habitat. By the early '90s, however, it was in general use throughout Massachusetts. The extended-residual briquet form of Altosid was tested against *Cq. perturbans*, as was Arosurf-MSF, but results were mixed and the briquet's high cost prevents it from being an attractive control agent for large cattail areas. Trials with Altosid pellets were encouraging but this control technique is not being used in Massachusetts.

In contrast to Altosid, the biological pesticide *Bacillus thuringiensis* var. *israelensis* was quickly accepted by Massachusetts's projects when introduced in the early 80's. It is a mainstay of most programs, despite some problems in salt marshes and aquatic habitats high in organic matter. The latter problem may be solved by the recent (1996) introduction of *Bacillus sphaericus,* a new biological pesticide that is designed specifically for *Culex* breeding in high-organic-matter habitats.

Flit-MLO disappeared from the market and was replaced by Golden Bear oils. Arosurf-MSF was used in small amounts for several years before it too was taken off the market. It has recently returned to the market as Agnique MMF. Bonide Mosquito Oil (Mineral oil) is now available but not used. Source reduction remained a mainstay of the projects during this time period but coastal communities shifted away from ditch maintenance towards open marsh water management. An emerging difficulty for control programs was the rise in wet basins mandated by storm water runoff regulations. If improperly designed these can breed considerable numbers of spring-brood and/or summer reflood mosquitoes.

The evaluation of control effectiveness by projects remained a combination of public complaints, adult counts, larval counts, and cases of human disease.

All projects maintained a public education component and several expanded their programs.

Throughout this period, outside of inadequate budgets and the inability to do more source reduction work, the main operational problems voiced by most projects has been the lack of applied research support to assist them in evaluating new technology and solving certain ever-changing problems. For example, the cattail mosquito, *Cq. perturbans*, is a major pest and potential epidemic vector of EEE in most projects but there is presently no recommended method for controlling this mosquito.

D. Current Mosquito Control Strategies in Massachusetts

1. Overview

Chemical control, including *Bacillus* products and IGRs (Table 4), and source reduction, including open marsh water management, dominate mosquito control in Massachusetts (Tables 5 and 6). Aerial applications of larvicides have been used by several programs (Table 7) and is likely to increase. Biological control has not been emphasized except to the extent that OMWM creates conditions under which biological control operates. Public education is a minor component of most programs.

Salt marsh mosquitoes are the primary target of coastal programs, whereas inland programs target spring-brood and summer-reflood *Aedes* (Tables 8 and 9). *Coquillettidea perturbans* is restricted by larval habitat to areas near cattail marshes. However, in those areas its populations can be extremely high.

Vector mosquitoes are not the primary targets of Massachusetts control programs, though projects do respond to requests for aid from DPH in times of EEE emergencies. *Culiseta melanura* larval populations may be incidentally reduced by treatment programs that target swamp areas. East Middlesex MCP did conduct trials with Altosid pellets aerially applied in April, 1992 for *Cs. melanura* control and were successful (Henley 1992). This work has not been repeated in Massachusetts.

Policy issues have revolved around wetlands and water quality preservation and endangered species. A chronic source of discussion is mosquito control's exemption from many of the state-level wetlands protection acts, making the Federal Section 401 Water Quality Certification Act (administered at the state level) and the state and federal Endangered Species Acts the primary means of "controlling" source-reduction work. Storm water runoff regulations have increased the number of wet basins (retention, wet detention) in many areas, on occasion creating breeding habitat. Engineers and public officials involved in designing and approving such basins have been slow to acknowledge mosquito control as design criteria, though the relevant sections of the Storm water Policy Handbook and Storm water Technical Handbook released by DEP in March 1997 should be incorporated into MCP practices (see Appendix E for listing of relevant information).

The EEE outbreak in 1990 highlighted a need for stronger DPH policies regarding emergency mosquito control. As a result, the Massachusetts Department of Public Health published "Vector Control Plan to Prevent Eastern (Equine) Encephalitis" (August 7, 1991) and implemented an extensive Public Education Program in 1991.

Table 4. Pesticide use by Project, 1993 through 1995.

Pesticide	Catagory	Amount Used		
		1993	1994	1995
Berkshire MCP				
Altosid Briquets	IV	24.3 lb	5.8 lb	1.8 lb
Bactimos Granules	IV	534.0 lb	2124.0 lb	
Bactomos Pellets	IV	232.0 lb	2026.0 lb	2093.0 lb
Abate 4E	III		0.6 gal	
Arosurf-MSF	III	16.0 gal	5.0 gal	
Scourge 18+54	III	10.1 gal	25.0 gal	20.1 gal
Bristol County MCP				
Altosid Briquets	IV		0.57 lb	45.6 lb
Bactomos Pellets	IV	1593.0 lb	80.2 lb	2300.5 lb
Scourge 12+36	III	151.9 gal	190.6 gal	173.4 gal
Cape Cod MCP				
Altosid Briquets[a]	IV	9.5 lb	8.4 lb	11.0 lb
Bactomos Pellets	IV	20,710.0 lb	41,497.0 lb	43,174.0 lb
GB 1111	III	671.0 gal	704.0 gal	330.0 gal
[a]Totals reported as briquets coverted to lbs				
Central Massachusetts MCP				
Altosid Briquets	IV	231.9 lb	192.7 lb	106.2 lb
Bactimos Granules	IV	281.1 lb	115.9 lb	2829.1 lb
Bactomos Pellets	IV	1223.0 lb	3313.0 lb	81.0 lb
Vectobac Granules	IV	96.9 lb		
Vectobac 12AS	IV		225.7 gal	171.7 gal
Witco GB-1356	III	65.1 gal	95.2 gal	5.6 gal
Witco GB-1111	III			23. 5 gal
Scourge 18 + 54	III	342.6 gal	398.5 gal	388.5 gal
[a]Dry and liquid ounces as reported coverted to pounds or gallons respectively				
East Middlesex MCP				
Acrobe	IV		125.0 gal	
Altosid Pellets	IV		15.0 lb	10.9 lb
Altosid Briquets[b]	IV	69.9 lb	20.7 lb	33.7 lb
Altosid XR Briquets[b]	IV	17.1 lb		
Arosurf MSF	III	2.3 gal	3.0 gal	
Bactimos Granules	IV		12,880.0 lb	6,785.0 lb
Bactimos Pellets	IV	2,324.0 lb		
Vectobac G	IV	8,062.0 lb	720.0 lb	
Vectobac 12AS	IV	8.4 gal	22.9 gal	169.2 gal
Permanone 10EC	III	2.4 gal	2.1 gal	1.7 gal
Scourge 18 + 54	III	20.2 gal	26.0 gal	18.1 gal
[a]Dry and liquid ounces as reported coverted to pounds or gallons respectively				

Table 4. Pesticide use by Project, 1993 through 1995 (continued).

Pesticide	Catagory	Amount Used 1993	1994	1995
Essex County MCP				
Altosid Pellets	IV			70.5 lb
Bactimos Granules	IV	3.8 lb		252.2 lb
Bactomos Pellets	IV	1993.1 lb	4439.6 lb	887.5 lb
Permanone 31-66[a]	III	39.0 gal	42.5 gal	12.8 gal
Scourge 18 + 54[a]	III	10.1 gal	25.0 gal	20.1 gal
[a]Ounces as reported converted to gallons				
Norfolk County MCP				
Altosid XR Briquets	IV	0.1 lb[b]	2.8 lb	254.8 lb
Bactimos Briquets	IV	0.6 lb	1.8 lb	48.8 lb
Vectobac 12AS	IV	79.0 gal	2.6 gal	
Vectobac AS	IV			52.3 gal
Arosurf-MSF	III	406.7 gal	83.1 gal	149.0 gal
Scourge 18 + 54	III	45.8 gal	53.2 gal	52.7 gal
[a]Rounded to the nearest tenth from reported values				
[b]Reported value = 0.038 lb				
Plymouth County MCP, Ground-application Pesticide Use[a]				
Altosid XR Briquets	IV			17.5 lb
Bactimos Pellets	IV	357.0 lb	500.0 lb	50.0 lb
Bactomos Briquets	IV	1.8 lb[b]	10.3 lb[b]	17.2 lb
Vectobac 12AS	IV	17.5 gal	2.5 gal	
Teknar HP-D	IV		17.5 gal	20.0 gal
Scourge 18 + 54	III	110.0 gal	85.0 gal	70.0 gal
[a]See Table 7, Aerial Application of Pesticides for information regarding aerial applications.				
[b]Total reported as briquets converted to lbs.				
Suffolk County MCP, Ground-application Pesticide Use[a]				
Altosid Briquets[a]	IV	3.5 lb	4.8 lb	3.3 lb
Altosid XR Briquets[a]	IV	57.5 lb	0.1 lb	11.4 lb
Bactimos Pellets	IV	25.8 lb	31.0 lb	
Vectobac 12AS[b]	IV	3.9 gal	7.9 gal	5.1 gal
Malathion 8EC[b]	III	1.5 gal	1.9 gal	0.2 gal
Permanone 10EC[b]	III	0.1 gal	1.4 gal	0.8 gal
Resmethrin[c]	III	11.2 gal		
Scourge 18 + 54[b]	III	6.3 gal	12.1 gal	3.5 gal
[a]Totals reported as briquets converted to lbs.				
[b]Rounded to the nearest tenth from reported values.				
[c]EPA reg #4-339-53853				

Table 5. Project distribution of operations by control method as expressed as a percentage of the budget allocated (average for 1981-1985) or as a percentage of the project's operations (1994 and 1995).

Berkshire MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	33	Source reduction (excluding OMWM)	20	20
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	5		40	40
Chemical larviciding/pupiciding	50	Chemical larviciding/pupiciding(excluding IGRs)	0	0
		IGR larviciding (methoprene)	5	10
Adulticiding	10		30	20
Public Education	2		5	10

Bristol County MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	60	Source reduction (excluding OMWM)	75	78
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	6		2	2
Chemical larviciding/pupiciding	3	Chemical larviciding/pupiciding(excluding IGRs)	0	0
		IGR larviciding (methoprene)	0	0
Adulticiding	30		22	19
Public Education	1		1	1

Cape Cod MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	70	Source reduction (excluding OMWM)	Information	
		Open Marsh Water Management		
Biological larviciding (Bti)	21		not	
Chemical larviciding/pupiciding	4	Chemical larviciding/pupiciding(excluding IGRs)		
		IGR larviciding (methoprene)	Supplied	
Adulticiding	0			
Public Education	5			

Central Massachusetts MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	70	Source reduction (excluding OMWM)	40	40
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	5		25	25
Chemical larviciding/pupiciding	5	Chemical larviciding/pupiciding(excluding IGRs)	5	5
		IGR larviciding (methoprene)	5	5
Adulticiding	15		15	15
Public Education	5		10	10

Table 5. Project distribution of operations by control method as expressed as a percentage of the budget allocated (average for 1981-1985) or as a percentage of the project's operations (1994 and 1995) (continued).

East Middlesex MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	34	Source reduction (excluding OMWM)	26	42
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	28		44	37
Chemical larviciding/pupiciding	27	Chemical larviciding/pupiciding(excluding IGRs)	<1	0
		IGR larviciding (methoprene)	4	4
Adulticiding	10		25	16
Public Education	1		1	1

Essex County MCP

	% of Budget 1981-1985[a]		% of Operations 1994	1995
Source reduction	--	Source reduction (excluding OMWM)	20	15
		Open Marsh Water Management	29	28
Biological larviciding (Bti)	--		40	50
Chemical larviciding/pupiciding	--	Chemical larviciding/pupiciding(excluding IGRs)	0	0
		IGR larviciding (methoprene)	0	1
Adulticiding	--		10	5
Public Education	--		1	1

[a]No response

Norfolk County MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	54	Source reduction (excluding OMWM)	50	50
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	4		25	20
Chemical larviciding/pupiciding	13	Chemical larviciding/pupiciding(excluding IGRs)	0	0
		IGR larviciding (methoprene)	14	20
Adulticiding	25		10	8
Public Education	4		1	2

Plymouth County MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	25	Source reduction (excluding OMWM)	45	53.0
		Open Marsh Water Management	0	0.0
Biological larviciding (Bti)	5		30	25.5
Chemical larviciding/pupiciding	25	Chemical larviciding/pupiciding(excluding IGRs)	0	0.0
		IGR larviciding (methoprene)	0	0.5
Adulticiding	40		20	16.0
Public Education	5		5	5.0

Table 5. Project distribution of operations by control method as expressed as a percentage of the budget allocated (average for 1981-1985) or as a percentage of the project's operations (1994 and 1995) (continued).

Suffolk County MCP

	% of Budget 1981-1985		% of Operations 1994	1995
Source reduction	1	Source reduction (excluding OMWM)	5	5
		Open Marsh Water Management	0	0
Biological larviciding (Bti)	26		30	30
Chemical larviciding/pupiciding	25	Chemical larviciding/pupiciding(excluding IGRs)	0	0
		IGR larviciding (methoprene)	15	15
Adulticiding	46		40	40
Public Education	2		10	10

Table 6. Types of Control Activity,[1] by Habitat

	Salt Marsh	Spring Brood	Summer Re-Flood	Cattail
Berkshire County		C,F	C,F	
Bristol County	A	C	C	F
Cape Cod MCP	A,C,D,E	A,C,D,E	A,C,D,E	A,C,D,E
Central Massachusetts		A,C,E,F	A,C,D,E,F	A,C,D,E,F
East Middlesex		A,C,D	A,C,D	
Essex		B,C	A,C	A,C
Norfolk	A,C,D,F	A,C,F	A,C,D,F	F
Plymouth	A,C,D,F	A,C,F	A,C,F	F
Suffolk	C,D,F	A,C,D,F	A,C,D,F	F

[1]Types of control activities -- indicate the types of control activities carried out on each wetland type using the following categories:

A -- Source reduction
B -- OMWM
C -- Biological larviciding
D -- IGR larviciding
E -- Larviciding, non-IGRs
F -- Adulticiding

Table 7. Aerial application of Pesticides, 1993 through 1995

Project/Town	Dates	Time of day	Acreage	Pesticide	Rate	Target Area
1993						
East Longmeadow	4/26 - 5/12	Daylight	1,000	Vectobac 12AS	1 qt/acre	
E. Middlesex MCP	April 12-22	6 AM - 8 PM	2,017	Vectobac G	1 pt/acre	
				Bactimos Pellets	5 - 7.5 lb/acre	
Plymouth MCP[a]	April 12-16	4 AM -Noon	1,360	Vectobac 12AS	1 pt/acre	Spring Brood
	May 3-7	4 AM - Noon	1,400	Vectobac 12AS	1 pt/acre	Spring Brood
	May 10-14	4 AM - 9 AM	1,920	Vectobac 12AS	1 pt/acre	Spring Brood
1994						
Chelmsford	April 16-22	Dawn - 11 AM	700	Bactomis Granules	5 - 7.5 lb/ac	
East Longmeadow	May 5 - 12	Daylight	1,000	Vectobac 12AS	1 pt/acre	
E. Middlesex MCP	April 19-28	6 AM - 8 PM	2,700	Vectobac G	5 - 7.5 lb/ac	Wetlands
				Bactimos Granules	5 - 7.5 lb/ac	
	August 23-27	6 AM - 8 PM	1,000	Vectobac 12 AS	1 pt/acre	Flood Plain/ Wetland
				Acrobe	1 pt/acre	
Plymouth MCP[a]	April 18-22	4 AM - 9 AM	8,000	Bactimos Pellets	8 lb/acre	Spring Brood
	April 25-29	4 AM - 9 AM	16,000	Bactimos Pellets	8 lb/acre	Spring Brood
	May 2-6	4 AM - Noon	8,000	Teknar HP-D	1 pt/acre	Spring Brood
1995						
Chelmsford	April 16-22	Dawn - 11 AM	700	Bactomis Granules	5 - 7.5 lb/ac	
East Longmeadow	May 5 - 12	Daylight	1,000	Vectobac 12AS	1 pt/acre	
E. Middlesex MCP	April 12-22	6 AM - 8 PM	2,800	Vectobac 12 AS	1 pt/acre	
				Bactimos Granules	5 lb/acre	
Essex MCP	June 10-17	5 AM - Noon	1,400	Vectobac 12AS	1 qt/acre	Salt Marsh
	June 20-24	5 AM - Noon	1,000	Vectobac 12AS	1 qt/acre	Salt Marsh
	July 8-22	5 AM - 8:30 PM	1,000	Vectobac 12AS	1 qt/acre	Salt Marsh
	August 5-19	5 AM - 8:30 PM	1,400	Vectobac 12AS	1 qt/acre	Salt Marsh
Plymouth MCP	April 10-14	4 AM - Noon	11,000	Teknar/Acrobe	1 pt/acre	Spring Brood
	April 18-21	4 AM - Noon	11,000	Teknar/Acrobe	1 pt/acre	Spring Brood
	April24-28	4 AM - Noon	11,000	Teknar/Acrobe	1 pt/acre	Spring Brood
	May 1-5	4 AM - Noon	11,000	Teknar/Acrobe	1 pt/acre	Spring Brood
	May 8-12	4 AM - Noon	5,500	Teknar/Acrobe	1 pt/acre	Spring Brood

[a]These are actual treatments for Plymouth County. Forms filed with SRMCB were for more dates and larger areas than actually treated.

Table 8. Estimated wetlands acreage affected, by habitat, exclusive of adulticiding.

	Salt Marsh	Spring Brood[a]	Summer Re-Flood[a]	Cattail
Berkshire County	0	500	250	0
Bristol County — no figures given				
Cape Cod MCP — no figures given				
Central Massachusetts	0	10,000	5,000 to 10,000	2,000
East Middlesex	0	2,767	1,192	0
Essex	5,000	500	1,000	0
Norfolk	38	1,087	523	0
Plymouth	100	7,860	1,000	0
Suffolk	240	130	130	5
TOTAL	5,378	22,844	9,095	2,005

[a]There is overlap between acreage affected by spring brood and summer re-flood

Table 9. Percentage of control effort, from monitoring through adulticiding (includes source reduction), by breeding habitat by Project.

Habitat	% Effort		
	1994	1995	Species targeted
Berkshire MCP			
Salt marsh	0	0	
Freshwater			
Spring re-flood	90	90	spring brood *Aedes*
Summer re-flood	10	10	*Ae. vexans*
Cq. perturbans	0	0	
Bristol County MCP			
Salt marsh	50	50	*Ae. sollicitans, Ae. cantator*
Freshwater			
Spring re-flood	30	40	*Ae. canadensis, Ae. excrucians, Ae. cinereus*
Summer re-flood	15	10	*Ae. vexans*
Cq. perturbans	5	0	
Cape Cod MCP			
Salt marsh	50	50	
Freshwater			
Spring re-flood	50	50	
Summer re-flood	0	0	
Cq. perturbans	0	0	

Table 9. Percentage of control effort, from monitoring through adulticiding (includes source reduction), by breeding habitat by Project (continued).

Habitat	% Effort 1994	1995	Species targeted
Central Mssachusetts MCP			
Salt marsh	0	0	
Freshwater			
Spring re-flood	40	40	*Ae. absrratus, Ae. excrucians*
Summer re-flood	30	20	*Ae.vexans, Ae. canadensis*
Cq. perturbans	30	40	
East Middlesex MCP			
Salt marsh	0	0	
Freshwater			
Spring re-flood	45	52	*Ae. abserratus, Ae. aurifer, Ae. canadensis Ae. cinereus, Ae. excrucians*
Summer re-flood	37	28	*Ae. vexans, Ae. trivittatus*
Cq. perturbans	13	14	
Essex County MCP			
Salt marsh	50	60	*Ae. sollicitans*
Freshwater			
Spring re-flood	5	5	spring brood *Aedes*
Summer re-flood	45	35	*Aedes* species
Cq. perturbans	0	0	
Norfolk CountyMCP			
Salt marsh	10	10	*Ae. sollicitans, Ae. cantator*
Freshwater			
Spring re-flood	60	60	*Ae. excrucians, Ae. abserratus, Ae. cinereus Ae. canadensis, Ae. vexans*
Summer re-flood	15	15	
Cq. perturbans	15	15	
Plymouth County MCP			
Salt marsh	20	20	*Ae. sollicitans, Ae. cantator*
Freshwater			
Spring re-flood	60	60	*Ae. excrucians, Ae. abserratus*
Summer re-flood[a]	10	10	*Ae. vexans, Ae. cinereus, Ae. canadensis*
Cq. perturbans[a]	10	10	

[a]1994 and 1995 were extremely dry years which resulted in lower than normal control efforts toward summer reflood and *Cq. perturbans*.

Table 9. Percentage of control effort, from monitoring through adulticiding (includes source reduction), by breeding habitat by Project (continued).

Habitat	% Effort 1994	1995	Species targeted
Suffolk CountyMCP			
Salt marsh	30	30	*Ae. sollicitans, Ae. cantator*
Freshwater			
Spring re-flood	22	22	*Ae. excrucians, Ae. abserratus, Ae. canadensis*
Summer re-flood	42	42	*Ae. cinereus, Ae. vexans*
Cq. perturbans	6	6	

2. Current Practice

a. Salt marsh Mosquitoes

The combination of large, affluent human population (both permanent residents and visitors) and prolific pest mosquito populations near Massachusetts coastal marshes suggests that the public may always demand control programs to deal with this intense annoyance problem. Most salt marshes that breed *Aedes* mosquitoes are now under management and, in most cases, the strategy is source reduction.

Open Marsh Water Management (OMWM) projects now underway in Essex, Norfolk and Plymouth counties are being expanded to include essentially all problem marshes in those counties. OMWM plans are developed and tailored to the specific circumstances of each individual estuary. The permitting and review process for these projects is time consuming. Thus, it will be some time before all marsh management will consist of this strategy even though it is currently the most environmentally sensitive and rational marsh management strategy for most situations. Public and State agency support for OMWM is solid. Wolfe's (1996) review article on the effects of OMWM provides a strong basis for accepting OMWM as the best salt marsh mosquito control technique currently available. Wolfe makes the interesting point that salt marsh mosquitoes are an increasing problem not because they are breeding in greater numbers than before, but because more people are choosing to live near the coast.

Regardless of the benefits of OMWM, maintaining grid ditch networks is still an important part of coastal programs. Grid ditches are aesthetically unattractive and some have clearly had some negative impact on the normal high salt marsh ecosystem. In contrast, evidence suggests that some ditched marsh may be more productive than unditched marshes (Shisler & Jobbins 1975). No qualitative studies on the impacts of grid ditching in Massachusetts have been done but clearly the habitat has been dramatically changed. Converting open systems to OMWM systems does create a more-nature, though still highly managed, system. In the interim, current ditch cleaning practice seems preferable to the increased use of larvicides.

There are certain salt marshes where old ditches are effectively controlling mosquito production and perhaps where new OMWM activities might actually disrupt the marsh more than maintaining the status quo. Thus, OMWM plans should not be automatically prescribed for every salt marsh without first examining this issue.

Larviciding is still carried out in salt marshes that are unditched or in which ditches are ineffective or unmaintained. Larvicides in current use include the biological pesticide Bti, the insect growth regulator Altosid, and surface oils. These are all pesticides that have lower risks associated with their use. Bti and Altosid have the least potential non-target effects because of their high selectivity for certain dipterous insects. Bti is not always as effective in highly organic salt marshes as it is in other habitats.

Adulticiding in coastal areas is often necessary because of the huge numbers of mosquitoes that breed on the marsh (a 99% kill with larvicide can still leave a lot of mosquitoes). Truck-mounted ULV application is the standard response, as is the case for freshwater adult mosquitoes discussed below.

b. Inland Freshwater Wetlands

Most projects do a considerable amount of source reduction work in freshwater wetlands. This activity consists primarily of ditch and culvert cleaning to discourage ponding along natural waterways and the resultant production of spring and reflood *Aedes.* Routine maintenance generally involves hand-cleaning of debris from drainage systems and brush removal where it is encroaching on the flow system. Machinery is not used for routine maintenance but is used where deteriorating conditions (a build-up of such sediments as road sand being a common example) require work that cannot be done by hand.

Larviciding is done with Bti products, Altosid or Golden Bear oil. The vast majority of larviciding is done after mosquito breeding has been documented. Most applications are made from the ground by backpack sprayer or by hand (briquets). Aerial applications to freshwater areas are limited, but increasing (Table 7). Pre-hatch work is done by several projects. In general the area must have a lengthy history of mosquito breeding.

Mosquito breeding in vernal pools, large acid swamps, and cattail/water willow ponds cannot be readily controlled by source reduction work. Even larviciding is often difficult in large or deep permanent swamps. Projects with a large acreage of these habitats (i.e., Norfolk, Plymouth and Bristol) still depend more on adulticiding than do projects whose larval sources are more accessible to larviciding. Helicopter application of granular larvicides is perhaps the only way to reach many of these habitats with larvicides, but this practice has been hampered in the past by the fact that flight plans had to be filed too far in advance. This problem was overcome by the East Middlesex MCP by filing the flight plan when flooding started, not when larvae were first seen. This carried the risk of requesting a treatment that turned out to be unnecessary but the predictability of *Ae. vexans* breeding after flooding is high. Regardless, changes made to the Pesticide Board regulations at the start of 1997 season to make it easier to conduct aerial work. Norfolk MCP is actively increasing its aerial application program.

Coquillettidea perturbans remains a problem for larval control. Slow-release Altosid formulations looked promising for the control of cattail mosquitoes (Walker 1987) but this technique is not being used today, most likely because of high cost. Altosid pellets have been used with some effect (Ranta et al. 1994) and this approach may make expanding *Cq. perturbans* larval control possible. Fortunately, this mosquito has not been a significant pest over the last several years in most projects (see Table 9 for low % of effort directed towards *Cq. perturbans*). In East Middlesex MCP, however, *Cq. perturbans* has continued to greatly exceed nuisance threshold levels, being the main nuisance species between mid-June and mid-July. In nine cities and towns of the East Middlesex MCP, there is at least one light trap site which annually records greater than 500 *Cq. perturbans* per night during the peak period for that species. Dry the dry summers of 1993, 1995, and 1997, *Cq. perturbans* has been the only significant mid-summer mosquito problem.

No source reduction programs are in place for the maple/cedar swamps in which *Cs. melanura* breeds. Larviciding these areas has had some success (Henley 1992, Woodrow et al. 1995).

No control programs target permanent-water breeding *Culex* or *Anopheles* except in cases where *Aedes* are breeding as well and in urban habitats (see below). With the exception of minor work with dumped tires, *Ae. triseriatus* is not targeted for control.

Freshwater wetlands have been the sites most likely to have control restrictions due to endangered species. Salamanders, turtles and dragonflies have all been cited as reasons to either forego work or to restrict larvicide choice. In at least one case, the existence of vernal pools alone, regardless of endangered species presence, was sufficient for the local conservation commission to halt drainage maintenance in the area.

c. Irrigated and Other Man-Made Reflood Habitats

Very little agricultural land in Massachusetts is irrigated. Those lands which are irrigated tend to have sandy soils with good percolating characteristics. Golf courses, athletic fields, etc., which temporarily flood and produce reflood *Aedes* are generally very accessible and larvicidlng is the common practice for dealing with the habitats. Source reduction is occasionally used to eliminate or limit breeding in these poorly graded and drained grassy habitats.

d. Urban Habitats

Most projects do both source reduction (cleaning and repairing) and larviciding work on storm drain catch basins to control *Culex* breeding. Slow release larvicide formulations are popular in these small enclosed habitats. This urban mosquito control activity is non-controversial. It is effective, but the real impact of these mosquitoes on biting annoyance is not clear (see Part IV).

Wet basins have emerged as a primary problem in areas of new development. Shallow-water basins often hold water long enough in the spring to breed *Ae. canadensis*. Basins that have deep water in the spring (one-plus feet) may not breed mosquitoes then but may dry down in July and be perfect *Ae. vexans* breeding sites after a heavy August rain. Basins that are deep all year round may have invasive cattail on which *Cq. perturbans* can develop. Only basins that hold water for a week or less, even during the wet spring months, will probably not produce mosquitoes and even these require maintenance to avoid wetlands type vegetative growth that eventually causes longer pooling. Two other problems with basins is that many are fenced off, so that they are difficult to monitor, and ownership is often hazy so that maintenance lapses. Prevention of mosquito breeding in basins must become a design consideration.

3. Current Policies

a. Requests for Control

Requests for control are almost invariably for adult mosquito control, though individuals may request that wetlands on or adjacent to their property be checked and larvicided. Requests for adulticiding are handled in varying ways by the projects (Table 10). In most projects, complaint calls are considered a valid form of determining spray schedules, if not on an immediate basis, certainly over the long term. Responding rapidly to complaint calls is considered a primary objective of many projects, as they are service organizations. Of course, their service is to the common public good, and individual requests should be judged on that basis. Whether all programs do so is not known.

Table 10. Adult Mosquitoes: Monitoring and Adulticiding Policies

	Techniques used to trigger adulticiding			
Project	Light Traps	Landing Count	Complaint Calls	Post-treatment Monitor
Berkshire	No	No	Yes (for local treat[a])	Reduction in calls
	Berkshire also stated that adulticiding is done on a pre-scheduled basis			
Bristol County	Not for Spray	No	Yes	Reduction in calls Reduction in light traps
Cape Cod	Yes, but no Adulticiding is done by Cape Cod			
Central Mass	Yes	3/min	Do landing count	Random re-checks
East Middlesex	100 human-biting	4/min (for local treat)	Supplement LT data	Not done
Essex	No	10+/min	5/square mile	Landing counts
Norfolk	Yes	2/min (for local treat)	Yes (for local treat)	Limited landing counts Reduction in calls
Plymouth	No	Informal	Yes	Staff observations Reports from residents
Suffolk	Yes	Yes	Do landing count	Informal checks

[a]Local treatment by hand-held or backpack sprayer only

Larviciding requests do not make up the majority of calls to MCPs. But, for example, East Middlesex MCP does receive calls for both larval control and information on how residents can control mosquitoes. In general these come as a result of their newspaper releases concerning larviciding or from residents who observe control crews in wetlands in the past (Henley, personal communication). Other programs most likely receive similar calls. In general, though, monitoring is based on historical knowledge and survey work by the MCP itself. When larvae are found, larviciding typically occurs.

Pre-hatch work, is an exception to the rule that larvae must be present and is conducted when the project superintendent feels there is sufficient historical data to justify applications prior to larval hatch.

b. Documentation for Control Implementation

All Projects keep records of complaint calls, most conduct light trapping and most conduct some landing counts (Table 10). Of the three, landing counts are the most casual, often being little more than a report that there are a lot of mosquitoes biting the field staff in a certain area. However, Berkshire County, Central Mass and Suffolk investigate each complaint call and take landing-count data.

Field workers record larval counts at the sites they visit. In some cases, they bring larvae back either for larval identification or for rearing to adults for ID. In many cases, the larvae are sight-IDed to genus and more specific identification is not done. Counts for aerial application and/or OMWM are much more detailed and generally involve taking a specific number of dips at a permanently situated sampling station.

An area that needs improvement is record keeping regarding aerial applications of larvicide. The general plans filed by projects with the state are not specific enough, as they tend to describe the maximum possible application acreage, rather than acreage actually treated. Projects do keep records of actual treatments and these should be filed with the state as a post-treatment report,

Record keeping for freshwater drainage maintenance is spotty and needs improvement. Without baseline data on channel cross-sections, it is impossible to monitor maintenance work to ensure that channels are not becoming larger.

c. Selection of Control Strategies

Control strategies may be selected at the project level for both short- and long-term work, and at the field worker level for short-term work. Examples of project-level long-term selections are the absence of adulticiding by the Cape Cod project and the strong push into wetlands restoration by the Essex County MCP. Short-term, project level decisions revolve around the choice of larvicides made available to field workers, aerial work, and the distribution of personnel among, surveillance, source reduction and pesticide application work. Project Superintendents use their experience, the input of their staff, professional journals, and any other resource that can guide them in creating a quality program.

An under-emphasized aspect of the selection process is the cost of each strategy. Strategies that cost more than is available will not be implemented. Ground application of larvicide is possible in larger areas than it is currently being done, however the manpower requirements are high. Altosid applications for *Cq. perturbans* populations control seem to be limited primarily due to cost.

Field staff are responsible for determining the need to treat a given site, the type of material to use (for example, briquets versus a liquid treatment in a series of vernal pools), and whether or not physical control (removing debris clogging a culvert) should be done immediately or can wait for non-breeding periods. The effectiveness of any program is directly linked to the skill of the field staff in determining the most appropriate response to current local conditions and their motivation to carry out the appropriate response effectively.

One of the goals of the GEIR is to help establish procedures for determining which control technique to use. However, a large amount of basic research into mosquito and wetlands ecology needs to be done to improve our basic understanding of the cause and effect relationships among the environment and the control procedures available.

d. Evaluation of Efficacy

No project has developed a comprehensive and comparable data base on mosquito densities to document the long term impact of control efforts on annoyance levels in their communities. While they might be faulted for this failure, such an effort requires resources that many projects do not have. Nearly all projects routinely operate light traps or make landing rate counts in order to monitor adult population levels. Just how these data are analyzed and used is not clear. No publicity or publications utilizing quantitative data on mosquito populations have been produced by any project. All projects seem to keep good records of how many complaints they receive annually from each section of their jurisdiction. Statistical treatment of these data would be difficult and appears to have not been attempted.

Larval sampling is routinely carried out by all projects before pesticide applications. Post-treatment checks are less common. However, one of the reasons the projects did not accept Altosid very quickly was that it was hard to tell if the treatment had worked (the larvae can take up to a week to die). From this it can be inferred that post-treatment monitoring was occurring. This is an area where a state-level entomologist would be of considerable help as she could carefully monitor larvicide applications with an eye towards developing more accurate delivery techniques and application rates for varying situations.

Post-treatment monitoring of adulticide applications is done on an *ad hoc* basis (Table 10). A drop off in complaint calls is the primary criteria by which adulticiding efficacy is judged. While aerial ULV applications are effective (Mount *et al*. 1996), truck-mounted ULV treatments depend heavily on proper weather conditions and on there being an adequate road network. The general attitude, with the notable exception of Cape Cod, is that the residents pay for mosquito control and adutlciding kills mosquitoes. Developing better evaluation techniques for efficacy of truck-mounted adulticiding would be a major step in improving mosquito control in Massachusetts.

e. Public Participation

All projects notify residents by press release or public notice of their intended control operations for the coming season. Most towns also notify the Departments of Health and the chief executive's office of the municipalities for which they do work of their plans for the season. In Norfolk, each health board receives a notice of which days of the week the project may be treating in their town. Maps are included. Suffolk takes the process one step further and notifies the mayor's office before each adulticide. With minor variations all projects do the same type of notification.

Requests for exclusion are handled virtually identically by all projects, with a list of exclusion sites given to drivers so that they know where to not treat. Maps of excluded properties are made available to the spray crews.

Multiple Chemical Sensitivity (MCS) is becoming an increasingly important concern to health officials as the number of individuals reporting disabilities linked to chemical exposure has increased dramatically over the past decade. Regardless, MCS has yet to become a major issue for mosquito control. In most cases, an individual with MCS can be accommodated by the standard exclusion request since most mosquito control programs do not, as a general rule, ask why an exclusion is requested. This lack of conflict, however, should not be taken to mean that MCS is a non-issue. Mosquito control programs are designed to protect people, not harm them, and individuals suffering from MCS deserve to have their needs addressed. At the same time, control programs must take into account the needs of those who do not suffer from MCS, yet do suffer from mosquito problems. So long as programs continue to work honestly and above-board with MCS suffers (and any other group which requests exclusion), and receives the same level of cooperation from those requesting exclusion, mutually acceptable solutions should continue to be the norm.

One source for additional information on MCS is:

MCS Referral & Resources, Inc.
508 Westgate Road
Baltimore MD 21229-2343
Telephone 410-362-6400
fax 410-362-6401

Public education is a vital component of a complete program but current education efforts represent only a tiny part of most projects (Table 5). Programs vary from distribution of handouts upon request to full-scale educational presentations, including videos and other visual aids (Table 11). In general, but not absolutely, the extent of the education program is a function of program size. It is not clear that all projects use the Fact Sheets currently available from DPH. These include "Eastern Equine Encephalitis", "Insect bites and Insect repellents", and "Mosquito Repellents" as well as a pamphlet "Bugged by Mosquitoes?"

E. Eastern Equine Encephalitis

1. Responsibility for Surveillance and Control.

Eastern Equine Encephalitis (EEE) is an alphavirus endemic to many passerine bird species found in freshwater swamp habitats. The virus is transmitted among wild bird populations in these areas by *Cs. melanura*, a mosquito species that feeds almost exclusively on birds. The freshwater swamp is the enzootic focus of EEE and under normal conditions the virus is restricted to this habitat, Occasionally, however, due to factors which include seasonal and yearly rainfall levels and temperatures, mosquito virus may "spill over" into mammalian populations. This phenomenon is due to the transmission of the virus from infected birds to mammals by one of more mosquito species which feed on both humans and birds. Species that transmit disease from normal reservoirs to accidental hosts are known as "bridge vectors". The Massachusetts mosquito species traditionally thought to be likely bridge vector species are *Cq. perturbans, Ae. vexans, Ae. sollicitans,* and *Ae. canadensis*. Recently published studies also suggest that *Anopheles* species and *Cx. salinarius* may be possible epidemic vectors (Edman et al. 1993; Vaidyananthan et al. 1997). EEE virus has been isolated from all of these species. The bridge vector(s) responsible for EEE transmission to humans has not, however, been unequivocally identified.

EEE is a rare form of encephalitis with a high rate of mortality. The overall case fatality rate is now about 30% and survivors often suffer lifetime disabilities. The severity of illness tends to be most grave at the extremes of age. Fatality rates are highest among the elderly and intermediate in children. Infants and children who survive the

Table 11. Public Education Programs.

Project	Visit Complaint Callers	Give Talks	Notes on Programs/Pamphlets Available
Berkshire	Yes	Yes	UMss Coop Extension Leaflet “Mosquitoes” the “Ten Commandments of Mosquito Control” Bookmark for schools
Bristol County	Yes	No	Supply information upon request
Cape Cod	Yes	Yes	Conducts school programs for all age groups, have developed and distribute an informational pamphlet, and routinely appear in local press.
Central Mass	Yes	Yes	News releases to member municipalities’ press Project staff attend various meetings A video “Working for You”, a display and a slide show are all available Pamphlets are distributed to Boards of Health and other offices and anyone else who requests them. School program for elementary schools.
East Middlesex	Yes	Yes	School eduation program (three grade groups: 1-3, 4-6, and 7+) Give talks upon request. 20-minute video DPH fact sheets Pamphlet on Mosquito IPM
Essex	Not mentioned	Not mentioned	Fact sheets available on request 3-panel display available to environmental groups Outreach through environemental groups
Norfolk	Sometimes	Yes	Fact sheets: IPM, Bti, Methoprene, The Facts about Mosquito Spraying Materials supplied to local Boards of health Provides interviews on Local Cable TV Personnel always available for town-sponsored meetings Has extensive school program Attend local health fairs
Plymouth	Sometimes	Yes	Speaker program: spokesperson available year-round for any community group Utilizes community channel on cable TV Pesticide information distributed to towns and available to residents upon request DPH fact sheets and pamphlet “Homeowner Mosquito Control” pamphlet
Suffolk	Yes	Yes (Schools)	Press releases in the spring Faxes to mayor prior to treatment

infection are most likely to be permanently neurologically impaired and often require lifelong supportive care.

Horse cases of EEE have been described as early as the nineteenth century in Massachusetts and human cases were likely to have occurred, although they were not recognized as EEE prior to 1938. Since the first recognized outbreak of human EEE in 1938, 74 cases have occurred in Massachusetts with cases disproportionately concentrated in the south-central and southeastern parts of the state.

Four multi-year outbreaks of human EEE have been recorded in the central-eastern and southeastern areas of Massachusetts,. Thirty-four (46%) cases were identified in 1938. Subsequent years of human EEE cases have been 1939 (1 case), 1955 (4 cases), 1956 (12 cases), 1970 (1 case), 1973 (2 cases), 1974 (3 cases), 1975 (1 case), 1982 (2 cases), 1983 (6 cases), 1984 (2 cases), 1990 (3 cases), 1992 (1 case), 1995 (1 case) and 1997 (1 case).

The two worst years for human cases of EEE (1938 and 1956) occurred before there was an EEE Surveillance Program. However, it is assumed that the virus carriage of mosquitoes, and mosquito populations, would have been unusually high compared to average levels of these indicators. Since the beginning of a prospective EEE Surveillance Program, there have been two years of extraordinarily high levels of virus carriage in mosquitoes, in 1973 and 1990. Although only a small number of human EEE cases were identified in 1973 (2 cases) and 1990 (3 cases), there were significant control interventions in each of the two outbreak years. Wide-area spraying with ULV malathion was done to reduce populations of the vector species.

In 1990, in response to surveillance data showing alarmingly high and increasing EEE virus levels in mosquitoes, multiple horse cases, and the risk of multiple human cases, the largest aerial application (ULV) of malathion in years was made over much of southeastern Massachusetts. Three people contracted the illness prior to the treatment and one died.

As a result of this outbreak, the Department of Public Health and the State Reclamation Board sought to strengthen ties between state and project officials and to better define their response to future outbreaks. While there was considerable controversy over what some felt to be an extreme response by the state, there can be no question that mosquito populations were effectively reduced by the application and that no new human cases of EEE occurred after the treatment. Mount et al. (1996) provide an excellent review of aerial applications of insecticide for mosquito control and conclude that ULV applications are efficacious, cost effective and can work over dense foliage or open housing. The results in 1990 in Massachusetts support these conclusions.

2. Effect of EEE on Projects

Of the nine Projects, Berkshire is outside the EEE risk area and Cape Cod and Essex County are defined as low-risk areas. The other Projects provide significant support for EEE monitoring and mosquito control. When requested larval and adult monitoring data are also supplied by the Projects to DPH. Bristol, Norfolk, Plymouth and East Middlesex MCPs traditionally increase truck-mounted aerosol applications in areas of high public use when DPH indicates elevated risk of EEE. These Projects also supply support for, or actually conduct, aerial applications for larval (Bti) or adult (malathion) mosquito control at the request of DPH.

Though the Projects do not target EEE vectors specifically, unless so directed by DPH, their general operations permit surveillance and control work to be carried out against vector species as necessary. As an example, East Middlesex has 50 CDC light traps set up through out its district, a portion of which monitor *Cs. melanura* populations. East Middlesex has also conducted aerial applications of Altosid pellets to control *Cs. melanura*. Emphasizing the problem of *Cq. perturbans*, however, East Middlesex has been unable to develop a larva control program to adequately deal with this potential vector.

A continuing source of friction is the definition of a nuisance versus a health threat. While several projects were formed as much because of the possibility of EEE as the nuisance factor, no project today considers preventing EEE to be their primary goal. Fortunately, DPH and the Projects in EEE areas work well together and a system of graduated responses (from regional ground control up to state-mandated aerial adulticiding) has been put in place.

IV. DESCRIPTION OF MOSQUITO SPECIES AND ABATEMENT HABITATS

A. Mosquito Species

1. General Biology

Mosquitoes belong to the family Culicidae of the Order Diptera (true flies), insects with one pair of clear wings. There are 167 North American species in 13 different genera (Darsie and Ward 1981). Of these, 46 in 9 different genera have been found in Massachusetts (Table 12). About one-half of these (from 5 different genera) may at times cause significant human annoyance in certain localities; the majority belong to the genus *Aedes*. No mosquito species feeds exclusively on humans. Those species that annoy humans feed on a wide variety of other mammals and occasionally on birds as well. Some non-human-biting species such as *Cs. melanura*, *Cs. morsitans* and *Cx. restuans* can be important in the maintenance of enzootic disease cycles in wildlife. Some of these diseases, e.g., Eastern equine encephalomyelitis (EEE), occasionally spill over into human populations via transient epidemic vectors.

Mosquito life cycles can be grouped into two basic types: permanent-water and temporary-water (or flood-water). Temporary-water species generally belong to the genus *Aedes* or *Psorophora* and present the major pest problem in Massachusetts. Adult females can readily be distinguished from permanent water forms because their abdomen terminates in a sharp point formed by the extended cerci. This group overwinters as dormant eggs laid singly by females (usually ca. 75-150/female) in the band of moist soil surrounding the evaporating temporary pools in which the larval stages developed. Hatch (stimulated by increased temperature or reduced O_2) occurs when these depressions are flooded by tides, rains, irrigation or flooding rivers. The eggs of most temperate flood-water species must undergo a prolonged cold-conditioning period prior to hatch so there is normally only a single generation early each season (univoltine species). In a few species such as the eastern saltmarsh mosquito, *Ae. sollicitans*, eggs laid in the earlier part of the season will hatch after only 2-4 weeks of conditioning so multiple generations (multivoltine) are commonplace. The terms generation and brood are not always synonymous because not all eggs hatch when flooding occurs, so that multiple <u>broods</u> may sometimes occur from a single <u>generation</u> of overwintering eggs. In Massachusetts, reflood species like *Ae. vexans*, *Ae. sticticus*, and *Ae. trivittatus* (and perhaps late spring-hatch species like *Ae. canadensis* and *Ae. cinereus*) may have multiple generations or just multiple broods caused by delayed egg hatch. In spring, larval development of temporary-water mosquitoes may require two months or more

Table 12. Systematic Index of the Culicidae of Massachusetts

Taxon	Taxon
Genus *AEDES*	Genus *CULEX*
Subgenus *Aedes*	Subgenus *Culex*
cinereus (Meigen)	*pipiens* Linnaeus
	restuans Theobald
Subgenus *Aedemorphus*	*salinarius* Coquillett
vexans (Meigen)	
	Subgenus *Neoculex*
Subgenus *Ochlerotatus*	*territans* Walker
abserratus (Felt & Young)	
atropalpus (Coquillett)	Genus *CULISETA*
aurifer (Coquillett)	
canadensis (Theobald)	Subgenus *Climacura*
cantator (Coquillett)	*melanura* (Coquillett)
communis (De Gerr)	
decticus Howard, Dyar & Knab	Subgenus *Culicella*
diantaeus Howard, Dyar & Knab	*morsitans* (Theobald)
dorsalis (Meigen)	*minnesotae* Barr
ercrucians (Walker)	
fitchii (felt & Young)	Subgenus *Culiseta*
implicatus Vockeroth	*impatiens* (Walker)
intrudens (Dyar)	*inornata* (Williston)
provocans (Walker)	
punctor (Kirby)	Genus *ORTHOPODOMYIA*
sollicitans (Walker)	*signifera*
sticticus (Meigen)	
stimulans (Walker)	Genus *PSOROPHORA*
taeniorhynchus (Wiedemann)	
trivittatus (Coquillett)	Subgenus *Grabhamia*
	columbiae (Dyar & Knab)
Subgenus Protomacleaya	
hendersoni Cockerall	Subgenus *Janthinosoma*
triserlatus (Say)	*ferox* (von Humboldt)
Genus *ANOPHELES*	Subgenus *Psorophora*
	ciliata (Fabricius)
Subgenus *Anopheles*	
barberi Coquillett	Genus *URANOTAENIA*
crucians Weidemann	Subgenus *Uranotaenia*
earlei Vargas	*sapphirina* (Osten Sacken)
punctipennis (Say)	
quadrimaculatus (Say)	Genus *WYEOMYIA*
walkeri Theobald	
	Subgenus *Wyeomyia*
Genus *COQUILLETTIDIA*	*smithii* (Coquillett)
Subgenus *Coquillettidea*	
perturbans	

while in summer it may be as brief as 4-6 days. Permanent-water mosquitoes deposit their eggs (generally a multi-egg raft of ca. 100-250 eggs except in the *Anopheles*) on the surface of permanent or semi-permanent (i.e. persists for several weeks) water and hatch occurs within 1-3 days. Populations are asynchronous compared to flood-water species (with several overlapping generations), and larval development tends to be longer. Some permanent water species (e.g., *Cq. perturbans*, *Cs. melanura* and *Cs. morsitans*) overwinter in a diapausing larval stage, but most overwinter as hibernating adult females that are fertilized, nulliparous (never having produced eggs), and non-blood-fed.

Mosquitoes metamorphose into the winged adult stage within the nonfeeding pupal stage. The pupa is active and aquatic (called tumblers) and is resistant to most chemical control measures (suffocating surface films are an exception). It normally lasts only 2-4 days. Males generally pupate and emerge about 1 day ahead of females of the same cohort.

Mating most commonly occurs in twilight swarms within 2-3 days after females emerge. Most, but not all, females mate before they take blood. Both sexes feed frequently on plant nectar; females take blood in order to obtain protein for egg development. A few species are autogenous, meaning they do not need a blood meal to produce eggs. One Massachusetts species, the pitcher plant mosquito (*Wy. smithii*), never takes blood. Most females begin seeking hosts 2-4 days after emergence but some species (e.g., *Cs. morsitans*) may delay feeding for 2 weeks or more. Thus, the time period between adult emergence and the first egg laying (first gonotrophic cycle) is usually 7-10 days. Subsequent host-feeding to egg-laying cycles in most temperate species require 4-6 days.

Species that transmit disease (vectors) must feed at least twice, once to acquire the infection, and once to transmit it, unless the infection is acquired transovarially (into the egg while in the ovary) from their mother. This means that females must normally survive for 12-14 days in order to be a vector. If the extrinsic incubation period of the pathogen/parasite in the mosquito is longer than the gonotrophic cycle, as is often the case, the survival time required for transmission is even longer.

Most females do not survive beyond the first oviposition but a few individuals in all mosquito populations live a long time (i.e., several weeks). Exceptionally, overwintering adults live 5-7 months. Males generally survive for shorter periods than females and never overwinter.

2. Saltmarsh mosquitoes

The leading pest mosquito problem in coastal communities in Massachusetts is caused by two brackish water species, *Ae*. *sollicitans* and *Ae*. *cantator*. The latter species is abundant only in the early part of the season (mid-May to mid-June); *Ae*. *sollicitans* is the major target of most saltmarsh mosquito control efforts. Both species develop in pans in the high salt marsh (dominated by *Spartina* grasses) which are normally only flooded by moon tides. Heavy rains or high tides caused by unusual winds can also cause intermittent flooding in the high marsh. *Ae. cantator* tends to occur more in the extreme upland edge of the high marsh. This area is often quite fresh and may include plants such as cattails. Unmaintained mosquito ditching can become an important breeding area, as *Spartina alterniflora* prevents the ditches from draining and shallow water is held between moon tides.

Aedes taeniorhynchus is a third species that occurs in salt marshes, often in conjunction with *Ae. sollicitans*. Complicating the control picture further is *Cx. salinarius* which sometimes breeds in after heavy, late-summer rains. As a result, salt marshes generally require monitoring at least twice a month (once after the full-moon high tide and once after the new-moon high tide) as well as after any major rain event. With regard to saltmarsh mosquito control, one should always assume that there are huge numbers of eggs available to hatch after any flooding; any other assumption will result in broods being missed and adult mosquitoes swarming in numbers not easily understood by one who has not experienced them.

Uncontrolled populations of salt marsh *Aedes* often reach extremely high biting densities (i.e., 100+ females landing/minute). Adults may not be particularly long lived, but because moon tides occur so regularly and often, multivoltine *Ae*. *sollicitans* can be a problem throughout the summer season. Because the economies of coastal areas affected by this mosquito often depend heavily on summer tourism, the impact of saltmarsh mosquitoes is greatly magnified. This is reflected in the percent effort coastal projects spend on saltmarsh *Aedes* control (Table 9).

Salt marshes and the estuaries they feed are the principal nursery grounds for a variety of marine and brackish water organisms, including several commercial forms. Disrupting these vital wetlands to control saltmarsh mosquitoes can cause unintended, long-term problems.

3. Freshwater mosquitoes. The most severe and predictable late-spring to early-summer mosquito annoyance in all inland (and many coastal) areas is caused by several species of *Aedes* collectively referred to as spring-hatch or snow-pool mosquitoes, the most common of which is *Ae. canadensis*. These mosquitoes tend to

develop in similar aquatic situations (i.e., temporarily flooded woodland depressions including the flooded borders of permanent swamps and bogs) and have similar life cycles. They overwinter as dormant eggs and have a single, spring generation each year (univoltine). Adult mosquitoes are most active from late spring to mid summer; the females taking blood meals and depositing their eggs in the moist soil and leaf litter around the edges of the evaporating woodland pools in which they developed as larvae. They are part of a larger grouping of mosquitoes called temporary-water or flood-water species which all have eggs that hatch synchronously when flooded by rain, tide, snow melt or rising rivers. In this case, snow melt and spring rain fill the woodland depressions that are stocked with eggs, usually causing hatch sometime in early March. Mild conditions in late February and early March followed by severe cold, or spring precipitation, can reduce larval populations by freezing or flooding. As a result, considerable year-to-year population variation occurs.

Spring-hatch *Aedes* can be subdivided into two major groups, dark-legged and banded-legged, based partly on the physical appearance of biting females and partly on some minor differences in their life cycles. The dark-legged group hatch and emerge about 1-3 weeks ahead of the banded-legged group and seem to survive as adults for a shorter period of time. Some members of this group (e.g., *Ae. punctor*) become more abundant at more northern latitudes (coniferous forest zone) and at higher elevations (e.g., near the top of the Holyoke Range). When people enter the densely shaded daytime resting places of these mosquitoes, females attack more aggressively than do members of the banded-legged group such as *Ae. stimulans* and *Ae. canadensis*. Dark-legged *Aedes* appear to be the principal vectors of California group encephalitis viruses. These viruses overwinter inside the eggs of their mosquito vector (Calisher & Thompson 1983).

The banded-legged group often develop in the same pools and rest in the same wooded, daytime resting habitats as some species in the dark-legged group. However, they tend to disperse further from the larval habitat and, during the early evening biting peak of both groups, banded-legged females feed more readily in open and semi-wooded habitats than to dark-legged females. Some banded-legged females survive into August, and this group seems to be the principal vector of dog heartworm in Western Massachusetts.

Although the general larval habitat of both groups is similar, considerable variation in habitat occurs and some species are more restricted than others. For example, certain dark-legged *Aedes* are mainly found in association with cranberry (*Ae. aurifer*) or sphagnum (*Ae. decticus*) bogs. Spring woodland pools vary from small, shallow depressions formed by fallen trees to large, deep ravines in mountain bedrock and natural swales in forested flood plains. Permanent woodland or grassy swamps and bogs are also a common source of some members of the spring *Aedes* group.

a. *Aedes canadensis*. *Aedes canadensis* is perhaps the dominant spring-breeding mosquito in the Northeast. It's primary habitat is woodland vernal pools; pools that having standing water from snow-melt until early summer. Larvae can be collected even before the last frosts but development is slow during the cool spring months and adults usually do not emerge until near the end of May or in early June. Although *Ae. canadensis* is an active biter, it does not generally fly far from the woods in which it breeds. As residential areas have cut their way into the woods of Massachusetts, however, *Ae. canadensis* has become an increasing problem.

Aedes canadensis control is difficult because the pools in which it breeds are isolated from each other. A small woodlot can contain many pools, some of which may require field workers to cut through poison ivy, multiflora rose, and bull brier just to reach. Ground application of larvicide under such circumstances is tedious and, regardless of intent, often less than complete.

Aedes canadensis is predominantly univoltine, but a second brood (either delayed hatch of over-wintering eggs or early hatch of spring-laid eggs) can develop in early fall if rainfall is sufficient to partially fill the woodland pools. In such cases, treatment is nearly impossible, as a summer's growth of the above-mentioned plants, coupled with a dense canopy of leaves from the many shrubs that line the pools make getting to the pool, and placing the correct amount of pesticide in the pool, extremely difficult.

b. *Aedes vexans*. *Aedes vexans* is the most ubiquitous floodwater mosquito in North America and is the predominant summer reflood mosquito in Massachusetts. *Aedes vexans* is found in lake and river flood plains, shrub swamps, flooded meadows, and shallow grassy depressions associated with open habitats such as roadside ditches, pastures, golf courses and athletic fields. It will also breed in woodland pools and shallow cattail marshes, such as those that develop in some retention ponds. The first *Ae. vexans* are normally not on the wing before mid-June. Populations of *Ae. vexans* are unpredictable because they depend entirely on the frequency and spacing of major rains. Rainfall of 1 inch many produce some *Ae. vexans* but it usually requires 3" of rain within a short period of time (several days) to produce a large brood.

Larval broods of *Ae. vexans* have been observed as late as mid-September in Amherst. It is not always clear whether such late season broods result from the delayed and staggered hatching of eggs that are a year or more old or from the hatching of non-diapausing eggs laid earlier the same season. Brust and Costello (1967) and

Horsfall *et al* (1973) have shown that many species such as *Ae. vexans* lay <u>some</u> eggs that will hatch without cold conditioning. Sequential hatching of eggs is also well documented in five reflood *Aedes* species (i.e., *canadensis, cinereus, sticticus, trivittatus,* and *vexans*). Larval development is rapid, 4-6 days, and the pupal stage lasts for about 2 days. Hence, the window for effective larval/pupal control is narrow. Moreover, a large number of scattered pools all need to be treated within the same brief time span following major rains. Control efforts suffer from the same difficulties as described for *Ae. canadensis*, as *Ae. vexans* will often breed in mid-summer in the same pools used by *Ae. canadensis* in the spring.

c. Additional *Aedes* species

Lesser, but at times significant, populations of *Ae. triseriatus*, *Ae. trivittatus* and *Ae. sticticus* do occur in Massachusetts. Larvae of the latter two species are associated with ground pools in wooded or semi-wooded flood plains. Extremely heavy general rains sufficient to cause river flooding commonly proceed large populations of *Ae. trivittatus* and *Ae. sticticus*.

Aedes triseriatus is a treehole mosquito, breeding in the wild in holes left in trees when a branch breaks off and/or insect damage causes a part of the tree to rot out. Within the shaded forest it is a ready biter but it does not venture far from it's breeding areas. Because it's larval habitat is widely dispersed (and often well above the height that a person could reasonably be expected to reach), larval control is not possible. Fortunately, because it stays within the woods, control targeting *Ae. triseriatus* is rarely necessary.

Aedes triseriatus overwinter as eggs in the larval habitat; hatching occurs in early spring and development to the adult stage takes about 3 months. The first biting adults appear in late June in Massachusetts. Larval populations are often crowded and asynchronous so some emergence continues until early August. A second generation of larvae has been observed, especially in tires, where water is usually warmer and development is faster. However, it is doubtful that many adults from this generation are successful at this latitude. This mammal-feeding, diurnal species does not normally disperse far from its sylvan larval habitats. Biting adults are particularly active in the late afternoon, pre-twilight period (i.e., 4-7 PM).

If *Ae. triseriatus* stayed in the trees, it would be a minor pest, but it has become well adapted to breeding in tires, particularly where they are shaded. As a result, *Ae. triseriatus* can be a locally important pest wherever rimless tires are stored. Tire removal, and the prevention of illegal tire dumping along wooded roads, is an important part of mosquito control.

Aedes atropalpus is another natural container breeder, but it is associated with rock pools, especially those in exposed riverbeds. The northern form is autogenous for the first egg batch so it is a less bothersome daytime pest species than its southern sibling, *Ae. epactius*. This species has also become adapted to tires in the Midwest.

A new Asian container breeder, *Ae. albopictus*, has recently been introduced into the Southern United States (Texas), apparently via imported used truck tires (Moore 1986). This diurnal urban pest throughout Asia has already spread as far north as Indiana and is likely to appear in Massachusetts at some point (Nawrocki & Hawley 1987) Locations where used truck tires are brought in and stored for recapping are the most likely points of introduction. This species has mainly been found in tares in the United States to date. It is an efficient laboratory vector of many Western Hemisphere arboviruses (Shorter 1986).

d. *Culex* species. *Culex* mosquitoes have an ambiguous place in mosquito control in Massachusetts. On the one hand, they are commonly encountered as larvae in storm drains, cisterns, drainage basins and other contain-type situations but, on the other hand, the extent to which they cause biting problems for people and are involved in the transmission of disease, for example encephalitis between birds, is unknown. Species such as *Cx. territans* and *Cx. restuans* are certainly not pests of humans, but *Cx. restuans* may be involved in transmission of EEE between birds (it is common to pick up EEE in *Culex* pools in areas where it is present in *Cs. melanura* pools–the problem being that *Culex* pools are rarely sorted to species before testing).

Culex mosquitoes are multivoltine, having several generations per year. There can be considerable overlap among the generations. Adult females overwinter and are among some of the first mosquitoes to be seen in the spring. *Culex* mosquitoes do not bite during the day and are more active later at night than are most *Aedes* species.

The house mosquito, *Cx. pipiens*, breeds prolifically from mid to late summer in urban storm sewers, ornamental/wading/swimming pools, bird baths, plugged rain gutters, tires, car bodies, empty barrels, and other similar manmade containers. This species tolerates pollution, so the highest densities often occur in eutrophic water enriched by animal waste (e.g., sewage oxidation ponds). Multiple, overlapping generations (each requiring 8-10 days) occur in the same habitat. Mated but non-blood-fed females produced late in the season overwinter in underground sewers, basements, and other protected places.

The southern form, *Cx. pipiens quinquefasciatus*, feeds readily on both mammals and birds (Edman 1974), but the northern form, *Cx. pipiens pipiens*, which occurs in Massachusetts, is mainly associated with avian hosts. In large urban centers in the North, a less common autogenous form (*Cx. pipiens molestus*) exists. It readily attacks humans after the initial blood-free gonotrophic cycle is completed. This form has been documented in Boston, where it is associated with underground sewers and subway tunnels (Spielman 1973). *Cx. restuans* is often found in some of the same container habitats as *Cx. pipiens*.

Culex salinarius differs from the above-mentioned *Culex* species in that it is an active human biter and can occur in significant numbers. It's breeding habits are poorly understood as it is generally classed as a permanent-pool breeder but dense larval populations have been found in rain-fed pools in salt marshes in Rhode Island (salinities close to 0 ppm) and large adult populations existed in the coastal residential area of Bonnet Shores, RI in 1986 (Christie, personal communication).

The extent to which *Culex* species require control can be debated. Species such as *Cx. territans* almost certainly play no role whatsoever in either pest or disease problems. However, the ability to identify mosquito larvae to species is often not well developed and field identification can be difficult (though separating A*edes* from *Culex* requires little more than direct observation). Under such circumstances, treatment of any larval population is the general rule. Defining the role of *Culex* species in the magnification of EEE within the bird population would aid in determining the extent to which larval control of *Culex* should take place.

e. *Culiseta* species

Culiseta melanura occupies an interesting position in Massachusetts mosquito control in that it is the only known vector species in Massachusetts that is not also a significant pest. Therefore, controlling *Cs. melanura* in the larval stage, especially prior to documentation of EEE in adult *Cs. melanura* populations, is controversial in that the MCPs, as established, are not expected to target vector mosquitoes as a part of their routine work. The decision as to whether or not to attempt larval control would be made easier if *Cs. melanura* bred in habitats occupied by other pest species such as *Ae. vexans* or *Ae. canadensis*. Unfortunately, *Cs. melanura* breeds in a very specific habitat, the holes that develop around the roots of trees with cedar/maple swamps and is not routinely affected by treatment work for other species. In fact, because the holes are not interconnected and are often have only small openings, they are extremely difficult to treat even when the decision has been made to attempt larval *Cs. melanura* control.

Other *Culiseta* species exist in the state but have not been identified as vectors of disease or pests of humans.

f. *Coquillettidea* (formerly *Mansonia*) *perturbans*. Among a group of insects already disliked by humans, *Cq. perturbans* stands out as being particularly disliked by mosquito-control personnel. First, it is a large, aggressive biter that sparks complaint calls like few other mosquitoes and, second, because the larva lives attached to the stems of cattail, it is exceedingly difficult to monitor and control

In Massachusetts, *Cq. perturbans* has one generation per year. It overwinters in the larval stage (3rd instar) and adults begin to emerge in mid to late June, peaking in mid-July. Breeding occurs principally in cattail/water-willow ponds. These ponds are often caused by road, railroad, pipeline, power line, and parking lot construction next to natural wetland or seepage areas. Adults feed primarily during evening twilight periods on larger mammals situated in open pastures or in transitional habitats (Edman 1971). Birds are also attacked when they are available in the foraging habitat of this mosquito.

Coquillettidia perturbans presents unique control problems because larvae and pupae remain attached to the base of emergent plants at the bottom of deep ponds. Oxygen is obtained directly from the plant cells in which the modified air tube is imbedded. At this time there is no known effective larval control for *Cq. perturbans*, making adulticiding the only real choice for control in residential areas located near cattail marsh. For this reason, the present pollution-control fade of cattail ponds must be carefully monitored by mosquito-control programs. Wherever possible, manmade cattail drainage basins should be avoided or should be so constructed that, for a period of several weeks in late summer, no standing water is present in the basin. This will break the aquatic part of the life cycle.

Coquillettidea perturbans is a vector of EEE, compounding the problem of it's control by increasing the stakes in any decision not to control it.

g. Other freshwater species. Mosquitoes of the genera *Anopheles* and *Psorophora* can also be pests in Massachusetts. *Anopheles* mosquitoes differ from the other genera of mosquitoes in that, as larvae, they lie, upside down, on the under-surface of the water. They commonly inhabit more permanent waters and can sometimes be found along the edges of slow-moving streams. They are also fairly common later in the summer in puddles in dirt roads and other pools, often being found together with *Ae. vexans* and/or *Culex* species. *Anopheles* mosquitoes do not occur in the kinds of swarming numbers that *Aedes* mosquitoes do, but they enter houses more readily. They overwinter as adults and are some of the first mosquitoes to bite in the spring. Individual females are not uncommon in-house biters on the occasional warm day in spring.

Psorophora ferox, is a large, aggressive mosquito that breeds in the flood plains of overflowing summer rivers and streams. It is not common in the northeast but, where it is present, it is an unforgettable insect, both because of it's size and the painful bite.

B. Habitats in which mosquito control takes place.

An understanding of where mosquitoes breed and feed is essential to understanding mosquito control. Perhaps one of the most frustrating things to the mosquito-control professional is the misunderstanding within the general public as to where mosquito breeding occurs and where mosquito control should take place. To anyone who works in coastal mosquito control, the new homeowner, experiencing her first summer brood of saltmarsh mosquitoes, is a familiar, and somewhat sorry, sight. Calls concerning, "...that pond of my neighbor's" are far more common than, "I have some vernal pools in the wood lot behind me."

The following discussion will start with breeding areas (coastal and inland wetlands and, to some degree, surface water bodies) and progress to adult habitats (surface water bodies, recharge areas, upland areas and agricultural areas). Finally, sensitive environments will be discussed from both a breeding perspective and with regard to adult mosquito control.

1. Coastal Wetlands

a. Marine. The marine habitat for mosquito breeding is restricted to salt marshes, generally between the level of mean high water and high high tide. Below mean high water tidal flushing is too frequent and too strong for mosquitoes to successfully breed and above high high tide the water longer has sufficient salinity to breed saltmarsh mosquitoes. The plant species most frequently associated with mosquito breeding are the short-form *Spartina alterniflora*, *Spartina patens*, and *Juncus gerardii*. Tall-form *Spartina alterniflora* generally defines the lower breeding edge (except in blocked ditching where the tall form edges the ditch) and *Iva fructesens* generally defines the upland edge.

Aedes cantator is the most common species when salinities are low (0 to 10 ppt) as occurs in the spring and after heavy summer rains. *Aedes sollicitans* dominates the mid-summer months when salinities are high (10 ppt and up). However, there is considerable overlap between the two species and it is not difficult to collect both in the same dip of water. *Aedes taeniorhynchus* is less common than above two species. *Culex salinarius* seems to be restricted to rain-fed pools at the upland edge.

b. Brackish. Both *Phragmites communis* (tall reed) and *Typha* species (cattail) obscure the boundary between fresh and salt water. Salinities in the range of 1 to 5 ppt occur and *Ae. cantator* dominates this type of habitat. Cattail tends to indicate a fairly constant source of freshwater, such as a stream or spring, while

Phragmites tends to indicate pooling of water for temporary periods at a level just high enough to avoid salt-water influence except under storm conditions.

2. Inland Wetlands.

Freshwater wetlands vary tremendously in size and hydrology, from small damp spots in isolated wood lots, to broad wooded swamps to sheet flow of spring water down the sides of hills. Mosquito breeding tends to be maximized in areas of temporary, standing water but the number of species that breed in freshwater makes generalizations difficult at best.

Red-maple swamps are a significant source of *Ae. absserratus* and *Ae. canadensis*. Flood plains, flooded meadows and shrub swamps produce *Ae. excrucians* and *Ae. vexans*.

Vernal ponds have received particular attention both because they breed mosquitoes and because they are an important breeding site for amphibians and other semi-aquatic animals. These ponds are rarely more than one-to-two-hundred square feet in surface area, and remain flooded from snow melt until drydown in mid to late June. They breeds *Ae. absserratus, Ae. excrucians, Ae. canadensis, Ae. cinereus* and, if dry down is late or the pool is reflooded by rain, *Ae. vexans* and *Anopheles* species. If such a pool is located in a flood plain, it can breed *Ps. ferox* as well.

Larger, deeper swamps cause considerable difficulty because, although the number of mosquito larvae per square foot may be low than in the vernal ponds, the size of the swamp more than makes up for the difference. Further, access to the central areas of the swamp is extremely limited, making aerial application the only practical control technique. *Aedes absserratus* and *Aedes* canadensis are two primary pest mosquitoes that emerge from these swamps. As the swamps dry down, innumerable pockets of water are left among the tree roots and *Cs. melanura* becomes increasingly easy to find as the swamps dry.

Flood-plain marshes, wet meadows and swamps produce *Ae. excrucians* in the spring and *Ae. vexans* in the summer. Flood plains are ideally suited for *Ae. vexans* as peak flooding is delayed for a day or more after rainfall and areas remain flooded longer than in other areas. This creates ideal conditions for breeding. In the summer East Middlesex MCP has recorded up to 5,000 *Aedes vexans* per night at collection sites in close proximity to river flood plains.

Shrub swamps are much less common than forested swamps so are less a target for mosquito control on that basis. *Aedes excrucians* seems to be the pest mosquito most likely to be found in such sites, and *Cu. restuans* is also common.

The mosquito problem associated with marshes depends on water depth and the presence of cattail. A marsh more than a foot deep with an extensive stand of cattail will breed *Cq. perturbans* and be a constant source of difficulty to control personnel. If water levels are lower, and cattail is replaced by emergent grasses and rushes, then *Ae. canadensis* and *Ae. vexans* may be present. Again, *Culex* and *Anopheles* species are fairly common in this type of marsh.

A less-common type of wetland is the sloping, forested wetland caused by water seepage and typically having a ground cover of skunk cabbage. Mosquito breeding is not high in such places, the slope preventing significant pooling, but manmade disturbances, such as cutting a dirt trail across the face of the slope, can pool water and provide breeding habitat.

3. Surface Water Bodies. As opposed to the wetlands described above, in which surface water often disappears for at least part of the year, surface water bodies generally have standing or moving water year-round and have an extensive, open water surface.

a. Lakes and ponds. Few mosquitoes breed in the open water of lakes and ponds. Breeding does occur in the wetlands, particularly cattail, that border the lake or pond. In East Middlesex MCP, flood plains and cattail marshes located on the edges of lakes and ponds produce massive populations of *Ae. Excrucians, Ae. vexans,* and *Cq. perturbans* (Henley, personal communication). Small ponds which become covered with floating plants such as duckweed can breed *Culex territans* and *Anopheles* mosquitoes. Small, manmade ponds lacking fish populations can also breed mosquitoes, especially where emergent vegetation exists.

Although not significant breeding sites, lakes and ponds are areas where adult mosquitoes congregate. Several reasons probably play a role, from the availability of water to drink, to the fact that mammals and birds tend to come to water to drink also and, that there are often wetlands immediately adjacent to more open bodies of water.

One important point to make is that there are numerous types of gnats and midges that, to the untrained observer, look much like mosquitoes. These insects breed in the sand or mud edging ponds and lakes and can give the appearance of huge numbers of mosquitoes as the adults swarm among the vegetation. Early-season complaint calls are often based on observations of these, no-biting, insects.

The fauna of all open bodies of water, including rivers and streams discussed below, are particularly susceptible to broad-spectrum pesticides such as malathion and the pyrethroids group. Larval control is rarely an issue, but adulticiding near open water always carries some risk of non-target kills.

b. Rivers and streams. The current in the open water of rivers and streams makes mosquito breeding impossible in all but the slowest moving sections. Even here the predator complex in most cases is too well developed for mosquitoes to survive in any numbers. Again, however, the wetlands bordering the river are significant breeding sites. Some breeding also can take place in intermittent streams, once they have stopped flowing and before they dry down completely.

4. Recharge Areas. Recharge areas are those in which surface water percolates down to recharge aquifers or drains into reservoirs. The obvious concern in such cases is that pesticides used in such areas may move along with the water, causing contamination of the aquifer or reservoir. The primary pesticides for mosquito control, resmethrin and Bti, break down quickly and do not pose a water-quality risk to reservoirs. Of course, adulticiding over wetlands can kill wetland species directly, though ULV rates are low enough that such kills are infrequent.

a. Wetland. Because wetlands are wet due to the impermiability of the substrate, their addition to recharge areas is often less than that of surrounded, drier areas. Pesticides applied to wetlands, therefore, are not likely to cause contamination by percolation. However, because wetlands do store water which can then move out of the wetland as runoff, pesticides applied to such areas may move off-site, including into reservoirs.

b. Upland. Upland recharge areas rarely have significant mosquito breeding, because the water percolates downward quickly. The primary concern in such areas would be heavy rainfall immediately after a treatment for adult mosquitoes. In such cases there could be overland flow of runoff contaminated by pesticide washed from leaf surfaces.

5. Upland Areas. This is a catch-all category for all lands not defined as wetlands. Obviously, the majority of human developments are located on uplands and the majority of adulticiding takes place within upland areas. Perhaps unconsciously, pesticides used for adult mosquito control are designed to be relatively benign to the plants and vertebrate animals of Massachusetts. No material that caused robins or squirrels to drop in their tracks, or which killed maple trees, would ever be permitted for use in Massachusetts. This makes ULV sprays in such areas appear reasonably benign. However, simply because the larger species do not exhibit acute effects, does not mean that no effects occur. One clear question that cannot be answered is what long-term effects do regular

adulticide treatments have on the less-visible fauna of the typical suburban woodlot-meadow habitat in Massachusetts.

6. Agricultural Areas. The muddy hoof-prints of the milk cows around the water hole may well breed *Ae. vexans*, but the proper control in such cases must take into account the fact that food for human consumption is the primary purpose of the land in question. The Bti and IGR larvicides currently available are unlikely to cause problems in meat, dairy or crop production, but adulticides are a different story. Pesticide residues are limited even on non-organically grown produce and a late-summer application has the potential to cause problems for growers. Of particular concern are the backyard gardens of homeowners which cannot help but receive the drift from pesticide applications.

Agricultural enterprises of particular concern are apiaries and organic farms. Bees are susceptible to pesticides but the exposure to bees caused by mosquito control applications of resmethrin at night is minimal since the bees have already returned to their hives.

During the EEE vector control aerial applications of malathion, beekeepers were advised to cover their hives. The applications were scheduled for 2.5 hour windows after dawn and before dusk. The criteria used in determining the period of the spray window included daylight periods when mosquito activity would be optimal and bee activity would be minimal.

The owners of properly run organic farms have gone to great lengths to become certified as pesticide free. In most cases the farms are small and the business, at least in the first years, marginal. The problem with organic farms, under normal circumstances, is knowing they exist, not avoiding them once known. Massachusetts MCPs have systems in place so that organic farmers can heave their land excluded from pesticide applications. Problems can develop when the question of drift from nuisance spraying occurs, or when there is a public-health threat.

7. Sensitive environments and populations. Certain environments and populations have special considerations which require a more cautious approach to mosquito control. Some of these have been discussed above but there are others worthy of mention.

a. Urban. The urban environment requires special care due to the increased population density and the difficulty in ensuring that people know the benefits and the dangers associated with mosquito control.

b. Recreation. People who enjoy outdoor recreation areas often have a higher tolerance for mosquitoes and a lower tolerance for spray vehicles than does the population at large. On the other hand, resort communities may demand higher than normal levels of mosquito control in order to make their site more enjoyable to the public. In any event, areas in which summer recreation takes place tend to polarize the debate over control and provide increased political headaches for MCPs, even where mosquito control itself is relatively straightforward.

c. Sensitive individuals. There are several groups of people who are sensitive to pesticide applications. Some individuals with emphysema or asthma can be adversely affected by airborne pesticide applications and such individuals sometimes request that their property be excluded from spraying.

Individuals with Multiple Chemical Sensitivity (MCS) have contacted MCPs and requested exclusion from spraying. No project has reported difficulty working with these individuals to create acceptable no-treatment zones. The causes, systems, diagnosis, and treatment of MCS all remain in a great state of flux, so MCPs are well advised to work carefully with MCS individuals and pay attention to the changing medical knowledge concerning MCS.

d. Public and Private Wildlife Refuges and Conservation Areas. These areas are often excluded from mosquito control at the request of the property owner because mosquito control runs counter to the goal of preserving the area in as natural a state as possible. Exclusion is not always absolute, however, as sometimes environmentally friendly pesticides like Bti can be used or water management may be practiced where pesticide applications are not permitted. The best way to approach such areas is to contact property owners and discuss with them possible mosquito-control alternatives.

e. ACEC and areas with rare or endangered species. Whenever rare or endangered species are present, pesticide applications and/or wetland alterations need to be approved by the appropriate agencies (see discussion under Rare and Endangered Species under impacts of physical control below). In many cases they will be rejected out of hand.

f. Water supplies. As stated above under surface water bodies and recharge areas, open water and water that is destined for drinking supplies, whether through percolation into the groundwater or by flow into reservoirs, must be very carefully protected. Fortunately, it is rare indeed that water supplies are held in such a way as to breed mosquitoes. For water supplies in general, therefore, mosquito control must consist of influencing the design of such systems to avoid creating habitats that would produce mosquitoes.

C. Mosquitoes as Disease Vectors

Most of the 9 organized mosquito control projects in Massachusetts justify their activities (and claim benefits) in part on the disease threat to human and animal populations posed by vector mosquitoes. Control programs in Berkshire County and Cape Cod (Fig. 1) lie outside of the area historically affected by outbreaks of Eastern equine encephalomyelitis (EEE) and therefore do not justify or plan their programs to address this disease problem. Dog heartworm is recognized throughout the Commonwealth (Arnott & Edman 1978). California group viruses have also been found in mosquitoes. To date human illness attributable to these agents has not been identified in Massachusetts..

A major practical difficulty in addressing the vector mosquito problem in Massachusetts stems from the fact that the specific species responsible for transmission of disease agents to humans and domestic animals are often unknown. The enzootic vector of EEE among birds is clearly *Cs. melanura*, but the vector(s) to horses and humans is unknown. The cattail mosquito, *Cq. perturbans*, and the most common reflood species, *Ae. vexans*, are prime suspects. Other mammal-feeding *Aedes* such as *Ae. canadensis* also may be involved and perhaps even *Cs. melanura* feeds sufficiently on mammals under unusual circumstances to cause some transmission to these dead-end hosts (Nasci & Edman 1981a).

Based on isolations in other states (Calisher & Thompson 1983) and a few in Massachusetts (Walker 1984), it seems likely that the important California group viruses in the Northeast, i.e. LaCrosse and Jamestown Canyon, are transmitted by the treehole mosquito, *Ae. triseriatus*, and spring, woodland *Aedes*, respectively. Dog heartworm also may be spread primarily by spring *Aedes* but reflood *Aedes* (e.g., *Ae. sticticus* and *Ae. trivittatus*), *Cq perturbans*, *Cx. salinarius* and *Anopheles* spp. also may be involved in transmission of this parasite (Arnott & Edman 1978).

1. Eastern Equine Encephalitis

MCP's in Southeastern Massachusetts, i.e., Norfolk, Bristol and Plymouth Counties, face the greatest threat from this disease. During major epidemic years, virus activity extends northward from this enzootic focus into southern New Hampshire and westward into Rhode Island, Connecticut and Central Massachusetts. All projects except Berkshire County give considerable continuing attention to this potential problem. Upon occasion, projects may submit mosquitoes to the SLI for EEE virus analysis.

The enzootic foci of EEE are red maple/white cedar swamps. The largest adult populations of the enzootic vector, *Cs. melanura*, occurs in or near the localized swamps where this species develops. Most human and horse cases also occur in the immediate vicinity of these same swamp habitats. Still, at times this mosquito may disperse several miles from its larval habitat (Morris et al. 1980. Nasci 1980. Nasci & Edman 1984) and human/horse cases occasionally occur in upland areas. This mosquito is unusual in that it overwinters in the larval stage (4th or 3rd instar). Adults from this generation emerge in late spring (i.e., mid to late May). Two to three summer generations occur about one month apart, e.g., in late June, July and August, depending on water levels and temperature (Nasci 1980). EEE virus is generally not isolated from this mosquito until late summer. During epidemic years it tends to be isolated earlier, i.e., beginning in early July, but apparently never from the overwintering generation. The location of the virus from November to July remains a mystery. *Culiseta melanura* feeds only after dark and the vast majority of blood meals are obtained from passerine birds (Nasci & Edman 1981a). This sylvan mosquito feeds equally at ground level and at higher elevations in the tree canopy. Activity is concentrated just after dark and just before sunrise (Nasci & Edman 1981b). The morning flight activity peak does not seem to involve blood-feeding but rather the return to suitable daytime resting sites.

The isolation of EEE virus from the cattail mosquito *Cq*. *perturbans* during disease outbreaks (Crans, personal communication) has focused suspicion on this species at the most likely epidemic vector to horses and humans. *Ae*. *vexans* and *Ae*. *canadensis* are two other prime suspects for EEE virus transmission to humans and horses in Massachusetts. Like *Cq*. *perturbans*, they are major pests. Their biologies will be described along with the other pest species.

A new EEE threat may be developing in New England as *Ae. sollicitans*, long a known vector in New Jersey (Crans et al. 1991), was, for the first time, found to be EEE-positive in Connecticut in 1996 (Andreadis 1996). Crans (1991) gave a suggested cycle for EEE transmission to *Aedes sollicitans* in which *Cs. melanura* infected night-roosting glossy ibis, which were then fed upon by *Ae. sollicitans* while feeding in the salt marsh. Though the link between glossy ibis and *Ae. sollicitans* is tentative, there can be no question that *Ae. sollicitans* is a potent vector in New Jersey and could be an important vector in Massachusetts as well.

2. California encephalitis vectors

Jamestown Canyon virus has been isolated from both dark-legged and banded-legged spring *Aedes* in Massachusetts and neighboring New York State (Walker 1984, Calisher & Thompson 1983). LaCrosse virus is associated with the tree-hole species *Ae*. *triseriatus* in Eastern New York State, but it has not yet been found in Massachusetts. All suspect human cases of arboviral disease which are found not to be EEE are sent by the SLI to the CDC for a full arbovirus analysis. No California Group virus infections have been identified.

3. Dog heartworm

A wide variety of mosquito species are capable of vectoring this debilitating nematode parasite of canines. Coin lesions in human lungs can occur from accidental infection with this parasite (Adkins & Dao 1984, Deren & Feinberg 1984). Felines are more susceptible to infection than was previously thought because they apparently do not produce microfilaria (Fukushima et al. 1984). Natural infections have been found in three different species of spring *Aedes* in Massachusetts but other potential vectors cannot be discounted (Arnott & Edman 1978). The treehole mosquito, *Ae. triseriatus*, and three permanent water species, *Cx. salinarius*, *An. punctipennis* and *An. quadrimaculatus*, are all possible late season vectors.

King and Munro (1989) reported on a questionnaire sent to Plymouth County veterinarians concerning dog heartworm. Infect rates were reported as generally less than 5% but one veterinarian reported rates above 20%. With between 25,000 and 30,000 dogs in the reporting area, the estimated cost of yearly preventative treatments was $750,000.

V. CURRENT ABATEMENT STRATEGIES AND THEIR IMPACTS

A. Chemical Control

1. Overview of Chemical Control

a. General Toxicity of Pesticides.

Pesticides are placed in one of four categories based on their acute toxicity (Table 13). Category I pesticides are extremely toxic while Category IV materials can range from mildly toxic to non-toxic.

Pesticides are also classified as either “General Use” or “Restricted Use” materials. General Use pesticides are available for use either by the general public or by licensed applicators. Restricted Use materials may only be applied by certified applicators or licensed applicators working directly under the supervision of a certified applicator. While Restricted Use materials are generally more toxic than General Use ones, toxicity is not the only issue. For example, resmethrin-based ULV products (Scourge) have recently been placed on the Restricted-use list, not so much because of toxicity but because the mode of application (ULV area-wide treatments) means that incorrect applications can have wide-ranging effects.

Table 13. Toxicity Category of Pestcides used in Mosquito Control

Category	Signal Word Required on the label	Categories of Acute Toxicity			Probable Oral Lethal Dose for 150 lb. man	Antidote Statement Other Cautions[a]
		LD_{50}		LC_{50}		
		Oral mg/kg	Dermal mg/kg	Inhalation mg/l		
I Highly Toxic	DANGER POISON	0 thru 50	0 thru 200	0 thru 0.2	A few drops to a teaspoon-ful	Skull and Crossbones “Call Physician Imme-diately” Antidote Statement
II Moderately Toxic	WARNING	from 50 thru 500	from 200 thru 2000	from 0.2 thru 2	>1 teaspoonful to one ounce	
III Slightly Toxic	CAUTION	from 500 thru 5000	from 2000 thru 20,000	from 2.0 thru 20	>1 ounce to one pint or one pound	
IV Relatively Non-toxic	CAUTION	>5000	>20,000	>20	Over one pint or one pound	

[a]All pesticide labels are required to include the statement, “Keep out of reach of Children.”

from: pesticide Applicator Trainging Core Manual: Northeastern Regional Pesticide Coordinators and Manual 2, Vectorborne Disease Control Homestudy Counrse 3013-G: Center for Disease Control

Newer pesticides have muddied the pesticide classification system. Bti and *Bacillus sphaericus* are biological organisms yet their mode of action is through the creation of a toxin that is activated in the insect's midgut. For the purposes of pesticide classification and this GEIR, therefore, they are considered pesticides, not biological control agents. Methoprene is also a case of a material (an insect growth regulator) that, while not directly toxic, so alters the life cycle of the insect that death results. Again, methoprene (Altosid) is classified as a pesticide but is far removed from the classic chlorinated hydrocarbon and organophosphate pesticides of the past.

b. Pesticides used for Mosquito Control In Massachusetts

Twenty-six different insecticide formulation distributed among fifteen product lines were used for mosquito control in Massachusetts between 1993 and 1995 (Table 14). Eight of these formulations used Bti as the active ingredient, five were methoprene-based, three were resmethrin-based, two each were pyrethin-based or malathion-based, and there were one each of temephos, isoctedecanol, and mineral oil. Of these, Acrobe (Bti) and Vectobac AS (replaced by 12AS) are no longer produced. Arosurf-MSF (Isoctadecnol) was removed from the market but has just reappeared under the name Agnique MMF. Abate 4E was not used in either 1994 or 1995 and both the Malathion 10EC and the Resmethrin product (EPA rep # 4-339-53853) were used in small amounts only (Table 4 gives a break-down by Project of chemical use).

Of the insecticides used, all of the larvicides were classed as Category IV materials by EPA. Bonide Mosquito Larvicide, available but not used, is border line between Category III and IV. VectoLex CG, a new *Bacillus sphaericus* product, is Category IV. All adulticides are in Category III.

Many pesticides have dual actions. They are important in controlling injurious pests, but they may also present a hazard to species not considered to be pests in the environment. As a result, the concepts of "target" and "non-target" organisms have arisen. For example, in many freshwater systems, control measures may be taken against undesirable target organisms such as mosquito larvae or unwanted algae. Non-target organisms are those whose destruction is not intended but which may be affected. These non-target organisms may play key roles in aquatic ecosystems.

The distinction between target and non-target species is not absolute, because the same group may be non-target organisms in one area of the country but target organisms, under certain circumstances, in another area. For example, larvae of caddisflies (Trichoptera) and naiads of mayflies (Ephemeroptera) are important food sources for

Table 14. Chemicals used in Massachusetts mosquito control, 1993 through 1995

Trade Name	EPA Registration Number	Active Ingredient(s)	% Active Ingredient	Toxicity Class	Other Warning Statements
LARVICIDES					
Abate 4E	241-132	Temephos	43	IV	
Acrobe[a]	62637-1-241	Bti[b]		IV	
Arosurf-MSF[c]	42943-8	Isooctadecanol	100	III	
Altosid					
Briquets	2724-375-64833	Methoprene	7.9	IV	
XR Briquets	2724-421-64833	Methoprene	1.8	IV	
Pellets	2724-448-64833	Methoprene	4.0	IV	
Bactimos					
Briquets	43382-3	Bti	10	IV	
Granules	37100-43-2217	Bti	0.2	IV	
Pellets	37100-42-2217	Bti	0.4	IV	
GB-1111	8898-16	Petroleum Hydrocarbons			
GB-1356	8898-16				
Teknar HP-D	2724-365-64833	Bti	0.8	IV	
Vectobac					
AS	275-52	Bti		IV	
12AS	275-66	Bti	1.2	IV	
Granular	275-50	Bti	0.2	IV	
ADULTICIDES					
Malathion 8EC	34704-119	Malathion	8	III	
Permanone 10EC	4816-688	Permethrin	10	III	
Permanone 31-66	4816-740	Permethrin	31	III	
Resmethrin	4-339-53853	Resmethrin		III	
Scourge 4+12	432-716	Resmethrin	4	III	RESTRICTED USE CLASSIFICATION Due to acute fish toxicity Retail sale to and use only by Certified Applicators or persons under their direct supervision and only for those uses covered by the Certified Applicators Certificate
		PBO	12		
Scourge 18+54	432-667	Resmethrin	18	III	
		PBO	54		
MATERIALS REGISTERED BUT NOT USED - LARVICIDES					
Altosid					
Liquid	2724-392-64833	Methoprene	5	IV	
Liquid Con	2724-446-64833	Methoprene	20	IV	
Bonide Mosquito Larvicide	4-195	Mineral Oil	98	III-IV	
VectoLex CG	275-77	*B. sphaericus*	50[d]	IV	
MATERIALS REGISTERED BUT NOT USED - ADULTICIDE					
Fyfanon ULV	4787-8	Malathion	95	III	

[a]No longer marketed
[b]*Bacillus thuringiensis* var. *israelensis*
[c]Now marketed as Agnique MMF

trout and other valuable freshwater fish. In certain areas, these species of insects can occur in such large numbers that they become nuisance pests, and their immature stages are the target of planned control operations with pesticides.

The ideal situation in most control operations is to be able to destroy the undesirable species at pesticide concentrations that will have minimal adverse effects on the rest of the biota. However, some degree of contamination and hazard is assumed with nearly all pesticide use. The hazard to aquatic organisms and other wildlife species depends on the chemical and physical properties of the pesticide, type of formulation, rate and method of application, and characteristics of the receiving ecosystem system (Nimmo 1985).

Looking at the change in pesticide use by MCPs over the past decade (Table 3), all Category II insecticides have been phased out and Methoxyclor, the only organochlorine compound on the list in the early eighties, has likewise been dropped. Using malathion and permethrin for larviciding has also been discontinued and Bti and methoprene have taken over from Mineral Oil (Flit-MLO) as the dominant larvicides. For adulticiding, permethrin and resmethrin have essentially replaced malathion. Theses changes indicate that MCPs have responded to the desire of the public at large (including the staff of the MCPs incidentally) for materials with the lowest risks. The other conclusion to be drawn is that, until the discovery of new materials, both adulticiding and larviciding are presently be conducted with the materials that have the least overall risk. Advances in reducing the risk of chemical use must therefore come from improved targeting and increased use of water management and/or biological control techniques.

c. General Properties of Registered Mosquito Control Insecticides in Massachusetts, 1996.

Physical Properties. Using both water solubility and KoW, the following insecticides are classified as water insoluble or practically water insoluble; Bti, isooctadecanol, methoprene, petroleum oil/Flit MLO, pyrethrin I, resmethrin and temephos. Malathion is the most water soluble insecticide used (145 ppm). Nevertheless, it still has a relatively high partition coefficient (KoW 779) and because of its rapid environmental and metabolic degradation is not expected to bioaccumulate in any appreciable fashion as discussed below.

Insecticides which have little or no volatility are; Bti, *B. sphaericus,* malathion, methoprene, and temephos. Isooctadecanol and mineral oil are slightly volatile. Although pyrethrin I and resmethrin have appreciable vapor pressures, they are most likely to be bound to suspended organic matter or soil particulate in natural systems. If volatilization occurs, they are rapidly photodegraded.

Four of the insecticides have vapor densities less than 1.0 (relative index to air) and so could concentrate near the surface, resulting in increased exposure via inhalation. However due to the low vapor pressure of isooctadecanol and methoprene, these compounds are mot likely to be available for concentration. The pyrethroid insecticides, as discussed above, are rapidly degraded by photolysis if they become available which is not likely from environmental surfaces.

For specifics on a given insecticide, the reader should refer to the sample labels and Material Safety Data Sheet (MSDS) for that material, located in Appendix C.

<u>Analytical Methodology</u> (from: The Pesticide Manual 7th ed. Worthing & Walker, British Crop Protection Council. Lavenham, UK. 1983. For more detailed methods consult The Agrochemical Handbook, 2nd ed. 1983).

1. Bti and *B. sphaericus* are measured in international toxicity units/mg product (i.u.) relative to that of an appropriate standard product against *Trichoplusis ni* or *Aedes egypti* in standard bioassays. Assays based on the number of spores are not satisfactory.
2. Methoprene is analyzed by GLC or HPLC w/UV detection.
3. Isooctadecanol is analyzed by GLC.
4. Pyrethrin I is analyzed by GLC.
5. Resmethrin is analyzed by GLC.
6. Temephos is analyzed by GLC.
7. Malathion is analyzed by GLC.
8. Petroleum Oil is analyzed by GLC.

<u>Transport, Persistence and Degradation in Soil, Air and Water</u>. None of the insecticides used for mosquito control in Massachusetts are included on the 1987 EPA lists (I + II) of the 51 priority pesticide leachers.

<u>Synergists and Inerts in Pesticide Products</u>.

Synergists are compounds added to a pesticide that increase the efficacy of that pesticide. Relatively few combinations of insecticides and synergists lend themselves to practical use, either because the degree of improved performance is small or because too much of the expensive synergist is required, or both (Casida 1970). By the same token, no example of increased toxicity to man or useful animals under practical conditions has been reported (Hayes 1982).

In mosquito control, the synergistic effect of various compounds on pyrethrum and synthetic pyrethroids is well known. piperonyl butoxide (PBO) is the sole synergist used in Massachusetts. It acts as a substrate for the microsomal enzyme-NADPH2 system, which also metabolizes many drugs and insecticides. By serving as an alternative substrate for the detoxification enzyme of the insect, PBO prolongs the persistence of the insecticide so that a lower initial dose is effective (Casida et al. 1966, Kamienski & Casida 1970, Casida 1970).

“Inert” materials which are used as formulation aids in the insecticides applied by towns/BOHs and Projects for mosquito control in Massachusetts are categorized as follows: Powders, granular carriers, solvents and special effects materials.

Dustable powders generally contain l-l0% a.i. mixed with powdered minerals as carriers and diluents. For wetable powders, the same diluents and carriers can be used as for dusts. However for dispersible powders, a finer particle-size spectrum is necessary, the proportion above 40 um not exceeding a few percent. No powdered materials are currently in use in mosquito control in Massachusetts.

Granular formulations are made by either impregnation (soaking or coating) of granular carriers or by granulation of powdery mixtures of active ingredient and formulation aids. These two types differ in the active ingredient concentrations attainable. For both types, an active ingredient content of 20% is the maximum technically feasible. Included in the grouping are Bactimos briquets, granules and pellets (Bti), Vectobac granules (Bti) and Altosid briquets, XR briquets, and pellets (methoprene).

Liquid formulations such as emulsifiable concentrates, soluble concentrates and ULV use various organic solvents as diluents. Aliphatic hydrocarbons are poor solvents for most active ingredients and are therefore normally only used for very dilute formulations. Aromatic hydrocarbons are used frequently, the fractions C6 to C12 being favored (e.g., from technical xylene mixtures to substituted naphthalenes). Apart from the toxicity of benzene, their high flammability prohibits the use of lower aromatics. On the other hand, phytotoxicity frequently increases with increasing molecular weight. Ketones are excellent solvents for many organic compounds. Most of them are at least partially water soluble, so they are mainly suitable for formulating water-soluble and liquid-active ingredients. When they are used for the formulation of emulsifiable concentrates of solid, water-insoluble active ingredient, the active ingredient often crystallizes out during the preparation of the spray mix. This is caused by the solvent passing into the aqueous phase whereupon the active ingredient is precipitated in the "oil droplets" of the emulsion. Here ketones can normally only be used together with other, water-insoluble solvents as cosolvents.

This is also valid for alcohols and glycols and their ethers and esters as well as for highly polar aprotic solvents such as dimethylsulfoxide and dimethylformamide. Chlorinated solvents are only used to a very slight extent. Chlorobenzene is used occasionally; dichlormethane is used more frequently as a relatively non-toxic, highly volatile, and nonflammable solvent for hygiene and stored-product agents and for aerosols.

Emulsifiable concentrates used for mosquito control include the larvicide Abate 4E and the adulticides Malathion 10EC, Permanone 10EC, Permanone 31-66, Resmethrin, and the Scourge products.

With increasing public concern of off-site deposition of pesticides (e.g. aerial drift) and the movement of the pesticide industry away from organic compounds to biological insecticides, new formulation technology has emerged. Flowable concentrates not only reduce drift, but provide better coverage and greater adhesion to the substrate. Dried active ingredients are ground to a uniform particle size (usually 10 um) as either a dry, wet (H_2O) or oil suspension (which then is diluted with water for application). Included in this grouping are the Bti products Teknar flowable (Bti) and Vectobac AS and 12AS.

None of the direct nerve toxins (pyrethrin and resmethrin) have inert ingredients which appear on EPA/SAP List 1. Scourge (resmethrin) contains a List 2 compound (0.025% xylene) and 4-12% PBO and 12% Chevron 100 (a soybean oil diluent) as additional active ingredients.

None of the indirect nerve toxins (malathion and temephos) have inert ingredients which appear on the EPA/SAP List 1. Of the products which contain malathion, malathion 57% EC contains a List 2 compound, 31.5% and 36.55% xylene range aromatics, respectively. Temephos (Abate 4E) contains 39% Chevron 100 as an additional active ingredient.

None of the selective insect toxins (Bti and methoprene) contain any List 1 or 2 compounds. No other additional active ingredients are listed.

None of the physical toxins (isoocadecanol (Arosurf MSF/Agnique MMF and petroleum oils) contain any of the List 1 or 2 compound. Petroleum hydrocarbons as a group are included on List 2 as potential toxic inerts of pesticide products.

d. Pesticide Handling and Application

Pesticide storage varies considerably from project to project. Cape Cod uses only bagged Bti so no formulation work is necessary nor are there stringent storage requirements. Five projects store and formulate chemicals in an area within the main garage, generally separated by a wire cage (cabinets within a metal shed at Suffolk) from the main garage area. Ventilation fans operate either continuously or whenever the lights in the garage are turned on. Bristol, Central Mass and Essex all have separate buildings for pesticide storage and formulation. Central Mass mentioned that their structure was built in consultation with the local fire department and the State Pesticide Board. East Middlesex constructed its storage area from Department of Defense specifications.

All projects use pickup-truck mounted ULV sprayers for adulticiding. No thermal foggers remain in use. Backpack sprayers are used to apply liquid larvicides and, in some projects, adulticides. Granular materials are applied by hand or with cyclone-type spreaders. Briquet formulations are applied by hand. Additional information on the pesticides may be found on the sample labels and MSDS sheets in Appendix C.

Applicator certification is done by the Pesticide Bureau of the Department of Food and Agriculture. Mosquito control applicators are certified under the "Mosquitoes and Biting Flies" subcategory of "Public Health and Nuisance Control". Aerial Applicators are licensed separately. Ongoing training is required and many mosquito-control personnel attend annual meetings of the Northeastern Mosquito Control Association for such training. Specifics for certification and other applicator issues are covered in CMR 333: Pesticide Board.

Most of the pesticides used are extremely safe, so handling instructions are minimal. For Bti, mineral oil or Golden Bear oil, and metheprene products, work areas should be ventilated and eye protection and impervious gloves worn. With these materials applicators should also wash thoroughly after handing or applying them. With malathion, permethrin and resmethrin products safety goggles, chemical resistant gloves and a respirator should be worn when formulating spray material. Eyes should be flushed immediately and skin washed with soap as quickly as possible if accidental contact occurs. Vomiting should not be induced for resmethrin and permethrin products but should be induced for malathion. In all cases where resmethrin, permethrin or malathion is ingested, a physician should be contacted immediately.

2. Larvicides

a. Biologicals: Bti and *B. sphaericus*

i. *Bacillus thuringiensis* var. *israelensis*

Mode of Action. *Bacillus thuringiensis* (Bt) is a naturally occurring, gram positive, rod-shaped, spore-forming bacterium, which is pathogenic to the larvae of a number of insects species, especially Lepidoptera, when ingested by the larvae. Bti is also a pathogen to the larvae of some insects in the order Diptera (e.g., mosquitoes and midges). *Bacillus thuringiensis* var. *israelensis* Serotype H14 (Bti) is a biological insecticide produced during sporylation of this bacterium. The protein product of the H14 serotype (e.g., Bactimos, Vectobac and Teknar) is used to selectively control the larvae of mosquito and blackflies. It is a stomach poison which alters gut permeability to salts under alkaline conditions. This decreases feeding and development and eventually causes death by starvation (Hartley & Kidd 1983).

Fate in the Environment. The residual period for Bti has been estimated at 48 hr in water, as it gradually settles out or adheres to suspended organic matter (SCAMP 1987). As a natural part of the ecosystem, Bti degrades to complex but non-toxic organic compounds which are ultimately mineralized (Hartley & Kidd 1983).

Effects on Non-target organisms. There is no evidence of acute or chronic toxicity of the spore-crystal complex to amphibians (tree frog tadpoles, toad tadpoles, California newt), fish (mosquito fish, rainwater kill fish, two-spine stickleback) or birds. It is non-toxic to bees. Groups of organisms that have been reduced by Bti applications are from the suborder Nematocera of the order Diptera which includes species of the families Dixidae, Chironomidae, and Ceratopogonidae (Fisher & Rosner 1959, Garcia et al. 1980, Hartley & Kidd 1983, Worthing & Walker 1983). A recently completed study in Minnesota found Bti reduced chironomids, tipulids, ceratopogonids and stratiomyids. There is reason to believe this may have negative impacts on nesting ducks and their ducklings, for which chironomids make up a significant part of their diet (SPRP 1996).

When a small stream was treated at 0.5 ppm/15 min. (13°C) with an aqueous suspension of unformulated Bellon primary powder of Bti, in contrast to the sharp reduction (89%) in black fly larvae in the 20-350 m area below the treatment point, Surber samples indicated increases in mayfly (35%), caddisfly (47%), stonefly (75%), chironomid (19%), and elmid (242%) populations. No adverse effect on any of these non-target populations was evident following stream treatment (Molloy & Jamnback 1981). In laboratory and field studies conducted with Bti to determine its effect upon *Ae taeniorhynchus* and non-target organisms in a salt marsh, Bti killed over 99% of the mosquito larvae at concentration of 4.5 IU/ml and above. Out of 39 species collected prior to treatment, only a homipteran (true bugs), *Notonecta indica*, showed a significant decrease in population. However, this genus is known to fly from deteriorating habitats (Purcell 1981). Experimental testing has demonstrated no adverse effect against other aquatic insects including dragonflies, damselflies, mayflies, stoneflies, caddisflies, water beetles or true bugs. Other invertebrates such as Daphnia, cyclops, rotifers and crustaceans are also unaffected (SCAMP 1987).

Many acute toxicity/pathogenicity studies with various varieties of Bt have been conducted using several routes of administration in rats, rabbits, and guinea pigs. Among the various studies reviewed, the highest dose tested was 6.7×10^{11} spores per animal. There were no significant adverse effects associated with these studies (Castillo 1986). No acute toxicity was observed in rats gavaged with the maximum dosage of 2 billion spores of Bti H-14. No erythema or edema formation were observed after dermal exposure to 1.6 billion spores. All other parameters of the test animals were normal. There was no evidence that Bti H-14 multiplied on the abraded epidermis. No adverse effects were observed in rats given 80 million viable spores by instillation into the lungs. There was no histological evidence of multiplication of the organism in lung tissue. Instillation of 10 million Bti spores into the ocular cavity produced no eye irritation beyond 48 hr. No multiplication occurred in the ocular cavity (Castillo 1986). Acute, oral and dermal toxicity (LD_{50}) of Bti H-14 (Vectobac) is in excess of 30,000 mg/kg.

No allergenic response to *B. thuringiensis* was elicited in guinea pigs by introcutaneous injection, inhalation, or topical application to the intact or abraded skin (Hayes 1982).

Each of 18 persons ingested 1 g of a commercial *B. thuringiensis* preparation containing approximately 3×10^9 spores daily for 5 days on alternate days. In addition to ingestion, five of them inhaled 100 mg of the powder daily for 5 days. There were no complaints and no positive findings by physical and laboratory examination (Fisher & Rosner 1959). When Bt was applied by aircraft at a rate of 2 kg of preparation (3×10^9 organisms/g) per hectare (6×10^{12} organisms/hectare) the concentration of viable organisms in the air over the field exceeded background by 42.5 times on the day of application and by 22.5 times 5 days later (Castillo 1986). No complaints were received from eight men exposed for 7 months to fermentation broth moist bacterial cake, effluent, and the final powder in the course of commercial manufacture of the pesticide (Fisher & Rosner 1959, Hayes 1982).

A dose of 10^7 (i.e., 10 million) Bti organisms killed the test animals when injected introcerebrally (IC). Death was probably due to the massive i.c. inoculum and not any infective process. Most of the animals died within 24 hours (Castillo 1986).

The EPA's review of the toxicological data on Bti determined that no data gaps exist in the toxicology data base and no major environmental mammalian safety concerns (except for certain endangered species of Lepidoptera) were identified (Castillo 1986). Toxicological data specially required for biochemical and microbial pesticide registration including: immunotoxicology studies, infecticity studies, intracerebral test, tissue culture tests and virulence enhancement studies (EPA 1984, Marquis 1986). Bti is effective only against dipteran larval (mosquitoes and black flies) and is safe to the environment (Worthing & Walker 1983).

Bti is non-phytotoxic and has shown no effects on seed germination or plant vigor (SCAMP 1987).

ii. *Bacillus sphaericus*

Mode of Action. . *Bacillus sphaericus* is a naturally occurring bacterium, which is pathogenic to the larvae of many genera of mosquitoes. There are a number of strains of *B. sphaericus*, that being most toxic to mosquitoes is *B. sphaericus* 2363. Like Bti, it produces a toxin that must be ingested and partially digested before it becomes activated. *Aedes* mosquitoes are generally less susceptible to *B. sphaericus.* It is currently marketed as a granular larvicide by Abbot Labs under the trade name VectoLex CG and is of interest because it works better than Bti in highly organic waters often favored by *Culex* species (Abbott Laboratories 1996). Also of interest is the fact that it is not toxic to other dipterans, including blackflies. Its limited range of toxicity, while a blessing in some respects, has slowed development as the market for *B. sphaericus* is likely to remain small (Federici 1985).

Fate in the Environment. *Bacillus sphaericus* has a field life of between two and four weeks. The spores settle out of the water column in as little as two days though they settle more slowly than Bti, as they adhere less to suspended particulates. The spores can remain viable for months in the field (Yousten et al. 1992). *Bacillus sphaericus* may undergo limited recycling (reproducing itself within the larval gut of *Culex* species), especially in rich organic environments (Abbott Laboratories 1996, Karch et al. 1990).

Bacillus sphaericus is ingested by other filter-feeding arthropods (*Daphnia pulex* and *Cypris* sp.) It can germinate within the gut of these animals and may be spread by them through the environment. It does not seem to adversely affect them and they may play a role in recycling *B. sphaericus*, thereby increasing the length of control achieved from a single application. *Bacillus sphaericus* does not affect populations of the predator species *Cleon* *dipterium, Corixa punctat* and *Nepa cinerea.* (Karch et al. 1990). *Bacillus sphaericus* can be used in conjunction with the fungus *Lagenidium gigateum* (Orduz and Axtell 1991).

Effects on non-target organisms. *Bacillus sphaericus,* technical material, had acute oral and dermal LD_{50} values for rats of >5g/kg and >2g/kg respectively, making it a class IV larvicide. The technical material can be moderately irritating to the skin and eyes of people.

Toxicity tests on mallards, bluegills, and rainbow trout showed the material to be extremely save to these animals. Acute toxicity tests on freshwater invertebrates (daphnia and mayfly larvae) and salt marsh and bay species (sheephead minnow, shrimp and oysters) all indicate that the material is essentially non-toxic. Honey bees are not affected by *B. sphaericus* (Abbott Laboratories 1996).

Bacillus sphaericus is not phytotoxic (Abbott Laboratories 1996).

b. Methoprene

Mode of Action. Methoprene is an insect growth regulator (i.e., a synthetic analog of the juvenile hormone) which does not allow insects to mature from the larval stages into reproductively capable adults. It shows little or no effect on the adult or pupal stages of insect development. Unlike ordinary insecticides, this relatively non-persistent chemical exhibits morphological rather than direct toxic activities. Although its exact mode of action is not completely known, three modes have been investigated: 1) methoprene binds JH receptors resulting in extended juvenile forms which are not reproductively competent, 2) methoprene competitively inhibits catabolic metabolism of JH which extends juvenile forms etc., and 3) methoprene binds to its own receptors and extends juvenile forms (Matsumura 1985).

Fate in the Environment. Methoprene is relatively stable but nonpersistent in the environment (SCAMP 1987). It does not biologically magnify. In soil, methoprene rapidly degrades with a half-life of approximately 10 days. In plants its degradation principally involves ester hydrolysis, Odemethylation, and oxidative clearage of the double bond of the C4-position. In lucerne and rice, the principle metabolite is 7-methoxycitronellal. Methoprene is very susceptible to photolytic decomposition under environmental conditions. It is degraded to many photoproducts which are present in relatively low yield (<10%). The rapid degradation of methoprene and multiplicity of photolytic products are indicative of extensive photodegradability in the natural environment (Quistad et al. 1975).

Technical grade methoprene is stable >4 yr. in glass in the dark at 43° (Worthing & Walker 1983). Sterile aqueous 0.5 ppm solutions at 98% pure $[C_5\text{-}^{14}C]$ methoprene, buffered at various pH values, were found to be extremely stable to hydrolysis over 4 weeks at 20°C in the dark. No degradation (detectable limit 1%) was seen in sterile water at pH 5.7 methoprene was rapidly photoisomerized (t1/2-30 min.) to a final 2E:2% isomeric mixture of 44:56. The 2% isomer of methoprene has a much lower biological activity than 2E-methoprene itself, hence photoisomerization of methoprene in the field should quickly result in a nondegradative loss of about half the biological activity. Solutions of methoprene (0.5 ppm) were found to undergo photoinitiated decomposition to more polar products, to the extent of 15% in 2 days and 332 in 3 days at 20°C. Earlier experiments at 0.1 ppm at two temperatures (24 and 40°C) had shown no breakdown at 24°C and only 5% breakdown at 40°C, in 1 day (Schooley et al. 1975).

In pond water, the half-life of methoprene is approximately 30 hr at 0.001 ppm and 40 hr at 0.01 ppm. Incubation of (2E)-[C_{10}-^{14}C] methoprene for 3 days at 0.42 ppm generated three primary metabolites, the result of ester hydrolysis and/or O-demethylation. These metabolites and recovered methoprene were photoequilibrium mixtures of 2-ene double bond isomers (e.g., E and %). In another incubation experiment with (2E)-[C_5-^{14}C] methoprene at 0.66 ppm in a pond water sample of presumably different microflora, a completely different metabolite was identified as resulting from oxidative scission of the 4-ene double bond. The principle metabolite in the latter experiment was 7-methoxycitronellic acid.

Methoprene was rapidly degraded when a thin film (0.1 u) on glass was exposed to sunlight through glass. The half-life under these conditions was 6 hr. After exposure to sunlight for 27 hr, only 3% of the applied dose remained as methoprene and it was isomerized to a 50:50 mixture of (2E,4E) and (2%,4E)-methoprene. The recovery of only 72% of the applied radioactivity after 27 hr suggested photolysis of methoprene to volatile products which were lost by vaporization. Collection of vapors above the photolysate resulted in recovery of 13% of the applied radioactivity. The volatile constituents were resolved into methoxycitronellal (4%), methoprene (0.2%) and $^{14}C0_2$ (6%). Since only a trace amount of methoprene (0.2%) was detected in the condensed vapors, volatility of methoprene is not considered a major route for loss of radioactivity.

Effects on Non-target Organisms. Methoprene is non-toxic to bees, and relatively non-toxic to non-target species but shrimp and crabs may be killed (Hartley & Kidd 1983, SCAMP 1987). Methoprene does have some toxicity to the saltmarsh copepod *Apocyclops spartinus*, but the concentration of methoprene in the water required to cause transient reductions in the early life stages of the copepod is above that which should occur during routine mosquito control (Bircher & Ruber 1988). Methoprene did not adversely affect the copopods *Cyclops vernalis* and *Cyclops* *navus* in a Minnesota study but did reduce chironomids, tipulids, ceratopogonids and stratiomyids (SPRP 1996). As for Bti applications, reducing chironomid populations may have a long-term effect on nesting ducks.

The acute toxicity (96hr-LC_{50}) of methoprene to a variety of fish ranged from 1.6 ppm for rainbow trout to greater than 100 ppm for channel catfish (Johnson & Finley 1980).

In a model ecosystem study on the uptake and degradation of methoprene by bluegills, the fish had a surprisingly large amount of radioactivity after 4 to 6 weeks of exposure. If the radioactivity was due to the presence of parent methoprene, one would have concluded that the compound was bioaccumulated several thousand times. However, less than 0.l% of the measured radioactivity was in the form of methoprene and its primary metabolites, with the rest being present in such natural products like cholesterol, proteins, free fatty acids, and glycerides. With this correction factor, methoprene was bioconcentrated by bluegills to a moderate extent. In clean water, bluegills eliminated 93 to 95% of the accumulated body burden of methoprene in less than 2 weeks.

Two formulations of methoprene were applied aerially (0.1 lb a.i./acre) to rice fields in the Sacramento Valley of California. The level of control of *Cx. tarsalis* was assessed in emergence cages established before and after spraying in these and control fields. After spraying, the treated fields had about one half the rate of *Cx. tarsalis* emergence as did control fields. None of the non-target organisms examined exhibited population fluctuations which could be statistically attributed to the methoprene applications (Case & Washino 1978).

Locomotor activities of mosquitofish (*Gambusia affinis*) and goldfish (*Carassus auratus*) were monitored for a 2-week period in the presence of methoprene at concentrations approximately 10-fold greater than those generally recommended for application. Methoprene, the active ingredient in Altosid SR-10, at 0.2 ppm did not significantly alter the locomotor activity of either mosquitofish or goldfish (Ellgaard et al. 1979).

The acute oral toxicity (LD_{50}) of methoprene to mallard ducks was assessed as greater than 2000 ppm. However, treatment levels as low as 520 ppm produced signs of intoxication in mallards (Smith 1987). The eight-day dietary LC_{50} for chickens was greater than 4640 ppm (Hartley & Kidd 1983). Thus, methoprene shows only slight toxicity to fish and birds and is relatively non-toxic to non-target species (SCAMP 1987).

When the metabolic fate of methoprene was studied in a guinea pig, a steer, and a cow, a rather large percentage of the radiolabel was incorporated in the tissues and respired by the animals. In the urine and feces, a small amount of radiolabel was metabolized into free primary metabolites, somewhat more was incorporated into simple glucuronides, and a considerable quantity of radiolabel was found in polar compounds, possibly complex conjugates or polar biochemicals. No parent methoprene was found in the urine, but approximately 40% of the radiolabel in feces was contributed by unmetabolized methoprene. The formation of conjugates and the metabolism of methoprene was more extensive in the steer than in the guinea pig (Chamberlain et al. 1975). Samples of fat, muscle, liver, lung, blood, and bile from a steer which received a single dose of [C_5-^{14}C]methoprene were analyzed for radioactive residues. No primary methoprene metabolites could be characterized, but the majority (16-88%, depending on tissue) of the total tissue radioactivity was positively identified as [^{14}C]-cholesterol. Seventy-two percent of the bile radioactivity was contributed by cholesterol, cholic acid, and deoxycholic acid. Radioactivity from catabolized methoprene was also associated with protein and cholesteryl esters of fatty acids (Quistad et al. 1975).

Acute oral toxicity (LD_{50}) of methoprene in rats is greater than 34,000 mg/kg. That for dogs is greater than 5000-10,000 mg/kg. Dermal LD_{50} values of methoprene are greater than 3500 mg/kg for rabbits. It is nonirritating to both the skin and eyes of rabbits (Hartley & Kidd 1983, Worthing & Walker 1983). Methoprene has an inhalation LC_{50} value of greater than 210 mg/l in rat (Sine 1984). In 2-yr feeding trials, no methoprene-related effects were observed in rats at 5000 mg/kg diet and in mice at 250 mg/kg diet. No effects were observed at the highest rates tested: in 3-generation reproduction studies in rats (2500 mg/kg diet); teratogenicity in rabbits (500 mg/kg) or rats (1000 mg/kg); mutagenicity in rats (2000 mg/kg) (SCAMP 1987). Hollingsworth calculated the VSR for methoprene to be greater than 1,730,000. Methoprene is one of the most selective insecticides presently available (Wilkinson 1976).

Methoprene is not phytotoxic.

c. Oils

Petroleum oils are also known as mineral oils and refined grades have been called white oil. Petroleum oils are prepared by the distillation and refinement of crude mineral oils. Those used as pesticides generally distill >310°C to 335°C, namely; "light" (67-79%), “medium” (40-49%), and “heavy” (10-25%) (SCAMP 1987). They consist largely of aliphatic hydrocarbons, both saturated and unsaturated, the content of the latter being reduced by refinement. Recently, highly refined oils have been used as adjuvants to increase the effectiveness of some other pesticides (Hartley & Kidd 1983). Petroleum oils may be used as diluents for pesticides or by themselves

Petroleum oils are also used alone as insecticides. Inhalation of oils from the surface of water attacks mosquito larvae through their respiratory system. Death occurs due to reduced oxygen levels (hypoxia) and lack of feeding. Petroleum oils also enhance penetration of the insect cuticle by the insecticide. In bioassays of insecticidal compounds, selective toxicity has been noted to vary for the same compound depending on the nature of the carrier solvent and site of application. The degree to which a solvent induces rapid penetration through the insect cuticle has been termed its carrier efficiency. This carrier efficiency can be directly related to and is dependent on the physical properties of the solvent-insecticide combination. Differences in carrier efficiency have been attributed to the ability of the solvent to dissolve the outer layer of the insect epicuticle (Schouest et al. 1983).

Petroleum oils are used as surface treatments to prevent mosquitoes from breathing at the surface. Petroleum oils have been shown to be phytotoxic to plants so use instructions should be followed and oil used only during the dormant period (Hartley & Kidd 1983).

Petroleum oils/Flit ML0 are mineral oils used as diluent/adjuvant oils or as a physical toxicant which kills mosquito larvae via suffocation. Both are prepared by the distillation and refinement of crude mineral oils. Those used as pesticides generally distill >310°C. They may be classified by the proportion distilling at 335°C, namely: 'light' (67-79%), 'medium' (40-49%), and 'heavy' (10-25%) (Worthing & Walker 1983). Acute oral LD_{50} for rats and mice >4300 mg 'Actipron'/kg. No toxicological problem due to petroleum oils has been reported in practice. Tests have shown there is no risk of polynuclear aromatic compounds entering the food chain using mineral oils for insect control (Hartley & Kidd 1983).

In 1968, the Medical Research Council in the United Kingdom published its report, "The Carcinogenic Action of Mineral Oils," based on work done in several British universities. The most biologically active fractions (boiling range of 300-400°C) were distilled further. The carcinogenic activity appeared to occur in materials which boiled above 350°C (presence in lower-boiling fractions was possibly the result of azeotropism), and activity was still present in fractions boiling at 420°C. Over 40 chemical compounds were isolated from mineral-oil fractions, many for the first time, by repeated chromatography, complexing with picric acid and trinitrobenzene, and fractional crystallization. Further studies of the nature of the active compounds did not identify any single highly potent carcinogen. Several of the compounds separated were structurally similar to very potent carcinogens, and the total activity of the oil could be caused by the combined effect of several individually weak carcinogens (Kipling & Cooke 1984).

Albino rats were dosed orally by stomach tube at varying rates up to 10,000 mg FLIT MLO/kg BW and observed for mortality and signs of systemic toxicity for 14 days. The LD_{50} was never reached and it was concluded that the LD_{50} for FLIT MLO is above 10,000 mg/kg BW. A dose of one pint of FLIT MLO administered to a horse by stomach tube showed no gross reactions.

FLIT MLO was applied to the exposed abdominal skin of albino rabbits at dosage levels up to 3.16 g/kg BW. After 24 hr, the residue was removed, and the animals were observed for a total of 14 days after application. There were no deaths or signs of systemic toxicity at any dosage level tested. There was no dermal irritation to unabraded skin on any of the animals. A slight to moderate redness appeared on abraded skin. At the end of the 14-day period, the skin of all animals was completely clear of any signs of irritation.

Albino rats (10 male and 10 female) were exposed continually for 1 hr to an atmosphere containing an average of 200 mg FLIT MLO (aerosol) per liter (1) of air. Observations of mortality or signs of acute toxicity were made at intervals throughout the exposure, and the animals were observed for 14 days after exposure. There were no deaths during exposure or in the 14 days thereafter. During the post-exposure period the respiration rates of the animals seemed elevated initially, but returned to normal within 24 hr. A slight loss of fur occurred after a few days, but this effect had disappeared in all but four animals by the end of the study. Other superficial effects (exudate around the eyes, etc.) were observed but quickly disappeared.

FLIT MLO (0.1 ml) was placed in the left eyes (the right eyes served as a control) of nine albino rabbits. The eyes of three of the rabbits were irrigated after two seconds; those of another three after four seconds; the eyes of the remaining three were left unirrigated. Periodic observations for signs of eye irritation were made, with the last observation made 7 days after application. There was no evidence of systemic effect due to any of the applications. Eye irritation was slight and transient in all animals. All signs of the effect had cleared within four days following application. Examination on the seventh day confirmed the absence of any corneal damage. Ratings on the Draize scale, a common scoring system, were as follows: 4 at one and four hours, 2 at 24, 48, and 72 hours, and zero thereafter (Exxon 1973).

Bonide Mosquito Larvicide is a low-order, low-viscosity, highly saturated petroleum hydrocarbon mineral oil that enters mosquito larval breathing tubes and spreads over main tracheal trunks. These respiratory pathways twist and collapse reducing oxygen levels to tissues. Death is by hypoxia and lack of feeding. It is virtually identical to Flit MLO.

The residual periods of petroleum oils are relatively short. Tests have shown there is no risk of polynuclear aromatic compounds entering the food chain. No toxicological problems due to the use of petroleum oils for mosquito control have been reported in practice (Worthing & Walker 1983). It has some hazard to fish but little or no hazard to birds. Flit MLO has been evaluated to determine its effects on the aquatic environment. In a series of laboratory tests on grass shrimp, fiddler crabs, goldfish, bluegill, sunfish, fathead minnows, coho salmon, killifish, and domestic ducks, in which field applications of the larvicide were simulated and exaggerated, Flit MLO was found to have no adverse effects even at concentrations well above the recommended application rates of 1 to 5 gallons per acre (Exxon 1973).

Little or no hazard has been associated with the application of petroleum oils to beneficial and non-target invertebrates. Other Diptera that land on pools treated with oils will be pulled into the water due to the loss of surface tension and water beetles can often be observed crawling out of treated pools (Christie, personal observation). The flies clearly die, the beetles probably do not. Some hazard has been determined for honey bees.

Isooctadecanol (Arosurf MSF), is a surface-acting ethoxylated fatty alcohol (i.e., a nonionic surfactant) which forms a thin film over the surface of water creating a physical barrier due to reduced surface tension. This results in the suffocation of aquatic larvae and pupae (EPA 2/15/84). Foliar absorption, translocation in plants, and metabolism and persistence in plants is not available (EPA 2/15/84). Data on microbial breakdown shows that Arosurf MSF is degraded by unacclimated, mixed cultures of microorganisms from natural sources by shake culture methods. Although not available for Arosurf MSF, similar ethoxylates degrade under field conditions with the major route of degradation being hydrolysis at the ether linkage and subsequent oxidation of the alkyl chain to lower molecular polyethylene glycole-like materials which are ultimately mineralized to $C0_2$ and H_2O. The resultant average persistence for isooctadecanol has been determined to be 2-10 days (EPA 2/15/84). Although incomplete, the 96 hr - LC_{50} for Daphnia is reported as 1.9 ppm. Bioaccumulation data is also lacking but studies on closely related fatty acid and fatty alcohol ethoxylates in shellfish support the contention that the compound is rapidly cleared from aquatic invertebrates as inert metabolites.

Arosurf MSF was used in small amounts for several years in the late 80's and early 90's and is not currently being sold. It is included here both for historical purposes and in the off chance that it might become available again. As a surfactant, it forms a thin film over the surface of the water. Its mode of action is physical rather than chemical in that it reduces the water surface tension resulting in suffocation of the larvae and pupae.

These nonionic surface-active films spread into uniform, nearly monomolecular layers, and can not be seen because they are too thin to absorb light or cause iridescence due to reflective interference. Periodic observations indicated that wind velocity as low as 2-3 mph can push the film over the water surface to the downwind side or corner of a pond within minutes after treatment, thereby establishing areas of highly compressed film and areas of essentially no film (Levy et al. 1980). Average persistence for Arosurf MSF has been determined to be 2 to 10 days at recommended dosage rates (Miller 1984). Monomolecular films are biodegradable and have shown no adverse effects on mammals and several species of vertebrate and invertebrate aquatic organisms so these materials should not pose a threat to the environment or a health hazard to man.

An exemption from the requirement of a tolerance for the pesticide in or on fish, shellfish, irrigated crops, meat, milk, poultry and eggs, when used as a mosquito control agent in aquatic areas has been established under 40 CFR 18Q.1078. Studies on closely related fatty acid and fatty alcohol ethoxylates having various degrees of ethoxylation supported the clearance of the chemical as an inert ingredient and were also used in support of the exemption as an active ingredient (EPA 1984). Arosurf MSF demonstrates low mammalian toxicity (category III). Isooctadecanol has demonstrated low toxicity to fish, birds and other wildlife and non-target organisms. Acute toxicity (96hr-LC_{50}) of isooctadecanol to fish range from 98 ppm (rainbow trout) to 290 ppm for bluegill (Miller 1984).

Qualitative data on non-target animals and plants exposed to various dosages of Arosurf MSF during field trials to control mosquitoes have indicated that this film will cause little or no adverse effects to the environment. Some mortality of pupae and/or emerging adults of certain midge species (Chironomidae) breeding in aeration and decomposition ponds at sewage treatment systems was noted. However, significant mortality of midges was also observed in some control (untreated) sewage ponds containing a similar layer of natural surface scums. Therefore, the true impact of Arosurf MSF on the reduction of the midge population is not known. Adult dragonflies were observed to oviposit in water treated with Arosurf MSF and a *Gambusia* sp. was observed eating large lenses of floating Arosurf MSF with no apparent adverse affects. Field and laboratory tests indicated that predation and asexual reproduction of the mosquito planarian *Dugesia dorotocephala* (Woodworth) and the infectivity and development of the mosquito nematode *Romanomermis culicivora* (Ross and Smith) were not adversely affected by Arosurf MSF at surface dosages of 0.4-0.5 ml/m^2. Although no quantitative data were obtained concerning the effects of Arosurf MSF on the natural populations of animals and plants, general observations indicated that there appeared to be few long-term effects (Ward 1966).

Arosurf MSF was effective in reducing 3rd and 4th instars of *Ae. nigromaculis* and *Ae. melanimon* populations at 0.5 and 1.0 ml/m2 surface rates, averaging 88% and 96% mortality reduction, respectively. Non-target arthropods which showed acute lethal effects were corixids (*Corisella* spp.). Notonectids (*Notonecta unifascfata*), clam shrimp (*Eulimnadia* sp.), and *Tropisternus lateralls* beetle adults. Non-targets that did not exhibit mortality were mayfly (*Callibaetis* spp.) naiads, chironomid larvae and copepods (Takahashi et al. 1984).

Under field conditions, this film-forming substance produced a high level of control (90%+) of larvae and pupae of *Cx. tarsalis* at the rate of 0.5 to 0.75 gal/acre with no apparent effect on non-target organisms such as mayfly naiads, diving beetle adults, ostracods and copepods (Mulla et al. 1983).

d. Others

Temephos (Abate) is a non-systemic insecticide used as a relatively selective larvicide against mosquitoes, midges, gnats, punkies sand flies, thrips and black flies (SCAMP 1987). It has not been used in Massachusetts for several years. It is non-phytotoxic when used as recommended but is not generally used on plants (Hartley & Kidd 1983. SCAMP 1987). It has relative long residual action but short residual time in soils and water (SCAMP 1987). In plants, temephos is oxidized to the sulfoxide and, to a lesser extent, to the sulfone and mono- and di-orthophosphates. Further degradation proceeds very slowly (Hartley & Kidd 1983). In insects, the thiophosphate group and sulfur atom in the sulfide group of temephos undergoes a step wise oxidation. The oxidative compound is then hydrolyzed, and the final metabolite is 4,4'-dihydroxy diphenyl sulfone (Aizawa 1982). These reactions are highly species dependent which provides temephos's selective action.

Temephos has some hazard to non-target and beneficial insect but is highly toxic to honeybees by direct contact (topical LD_{50} is 1.55 ug/bee). It is also hazardous to crustaceans such as shrimp and crabs (SCAMP 1987). At 100-1000 ppb, temephos causes some reduction in °2 evaluation by algae (Verschueren 1983). The 96 hr - LC_{50} for temephos to crustaceans range from 45-82 ppb and the median threshold limit (TLm) for shrimp range from 249 ppb 2550 ppb. The LC_{50} values of temephos to non-target aquatic insects range from 1-2 ppb (Ephemeroptera) to 500-1000 ppb (Tricoptera) (1 hr-LC_{90-95}). The 96hr-LC_{50} value for stoneflies is 10 ppb (Verschueren 1983). Temephos (Abate 4E) did reduce populations of copepods and cladocerans in a test in man-made ponds but the populations recovered within several weeks. Ostracods were not affected (Fortin et al 1987).

Temephos is stable when stored at room temperature, moderately stable to hydrolysis in contact with aqueous alkali, but the rate of hydrolysis increases with pH. Optimum stability is at pH 5-7 with increased hydrolysis occurring at 2>pH>9 at rates depending on temperature. Temephos may be oxidized to the sulfoxide, the sulfone, and the mono- and dioxygen analogs. The sulfoxides and sulfones of the oxygen analogs have not been observed. Hydrolysis products include the thiophenol and the corresponding sulfoxide and sulfone (Reed 1982).

In a study using 3H-labeled temephos topically applied to bean plants, unchanged temephos comprised more than 70% of the terminal residues after 28 days. The sulfoxide comprised about 4% of the residues. The other oxidative metabolites were present in very small amounts. Conjugates of the hydrolysis products comprised the remaining residues. More than 90% of the applied activity remained after 28 days, indicating that residue decline is primarily the result of growth dilution (Reed 1982).

In laboratory studies, temephos has a half-life of 108 days in aqueous media. However, temephos degrades more rapidly in samples of reservoir, polluted brook, and puddle waters with half-lives ranging from 9-32 days. Temophos rapidly photodegrades to the sulfoxide and then to other oxidative and hydrolytic products. Sanders et al., (1981) reported concentrations ranging from 0.15 ug/l to 10 ug/l in small freshwater ponds 24 hr after application. Henry et al. (1971) measured temephos concentrations after simulating saltmarsh application rates (26 to 131 ug/l) and reported disappearance rates as a function of temperature. Temephos concentrations ranging from 16 ug/l to 34 ug/l were found in stagnant ponds after application by helicopter, with a half-life of approximately 5 hr (Lores et al. 1985). Peak concentration of temephos in water during early May occurred within 1 hr of treatment of a 4 EC formulation (mean approx. 20 ug/l) and within 8 hr of treatment with the 2G formulation (mean approx. 9 ugtl). The rate of degradation in water appeared to be affected by the initial solubility of temephos which is itself influenced by the application site, the water temperature and the formulation applied. These findings support a general half-life disappearance of 24 hr for the active ingredient under conditions found in local spring *Aedes* breeding habitat (Mackenzie et al. 1983).

Little data exists for soil degradation, but there are indications that certain soil bacteria are capable of causing rapid degradation of temephos to water-soluble hydrolysis products. The mean peak concentrations of temephos residues in sediments were in the 250-500 ug/kg range following a single early spring application of 90-100 g/ha and declined to negligible levels in 10 days (Mackenzie et al. 1983).

From an animal metabolism study, data from cattle indicate that temephos and its sulfoxide are interconvertible in animals. The sulfoxide was present in the milk of cows fed 20 ppm temephos and temephos was present in the milk of cows fed 5 ppm of the sulfoxide (EPA 1986). All of the oxidative metabolite of temephos are expected ChE inhibitors, but terminal residues appear to consist primarily of temephos and its sulfoxide (EPA 1981). When 3H-temephos was orally administered to rats, radioactivity reached a peak in the blood between 5 and 8 hrs and then dissipated with a half-life of about 10 hrs. Appreciable radioactivity was found only in the gastrointestinal tract and fat. Both in feces and in fat, most of the activity came from unchanged insecticide, but small amounts of the sulfoxide were present also. While traces of temephos were found in the urine, the principal urinary metabolites were sulfate ester conjugates of 4,4'-thiodiphenol, 4,4'-sulfinyl-diphenol, and 4,4'-sulfonyldiphenol. At least 10 other components could be extracted but were not identified. In the guinea pig, absorption apparently was less than in the rat, and biliary excretion of metabolites was demonstrated (Hayes 1982).

Temephos was dermally applied to cattle as a 0.l% spray and the cattle were slaughtered 7, 14, 28, 42, and 56 days after treatment. Temephos was not detected (<0.05 ppm) in any sample of muscle or liver, but was detected in the kidney at 0.08 and 0.13 ppm in 2 of the 3 animals slaughtered after 7 days. Temephos averaged 1.19 ppm in the fat of the 3 animals killed at 7 days and declined thereafter with a half-life of 6 days. Temephos sulfoxide was detected at levels of 0.39 and 0.09 ppm only in the fat of cattle killed 7 and 14 days, respectively, after treatment. In a study where ^{14}C-labeled temephos was sprayed on lactating goats, residues in the back fat were predominantly temephos. Residues in omental fat and milk were predominantly the sulfoxide with some sulfone and, in liver, residues of the sulfoxide and the sulfone were roughly equal. Other oxidative and hydrolytic metabolites were present in only small amounts. Therefore, metabolism and elimination of temephos is rapid with about 95% of a single oral dose eliminated in the urine and feces within 96 hours (EPA 1981).

The acute oral toxicity (LD_{50}) of temephos in rats is 770-13,000 mg/kg t8600 mg/kg), and 4000 mg/kg for mouse. Temephos has an acute dermal toxicity (LD_{50}) for rabbit of 1300-1930 mg/kg and greater than 4000 mg/kg for rats (Hartley & Kidd 1983, Worthing & Walker 1983). Temephos and malathion showed an approximately fourfold potentiation in rats when they are given together at levels approaching their LD_{50} values (Gaines et al. 1967). However, under other conditions no potentiation was observed between temephos and 23 other organic phosphorus compounds (Levinskas & Shaffer 1970). Temephos has a TWATLV value of 10 mg/m3. The threshold limit value of 10 mg/m3 indicates that occupational intake at a rate of 1.4 mg/kg/day is considered safe.

In a neurotoxicity study, hens were fed 230, 460, and 920 ppm temephos for 30 days. Microscopic examination of nerve tissues revealed no demyelination (Reed 1982). Temephos in a dosage of 500 mg/kg produced a rapid onset of leg weakness in chickens, from which survivors recovered within 36 days or less. An intake of 125 mg/kg produced very mild leg weakness, followed by prompt recovery. This sign was produced in 30 days at a dosage of 15.3 mg/kg/day but not in 108 days at a level of 7.4 mg/kg/day (Gaines et al. 1967). Thus, the effect of temephos in chickens is similar to that of malathion, and the lack of myelin loss in hens fed the compound at a dietary level of 920 ppm (about 53 mg/kg/day) for 30 days, as reported by Levinskas & Shaffer (1970), would be expected (i.e., low OPIDN hazard).

The subacute and chronic toxicity of temephos is detailed below. Temephos has been shown to inhibit ChE activity *in vivo*. In rats, subchronic oral doses as low as 6 ppm resulted in depressed red blood cell ChE activity. In dogs, subchronic oral doses of 500-700 ppm caused depressed red blood cell, plasma, and brain ChE activities. Subchronic oral dosing with temephos caused no observed effect on survival, food consumption, or tissue and organ histopathology in rats given up to 350 ppm in the diet, and in dogs given 500 or 700 ppm in the diet for 90 days. Weight gain was reduced in rats given 350 ppm in the diet. In a 30-day study with male rats fed 0, 250, 500, and 1000 ppm technical temephos, the NOEL was 250 ppm (which is equivalent to 12.5 mg/kg B.W./day) for any effect other than ChE inhibition, which was noted at all dose levels. Weight gain depression was the effect noted at 500 ppm and above. No adverse effects were noted at feeding levels up to 300 ppm in a 2-year rat study. However, ChE activities were not measured (EPA 1981).

Over a 90-day period, rats tolerated a diet containing 9 ppm of the sulfoxide with no apparent effect except inhibition of RBC ChE activity. No inhibition occurred at 3 ppm (Levinskas and Shaffer 1970). In a study with human volunteers, increasing doses of temephos (2 to 256 mg/day) or constant doses of 64 mg/day were ingested over a four week period. No alterations in red blood cell or plasma ChE activity and no clinical symptoms were observed (EPA 1981).

The reproductive and teratogenic effects of temephos are as follows. Male and female rats were started on diets containing 500 ppm temephos at mating. Dosage was maintained throughout mating, gestation, parturition, and lactation. There were no significant differences in number of litters produced, litter size, viability of young or the incidence of congenital defects between treated and control groups even though the dosage caused signs of poisoning in some rats (Gaines et al. 1967). In a second reproduction study, no compound-related effects on reproductive capacity were noted in rats fed 25 or 125 ppm of temephos. No effects were noted in the offspring (EPA 1981). Temephos at oral dosage levels as high as 2.5 mg/kg/day for 422 days or at 5 mg/kg/day for 186 days caused no ill effects in sheep or their lambs (McCarty et al. 1968).

No oncogenic effects were noted in a 2-year study with rats fed 0, 10, l00, and 300 ppm. There exists no mutagenicity data for temephos. The EPA Registration Standard for temephos states that toxicological data gaps related to reregistration of temephos for the food uses are a second oncogenicity study (in mouse) and teratogenicity and mutagenicity testing.

Acute toxicity (96hr-LC_{50}) of temephos in a variety of fish species range from 0.16 ppm (rainbow trout) to 34.1 ppm (fathead minnow). Test conditions and size did not appreciably change the toxicity of temephos to fish. Variations in pH from 6.0 to 9.0, hardness from 40 to 162 ppm, or size from 1 to 20 g gave a range of less than 4 mg/1 in 96hr-LC_{50} values. Flow-through tests for up to 15 days with cut-throat trout and lake trout produced $TILC_{50}$ (time-independent LC_{50}) values for temephos of 0.20 and 1.05 mg/1 (ppm) and cumulative toxicity indices (96hr-LC_{50} value divided by $TILC_{50}$ value) of 5.0 and 1.0, respectively. This indicates little or no cumulative action of temephos in fish (Johnson & Finley 1980).

Following the treatment of the Upper Volta River with Abate for the control of Simulium larvae, no fish died, but fish in the treated area were prone to easy capture. The catch per unit effort, and the number of species captured in the 24-hr period following treatment, were higher. Evidently, sublethal stress leading to under- or hyper-activity, make the fish an easy prey in nature and affect the stability of the population. When Abate was applied to River Oti in Ghana to control Simulium larvae, fish 300 m upstream from the point of application were normal, whereas fish at the site of application swam erratically. Fewer numbers and species were collected in the 24-hr period following application than before application, suggesting possible avoidance reaction of fish to Abate. Exposure to 96hr-LC_{50} of fenitrothion for 24 hr completely inhibited the learning ability of salmon perr; Abate at 5 mg/l retarded learning (Murty, Vol. II, 1986).

Acute oral toxicity (LD_{50}) of temephos for the bullfrog is greater than 2000 ppm (Smith 1987).

Acute oral toxicity (LD_{50}) of temephos for a variety of birds ranges from 18.9 ppm (California quail) to 270 ppm (chukar). Its dietary LC_{50} values range from 92 ppm (northern bobwhite) to 894 ppm (mallard duck). There are few data on its dermal toxicity. Mallard ducklings (12-24 hr of age) were fed diets treated with temephos for 7 days and housed in either heated or unheated brooders. High mortality occurred in the 100 ppm group housed in unheated brooders, but diets containing up to 10 ppm did not affect duckling survival (Fleming et al. 1985).

A reproductive study conducted with game-farm mallards fed 0, 1, and 10 ppm Abate 4E (temephos) did not result in treatment effects for hatching success, clutch size, fertility, nest attentiveness of incubating hens, and duckling avoidance behavior. However, the mean interval between eggs laid was greater for the 10 ppm group, and duckling survival to 21 days was significantly lower for both treatment groups than for controls (Franson et al. 1983).

There have been no published accounts of wildlife die-offs that have been related to field applications of temephos (Smith 1987). However, the 30-day EMLD (empirical minimum lethal dose, lowest daily oral dosage that produces 1-2 deaths over a 30 day period) for mallards (n - 22) is 2.5 mg/kg per day for both sexes. The resulting cumulative toxicity index for temephos is 79.4/2.5 - 32, indicating a high degree of cumulative action for an organophosphate in birds (Hudson et al. 1984).

3. Adulticides

a. Pyrethrum and Synthetic Pyrethroids

Pyrethrin I is insoluble in water, has appreciable vapor pressure but an extremely large partition coefficient (KoW) indicating that it is immobile in soil and migrants slowly, if at all. It is unstable in sunlight and rapidly hydrolyzed by alkali with loss of insecticidal properties. Photodecomposition of pyrethrin I as thin films on glass yields 11-15 products, none of which are insecticidal or of toxicological significance. Saponification (alkalihydro1ysis) of the pyrethrum mixture of ester products liberates 12-16 acids, again with the subsequent loss of insecticidal activity.

Many invertebrates and microorganisms are capable of metabolically detoxifying this natural insecticide. Although the levels of Pyrethrin I in water, air, and soil are not known, little is expected to persist because of its photolabile and biodegradable nature.

Similar to pyrethrin I, resmethrin decomposes rapidly on exposure to air and sunlight and is unstable in alkaline media. However, photolysis of the ester bond is a significant reaction for trans- and cis-resmethrin but apparently not for pyrethrin I. Resmethrin and other type I pyrethroids generally yield a large number and great variety of photoproducts, most of which originate from further reactions of the primary cleavage products. For example, the alcohol moiety liberated on photolysis of resmethrin degrades further to benzyl alcohol, benzaldehyde, benzoic acid and phenylacetic acid, the latter contributing to the unpleasant odor of photodecomposed resmethrin. The environmental and toxicological impact of these breakdown products are unknown at this time but due to the low rates and quantities used in mosquito control, they are not expected to be particularly significant.

As with pyrethrin I, resmethrin is rapidly biodegraded by invertebrates and microorganisms by established metabolic pathways. Although the levels of resmethrin in water, air, and soil are not known, little is expected to persist because of its photolabile and biodegradable nature.

Pyrethrins are potent, non-systemic contact insecticides causing rapid paralysis and knockdown with death occurring at a later stage of intoxication. Insecticidal activity is markedly increased by the addition of synergists such as PBO. Pyrethrins are not phytotoxic. Although toxic to bees, pyrethrins show less hazard than indicated by topical bioassays (approximately 1 ug/housefly) due to their repellent effect (Hartley & Kidd 1983). Pyrethrins are degraded in the environment by sunlight, chemical hydrolysis and by many invertebrate organisms via hydrolytic and oxidative metabolism. The approximate residual period for pyrethrins is 1-3 days on plants and similar short duration in soil and water (SCAMP 1987). No biological magnification has been shown. Degradative products have not been determined to be as toxic or more toxic than the parent pyrethrin compounds. Its toxicity (96hr-LC_{50}) to crustaceans range from 11 to 42 ppb and for nontarget aquatic insects approximately 1.0 ppb (Verschueren 1983).

The synthetic pyrethroid resmethrin is also a non-systemic, contact insecticide with fast knockdown similar in action to the natural pyrethrins (Hartley & Kidd 1983). Although sometimes formulated with synergists (e.g., piperonyl butoxide), resmethrin's toxicity is not enhanced in their presence (SCAMP 1987). Resmethrin is not phytotoxic if used as recommended. Resmethrin is toxic to bees, but field data indicates that ULV sprays of resmethrin are not hazardous to honeybee colonies in the area treated for adult mosquito control (Scourge Tech. Bull. 1986). *Daphnia magna* has an LC_{50} of 0.1 ppm (48 hr), *Penaeus* shrimp 1.25 ppb and the American oyster 1.79 ppm.

Piperonyl butoxide (3,4-methylene-dioxy-6propylbenzyl(heptyl) diethylene glycol ether) is used as a synergist in conjunction with pyrethrins and pyrethroids such as resmethrin. It is relatively stable to hydrolysis and UV irradiation. It is not toxic to bees or other beneficial insects and is degraded by invertebrates by oxidative attack on the carbon atom of the methylenedioxy group forming dihydroxyphenyl compound. Side-chain oxidations also occur. Elimination is by glucoside or amino acid conjugations (SCAMP 1987, Hayes 1982).

Pyrethrum and the synthetic pyrethroid resmethrin share a common mode of action as direct nerve toxins which interfere with nerve impulse generation via modulation of voltage-gated ion channels, particularly sodium and possibly calcium channels (Narahashi 1987, Clark & Brooks 1988).

As summarized by Hayes (1982), pyrethrum may be absorbed from the gastrointestinal tract and by the respiratory route. It is not absorbed to a significant degree through the skin. However, allergic reactions may result from this route of exposure. The esters constituting pyrethrum mixtures are rapidly detoxified by hydrolysis in the gastrointestinal tract and to some extent in the tissues of adult warm-blooded animals. The chrysanthemum monocarboxylic acid formed is excreted in the urine. Pyrethrins or their metabolites are not known to be stored in the body or to be excreted in the milk, but no study of the matter has employed modern methods. Partly because of their ready excretion, these compounds exhibit little clinical effect in animals following repeated exposure to moderate doses, but they or their metabolites do lead to liver changes in rats. Studies describe the very extensive metabolism that pyrethrins undergo, mainly in the liver. Various active ingredients undergo significantly different biotransformation. For example, within 48 hours of oral administration of ^{14}C-pyrethrin II to rats, 53% of the ^{14}C was recovered as exhaled $C0_2$, whereas only 0.3% of ^{14}C pyrethrin I was recovered in that form under the same circumstances. The corresponding proportions of ^{14}C recovered from the urine were 7 and 46%, for pyrethrins II and I, respectively. Some of the orally administered material is excreted in the feces, at least partially in metabolized form. Three compounds have been isolated from urine and identified by NMR and mass spectra. All three are produced by both pyrethrin I and II. All three are the result of oxidation of both the acid and alcoholic moieties leaving the main structure of the molecule intact (Elliott et al. 1972a, 1972b). So far the numerous compounds that result from hydrolysis of the esters have not been identified. The fact that the most severe cases of poisoning have been reported in infants suggests that very young children may not hydrolyze the pyrethrum esters efficiently. In any event, mammals show approximately the same susceptibility to injected pyrethrins as do cold-blooded animals, including insects (Gaudin 1937).

Acute oral LD_{50} values of pyrethrum in rats range from 584- 1500 mg/kg, 272-796 mg/kg for mice and 1500 mg/kg for rabbit (Farm Chemical Handbook 1988, Hartley & Kidd 1983, Hayes 1982). Lehman (1952) estimated that the fatal human dose might be 100 grams (1430 mg/kg) for a 70-kg man. Acute dermal LD_{50} values for rats are greater than 1500 mg/kg and for rabbits 5000 mg/kg. Dermatitis is possible in sensitive individuals from constituents of the flowers. Rats and dogs inhaled a concentration of 16 mg/m^3 of pyrethrins for 30 min. periods during 31 calendar days with only slight lung irritation (SCAMP 1987). Inhalation of pyrethrum at 6000 mg/m^3 for 30 min. caused only moderate lung congestion (Carpenter et al. 1980).

The subacute and chronic toxicity of pyrethrum is also low. Groups of 12 male and 12 female rats were fed pyrethrin in soybean oil at dietary levels of 0, 200, 1,000, and 5,000 ppm for 2 years. The daily dosages were, therefore, approximately 0, 10, 50, and 250 mg/kg, respectively. Even at the highest level pyrethrin had no significant effect on growth or survival. A slight though definite liver damage was observed, especially at the higher dosage levels (Lehman 1965). Dogs fed pyrethrins at a dietary level of 5,000 ppm for 90 days showed tremor, ataxia, labored respiration, and salivation during the first month of exposure (Griffin 1973). Ambrose & Robbins (1951) reported no effect in rats fed pyrethrins at a dietary level of 1000 ppm for two years, but tissue damage and gross signs of intoxication appeared at 5000 ppm. When pyrethrins were fed to rats at a dietary level of 1,000 or 5,000 ppm for 2 years, the liver lesions included bile duct proliferation and focal necrosis of the liver cells (Lehman 1965). Pyrethrins, especially synergized pyrethrins, produced enlargement, margination, and cytoplasmic inclusions in the liver cells of rats. At a dietary level of 1,000 ppm, pyrethrins and 10,000 ppm piperonyl butoxide, the changes were well developed in only 8 days, but were not maximal. The changes were proportional to dosage and similar to those produced by DDT. The effects of the two materials were additive (Kimbrough et al. 1968). No relevant pathology was detected in rats fed pyrethrins at a dietary level of 8,000 ppm for 5 weeks (Griffin 1973).

The sensitizing property of pyrethrins is apparently more evident in humans than in other animal vertebrates (Hayes 1982). When 200 people (177 women and 23 men) were patch tested with a 1% water dispersion of pyrethrins, no evidence of primary irritancy or of sensitization was found (unpublished report cited by FAO/WHO 1971). It must be noted, however, that both the formulation used and the duration of exposure were different from those that have caused the most severe dermatitis or sensitivity of any kind under practical conditions of exposure. There is little doubt that commercially available pyrethrin extracts are less sensitizing than native pyrethrum. However, apparently no study has been made to measure the difference in way that would be statistically valid. Mitchell et al., (1972) found all the active ingredients of pyrethrum, except pyrethin II, to be inactive on patch test in a patient who had a history of allergenic dermatitis to pyrethrum and who reacted positively to pyrethrum flower heads, powder extracts of the plant, and pyrethrosin. The no-effect level corresponds to a rate of 3600 mg/man/day (SCAMP 1987).

Pyrethrum has little or no reproductive or teratogenic hazard (Hayes 1982). Rabbits that received pyrethrins orally on days 8 to 16 of gestation at dosages as high as 90 mg/kg produced litters with no statistical increase in abnormalities (unpublished report cited by FAO/WHO 1971). When rats were fed pyrethrins at a dietary level of 5,000 ppm beginning 3 weeks before first mating, reproductive performance was not reduced, but the weights of weanlings were significantly lower than those of controls (Griffin 1973).

The synthetic compounds are more photostable, sometimes providing control for many weeks following a single field application. In addition, some of the synthetic pyrethroids are metabolized more slowly by both insects and mammals and hence have increased toxicity. Enhanced environmental and biological stability of these compounds have triggered needs for residue analysis and for understanding their potential toxicity to mammals (Marquis 1986).

Resmethrin was one of the first or "early" pyrethroid synthesized which is not halogenated nor does it contain a cyanophenoxybenzyl alcohol. Thus, its metabolism and pharmacokinetics are more similar to the pyrethrins than the more stable type II pyrethroids (e.g., fenvaleratte, cypermethrin, deltamethrin).

Resmethrin has an acute oral LD_{50} of 2700 mg/kg in rats and 4250 mg/kg in rats exposed to technical resmethrin (SBP-1382). The dermal LD_{50} value in rabbits is greater than 2000 mg/kg and greater than 3000 mg/kg in rats. Resmethrin was found to be non-irritating to skin and eyes (rabbits). SBP1382 is classified as a very mild conjunctival irritant. The inhalation (4 hr) for rats and dogs is established at greater than 9.49 g/m^3. No effect level was 420 mg/m3 (4 hr). The NOEL in rats for a subchronic inhalation study (90 days) is 0.1 g/m^3.

In 90 day feeding trials, rats receiving 3000 mg resmethrin/kg diet showed no ill effects. The NOEL (no observable effect level) for resmethrin in a 180-day subchronic feeding study in dogs is 10 mg/kg/day.

In three generation reproduction tests for resmethrin, the NOEL for rats is 500 ppm. No teratogenic effects are observed in rats receiving resmethrin at dosages up to 80 mg/kg/day, up to 25 mg/kg/day for rabbits and up to 50 mg/kg/day for mice. The NOEL for fetotoxicity is 40 mg/kg/day.

Although limited, two studies support the contention that resmethrin has little carcinogenicity hazard. In an 85-week mouse feeding/oncongenicity study, SBP-1382 was not oncongenic at 1000 ppm. In a 2-yr rat chronic feeding/ oncogneicity study, SBP-1382 was not oncogenic at 5000 ppm, the highest dose tested. The above data have been compiled from the following sources: Hartley & Kidd 1983, Worthing & Walker 1983, SCAMP 1987, Penick-Bio UCLAF Corp. 1986. Although overall evidence for chronic toxicity in mammals is limited, pyrethrin/pyrethroids still represents one of the safest classes of pesticides present available.

Because piperonyl butoxide (PBO) is included in various pyrethrum and pyrethroid (i.e., resmethrin) products used for mosquito control, the following mammalian toxicology is included. The acute oral toxicity (LD_{50}) for PBO in various mammal range from 3800 mg/kg (mouse) to 11,502 mg/kg in rat. Dermal LD_{50} for PBO in rabbit is greater than 1880 mg/kg. Although dermal absorption is poor, multiple inunction at 200 mg/kg may be fatal to animals. In a subchronic feeding study, rats tolerated without harmful effects 5000 ppm in the diet for 17 weeks; 10,000 ppm were endured through 3 successive generations with moderate toxic effects and; 25,000 ppm in the diet were fatal to rats in from 4 to 46 weeks. In 2-yr chronic feeding trials, rats receiving 100 mg/kg diet suffered no ill-effect. PBO is noncarcinogenic and the safe human tolerance for chronic ingestion is estimated at 42 mg/kg diet (Negherbon 1959, Worthing & Walker 1983).

Pyrethrins (pyrethrum) are highly toxic to fish (Hartley & Kidd 1983). Acute toxicity of pyrethrum as judged by 96hr-LC_{50} ranged from 13 ppb (channel catfish) to 58 ppb (bluegill). Temperature and pH of test solutions affected the biological activity of natural pyrethrins. Toxicity to channel catfish was 12-fold higher at 18°C than at 12°C. Toxicity increased in acid water (low pH); the 96hr-LC_{50} for bluegills was 41 ug/l (ppb) at pH 6.5 and 87 ug/l (ppb) at pH 9.5. Water hardness (44-314 ppm) had little influence on toxicity (Johnson and Finley 1980). Excellent control of larvae of *Cx. tarsalis* in experimental ponds was obtained at the rate of 1 pyrethrin tossits/ m2 (44 B ai/ha). At the same rate, satisfactory control (92%) of *Cx. peus* larvae was obtained in dairy waste-water lagoons in Riverside County, Ca. At the effective mosquito larvicidal rate (44 g/ha), mosquito fish, *G. affinis*, was affected when some tossits were placed with the fish in 0.9 m^3 screened cages. Five successive weekly treatments of *G. affinis* at the larvicidal rate and double that rate (44 and 88 g/ha) resulted in 37% and 67 % reduction of fish yield harvested 42 days after the first treatment compared to the yield obtained from the untreated ponds (controls), respectively. No marked effects on some of the non-target organisms such as dragonfly naiads, ostracoda, copepods, and Dixa midge larvae were noted. Mayfly naiads were eliminated at all rates applied, but recovered within 2-3 weeks after treatment.

Pyrethroids have very high insecticidal activity and have found wide use in the last few years. Though they are not persistent in the environment, their acute toxicity to fish is high. The cyano-substitution of the phenoxybenzyl alcohol moiety (as in cypermethrin and fenvalerate) enhances the toxicity of pyrethroids to fish.

Similarly, pyrethroids with (lR)-cis-isomers for the acid moiety are more lethal than the corresponding cis-,trans-racemates. Fenvalerate and permethrin are more toxic than many OC compounds, the 96hr-LC_{50} being 0.5 to 12.0 ug/l (ppb). Cold water fish were reportedly more susceptible than warm water fish to natural permethrins as well as synthetic pyrethroids.

Pyrethroids are metabolized in fish by both hydrolytic and oxidative processes. It appears that, in general, esterases are more important in metabolizing the trans-chrysanthemates of primary alcohols whereas oxidases are more important with the cis-chrysanthemates of primary alcohols. Pyrethroids are rapidly metabolized by fish (Murty, Vol. II 1986). Resmethrin (SBP-1382) is toxic to fish (Hartley & Kidd 1983) with an acute toxicity (96hr-LC_{50}) to freshwater fish ranging from 1.7 ppb (lake trout, bluegill) to 16.6 ppb (channel cat fish) (Johnson and Finley 1980). Resmethrin has a 96hrLC_{50} value of greater than 150 ppb for coho salmon (Verschueren 1983). Resmethrin was the least toxic pyrethroid against frogs (*Rana pipiens pipiens*) with a subcutaneous LD_{50} value of greater than 60 ppm (Cole and Casida 1983).

The acute oral toxicity of resmethrin to California quail has been determined to be much greater than 2000 ppm (Johnson and Finley 1980).

b. Malathion

Malathion is a non-systemic insecticide and acaricide that acts as a cholinesterase inhibitor. It is generally non-phytotoxic but may damage glasshouse cucumber, beans and certain ornamentals. Some varieties of apple, pear and grape may also be injured (Hartley & Kidd 1983). Its approximate residual period on plants is 5-10 days but has a short residual time in soils. Malathion is rapidly degraded *in vitro* by saltmarsh bacteria to malathion monocarboxylic acid (monoacid), malathion dicarboxylic acid (diacid) and various phosphothionates as a result of carboxyesterase cleavage. In addition, some expected phosphatase activity produces desmethyl malathion, phosphomono- and phospho-dithionates, 4-carbon dicarboxylic acids and the corresponding ethylesters (Verschueren 1983). In insects, malaoxon is the major metabolite formed by oxidative desulfuration at about 25% of all total. Predominant degradation is caused by hydrolysis in insects (Aizawa 1982). Biological magnification of malathion is not likely (SCAMP 1987).

Malathion presents some toxicity to beneficial insects including honey bees (Hartley & Kidd 1983). The topical LD_{50} for honey bees is 0.71 ug/bee (SCAMP 1987). The 96 hr-LC_{50} for non-target aquatic insects range from 1.1 to 10 ppb, and for crustaceans 0.76 ppb to 3000 ppb. The median tolerance limit (TLm) for the American oyster is 9070 ppb (48 hr) for egg and 2600 ppb (14d) for larval (Verschueren 1983).

Degradation of malathion in soil is quite rapid. It was found that after the application of malathion at 5 lb/acre only 15% of the applied dosage was recovered 3 days later. After 1 week, 95% of the applied malathion had disappeared. In Ludhiana, Palamput, and Kamma soils, malathion was 100% degraded 4 days with higher temperatures producing more rapid degradation (Laveglia & Dahm 1977).

Walker & Stojanovic (1973) also found that malathion was quite stable under neutral or acid pH conditions and that susceptibility to hydrolysis increased with increasing alkalinity. They demonstrated that malathion disappeared more rapidly under nonsterile than sterile conditions and indicated that malathion disappearance is stimulated by various microbiological systems in soil. Under sterile conditions, the observed malathion remaining in the Trinity loam, Okolona clay, and Freestone sandy loam after 10 days of incubation was 91%, 77% and 95%, respectively. In nonsterile soil, complete disappearance of malathion had occurred. Getzin and Rosefield studied the degradation of malathion in nonsterile, heat-sterilized, and gamma-sterilized soil. After 1 day, 97% of the malathion was degraded in the nonsterile soil, 90% in the irradiated soil, and only 7% in the autoclaved soil. Because of the rapid degradation in nonsterile soil, it was suggested that microorganisms were partly responsible for the degradation of the compounds. The difference between the amount of malathion decomposed in irradiated soil and autoclaved soil was attributed to nonviable, heat-labile substances. A stable, heat-labile enzyme, which catalyzed the hydrolysis of malathion to its monoacid, was partially purified. This esterase was extracted from irradiation-sterilized soil as well as from nonirradiated soil. When the partly purified enzyme was applied to the soil, it possessed many of the characteristics necessary for prolonged activity in a cell-free state in soil. It was less heat-labile than most enzymes, lost little or no activity upon prolonged storage, and survived desiccation in the soil. There have been many reports of microorganisms metabolizing malathion to various products. Carboxyesterase activity, which degrades malathion to its monoacid and diacid, is the predominant degradative pathway. Phosphatase activity also has been reported. Oxidative desulfuration and demethylation seem to be rather minor metabolic routes (Laveglia & Dahm 1977).

Walker (1976) reported that malathion dissipated rapidly in both sterile and nonsterile water in that only 3% of the added insecticide could be detected after 18 days incubation. The similarities between malathion degradation in the presence and absence of biologically active systems dictates that malathion disappearance is by purely chemical mechanisms. The effect of salinity on the degradation of malathion in estuarine water was determined by incubating the insecticide in sterilized seawater varying in salinity from O to 25 ppt. The degradation of malathion was found to be directly proportional to the length of incubation and to increasing salinity in this sterile system indicating direct chemical hydrolysis.

The organophosphate insecticides included in this classification share a common mode of action as potent indirect nerve toxins via inhibition of cholinesterases (ChE).

Acetylcholine (ACh), the neurotransmitter secreted by cholinergic neurons, allows for chemical transmission of nerve impulses across the synapse. Acetylcholinesterase (AChE) is the enzyme responsible for the breakdown of ACh, thereby terminating the electochemical connection between two nerve cells. Organophosphorus insecticides (OP) phosphorylate AChE in an irreversible reaction that inhibits the activity of AChE to hydrolyze the neurotransmitter at the nerve synapse. The accumulation of ACh results in continuous nerve firing and eventual failure of nerve impulse propagation. Respiratory paralysis is generally the immediate cause of death. Brain ChE activity is used in the diagnosis of OP poisoning with a reduction of 20% of normal activity indicating exposure. A ChE inhibition of 50% or more is considered the diagnostic threshold for determining the cause of death. Because of the irreversible nature of the pesticide-enzyme binding reaction characteristic of OP poisoning, recovery from a sublethal OP exposure depends on synthesis of more ChE. There is evidence that recovery of ChE activity in plasma is as fast or faster than in the brain (Hayes 1982).

In addition to anticholinesterase activity, some OP pesticides have other adverse biochemical effects. A number of have been determined to inhibit neurotoxic esterase, an enzyme that has not been isolated and whose biochemical and physiological functions in nerve tissue are unknown (Metcalf 1982). Organophosphate-Induced Delayed Neuropathy (OPIDN) has been recently reviewed (Marquis 1986). Little information is available on delayed neurotoxicity in wildlife species. However, species differences can be great and the capacity to produce delayed neurotoxicity is widespread among OP (Metcalf 1982).

Other sublethal biochemical effects have been described for OP, such as impaired reproduction in birds through possible hormonal effects and reduced tolerance to cold stress (Rattner et al. 1982a, 1982b). Embryotoxicity and teratogenic effects have been demonstrated for some OP (Hoffman & Albers 1983), and some have been shown to cause changes in brooding behavior or nest attentiveness of birds which could result in death of the young (Grue et al. 1983, Smith 1987). Central nervous system toxicity and noncholinergic effects of OP in mammals have been recently reviewed by Marquis (1986).

As summarized by Hayes (1982), the most striking difference between the metabolism of malathion and that of the majority of organic phosphorus compounds used as insecticides depends on the presence of two carboxy groups in malathion. Malathion is subject to the various kinds of metabolism that other organic phosphorus insecticides undergo, but the splitting of either carboxyester linkage renders the compound non-toxic. Details of the metabolism have been reported by O'Brien (1960) and by Heath (1961).

The excretion of absorbed malathion is rapid. When 25 mg of ^{14}C-labeled malathion was administered to each of six male rats, activity appeared in the urine within 2 hr, and 91.72% was eliminated within 24 hr while an additional 7.75% remained in the gastrointestinal contents. Excretion was mainly via the urine (83.44%) and partly by the feces (5.51%), but 2.77% was exhaled as carbon dioxide. No unmetabolized malathion could be detected 8 hrs after dosing (Bourke et al. 1968). In in vitro studies of human and rat liver, no important difference was found in ability to degrade malathion (Matsumura & Ward 1966) concentrations of 1 ug/l (ppb) of methoxychlor or MDE, Daphnia exposed for three generations grew and reproduced normally, but the emergence of mayfly nymphs was drastically reduced. In ponds treated with 10 to 40 ug/l (ppb) of methoxychlor, the total number of benthic organisms increased and species composition changed with chironomids becoming the dominant species. Neither survival nor growth of bluegills in the treated ponds was affected. However, most of the fish examined showed nonspecific liver degeneration and an accumulation of a muco- or glyco-proteinaceous material inside the major blood vessels. Regression of these effects had occurred by 56 days after treatment (Johnson & Finley 1980).

Greater sensitivity of young striped mullet than older juveniles to methoxychlor has been reported. Adult striped mullets had larger amounts of the residues, owing to the presence of a relatively higher percentage of body fat in the adult when compared with the juveniles. That it is the lipid content that confers a greater degree of tolerance of the larger fish to the DDT-type compounds is confirmed by the toxic concentrations of DDT, endrin, and malathion, to brook trout, cut-throat trout, and coho salmon of 1-g size and 1- to 2-g size. With DDT and endrin, there was reduction in the toxicity with in-crease in size, whereas no such difference in the toxicity of malathion to smaller and larger fish was found. Exposure to a 96hr-LC_{50} value of fenitrothion for 24 hr completely inhibited the learning ability of salmon parr and Abate at 5 mg/l retarded learning. DDT (OC) at 0.07 mg/l mildly enhanced learning whereas methoxychlor had no effect (Murty, Vol II, 1986).

Organophosphate insecticides have negligible chronic toxicity, but some have moderate to high acute toxicity in fish. The 96hr-LC_{50} of several organophosphate compounds to various species of North American freshwater fish are listed below:

The acute toxicity (96hr-LC_{50}) of malathion for a variety of fish species ranged from 62 ppb (red ear sunfish) to 12,900 ppb (black bullhead). In lake trout, fry (0.3 g) were twice as sensitive as fingerlings (4.5 g) to malathion. An increase in temperature from 10° to 21°C caused an 11-fold decrease in toxicity to the daphnid *Simocephalus*. However, an increase from 7° to 29°C caused a fourfold increase in toxicity to bluegills. Variations in water hardness did not appreciably alter the toxicity to fish or invertebrates. Mixtures of malathion with Baytex (fenthion), parathion, EPN, Perthane (ethylan), or carbaryl were synergistic in their toxicity to rainbow trout and bluegills. Combinations of malathion with DDT or toxaphene were only additive. Malathion has more-than-additive toxicity with more than half of the pesticides with which it was combined (Murty 1986) and is no longer used as a larvicide in Massachusetts.

Organophosphate compounds, because of their relatively higher water solubility, are in general taken up to lesser extent than organochlorines and eliminated faster. The time for achieving the highest levels of uptake and the extent of retention of OP residues by fish was directly related to the extent of persistence of a compound in water. Motsugo fish exposed to 0.6 to 1.2 ppm malathion, attained the highest body concentrations 2.4 mg/kg of malathion after 1 day. No malathion residues were found 24 hr after the exposure of pinfish to 75 ppb concentration. Only malathion monoacid was recorded in the gut (Murty 1986). With DDT and endrin, there was reduction in the toxicity with increase in size, whereas no such difference in the toxicity of malathion to smaller and larger fish was found. The natural degradation products of pesticides, in general, are less toxic than the parent compounds. But occasionally, the primary degradation product may be more toxic. The hydrolysis product of malathion, diethyl fumarate, was more toxic than the parent compound to the fathead minnows (Murty 1986).

Acute oral toxicity (LD_{50}) of malathion is 4100 mg/kg for rabbits and greater than 4000 mg/kg for rat$_s$ (Hartley & Kidd 1983, Worthing & Walker 1983, Smith 1987).

Based upon the low toxicity of this compound, it would appear that a time-weighted average TLV of 10 mg/m3 is sufficiently low to prevent systemic effects (Hartley & Kidd 1983). Workers exposed to 84.8 mg/m3 experienced moderate eye irritation (SCAMP 1987). Hollingsworth has established a VSR for malathion of 38 (Wilkinson 1976).

Under subacute and chronic experimental conditions, malathion has been fed to rats for 104 weeks at levels as high as 5000 ppm in the diet with no gross effects. In 1.75 yr trials rats receiving 100 mg tech./kg diet showed normal weight gain. There was no effect found on blood ChE when malathion was fed to human volunteers for 47 days at the rate of 16 mg/man/day. Volunteers dosed dermally showed no change of blood ChE or other injury while exceeding an average of 47 mg/man/day and a maximum of 220 mg/man/day.

Whereas there is no evidence that malathion is teratogenic in mammals, it does cause a characteristic syndrome of deformity in chickens that apparently depends on tryptophan metabolism and may be peculiar to the egg, which is closed system (Hayes 1982). When 1.17 to 29.20 mg of malathion was injected directly into the yolk of each egg, it often killed the embryo and deformed many of those that survived. When injections were made on days 8 to 12, half of the survivors lacked feathers or had only a few feathers on the abdominal region. When injections were made on days 6 or 7, 95% of the survivors were smaller than normal. When injections were made on days 4 or 5, the legs were half the proper size and the phalanges were permanently flexed in 95% of the survivors, and the maxilla was curved downward over the shortened mandible in 50% of cases. All of the hatched chicks had abnormal feathers, and some lacked feathers completely or in some areas. Most of the hatched chicks were about two-thirds normal size, and 6% were only one-fourth normal size (Greenberg & LaHam 1969). Tryptophan prevented the hind limb, beak, and feather defects and overall growth retardation in malathion-dosed embryos (Greenberg & LaHam, 1970). Application of 0.1 ml of 0.2 M nicotinamide or 0.1 ml of 0.1 M tryptophan simultaneously with malathion prevented development of the syndrome in all survivors, although the nicotinamide increased mortality. Tryptophan was also effective when injected into the yolk, and it was not toxic. It was speculated that malathion interferes with mobilization of tryptophan from yolk proteins, consequently decreasing synthesis of nicotinamide, which is essential for pyridine nucleotide-dependent reactions involved in differentiation of legs, beak, feathers, and other organs. Deformities of chicks can also be produced by feeding malathion to laying hens for 3 weeks at dietary concentrations up to 600 ppm (Ghadiri et al. 1967). However, the most likely problem for poultry is not teratogenicity but simple toxicity.

The hatchability of eggs was reduced when the hens were fed dietary levels of 1.0 ppm or higher but not 0.1 ppm (about 0.0058 mg/kg/day) (Sauter & Steele 1972).

Although malathion has been reported to produce delayed neuropathological syndrome in a human suicide attempt (Hierons & Johnson 1978), these findings are not substantiated in more sensitive animal models (Hayes 1982).

None of the 8 mutagenicity studies reported in NCI were positive for malathion. In general carcinogenicity/oncogenicity studies carried out by NCI, malathion was not implicated as a carcinogen (personal communication, Pesticide Bureau, DFA, Boston, MA). IARC concluded that malathion and its metabolite malaoxon were tested for carcinogenicity in mice and rats by administration in the diet. No evidence of carcinogenicity was found. Maddy (1984) ranks malathion in category 3 (negligible oncogenic potential, controversy as to any such potential, or not oncogenic).

Salmonids exposed to 120 to 300 ugtl (ppb) malathion showed AChE inhibition of 70 to 80%, and activity indices were reduced by 50 to 70% of that of unexposed fish. Goldfish exposed to sublethal levels of malathion showed a significantly reduced frequency of avoidance response at levels below that causing a reduced AChE activity. One-hour bath exposures of rainbow trout to sublethal levels of malathion caused severe tissue damage to the gills and minor nonspecific liver lesions. Ponds given four semi-monthly treatments during May-July at levels up to 0.02 mg/1 (20 ppb) produced no discernible effects on resident bluegill and channel catfish populations. Aquatic insect populations were significantly depressed at the high treatment level but not at the lower levels (Johnson & Finley 1980).

Irrespective of the exposure time and exposure concentration, the AChE activity of dying pinfish was reduced by 72 to 79%. Enzyme inhibition was higher in lethal exposures than in sublethal exposures. The observed correlation between brain AChE activity and deaths was considered to be of diagnostic value. After 3.5, 24, 48, or 72-hr exposure to 575, 142, 92, and 58 ppb of malathion, 40 to 60% of the pinfish died and the extent of inhibition of AChE was in the range of 72 to 79%. Following the exposure of brook trout and rainbow trout to malathion, the AchE levels were approximately 24 and 28% of those of the controls, and the fish had less than one third the ability of the controls to do work. Thus malathion, though not directly and immediately toxic, had a deleterious effect, owing to the impairment of the ability of the fish to maintain equilibrium, to search for food, and to avoid predators (Murty 1986). In their examination of population and ChE responses in Walleye exposed to malathion aerial sprays, Lockhart et al. (1985) found that cholinesterase activity fell to about 25% of prespray values within 12 hr after the first spray, and then gradually recovered to about 80% of prespray values over 2 weeks. The same pattern was evident after the second spray, but the inhibition of ChE activity was not quite as large. Fish captured for analysis showed no indication of the symptoms of OP poisoning. The population statistics indicated small temporary decreases in both catch per unit effort and weight gains after the first spray. Evidently a reduction in ChE activity to about 25% of preexposure levels was the approximate threshold for population effects caused by malathion.

The acute oral toxicity (LD_{50}) of malathion to various species of birds range from not toxic at 100 ppm (European starling, red-winged black bird) to 1485 ppm for mallard duck. Dietary LC_{50} values range from 2639 ppm (ringnecked pheasant) to greater than 5,000 ppm for mallard duck. Acute dermal LD_{50} values are not available (Smith 1987).

Malathion applied at 0.6 to 1.1 kg/ha (0.5 to 1.0 lb/acre) resulted in no observed mortality of wild birds in one study conducted, and bird counts after spraying were either higher or nearly the same as before spraying (Black & Zorb 1967). At applied rates of 852-1140g malathion/ha (12-16 oz/acre) to fields containing caged quail, no evidence of mortality or population changes of wild birds were observed (Smith 1987). After malathion was aerially applied to a forested watershed at the rate of 0.81 kg/ha, birds reacted to the spraying for 2 days without lasting effects and no effects on reptiles and amphibians were observed. However, populations of mice and chipmunks were reportedly reduced by at least 30% (Giles 1970). Tadpoles exposed to 5 mg/1 (5 ppm) malathion through a continuous-flow apparatus did not bioaccumulate levels that were toxic when fed to 2-week-old mallard ducklings in a single meal (Hall & Kolbe 1980). The predicted bioconcentration factor (BCF) for malathion is low.

Thus, malathion has moderate to slight acute oral toxicity to birds and there are no published reports of wildlife die-offs that can be attributed to the use of malathion. Its persistence and toxicity to birds is relatively low. However, malathion's toxicity has been reported to be potentiated by EPN treatment (Murphy 1969), and the interaction of these and other pesticides is not fully understood (Smith 1987).

B. Biological Control.

1. Introduction

Biological control includes attacks on the pest species by other species and manipulation of the pest species itself. The former includes the traditional biological control agents, predators, pathogens and parasites, whereas the later includes such techniques as sterile-male release and genetic manipulations.

Biological control agents are grouped into three categories: predators, parasites and pathogens. Predators include both vertebrates and invertebrates and may attack both adult and immature stages of mosquitoes. Helminth, protozoan and fungal parasites and microbial pathogens generally only invade immature stages, though mortality may not occur until the early adult stage. Parasitic water mites are an exception in that they attach to certain adults as they emerge from the pupal stage and apparently reduce adult survivorship if they are abundant (Lanciani & Boyett 1980) In general, biological control is much more feasible in managing permanent water mosquitoes than temporary water forms.

There are three basic strategies for utilizing all biological control agents: (1) increasing existing natural enemy populations by habitat alteration, (2) one-time introduction of sustainable exotic agents from other regions or habitats, and (3) augmentation of natural or exotic enemy populations by repeatedly releasing non-sustainable, lab-reared (or field collected) organisms. To date only the first, increasing fish habitat through OMWM, has been used in Massachusetts. Bti is sometimes classified as a biological control agent but its application technique and mode of action as a stomach poison more closely resemble a pesticide than a biological control agent *per se*. *Bacillus sphaericus* may more closely fit the model of repeatedly releasing non-sustainable lab-reared organisms as there is evidence to suggest that it recycles within the environment.

No other biological control agent is currently available for general field use, though experiments continue with may different organisms (see below). There are important reasons why biocontrol is not more widely used against mosquitoes. First, the differences in biology of the various species of mosquitoes make it unlikely that any one control agent will operate across a wide range of species. Second, mosquito breeding is wide spread, making it difficult for a biological control agent to find, or be placed in, all breeding areas. Third, predators such as bats and purple martins, may eat mosquitoes but prefer to eat other, larger insects. Further, even when abundant, they do not drive mosquito populations below levels that people generally find intolerable. Finally, there is a high cost associated with sustained releases of a biological control agent and there are not, at this time, control agents available that require a single, or a few, releases to become established.

Because of the limited application of biological control to mosquitoes in Massachusetts, the following discussion will focus primarily on the feasibility of control agents currently being studied for mosquito control. An important point to make regarding biological control is that the mosquito control have limited research capabilities. While conducting field evaluations of new control techniques is a desirable practice for any mosquito control program, the projects should not be expected to find and bring forward biological control agents without substantial help from research institutions such as the state university.

2. Predators

a. Introduction

In order for any predator to independently be an effective control agent, it must meet two important criteria: (1) its size and abundance in relation to the target species must be sufficient for it to kill or consume a high percentage of the prey population within a relatively short time period, and (2) its feeding behavior should be selective toward the prey species when it is present but allow it to utilize other food items when the target species is absent. These criteria are rarely met in full. Predators that are sufficiently large and/or abundant to have a major impact, usually lack feeding specificity. Conversely, those with feeding specificity are usually less abundant because their populations are regulated by a more restricted food supply. Vertebrate predators of insects have a clear size advantage but invertebrate predators tend to exist in much greater numbers.

Because of the limitations of predators as biocontrol agents, it is normally essential to continuously raise and release the predator to achieve field densities high enough to cause real reductions in the prey species. However, in some cases, manipulation of the environment to the advantage of natural predator populations can provide an adequate augmentation effect.

b. Vertebrate predators

<u>Fish</u>

Larvivorous fish are the oldest and perhaps most effective traditional biological control agent used against mosquitoes. In certain habitats they may, by themselves, provide adequate larval control throughout the breeding season. If not, pesticides such as BTI or methoprene which are non-toxic to vertebrates can be used in an integrated fashion with fish.

As already mentioned, the main reason open saltmarsh management strategies effectively control many saltmarsh *Aedes* in the Northeast is because this method provides access for the abundant estuarine populations of larvivorous killifish (*Fundulus* spp.) into the mosquito breeding pools in the high saltmarsh (Hruby & Montgomery 1986).

The mosquitofish *Gambusia affinis* is distributed widely throughout the warmer parts of the world and is the species most often reared and introduced into fresh water habitats for mosquito control. The biology and use of this fish in mosquito control was reviewed by Meisch (1985). It is an opportunistic feeder and avidly eats pupae and late-instar larvae of culicines and chironomids. It is most effective against *Culex* in unvegetated, permanent ponds but has been widely used in California and the Gulf States against ricefield *Aedes* and *Psorophora*.

Because *Gambusia* is so aggressive and fecund, it may replace important commercial or rare native fish species. This has raised environmental concern over the introduction of this fish into natural waters where it does not already occur. A recent article by Rupp (1996) has renewed this debate, both emphasizing real successes and real concerns over *Gambusia* use (see "Comments on 'adverse Assessments of *Gambusia affinis*'" (JAMCA 1996) and Boklund 1997, Eliason 1997, and Rupp 1997). Because it is not a native species of Massachusetts it may not be imported and released in state waters.

Outside of the mosquitofish, the common guppy (*Poecilia reticulata*) has received the most attention for mosquito control (Bay 1985). Comparative studies indicate that it is a less effective predator than Gambusia but it is more tolerant of polluted waters. Many other native fish have been explored for their mosquito control potential (Bay 1985). Studies in North Africa (Allo et al. 1985) suggest that malaria may be controlled through the annual introduction of native fish from streams into the manmade water storage tanks which produce the vector *Anopheles* in this region.

<u>Birds</u>

Many birds depend on insects as food and those which capture insects on the wing (e.g., the swallows), have been credited with consumption of significant numbers of mosquitoes. Purple martins specifically have been promoted on the basis of the claim that they often consume 10-12 thousand mosquitoes per day but Kale (1968) concluded on the basis of existing evidence that all claims of martins significantly reducing mosquito populations were unsubstantiated and, because of several biological facts, were unlikely to ever be demonstrated. The facts on which these conclusions were drawn are as follows:

(1) Mosquitoes were a negligible item in the diet of martins in the only two published studies in which the contents of martin gizzards were examined.

(2) None of the published statements appearing in the popular ornithological literature which attributes a mosquito-eating habit to martins is based on factual study or scientific reference. In fact, there is evidence that martins feed more on larger insects including species of dragonflies which may be predators of adult mosquitoes.

(3) Behavior patterns of mosquitoes and martins are such that they tend to not fly at the same height or at the same time. Thus, contact between the two is minimal.

(4) There is no evidence that any avian species can effectively control a pest insect upon which it feeds when the insect is at or near peak abundance.

Other Vertebrates

Mosquito control by insectivorous bats was tried in the early part of this century but without success (Kale 1968, Storer 1926). Bats continue to appear in the popular press as legitimate mosquito-control agents (Wright 1996) but are not considered worthwhile agents in Common-sense Pest Control (Olkowski et al. 1991), which is very thorough in its coverage of non-chemical control options, or in mainstream mosquito control (Mitchell 1992).

c. Invertebrate predators

Predators of mosquito eggs.

Evidence exists of predation on diapausing flood water mosquito eggs by mites and beetles, and on *Culex* egg rafts by fish (Collins & Washino 1985). Nonetheless, egg predation appears to be a relatively minor component of natural mosquito mortality and is not being studied for biological control.

Terrestrial insect and spider predators of mosquito adults

Predation on emerging and indoor resting adult mosquitoes has been readily observed but the impact of this mortality on populations is extremely difficult to assess. Certain spiders (especially Tetragnatha) and predatory flies (mainly Empididae, Anthomyiidae and Dolichopodidae) have been shown by precipitation tests to have consumed emerging mosquitoes (Collins & Washino 1985). In one British study, up to 28% of the spiders tested had eaten mosquitoes (Service 1973). Certain adult dragonflies reportedly capture mosquitoes on the wing but these observations have not been backed up by any controlled field studies. Synanthropic emesine bugs (Reduviidae) appears to be potentially important predators of indoor resting mosquitoes in the tropics. In sum, the prospect for enhancing or managing invertebrate predators for more effective adult control is not encouraging, especially in temperate regions.

Aquatic insect predators of mosquito larvae & pupae

Aquatic insect predators seldom occur in significant numbers in the temporary floodwaters that produce most pest mosquitoes. Studies of predation have therefore largely taken place in permanent ponds or semi-permanent habitats such as rice fields, rock pools or vernal woodland pools. The adult stage of most predaceous aquatic beetles and true bugs can fly (usually at night) so natural colonization of newly flooded habitats can occur in a matter of days. Development time for these insects is usually from several weeks to several months.

Among the beetles, the dytiscids (predaceous diving beetle), which are predaceous both as larvae and adults, are the most effective predators of mosquitoes. There is evidence from studies in rice fields that adult dytiscids selectively locate and colonize sites with locally high concentrations of mosquito larvae (Collins & Washino 1985). Mass production methods for dytiscids have never been developed. Whirligig beetles (Gyrinidae) only feed at the surface where they may prey on concentrations of emerging adult mosquitoes. Hydrophilids are only predaceous as larvae and seem to feed mainly on chironomid midges.

Only two aquatic families of true bugs, the back swimmer (Notonectidae) and pigmy back swimmer (Pleidae) have received serious consideration as mosquito control agents. Pleids are generally not abundant enough to have significant impact but notonectids can become quite dense in certain habitats. Mass rearing of the latter appears to be possible. Water boatmen (Corixidae) are also common and similar in appearance to backswimmers but they are mostly detritus feeders. Other predaceous aquatic Hemiptera that have been suggested as mosquito predators but which normally occur in insufficient densities to have much value as natural control agents include the giant water bugs (Belostomatidae), water scorpions (Nepidae), water measuring bugs (Hydrometridae) and the two family of surface-feeding, water striders (Gerridae and Veliidae).

Dragonfly naiads have been marketed commercially for mosquito control and at least one town in Massachusetts, and others in New Hampshire and Maine, have purchased dragonflies for mosquito control. In northern climates these insects require 1-5 years to mature, so they normally occur in permanent waters only. Furthermore, many are bottom feeders that seldom if ever come in contact with mosquito species that feed at the surface or in the water column. Most bottom-feeding mosquitoes (i.e. *Aedes*) occur in temporary water containing few if any dragonfly naiads. Another factor weighing against the mosquito control efficiency of these aquatic predators is the fact that they normally occur at low densities. Adults of many species are territorial and this seems to spatially limit population densities of naiads as well as adults. In certain habitats such as rice fields, naiads may become quite abundant but populations fluctuate greatly and their role in limiting populations of rice field mosquitoes is limited at best. No controlled, field studies have been done in which naiads have performed well as biological control agents.

The trichopteran *Limnephilus indivisus* may be an important predator of early spring *Aedes* in woodland swamps in Ontario but most caddisflies are omnivorous shredders rather than predators (Collins & Washino 1985, Merritt & Cummins 1985). Prospects for mass rearing and manipulating caddisfly larvae are not very bright. Many of the aquatic nematoceran relatives of mosquitoes contain groups with predaceous larvae. These include the families Chaoboridae, Chiromomidae, Ceratopogonidae, Tipulidae, Anthomyiidae, and others. Most are too small to consume many mosquito larvae. Predation on small, early instars occurs but it is far less efficient in reducing the numbers of adults than is predation on late instars and pupae. *Mochlonyx* (Chaoborid) predation on spring *Ae. communis* populations has been observed in woodland pools in Massachusetts (Edmans, personal communication) and in Europe (Chodorowski 1968). The impact of this small but voracious predator is unknown.

The insect predator with the most promise in mosquito control is another mosquito. Larvae of the non-biting genus *Toxorhychites* are large and effective predators of mosquitoes that develop in natural and man-made containers such as tires, tree holes, metal cans, and leaf axis (Steffan & Evenhuis 1981). Unfortunately, none of the 70 some species in this mainly tropical genus can survive the winters as far north as Massachusetts. Their use here would therefore require repeated, annual releases of lab-reared females. This is not warranted at the present time since container-breeding species generally do not represent the major nuisance or health threat in Massachusetts. This situation could change if *Ae. albopictus* becomes well established in used tires in the Northeast. Focks (1985) states that although it is possible to control or reduce certain species of container-breeding mosquitoes with inoculative or inundative releases of *Toxorhynchites*, the usefulness of this genus in practical, operational control programs has yet to be demonstrated.

Other invertebrate predators of larvae and pupae.

Among the non-insect predators of the immature stages of mosquitoes, only hydra (Cnidaria: Hydrozoa), flatworms (Platyhelminthes: Turbellaria) and copopods (Cyclopoida) have been studied in any detail.

Both hydra and flatworms can be easily mass produced and, unlike most predaceous insects, they can be maintained at high densities without cannibalism. In the laboratory, they kill far more larvae than they consume. Both groups produce semi-dormant eggs so they occur naturally in shallow temporary pools as well as permanent swamps and ponds. Detrimental effects on young fish have been reported when these predators are at high densities (Mulla & Tsai 1978).

Both of these predators have good potential as control agents in the Northeast but additional long-term field evaluations are needed. As with mosquito fish, the laboratory production, storage, and field translocation of these organisms requires a certain degree of sophistication, which is usually lacking at the local level. Currently, there are no commercial sources for the quantities that would be required for mosquito control applications.

Natural populations of predaceous cyclopoid copepods appear to limit the distribution of container breeding mosquitoes in certain tropical settings (Marten 1984). However, they have never been shown to be important predators in temperate regions or in other types of aquatic habitats. Therefore their potential for the biological control of pest and vector mosquitoes in Massachusetts appears to be nil.

3. Parasites and Pathogens

a. mermithid nematode parasites

Outside of bacteria, parasitic nematodes are the only natural parasites and pathogens that have ever achieved operational status in mosquito control. Known parasitic roundworms of mosquitoes now number over 20 species. The free-living, aquatic, preparasitic stage which hatches from the nematode egg, seeks out and penetrates the cuticle of host mosquito larvae. Larvae are usually killed in the last instar. In a few species, the mature worms are carried over in the adult mosquito and cause mortality when they exit during attempted pseudo-oviposition.

Romanomermis culicivorax (including most references to *Reesimermis nfelseni*) is the species that has been most extensively studied. Methodologies for the mass production and commercial preparation of this species have been developed and it was briefly marketed as Skeeter Doom in the late 1970'g. Low sales and problems with the shipping and shelf-life of viable eggs appear to have been the major factors which led to the marketing failure of this agent (Service 1983). Other economic drawbacks include host specificity which limits its effectiveness to only certain species (e.g., it is ineffective in cold, polluted or brackish water), and the lack of patent protection for companies investing in the production and marketing of this product. In addition, applicators need some special skill and training to effectively use this biocontrol agent. The tendency of this agent to naturally recycle once it is introduced into favorable aquatic habitats is beneficial from a control viewpoint, but it further reduces the long-term marketability and profit potential for private producers. It remains under study, however, as a recent article (Mijares et al. 1997) discussed the establishment of *R. culicivorax* in sewage settling ponds and natural ponds in Cuba.

On the biological plus side, mermithids appear to be highly compatible with a wide range of chemical pesticides and growth regulators. Moreover, they: 1) are non-specific and well suited to the life cycle of their mosquito host, 2) produce high levels of infection and mortality, 3) can be easily mass-produced and applied with standard spray equipment, and 4) offer no threat to non-target organisms or the environment.

There are species of mermithids which appear to be highly specific to spring snow-pool *Aedes* and to saltmarsh *Ae. sollicitans* (Petersen 1985). However, these worms have not been established and studied in the laboratory. Such species may have greater control potential in northern coastal states like Massachusetts than the more tropically adapted *R. culicivorax.*

Since the technology for using mermithids in mosquito control already exists, and there are numerous field trials documenting their control potential, the future availability and use of these biocontrol agents in operational programs seems to depend on changing economic and market forces (Petersen 1985).

b. Microsporidia

Virtually all mosquito species carefully examined have been found to harbor these parasites. Larvae are infected by ingesting the spore stage. Spores, which are produced at the end of the life cycle, have often proven difficult to induce and to reinfect larvae in lab cultures.   Few microsporidian life cycles are well enough known to assess biocontrol potential. Life cycles vary from simple to complex and often form the basis for the non-taxonomic grouping of these protozoan parasites. The simplest forms (Type I) occur mainly in terrestrial insects and even the one aquatic species known from mosquitoes (*Nosema algerae*), does not cause mortality until, the adult stage. For this reason *N. algerae* has limited potential for reducing pest problems but may impact on disease transmission by reducing survival and fecundity. Wild strains only persist in larval populations for short periods and cause little direct mortality. Type II microsporidia have simple, asexual life cycles similar to Type I forms and they also show little promise in mosquito control (Hazard 1985). Type III forms are dimorphic, have binucleate spores, and kill mosquitoes in the larval stage. Only one species (*Hazardia milleeri*) is known from mosquitoes and it seems to have low infectivity (Hazard 1985). Type IV microsporidia include many species from mosquitoes and have the most control potential. Infected larvae are usually killed but a few females survive and carry the infection via the ovary to the next generation. However, transovarial infection ceases after a single generation. Non-ovarian modes of transmission must exist but this issue along with the possibility of sexual reproduction and alternate hosts are as yet unresolved. Additional basic research is required before any microsporidian can be considered in the biocontrol of mosquitoes (Hazard 1985).

Tetrahymena and *Lambornella* (tetrahymenid ciliates)

The lack of a resistant resting stage and difficulty in culturing these ciliated protozoa has prevented the thorough study and evaluation of this group of potential biocontrol agents. Ongoing studies of *Lambornella clarki* in California treehole *Ae. sierrensis* should help to better assess the control value of these parasites in the near future (Anderson et al. 1986).

Helicosporidium

There is still debate concerning the proper classification of this spore-forming group of parasites; some believe they are primitive Ascomycetes fungi. There are only 3 reports of natural infections in mosquitoes. They appear to infect a wide range of species but also may infect non-target insects as well. High dosages of spores are required to infect older instars in the lab. Continuous cultures of these parasites do not exist so the basic research needed to evaluate their biocontrol potential is not forthcoming.

c. Fungal Pathogens

Coelomomyces

Many forms of pathogenic fungi have been known from both larval and adult stages of mosquitoes since the 1930's. However, it was not until the discovery of the obligate alternate host (i.e., microcrustacea) in the mid-70’s that cultures and full-scale laboratory investigations were possible with *Coelomomyces* (Whisler et al. 1974, 1975). The rather complex life cycles of some species have recently been described and methods for in vivo culturing established. Before wide-scale field application can occur, mass in vitro cultivation of the infective biflagellate zygote stage needs to be developed. If *Coelomomyces*, and perhaps their copepod and ostracod intermediate hosts, are introduced into favorable habitats, the potential for natural recycling exists. However, too little is known about the host ranges and habitat requirement of most *Coelomomyces* to recommend any such introduction at the present time. Moreover, species of *Coelomomyces* do not routinely provide high and predictable levels of mosquito control. It is, premature to critically assess their potential as control agents to be used independently or as part of an integrated control program (Federici et al. 1985). Studies related to their evaluation as operational control agents have only recently been initiated and it is not likely that any *Coelomomyces* will be operational within the near future.

Lagenidium giganteum.

This mosquito-specific water mold is a very promising biological control agent, especially in fresh water and in warmer climates. This fungal pathogen can be mass produced on artificial media and can recycle in as little as 3 hours (McCray 1985). It has a resistant, dormant stage and infects a wide range of mosquito species. Unfortunately, it is not effective in polluted, brackish or colt waters. This limits its commercial value and it potential usefulness in northern and coastal states like Massachusetts (Service 1983).

Other Fungi

Fungi are among the commonest pathogens of insects and many other genera besides *Coelomomyces* and *Lagenidium* have been reported from mosquitoes. Of these, *Culicinomyces* and *Metarhizium* have received the most attention. Both groups infect a wide range of mosquito species but relatively high concentrations are required to cause infection. They can tolerate organic pollution and salinity but not high temperatures (i.e. above 30°C). These fungi can be grown on inexpensive artificial media but no resistant resting stage has been fount. Difficulty in achieving long term storage of infective stages and formulation problems remain as barriers to commercial production. Nonetheless, these fungi are a promising group of biocontrol agents which may provide new mosquito control tools in the future.

Erynia aquatica

Erynia aquatica is an Entomophthorales fungus, and is the only species of the genus known to infect the immature aquatic stages of mosquitoes. It was first discovered infecting *Ae. canadensis* and *Cs. moristans* larvae in woodland pools in Hartford County, Connecticut from late May to early June (Anderson & Ringo 1969). It has since been recovered in early May from *Ae. stimulans* in woodland pools near the village of Cambridge, New York (Molloy & Wraight 1982) and from *Ae. cantator* on May 21, 1981 in a shallow salt meadow pool in Milford, Connecticut (Andreadis & Magnarelli 1983). Most recently, is was discovered in 1995 and 1996 in a woodland pool in Bristol, Rhode Island (Christie 1997).

Steinkraus and Kramer (1989) collected *Ae. fitchii* larvae infected with *E. aquatica* from a semi-permanent woodland pool in Tompkins County, New York. They used infected pupae to successfully transmit the disease to emerging adult *Ae. aegypti,* on which resting spores of the fungus developed.

Erynia aquatica has characteristics which make it attractive as a microbial agent: it is capable of causing epizootics, has been found in both freshwater and brackish water mosquitoes and has a resting spore stage that may survive well in storage. Operating against it is the fact that it has only been found in cooler, springtime waters. One thought is that infected pupae may be removed from the original infestation site and placed in other, nearby pools. A fungus that kills in the pupal stage works against its own spread.

d. Bacterial pathogens

Bacillus thuringiensis var. *israelensis*

Bti Serotype H-14 has become an important biological larvicide following its discovery in the Negev desert in 1976. Within the last 5 years it has become widely used by the mosquito control projects in Massachusetts. It is now the larvicide of choice in many situations because of its host specificity, high and rapid mortality to many mosquitoes species, and its environmental safety. It is quite distinct from the Bt strains which infect lepidopterous insects. Its track record in controlling polluted-water *Culex* is mixed, apparently because it sinks to the bottom and the active moiety rapidly binds to organic particulates. Consequently, higher dosages are required to achieve good control in highly organic and deep-water situation. Saltmarsh mosquitoes generally require rates at the high end of the labeled application rates for effect control. Liquid, powder, granular and slow-release briquet formulations are commercially available.

Bti must be ingested to cause toxicity to filter-feeding mosquito larvae; pathology occurs in cells of the midgut wall. It is least toxic to 4th instars since they cease feeding at least 12 hours prior to pupation. The mosquito toxic ingredient of Bti preparations is the heat labile deltaentotoxin located in the proteinaceous parasporal crystalline inclusions synthesized concomitantly with the spore during sporogenesis. Once released in the environment, it biodegrades rapidly (it is usually only active 1-3 days) and this bacterium (gram negative Bacillaceae) does not recycle. This is considered the only major drawback of this highly effective mosquito pathogen but it has enhanced its commercialization (Lacey & Undeen 1986).

The biocidal activity of Bti toxin appears to be limited to larvae of certain families of nematocerous Diptera. A large number of laboratory and field tests have confirmed that all non-nematocerous, non-target organisms are virtually unaffected (Lacy 1985). All existing data indicate that the unaltered protoxin of Bti is also safe to vertebrates including humans (Lacey 1985). Further improvements in the efficacy and price competitiveness of this control agent, brought about by formulation changes and genetic engineering, are likely to occur in the near future. In addition, formulation of this agent with other compatible and perhaps synergistic agents such as juvenile hormone analogs (e.g. Altosid) is currently underway. Such mixture have two important advantages. They reduce the likelihood of mosquitoes developing resistance to either agent and, secondly, they widen the window for control since Bti is most effective against early instars and growth regulators against later instars.

Bacillus sphaericus.

Although only recently available, *B. sphaericus* may have greater control potential than Bti because of its ability to continue to recycle once it is introduced. It has many of the same beneficial attributes of Bti but all strains isolated to date are less effective against a wide range of species than is Bti. At the moment it is primarily marketed against *Culex* in high-organic waters but research is on-going in expanding its control potential.

e. Viral Pathogens

The biological control potential of both non-accluted (iridoviruses and densonucleosis viruses) and occludet (baculoviruses, cytoplasmic polyhedrosis viruses and entomopox viruses) viruses pathogenic to mosquitoes has recently been reviewed by Federicci (1985). It is sufficient here to simply paraphrase from the summary of this thorough review as follows:

Analysis of research conducted to date makes it clear that none of the viral pathogens of mosquitoes can currently be considered good candidates for mosquito management programs. The two main reasons for this assessment are that viruses discovered so far possess low infectivity for original or alternate hosts and there is no readily available method for mass production of virions. This apparent lack of control potential is most obvious when one considers that few field trails have been conducted with these agents even though the first one was discovered over 15 years ago. While it appears unlikely that viruses will be developed for mosquito control in the near future, they may prove to be extremely useful microbial agents in the long term, perhaps in 2 or 3 decades, once we learn how to manipulate them effectively. Biotechnology has the greatest potential for engineering new more useful biocontrol organisms among the viruses because of their simple molecular structure.

4. Pest Species Manipulation

A somewhat different approach to biological control is manipulation of the mosquito genome to either 1) induce reproductive failure (leading to population elimination) or 2) bring about permanent changes in the behavior or physiology of the target population so it no longer vectors disease or bites people. There are numerous theoretical mechanisms by which this could be accomplished. Following is a brief discussion of the three approaches that have been most commonly discussed and researched.

a. Sterile Insect Technique

The early and continuing success of the sterile male release program in eliminating the screwworm fly from the U.S. and Mexico has given rise to many investigations and new ideas for controlling other insects (inoculating mosquitoes) through the use of this or some other genetic technique. Except for fruit flies, this method has not yet been successfully applied to other insects in operational programs and the technique is not currently being pursued for mosquito control.

b. Incompatibility

Incompatibility resulting from a lack of fertility in sexual unions may occur due to a variety of genomic failures or due to the effort of bacteria-like symbionts to control the reproduction of host (Barr 1985). The feasibility of suppressing *Culex pipiens* through cytoplasmic incompatibility was demonstrated in a Burmese Village over 20 years ago (Laven 1967) but the practicality of this method has not been confirmed by any other field tests. Moreover, incompatibility factors have been isolated in only a few mosquito species to date.

c. Chromosomal Aberrations

There are several heritable chromosome rearrangements that can, in theory, be used to inject genetic load into a mosquito population and/or to effect a permanent change in the genetic makeup of the population. These aberrations can be used to 1) increase genetic lethal load (serility is limited to 50-80% because of the low chromosome number (three, in most mosquitoes) or 2) replace noxious species with harmless strains if appropriate viable homozygous rearrangements are available. The latter is perhaps only applicable in the case of important disease vectors. Naturally occurring aberrations can be screened for in wild populations but their frequency is greatly increased through exposure to mutagens.

Controlling mosquitoes through the use of chromosomal aberrations requires a major basic research effort and a target species that is easily colonized. This later requirement automatically eliminates many important species from consideration.

d. Competitive Displacement

The final, and somewhat abstract, strategy for controlling mosquitoes biologically is the ecologically based notion of displacing a noxious species by introducing a benign but more competitive (i.e. better adapted) exotic one. This idea has been suggested primarily to control container-breeding species like *Ae. aegypti*. However, benign mosquito species are difficult to find, as most mosquitoes that have become established (*Ae. aegypti, Ae. albopictus*) are as bad or worse than the species with which they compete (container-breeding *Culex* and *Ae. triseriatus*).

5. Other Control Approaches

a. Trap out techniques. All experience to date indicates that while various traps may be good sampling devices for adult mosquitoes, they are too inefficient and limited in their range to provide any benefit in reducing biting annoyances (Nasci et al. 1983). Work is ongoing on attractants (octanol) that would both greatly increase trap collections of mosquitoes and reduce non-targets trapped, but no products are marketed for this purpose to date.

Electrocutor traps ("Bug Zappers") continue to be a popular item, with an estimated 1.75 million sold in the United States each year (Mitchell 1992) but they are extremely non-specific (mosquitoes generally make up less than 5% of the catch, and may be harmful to other insect species. They cannot be considered a part of any mosquito-control program.

b. Repellents. Personal protection through the use of mosquito repellents is an appropriate alternative to controlling the mosquito populations before they bite. This is especially true if the periods of annoyance are infrequent and brief and where the land areas are too vast and unpopulated to economically consider control programs.

The most commonly used mosquito repellent is DEET (N,N)(diethyl-metatoluamide) which has been formulated and sold under a variety of trade names (e.g., Off, Muskol, Cutters), in a variety of concentrations and as both aerosol sprays (usually ca 15%) and lotions (up to 100%). Laboratory tests have shown that maximum repellent duration (ca. 1-2 hours) is obtained with a concentration of ca. 50% so that higher concentrations do not provide appreciable advantages. The major disadvantage o£ DEET are:

1) relatively short protection time

2) somewhat offensive odor

3) damage to some fabrics and surfaces at higher concentrations

4) high cost

5) possible hazards from heavy use

Small children frequently have skin reactions to DEET. Small children are also most likely to be the individuals that develop meurotixicological symptoms from DEET. Thirteen of 14 cases of encephalopathy (toxicity of the central nervous system), found in publicly available reports by a recent review (Osimitz and Grothaus 1995), were in children 8 years old or younger. Three of these children died, all having used “heavy” amounts of repellent, even though the repellent in each case had DEET concentrations of 20% or less. Oral ingestion may have played a role in some of the cases. Osimitz and Grothaus (1995) concluded that there is no evidence that increased DEET concentration has an effect of the severity of symptoms. They also compared reports that the Poison Control Center received for DEET (6,724 in children under 6 years old during a five-year period) to laundry detergent reports (10,789 in 1989) and household bleach (16,169 in 1989), concluding that accidental exposure, while undesirably high, is in line with, or lower than, exposure to other household chemicals.

There is one unsubstantiated report in the Russian literature of carcinogenic effects in rats at high doses.

Three other repellent materials are in common use. Dimethyl phthalate (generally sold as 6-12) is not as effective as DEET against mosquitoes but still has a share of the market. Citronella-based repellents have long been marketed as candles or in oil-burning lamps. Citronella is also available as a repellent to be sprayed in skin and clothing (Natrapel). The third material (Avon skin-so-soft) is a popular bath oil that is not marketed as a mosquito repellent but has, through word of mouth, been recognized for its as yet uncharacterized mosquito repellent affect. It is as effective as DEET but it does not persist as long. On the other hand, it is much cheaper, smells better, and apparently does not damage any fabrics or surfaces. The active ingredient(s) of skin-so-soft has not been isolated or identified to date. It also has not undergone the EPA safety testing that other repellents have because it is marketed as a beauty aid rather than a pesticide (Note: repellents are classified as pesticides by EPA).

Electronic mosquito repellent devices which are periodically marketed in the U.S. (usually by mail order houses) are completely ineffective and are not based on any biological rationale (Foster & Lutes 1985, Mitchell 1992, Curtis 1994).

C. Physical Control

1. Types of Habitat Modification

a. Open marsh water management (OMWM)

Originally developed for New Jersey salt marshes (Ferrigno 1970, Ferrigno & Jobbins 1968, Ferrigno et al. 1969), this strategy basically attempts to overcome the limitations of ditching by the incorporation of other water management strategies. In particular, champaign pools or reservoirs (which permanently hold water and sustain larvivorous fish) are created (by backhoe, dragline or rotary ditcher) in selected tidal pools or large shallow pans and are connected via small shallow ditches to surrounding mosquito breeding depressions. If old ditches are re-dug and used as reservoirs, then plugs must be inserted at the tidal end to prevent drainage. This customized approach to marsh management represents the least deleterious and most efficient nonpesticidal method for controlling saltmarsh mosquitoes and has been adapted to New England conditions (Boyes and Capotosto 1980, Hruby et al. 1985, Christie 1990). A manual outlining this method was developed by the Massachusetts Audubon Society (Hruby and Montgomery 1986) and OMWM is currently being practiced by coastal projects in Essex and Plymouth Counties in Massachusetts. As of 1996, OMWM had become the accepted technique for new salt-marsh water management work, though maintenance work remains dominated by cleaning existing ditching, as opposed to conversion to OMWM.

b. Other Modification Strategies

Mosquito control efforts in Massachusetts predate modern chemical insecticides. Early control efforts consisted of source reduction work, mostly in salt marshes (see “History of Cape Cod Mosquito Control Project, 1928-1971”). This emphasis was largely abandoned when cheap and seemingly more effective organo-chlorine insecticides became available in the early 1950's. Early control programs capitalized on cheap WPA labor but they failed to achieve the level of control that the public has come to expect of modern control programs. Nonetheless, they serve as a reminder that mosquito control, from its earliest inception, considered and practiced control alternatives to synthetic chemical pesticides.

Except for new OMWM projects in salt marshes, mosquito control source reduction work now consists primarily of maintenance work on existing culverts, storm sewers and ditches. Very little new ditch construction has taken place in recent years. Ditch cleaning, which often involves excavating spoil with a backhoe or plow, is an activity which has drawn great concern when it takes place in estuarine environments. This is because many of the old grid ditches in the saltmarsh served no real purpose for mosquito control but they must be re-cleaned periodically or they themselves become shallow breeding areas for saltmarsh mosquitoes.

c. Origination of Requests for Physical Control.

The exemption from certain regulations enjoyed by mosquito control is a two-edged sword. On the one hand, it enables mosquito control projects to more quickly respond to drainage problems. On the other hand, it makes the heading "Mosquito Control" particularly desirable for drainage projects in which mosquito control is, at best, a marginal goal. This pressure can come from property owners, public officials, or from within control projects themselves. The pressure to conduct drainage work that does not have a mosquito-control component must be resisted.

The best interests of mosquito control programs are served by conservative application of the definition of mosquito control, as over-use of the wetlands exemptions may result in the loss of those exemptions. To this end, mosquito control programs, in conjunction with state and federal wetlands protection agencies, must develop a strong set of guidelines for alterations exempt from Wetlands Protection Act.

2. Ecosystem changes of non-target biota as a result of physical controls.

a. Salt Marsh .

New England coastal wetlands have been heavily impacted by man (Shisler 1990). However, evidence concerning the negative impact of saltmarsh ditch maintenance activity is mixed. The principal concern is with disposal of the spoil on the marsh and the invasion of upland plants that can occur with even slight elevation increases (i.e. 1-2 inches) (Miller and Egler 1950, Buchsbaum 1994). Ditching also permits *Spartina alterniflora* to invade the upper marsh (dominated by *Spartina patens* and *Distichlis spicata*) along the edges of the newly created ditches. There is evidence to support the claim that this increases marsh productivity (Buchsbaum 1994).

In 1979, staff biologists from the New England Division of the U.S. Army Corps of Engineers (DeSista & Newling 1979) carried out preliminary investigation in several Massachusetts salt marshes to explore the issue of spoil deposition and upland plant invasion. In many instances they found little plant invasion despite evidence of previous spoil deposition of 2 inches or more in depth on the marsh. In a few locations with minimal tidal influence, some invasion by species such as common ragweed (*Ambrosia artemisifulia*), march elder (*Iva frutescens*), and seaside goldenrod (*Solidago semprevirens*) had occurred over time. However, they concluded that it was not obviously correlated with the spoil itself but was perhaps caused by some other factor associated with the disturbance to the marsh. They recommended the sort of long-term monitoring studies which have as yet not been carried out in Massachusetts salt marshes.

Clarke et al. (1984) studied the effect of ditching and vegetation changes on the use of the saltmarsh by birds in Rowley, Massachusetts. They concluded that bird use of the marsh was negatively impacted by mosquito control ditching. This is in contrast to the studies of Shisler & Jobbins (1977) in New Jersey marshes where increase productivity was observed in ditched marshes. Daiber (1986) noted that, where ditches drain pannes, birds that need a constant water supply (American bittern, pied-billed grebe and American coot) may decline. Also noted was a case where spoil ridges invade by *Baccharis* and *Iva* caused gulls to seek less brushy areas for nesting. Scheirer (1994) encouraged mosquito control programs to develop water management partnerships with the U. S. Fish and Wildlife Service, especially for OMWM-type marsh restorations designed to improve migrant waterfowl habitat.

In a series of investigative reports by staff biologists from the National Park Service, the environmental impact of ditching and diking of salt marshes in the Herring River basin of Cape Cod National Seashore were investigated (Soukup & Portnoy 1983, Portnoy 1984a, 1984b). These reports held that Cape Cod marsh management practices were responsible for the freshening, stagnation, acidification and high sulfate and aluminum concentration in diked marshes. These authors suggest that the destruction of a thriving eel and herring fishery in Wellfleet was the direct result of these marsh disruptions. However, the main dike across the mouth of the Herring River (from Griffin Island to the Mainland) was constructed in 1909 with the main objective of providing for agricultural use of the basin. These structures are not typical of early mosquito marsh management practices in other coastal regions in Massachusetts. The impact may be largely reversible if dikes are removed and normal tidal flow is allowed to return to these areas. OMWM tailored to the unique characteristics of these small estuaries should be explored as a way to manage the *Ae. sollicitans* populations which are likely to replace the present *Ae. cantator* populations if tidal flow and normal vegetation and salinity are restored in these marshes.

Perhaps the most damaging assessment of ditching in salt marshes was the report of Bourn and Cottam (1950) in which they blamed open ditching for converting up to 90% of the *Spartina alterniflora* marsh along the Mispillion River in Delaware to *Baccharis*. However, Provost (1977) reported that the area had returned to *Sp. alterniflora* after navigational dredging of the river had ceased and concluded that it was the dredging of the main channel, not the marsh ditching, which had permitted *Baccharis* to invade the marsh (see Daiber 1986 and

Buchsbaum 1994 for reviews of this debate). Arguing against significant water-table lowering in salt marshes is the strong affinity for water exhibited by salt marsh soils. Because permeability is so low, the water table may be lowered only within a meter or so of the ditch itself (Balling and Resh 1982).

Grid ditching, even if not the marsh destroyer some claim it to be, still reduces standing water on the marsh and creates an unnatural and aesthetically unpleasing view. Open marsh water management was designed to more closely approximate the diversity of the natural marsh while eliminating the shallow pannes in which mosquitoes breed.

Wolfe (1996) reviewed the effects of OMWM on numerous tidal marsh resources. OMWM systems tended to enhance tidal exchange and salinity in marshes that were converted from grid ditching. Except where spoil piles were left (improperly) on the marsh, vegetation change was slight and favored salt-marsh species such as *Spartina patens* and *Distichlis spicata*. Small changes in elevation due to spoil deposition sometimes result in invasion by *Iva, Baccharis,* and *Phragmites*. Salt-marsh snails (*Melampus bidentatus*) have declined in some OMWM sites but not in others. Similar mixed observations have been made for marsh periwinkle (*Littorina irrorata)* and fiddler crabs (*Uca* species). Marsh fish populations are, by design, enhanced by OMWM. However, changes in species composition may occur where existing pools are deepened. Mummichogs (*Fundulus heteroclitus*)and spotfin killifish (*Fundulus luciae*) should decrease while sheepshead minnows (*Cyprinodon variegatus*), inland silversides (*Menidia menidia*) and rainwater killifish (*Lucania parva*) should increase (Talbot et al. 1986). The small reservoirs are not particularly attractive to birds and the minor changes in hydrology, flora and invertebrate fauna caused by OMWM do not cause significant changes in bird use on OMWM sites. Effects on mammals are not well documented. OMWM has had no long-term detrimental effects on water quality. As a result, Wolf concludes that, “Open Marsh Water Management is an environmentally focused management tool that is designed to be compatible with nature rather than compete with it.” Of course, the technique is new enough that long-term monitoring is required to ensure that altered sites remain functional salt marshes.

b. Freshwater Wetlands (exclusive of Vernal Pools). Palustrine wetlands, including emergent, scrub-shrub and forested wetlands, are the dominant system in which Massachusetts freshwater physical control take place. In the vast majority of cases, this work consists of maintaining existing ditching designed to remove standing water from the wetland, thereby reducing mosquito-breeding habitat. For most MCPs, this type of work (source reduction) makes up a large percentage of their control effort. Though reducing standing water certainly reduces mosquito breeding, there has been little research concerning the overall effects of these alterations on the modified wetland. Ditch systems can become problems in their own right, producing mosquitoes if left unmaintained. Most of these systems were never designed specifically for mosquito control and their other, primary function, such as removing runoff from large parking lots, may cause considerable damage to the ecosystem, leaving the MCP to clean up, or at least deal with, someone else's mess.

The majority of drainage systems currently maintained by MCPs were not initially constructed by MCPs and the effort of MCPs today is almost entirely restricted to removing blockages to existing flows, rather than enlarging or straightening channels to increase flow. Most freshwater drainage is an inherited problem which requires intervention not because of mosquito-control activities but because of the activities of others. Road sand and yard waster represent two of the most common obstructions MCPs are called upon to remove from existing streams and drainage networks. New developments also can cause dramatic changes in the sediment load in streams, despite regulations designed to prevent such problems. Road sand, yard waste and increased sediment load from development can all have impacts on a stream that are as greater or greater than regular ditch maintenance.

Because MCPs are often involved in removing manmade sediments from streams, a system under appropriate ditch maintenance may function more closely to a natural system than one in which manmade wastes are allowed to accumulate unabated. The appropriate response by the MCP in such cases is not obvious because, although the problem, and its cause, may not be mosquito related, the mosquito control program may be the organization best equipped, both from and equipment and a training perspective, to rectify the situation.

Since mosquito control projects came into being in Massachusetts, the perceived values of wetlands have changed. Once shunned as disease-bearing waste lands, best suited for dumping, draining or filling, wetlands are now viewed in a much more positive way. They are important wildlife habitats, perform a myriad of water quality maintenance functions, and serve as flood control, erosion, ground-water recharge and water supply regulators (Tiner 1989). Mosquito control programs have been slow in adapting to the increased value accorded wetlands. On the one hand, long-residual and/or broad-spectrum pesticides are no longer used in wetlands in Massachusetts. On the other hand, there is real resistance to halting maintenance work in drainage networks that may be seriously damaging wetland habitat.

There has not been a great deal of work done specifically on the effects of physical control for mosquitoes on non-target organisms. Therefore the following discussion is based on the general effects that can be expected when wetland alterations are made. Care should be taken in extending these general concerns to mosquito control in Massachusetts. For example, channelization (straightening) of natural streams is not permitted in Massachusetts, where programs are required to follow the natural meanders of the stream. The three broad categories of wetlands alteration are outright loss, changes in the abiotic system and changes in the biotic community. Filling and/or draining wetlands to convert them to upland is a mosquito-control practice that has been all but eliminated in Massachusetts. There is no indication that MCPs are intentionally reducing wetland acreage in order to control mosquitoes. However, the fact that the wetlands boundary remains essentially unmoved by a mosquito-control alteration does not mean that profound alterations have not occurred.

Changes in the abiotic system and biotic community are deeply intertwined, though physical control most often causes abiotic changes which then cause biotic changes. For channels changes in flow rates, microhabitats, sediment load, sedimentation, and groundwater interactions can all occur. For wetlands (outside of channels) changes can include lost water-storage capacity, increased sedimentation and pollutant load, changes in water depth, and changes in groundwater hydrology.

When a stream is altered to improve water flow for the purpose of removing standing water, either within the stream or from adjacent wetlands, a number of changes may take place. By definition, improving water flow increases runoff. This, in turn, may decrease the surface-water storage capacity of the wetland system and decrease the capability of the wetland to retain load (suspended solids). This may increase the load of the water moving through the stream (Brown 1988). Increasing runoff into a given stream tends also to increase erosion, which further increases load (Williams & Feltmantle 1992). Not only is total flow increased, but alteration tends to increase peak flow, which is associated with reductions in faunal diversity (Hynes 1972).

The effects of increased flow and loading are many. At its most obvious, higher peak flows increase scouring of the stream bed by gravel and sand being transported by the water. Bottom dwelling animals are either affected on-site or swept downstream, leaving an impoverished community as flows return to normal (Hynes 1972). Increased flows can also remove organic matter, leaving a sandy bottom on which macrofauna is reduced (Ward 1992). As stated earlier, higher peak flows also encourage erosion, a process that can increase stream load long after sediment controls put in place during the actual drainage work are removed.

High levels of suspended solids alter the stream habitat by:

1. reducing light penetration

2. reducing primary production
3. altering the trophic structure
4. altering nutrient dynamics
5. changing thermal conditions
6. reducing oxygen levels (Ward 1992).

These effects can, in turn can have the following impacts on the stream fauna:

1. abrating respiratory epithelia
2. clogging respiratory structures
3. reducing feeding rates
4. reducing feeding efficiency
5. increasing exposure to toxins
6. reducing vision
7. inducing organisms to drift.

All of these effects can alter behavior patterns, change predator/prey interactions and change the outcome of inter and intra-specific competition (Ward 1992).

Maintenance for the purpose of reducing mosquito breeding also includes removing obstructions within streams. Tree branches and fallen trees are a particularly important part of the stream environment, providing food, living space, concealment from predators, protection from abiotic conditions and emergence sites (Ward 1992). They also provide varied microhabitats by deepening and slowing flow on the upstream side and often creating deeper pools on the downstream side. Removing these obstructions diminishes the variability of the stream ecosystem.

At the other end of the flow-rate spectrum, increasing peak flow may lead to faster drying in intermittent streams. The insect fauna (and biotic community in general) of intermittent streams does not overlap to a great extent with that of permanent streams (Ward 1992). As a general rule, this is because intermittent stream dwellers have evolved to deal with the drying down stream. Survival mechanisms include leaving the stream (swimming down stream or emerging as land-living forms), surviving in crayfish burrows or remaining pools of water, burying either at shallow depths or quite deeply into the substrate or hiding under rocks or leaflitter within or along the stream course (Ward 1992). Streams the dry more quickly, and stay drier longer, may disrupt all of these techniques as insects that emerge as adults may not have enough time to complete development (the primary example being mosquitoes themselves), remaining pools may decrease in size and number and shallow burrows and hiding sites under rocks and leaf litter may become too dry to support the fauna hiding there.

The effect of rapid drying brings up the aspect of the hyporheic zone. This is the interstitial space between the substrate particles in a stream bed. Within the hyporheic zone the macrofauna can find shelter from floods, drought and extreme temperatures, can find suitable and predictable conditions for immotile stages such as eggs, pupae and diapausing nymphs and larvae and, particularly for early instars, protection from predation. Gravel beds provide the best hyporheic zones and animals can often be found many feet down (Ward 1992). This hyporheic zone fauna can be an important source of recolonizing organisms after a stream bed is denuded (Williams & Feltmantle 1992). Excessive drying can reduce the viability of the hyporheic zone.

Sedimentation, both within stream beds and in wetlands into which streams flow, is a problem because it can alter the stream bed composition, thereby altering the fauna, and can clog interstitial spaces, thereby reducing the hyporheic zone and/or reducing groundwater recharge. Sediments can also increase exposure to pollutants as they provide additional sites for pollutant binding while suspended, and then carry the pollutants to the benthic fauna.

MCPs routinely conduct maintenance to remove sediments. Therefore, there is good reason to expect the overall effect of maintenance may be to reduce the negative impacts of sedimentation within the stream. In such cases, it would be preferential to develop systems designed to prevent the deposition of road sand into drainage systems, rather than to prevent the removal of that sand, once it has entered the system. Removing the dense, rotting masses of grass clippings that are dumped into streams by property owners should also improve overall stream quality.

Up to this point the discussion has focused on the stream itself, but freshwater wetland alterations are typically designed to change standing-water wetlands to soil-saturated wetlands (New Jersey DEP 1997). The obvious problem is that any organism that requires standing water for periods other than peak flooding, the wetland may become unusable. Mosquitoes fit this definition perfectly, but so do many other organisms. Many species of amphibians use temporary standing water for breeding and are becoming scarce as these habitats are eliminated.

Increased drainage also may have an effect on groundwater. Precipitation and inflow determine the amount of water initially available to a wetland for ground water recharge (Todd 1972). Increasing the amount of water removed from the wetland prior to percolation downwards can decrease the capacity of the wetland to recharge groundwater supplies. Not only can groundwater recharge within the wetland lowered, it can be lowered with the outflowing stream as well. During peak flows, water moves from the stream into the substrate and raises the water table (increases groundwater). As the flow declines, groundwater percolates back into the stream (if it does not, the stream dries out). By eliminating upstream reservoirs (wetlands), more water flows out of the system initially, leaving less water within the system. As water levels fall, groundwater discharge occurs sooner than might otherwise be the case. If nothing else, stream depth is liable to vary more widely after adjacent wetlands are reduced to soil saturation.

What is most needed is a comprehensive understanding of the true ecological costs of physical alterations for mosquito control. This is particularly important because, although the environmental effects of pesticides receive the lion's share of concern, it is possible that the long-term effects of physical controls may have a greater effect on the environment than does pesticide use (Buchsbaum 1994). This may be especially true today with the switch from broad-spectrum, more-persistent pesticides to methoprene and Bti.

New Jersey has recently updated it's Best Management Practices for Mosquito Control and Freshwater Wetlands Management and Massachusetts should look to such guidelines to establish a protocol for physical control in freshwater wetlands. At a minimum the common-sense requirements that all alterations be planned (not random), necessary, and desirable should be rigorously applied to all MCP water management projects regardless of whether they are defined as new or maintenance work. The North East Massachusetts MCP Standards for Ditch Maintenance (Appendix F) can be viewed as a starting point for a statewide protocol, though it fails to mention the need for sediment controls during maintenance work and leaves the MCP superintendent with wide latitude for determining the necessity of a given project. A response from the Massachusetts Audubon Society (also Appendix F) to these Standards provides additional comments which deserve consideration when a protocol is established.

c. Vernal Pools. Vernal pools form in contained depressions in which water stands for a period of several months, generally from mid- to late winter through the spring. Water either comes in the form of snow melt or spring precipitation or can be a result of a rising water table. Some pools dry down within two or three months, others may only dry when the water table is lower than normal, resulting in a pool that is semi-permanent. Regardless, a key feature of vernal pools is that they undergo periods of dry down. Vernal pools may have permanent inlets but do not have permanent outlets (Kenney 1995).

There are numerous obligate species for vernal pools, the most visible of which include fairy shrimp, the wood frog (*Rana sylvatica*) and several species of salamander (*Ambystoma* spp.).

The Massachusetts Division of Fisheries and Wildlife (Publication #15498-10-600-6-1-88C.R) has created guidelines for certifying vernal pool habitat on the grounds that many vernal pool species cannot successfully survive without vernal pools and that vernal pools are under pressure from continued development within the state. The certification program is coordinated by the Natural Heritage and Endangered Species Program (NHESP - see next section). "Automatic" protection is given to vernal pools only if they

1. occur either (a) within the 100 year inland flood plain or (b) on "isolated land subject to flooding" (as defined in the regulations at 310 CMR 10.57 (2)(b)); and

2. its existence and location has been certified by the Massachusetts Division of Fisheries and Wildlife.

Curiously, upland vernal pools are not granted the same protection but may be certified as vernal pools. The NHESP does not seek out pools to certify; it certifies submissions from the public. A guidebook for vernal pool certification (Wicked Big Puddles) is available to help those who wish to submit a vernal pool site for certification (Kenney 1995).

Mosquitoes, particularly *Ae. canadensis*, also use vernal pools for breeding. From a control perspective, vernal pools are important because, due to increasing protection, vernal pool habitat is often left undeveloped while the land adjacent to the pool is built up. As a result, many new developments surround known breeding sites. Regardless of the wisdom of developing so close to vernal pools, mosquito-control personnel are charged with controlling the mosquitoes coming from the pool.

d. Rare and Endangered Species. Hynes (1972) states three axioms of running water biotic communities:

1. The greater the diversity of the abiotic system, the greater the number of species within the system.

2. The more conditions deviate from the normal, the fewer species will be present, but those remaining will be present in greater numbers.

3. The longer a system is left undisturbed, the richer and more stable is the biotic community.

Operating under the assumption that it is rare and endangered species which are most likely to be lost from the system first, the above statements would suggest that reductions in habitat diversity, alterations from the natural state, and frequent disturbances will all work against these species. Channelization of streams reduces diversity by removing obstructions, straightening the channel and increasing flood levels. Wetlands changed from standing-water to saturated-soil regimes have been drastically changed from their natural state. Maintenance is ongoing, as is the disturbance it causes.

The key question is, however, to what extent does mosquito control contribute to the above problems. First, Massachusetts MCPs do not channelize streams, as their certification manual calls for following the existing meanders. Second, MCPs work neither in historically undisturbed, nor currently undisturbed streams. There is every reason to argue that there is no specific "natural" state that can be assigned a ditch dug by man and intermittently filled with road sand and grass clippings. Even with natural streams, the "natural" habitat in which they flow has long been altered and continues to be altered.

The Natural Heritage and Endangered Species Program (NHESP) was created in order to conserve and protect those plants and animals not hunted, fished, trapped or commercially harvested in the state. The program's highest priority is to inventory rare and endangered species and to develop conservation plans through research, management and habitat protection for those species. One such program that directly impacts mosquito control is the vernal pool certification program mentioned above.

The NHESP also reviews proposed alterations to wetlands habitats under the Wetlands Protection Act (M.G.L. c. 131, s. 40 and regulations 310 CMR 10.00). NHESP has produced a series of estimated habitat maps for rare and endangered species (Massachusetts Natural Heritage Atlas) which proponents of a given alteration are required to check. Should a project fall within an estimated habitat, NHESP will then determine if the area to be altered is actual wetland habitat for a state-listed species. The results of the NHESP determination are given to the inquiring MCP.

The Massachusetts Endangered Species Act (M.G.L. c. 131A and regulations 321 CMR 10.00) prohibits the "taking" of rare plants or animals. From a mosquito-control perspective, the most important definition of "taking" is disrupting nesting, breeding or feeding sites of animals or killing or cutting a plant. Aside from directly protecting rare or endangered species, this Act also allows areas to be designated "significant habitats." Alterations in "significant habitats" require a permit from the Division of Fisheries & Wildlife.

In Massachusetts, the species that have caused modifications in mosquito control practices are the Blue-spotted salamander (*Ambystoma laterale*), Mystic Valley amphipod (*Crangonyx aberrans*), and banded bog skimmer (*Williamsonia lintneri*). In addition, ditch maintenance in vernal pond areas has been curtailed to protect this type of habitat. Other animals for which concerns have been raised are the yellow-spotted turtle and osprey.

The presence of a threatened species need not prevent water management, however. In the East Volusia Mosquito Control District in Daytona Beach, Florida, OMWM was carried out in a salt marsh that contained the Atlantic salt marsh snake (*Nerodia clarkii taeniata*). An observer walked in front of the ditching machinery and work was halted until observed snakes left the area. In practice the snakes were difficult to spot and several were seen in the freshly cut ditches behind the ditcher. Two dead snakes were found, and assumed killed by the work. The dead snakes were handled as "incidental take" and placed on ice for delivery to the Florida Game and Fresh Water Fish Commission (Goode 1996). With an increased understanding of the ecosystems in which mosquito control takes place, mosquito control projects should improve their ability to work in areas containing endangered species with minimal impact to those species.

Under the current system mosquito-control maintenance activities are exempt from the Massachusetts Wetland Protection Act, leaving only the federal 401 Water Quality Certification Act and both the Massachusetts and federal Endangered Species Act as methods for regulating maintenance. Unfortunately, water quality, while important, does not address the issue of changing habitat and the presence or absence of a rare and endangered species has little to do with the merits of a given project.

Rare and endangered species will probably increase in their impact for several reasons. First, as data is collected on these species, additional species and additional habitats will most likely come under protection. Second, residential areas are creeping closer to wetlands areas. The net effect is that the clash between economic development and environmental protection will likely increase, with mosquito control being one component of an intense debate. Again, a more comprehensive understanding of the true ecological effects of mosquito control is required to better determine the cost/benefit ratio for different types of mosquito control.

D. Food Web Effects of Mosquito Control.

Throughout their life cycle mosquitoes are a part of the food web, both as consumer s and prey. As larvae most species feed on algae, protozoa, and organic debris (Pennak 1953). As adults they drink nectar and the females of most species take blood meals from a wide variety of animals. Larval mosquitoes are eaten by an impressive array of animals (Bates 1949) while adult mosquitoes are taken by spiders, predatory flies, odonates, bats and birds (Collins and Washino 1985). Given that mosquitoes are so thoroughly embedded in the food web, the question arises as to the effect of removing a large percentage of the mosquitoes from that food web.

At first glance, the effect would appear to be large, particularly in habitats with dense larval populations. However, mosquitoes are r-strategists, in that they produce large numbers of eggs that develop quickly (when immersed in water) to adulthood. Most pest species seek out temporary and spatially disconnected habitats for breeding and can complete a breeding cycle long before an adequate predator complex can develop. Mosquitoes are, therefore, a highly unpredictable food source for predators, and predation rates must be equally unpredictable (this section will focus on predation, as parasites and pathogens are not widespread control agents in Massachusetts). This is borne out by the fact that mosquito predators are generalists which can readily switch to other prey when mosquitoes become scarce (Collins and Washino 1985). In a study in Florida, immature mosquitoes made up over 50% of the diet of several species of saltmarsh fish (*Fundulus confluentus, Lucania parva, Gambusia a. holbrooki*). But each of these species fed on other items as well, including copepods, shrimp, other fish and even some plant material (Harrington and Harrington 1961).

One important point regarding predation and larval broods is that the concepts of handling time and satiation come in to play (Varley et al. 1973). A predator must spend a certain amount of time with each prey. Hydrophilid larvae took several minutes to feed on larvae and pupae taken in a panne in Tiverton, Rhode Island (Christie, pers. observation). Not only does it take time to catch and eat the prey, but invertebrate predators are typically not much larger than the mosquito larvae they are attacking. Satiation must play a role in limiting predator take, particularly when mosquito numbers are high.

Predators can play an important role in regulating mosquito numbers in some situations. That mosquitoes are absent from waters with fish populations is well known. Less well known is the influence of chaoborid larvae, which can severely reduce mosquito populations in vernal pools (Morrison and Andreadis 1990). In this case the larvae are present in snow-melt pools for approximately two months, so predation has time to operate as a regulating mechanism.

Although adult mosquitoes are eaten by numerous predators, it is rare that they make up an appreciable proportion of the diet of any one predator. One exception is the spider *Tetragnatha montana* for which, in Poland, mosquitoes made up 74% in June and 62% in July of all prey captured (Collins and Washino 1985). Bats and purple martins are not effective mosquito predators nor do mosquitoes form a significant part of their diet.

From a mosquito-control perspective, the mosquitoes to be controlled are, for the most part, those which have escaped predation to become predators in their own right. In the absence of scientific data supporting the necessity of mosquitoes in the diets of specific animals, removing mosquitoes from the food web by chemical, biological or physical control remains an easily justifiable activity. Even so, control personnel should take care to avoid chemical applications where mosquito larvae are not present or are present in very small numbers, should use control measures that do not harm existing predator complexes, and should limit control to areas where control is necessary, allowing natural cycles to continue in areas where human activity and the risk of disease transmission is slight. One argument made in favor of Altosid is that it does not kill the young larvae, leaving them available as food for the existing predator complex.

Up to this point, the discussion has focused on the effect of chemical control (including *Bacillus* products and IGRs) of mosquito populations on other species. Within the context of biological control, one of the primary reasons *Gambusia* are not being used in Massachusetts is the fear that they might displace native species of fish, thus altering the natural biota, not by predation but by competition for the same resource.

Physical control by water management may increase predation, as in OMWM, or may eliminate predator and prey as when wetlands are drained to soil saturation. Mosquito breeding must be thoroughly documented before new work is done. Because disturbances may displace some species, and because predator species tend to rebound more slowly than their prey, maintenance work should be conducted only when necessary.

E. No Program

Another alternative strategy to current mosquito control practice is no control. Many communities in Massachusetts have chosen this option. These town are usually outside of the enzootic EEE zone so the risk of human diseases transmitted by mosquitoes is viewed as practically nil by these communities. In addition, they are not located near salt marshes and their attendant pest mosquito problems. The mid-section of Massachusetts, where most no-control communities occur, also has a more rural character, less wetland , lower human populations, and a lower mean family income than most eastern areas with organized mosquito control programs. In general, the view of these communities is that the anticipated benefits from mosquito control do not outweigh the anticipated costs and perceived risks.

A more precise way of polling the public and confirming this opinion would be through establishing the Human Annoyance Threshold (HAT) for the town. Communities in which the HAT is below the actual annoyance level should be persuaded to choose the no control option since justification for control is lacking unless a documented disease threat exists.

In some communities, biting annoyance is created by a combination of biting insects (i.e. mosquitoes, black flies, biting midges and tabanids) which require completely different control approaches. Many people do not recognize the difference between these insects, especially in dim evening light. It is critical to accurately identify the biting insects actually responsible for the human annoyance. In general, black flies and tabanids only cause annoyance during the daytime while mosquitoes and biting midges are most annoying from 6-10 PM. The HAT level for tabanids and biting midges is likely to be less than for mosquitoes because of their more painful bites.

Perhaps part of the reason why Berkshire County communities have supported a MC program while other Western Massachusetts communities have not, lies in the fact that this region supports many summertime outdoor activities (e.g. camps, resorts, golf courses, Tanglewood, etc.). In addition, this more mountainous region has a significant black fly annoyance problem superimposed on top of the mosquito problem. Vacationers are likely to have a lower HAT than permanent residents since they are spending more time and money on outdoor recreational activities.

In addition to risk-benefit considerations, other criteria for weighing the control/no control option are 1) the feasibility of successfully reducing annoyance below the HAT level, and 2) the adequacy of community resources for reducing annoyance to acceptable levels.

Towns with large areas of mosquito-producing freshwater wetland should recognize that effective mosquito control in these habitats is difficult at best and often impossible. As indicated earlier in this report, permanent wetlands do not usually produce large numbers of pest mosquitoes but in situations where they do, the public needs to be aware that these wetlands are a valuable resource that must be protected from significant perturbation and that options for mosquito control are therefore few. Community planning boards and zoning laws can and should be used to restrict residential development and other human activities from such wetland areas.

Towns with annoyance problems but with large land areas and thinly, scattered populations must understand that the same level of mosquito control achieved in more populated communities will cost them significantly more per capita. In many such cases, the economic status of the population means that insufficient tax dollars can be generated to adequately deal with the problem.

Nantucket provides an interesting case study. Mosquito control had lapsed in the early eighties. However, by 1989 saltmarsh mosquitoes were becoming a significant problem in the west and north areas of the island. The town began applying Altosid (including aerial applications of pellets in 1992) to control the mosquitoes while. getting the requisite permits for OMWM in several west-end marshes (Madaket, Warren's Landing Eel Point). The OMWM systems were dug in January 1993 (Christie 1993). It was hoped that the OMWM alone would be sufficient to control mosquitoes but large-scale breeding continued in the north end (Pocomo) and the low tidal range has hindered the effectiveness of the OMWM as dug. As a result, some lariviciding continues. The conclusion on Nantucket is that mosquito control against saltmarsh mosquitoes must be continued at some level in order to provide residents with the summer environment they want. However, Nantucket does not target freshwater mosquitoes at all and does no adulticiding. Nantucket and Cape Cod together indicate that adulticiding is not a requirement even in high-tourist areas.

It is difficult to measure the impact of choosing the no control option. The example of towns that have left, and left and later rejoined MC projects is perhaps the only available basis for estimating public opinion concerning such impact. No documentation of annoyance levels, cases of disease, recreational dollars spent, etc., was ever attempted in these towns when they had mosquito control versus when they did not. Thus, public complaints were apparently the main indication of the impact of the no control option that was used in guiding town decision making.

In the 1986 questionnaire, only about 10% of the towns in organized projects indicated that there had been controversy relative to leaving, joining, or rejoining a project. Those that had experienced controversy indicated that 4 factors were about equally involved. These were: 1) monetary constraints, 2) concern over the effectiveness of project control programs, 3) concern over the safety of the methods used by the project, and 4) concern over the environmental impact of the control procedures. Paradoxically, 86% of these towns indicated they were unwilling to spend more money (if legally possible) to obtain more effective control and 67% indicated unwillingness to spend more money to support less hazardous control methods. However, the bias of the people filling out the questionnaire sent to each town may have influenced these responses; no town in Massachusetts has actually polled their citizens on these questions. In fact, some towns within projects have taken advantage of new provisions which allow towns to collect additional money for MC activities which projects can then only spend in these towns.

Among towns that actually withdrew from MC programs, monetary constraints played a role in 73% of these decisions, followed by environmental concerns in 32% and concern over effectiveness in 27% of these cases. Towns that contemplated withdrawing but did not do so, indicated that monetary and effectiveness considerations dominated their concern.

The number of towns in MCPs declined in the late eighties. Economic factors, not environmental concerns, were the dominant reason given for withdrawal. This trend has reversed itself significantly in the last several years. The 1990 EEE problem is probably one reason, coupled with the fact that several coastal programs tried the no-control option and found mosquito numbers rose quickly.

Many towns in the Berkshire County and South Shore projects withdrew in 1981 mainly in response to Proposition 2-1/2 monetary constraints. The remaining 8 towns in Berkshire County subsequently chose to continue as a multi-town Project (Note: the town of Lanesborough rejoined in 1986, the city of Pittsfield rejoined in 1988, and other towns are contemplating reentry). South Shore actually disbanded as a project but by 1988 most towns had joined neighboring MC projects in Norfolk and Plymouth Counties. These actions suggest that these communities were not content with the no control option that resulted from the disbanding of their former project. Towns that voluntarily withdrew from MC projects but then later rejoined a project, did so for a variety of reasons. These were in order of their importance: increased public support for MC, increased mosquito annoyance, alleviation of monetary constraints, threat of EEE, improved methods and effectiveness of the project.

The Environmental Impact Statement (Sjogren 1977) prepared for the Metropolitan Mosquito Control District in Minnesota attempted to quantify the no control option for their community. Any attempt to develop similar estimates for Massachusetts would be meaningless given the lack of appropriate baseline data.

B. Biological Control.

1. Introduction

Biological control includes attacks on the pest species by other species and manipulation of the pest species itself. The former includes the traditional biological control agents, predators, pathogens and parasites, whereas the later includes such techniques as sterile-male release and genetic manipulations.

Biological control agents are grouped into three categories: predators, parasites and pathogens. Predators include both vertebrates and invertebrates and may attack both adult and immature stages of mosquitoes. Helminth, protozoan and fungal parasites and microbial pathogens generally only invade immature stages, though mortality may not occur until the early adult stage. Parasitic water mites are an exception in that they attach to certain adults as they emerge from the pupal stage and apparently reduce adult survivorship if they are abundant (Lanciani & Boyett 1980) In general, biological control is much more feasible in managing permanent water mosquitoes than temporary water forms.

There are three basic strategies for utilizing all biological control agents: (1) increasing existing natural enemy populations by habitat alteration, (2) one-time introduction of sustainable exotic agents from other regions or habitats, and (3) augmentation of natural or exotic enemy populations by repeatedly releasing non-sustainable, lab-reared (or field collected) organisms. To date only the first, increasing fish habitat through OMWM, has been used in Massachusetts. Bti is sometimes classified as a biological control agent but its application technique and mode of action as a stomach poison more closely resemble a pesticide than a biological control agent *per se*. *Bacillus sphaericus* may more closely fit the model of repeatedly releasing non-sustainable lab-reared organisms as there is evidence to suggest that it recycles within the environment.

No other biological control agent is currently available for general field use, though experiments continue with may different organisms (see below). There are important reasons why biocontrol is not more widely used against mosquitoes. First, the differences in biology of the various species of mosquitoes make it unlikely that any one control agent will operate across a wide range of species. Second, mosquito breeding is wide spread, making it difficult for a biological control agent to find, or be placed in, all breeding areas. Third, predators such as bats and purple martins, may eat mosquitoes but prefer to eat other, larger insects. Further, even when abundant, they do not drive mosquito populations below levels that people generally find intolerable. Finally, there is a high cost associated with sustained releases of a biological control agent and there are not, at this time, control agents available that require a single, or a few, releases to become established.

Because of the limited application of biological control to mosquitoes in Massachusetts, the following discussion will focus primarily on the feasibility of control agents currently being studied for mosquito control. An important point to make regarding biological control is that the mosquito control have limited research capabilities. While conducting field evaluations of new control techniques is a desirable practice for any mosquito control program, the projects should not be expected to find and bring forward biological control agents without substantial help from research institutions such as the state university.

2. Predators

a. Introduction

In order for any predator to independently be an effective control agent, it must meet two important criteria: (1) its size and abundance in relation to the target species must be sufficient for it to kill or consume a high percentage of the prey population within a relatively short time period, and (2) its feeding behavior should be selective toward the prey species when it is present but allow it to utilize other food items when the target species is absent. These criteria are rarely met in full. Predators that are sufficiently large and/or abundant to have a major impact, usually lack feeding specificity. Conversely, those with feeding specificity are usually less abundant because their populations are regulated by a more restricted food supply. Vertebrate predators of insects have a clear size advantage but invertebrate predators tend to exist in much greater numbers.

Because of the limitations of predators as biocontrol agents, it is normally essential to continuously raise and release the predator to achieve field densities high enough to cause real reductions in the prey species. However, in some cases, manipulation of the environment to the advantage of natural predator populations can provide an adequate augmentation effect.

b. Vertebrate predators

<u>Fish</u>

Larvivorous fish are the oldest and perhaps most effective traditional biological control agent used against mosquitoes. In certain habitats they may, by themselves, provide adequate larval control throughout the breeding season. If not, pesticides such as BTI or methoprene which are non-toxic to vertebrates can be used in an integrated fashion with fish.

As already mentioned, the main reason open saltmarsh management strategies effectively control many saltmarsh *Aedes* in the Northeast is because this method provides access for the abundant estuarine populations of larvivorous killifish (*Fundulus* spp.) into the mosquito breeding pools in the high saltmarsh (Hruby & Montgomery 1986).

The mosquitofish *Gambusia affinis* is distributed widely throughout the warmer parts of the world and is the species most often reared and introduced into fresh water habitats for mosquito control. The biology and use of this fish in mosquito control was reviewed by Meisch (1985). It is an opportunistic feeder and avidly eats pupae and late-instar larvae of culicines and chironomids. It is most effective against *Culex* in unvegetated, permanent ponds but has been widely used in California and the Gulf States against ricefield *Aedes* and *Psorophora*.

Because *Gambusia* is so aggressive and fecund, it may replace important commercial or rare native fish species. This has raised environmental concern over the introduction of this fish into natural waters where it does not already occur. A recent article by Rupp (1996) has renewed this debate, both emphasizing real successes and real concerns over *Gambusia* use (see “Comments on ‘adverse Assessments of *Gambusia affinis*’” (JAMCA 1996) and Boklund 1997, Eliason 1997, and Rupp 1997). Because it is not a native species of Massachusetts it may not be imported and released in state waters.

Outside of the mosquitofish, the common guppy (*Poecilia reticulata*) has received the most attention for mosquito control (Bay 1985). Comparative studies indicate that it is a less effective predator than Gambusia but it is more tolerant of polluted waters. Many other native fish have been explored for their mosquito control potential (Bay 1985). Studies in North Africa (Allo et al. 1985) suggest that malaria may be controlled through the annual introduction of native fish from streams into the manmade water storage tanks which produce the vector *Anopheles* in this region.

<u>Birds</u>

Many birds depend on insects as food and those which capture insects on the wing (e.g., the swallows), have been credited with consumption of significant numbers of mosquitoes. Purple martins specifically have been promoted on the basis of the claim that they often consume 10-12 thousand mosquitoes per day but Kale (1968) concluded on the basis of existing evidence that all claims of martins significantly reducing mosquito populations were unsubstantiated and, because of several biological facts, were unlikely to ever be demonstrated. The facts on which these conclusions were drawn are as follows:

(1) Mosquitoes were a negligible item in the diet of martins in the only two published studies in which the contents of martin gizzards were examined.

(2) None of the published statements appearing in the popular ornithological literature which attributes a mosquito-eating habit to martins is based on factual study or scientific reference. In fact, there is evidence that martins feed more on larger insects including species of dragonflies which may be predators of adult mosquitoes.

(3) Behavior patterns of mosquitoes and martins are such that they tend to not fly at the same height or at the same time. Thus, contact between the two is minimal.

(4) There is no evidence that any avian species can effectively control a pest insect upon which it feeds when the insect is at or near peak abundance.

Other Vertebrates

Mosquito control by insectivorous bats was tried in the early part of this century but without success (Kale 1968, Storer 1926). Bats continue to appear in the popular press as legitimate mosquito-control agents (Wright 1996) but are not considered worthwhile agents in Common-sense Pest Control (Olkowski et al. 1991), which is very thorough in its coverage of non-chemical control options, or in mainstream mosquito control (Mitchell 1992).

c. Invertebrate predators

Predators of mosquito eggs.

Evidence exists of predation on diapausing flood water mosquito eggs by mites and beetles, and on *Culex* egg rafts by fish (Collins & Washino 1985). Nonetheless, egg predation appears to be a relatively minor component of natural mosquito mortality and is not being studied for biological control.

Terrestrial insect and spider predators of mosquito adults

Predation on emerging and indoor resting adult mosquitoes has been readily observed but the impact of this mortality on populations is extremely difficult to assess. Certain spiders (especially Tetragnatha) and predatory flies (mainly Empididae, Anthomyiidae and Dolichopodidae) have been shown by precipitation tests to have consumed emerging mosquitoes (Collins & Washino 1985). In one British study, up to 28% of the spiders tested had eaten mosquitoes (Service 1973). Certain adult dragonflies reportedly capture mosquitoes on the wing but these observations have not been backed up by any controlled field studies. Synanthropic emesine bugs (Reduviidae) appears to be potentially important predators of indoor resting mosquitoes in the tropics. In sum, the prospect for enhancing or managing invertebrate predators for more effective adult control is not encouraging, especially in temperate regions.

Aquatic insect predators of mosquito larvae & pupae

Aquatic insect predators seldom occur in significant numbers in the temporary floodwaters that produce most pest mosquitoes. Studies of predation have therefore largely taken place in permanent ponds or semi-permanent habitats such as rice fields, rock pools or vernal woodland pools. The adult stage of most predaceous aquatic beetles and true bugs can fly (usually at night) so natural colonization of newly flooded habitats can occur in a matter of days. Development time for these insects is usually from several weeks to several months.

Among the beetles, the dytiscids (predaceous diving beetle), which are predaceous both as larvae and adults, are the most effective predators of mosquitoes. There is evidence from studies in rice fields that adult dytiscids selectively locate and colonize sites with locally high concentrations of mosquito larvae (Collins & Washino 1985). Mass production methods for dytiscids have never been developed. Whirligig beetles (Gyrinidae) only feed at the surface where they may prey on concentrations of emerging adult mosquitoes. Hydrophilids are only predaceous as larvae and seem to feed mainly on chironomid midges.

Only two aquatic families of true bugs, the back swimmer (Notonectidae) and pigmy back swimmer (Pleidae) have received serious consideration as mosquito control agents. Pleids are generally not abundant enough to have significant impact but notonectids can become quite dense in certain habitats. Mass rearing of the latter appears to be possible. Water boatmen (Corixidae) are also common and similar in appearance to backswimmers but they are mostly detritus feeders. Other predaceous aquatic Hemiptera that have been suggested as mosquito predators but which normally occur in insufficient densities to have much value as natural control agents include the giant water bugs (Belostomatidae), water scorpions (Nepidae), water measuring bugs (Hydrometridae) and the two family of surface-feeding, water striders (Gerridae and Veliidae).

Dragonfly naiads have been marketed commercially for mosquito control and at least one town in Massachusetts, and others in New Hampshire and Maine, have purchased dragonflies for mosquito control. In northern climates these insects require 1-5 years to mature, so they normally occur in permanent waters only. Furthermore, many are bottom feeders that seldom if ever come in contact with mosquito species that feed at the surface or in the water column. Most bottom-feeding mosquitoes (i.e. *Aedes*) occur in temporary water containing few if any dragonfly naiads. Another factor weighing against the mosquito control efficiency of these aquatic predators is the fact that they normally occur at low densities. Adults of many species are territorial and this seems to spatially limit population densities of naiads as well as adults. In certain habitats such as rice fields, naiads may become quite abundant but populations fluctuate greatly and their role in limiting populations of rice field mosquitoes is limited at best. No controlled, field studies have been done in which naiads have performed well as biological control agents.

The trichopteran *Limnephilus indivisus* may be an important predator of early spring *Aedes* in woodland swamps in Ontario but most caddisflies are omnivorous shredders rather than predators (Collins & Washino 1985, Merritt & Cummins 1985). Prospects for mass rearing and manipulating caddisfly larvae are not very bright. Many of the aquatic nematoceran relatives of mosquitoes contain groups with predaceous larvae. These include the families Chaoboridae, Chiromomidae, Ceratopogonidae, Tipulidae, Anthomyiidae, and others. Most are too small to consume many mosquito larvae. Predation on small, early instars occurs but it is far less efficient in reducing the numbers of adults than is predation on late instars and pupae. *Mochlonyx* (Chaoborid) predation on spring *Ae. communis* populations has been observed in woodland pools in Massachusetts (Edmans, personal communication) and in Europe (Chodorowski 1968). The impact of this small but voracious predator is unknown.

The insect predator with the most promise in mosquito control is another mosquito. Larvae of the non-biting genus *Toxorhychites* are large and effective predators of mosquitoes that develop in natural and man-made containers such as tires, tree holes, metal cans, and leaf axis (Steffan & Evenhuis 1981). Unfortunately, none of the 70 some species in this mainly tropical genus can survive the winters as far north as Massachusetts. Their use here would therefore require repeated, annual releases of lab-reared females. This is not warranted at the present time since container-breeding species generally do not represent the major nuisance or health threat in Massachusetts. This situation could change if *Ae. albopictus* becomes well established in used tires in the Northeast. Focks (1985) states that although it is possible to control or reduce certain species of container-breeding mosquitoes with inoculative or inundative releases of *Toxorhynchites*, the usefulness of this genus in practical, operational control programs has yet to be demonstrated.

<u>Other invertebrate predators of larvae and pupae.</u>

Among the non-insect predators of the immature stages of mosquitoes, only hydra (Cnidaria: Hydrozoa), flatworms (Platyhelminthes: Turbellaria) and copopods (Cyclopoida) have been studied in any detail.

Both hydra and flatworms can be easily mass produced and, unlike most predaceous insects, they can be maintained at high densities without cannibalism. In the laboratory, they kill far more larvae than they consume. Both groups produce semi-dormant eggs so they occur naturally in shallow temporary pools as well as permanent swamps and ponds. Detrimental effects on young fish have been reported when these predators are at high densities (Mulla & Tsai 1978).

Both of these predators have good potential as control agents in the Northeast but additional long-term field evaluations are needed. As with mosquito fish, the laboratory production, storage, and field translocation of these organisms requires a certain degree of sophistication, which is usually lacking at the local level. Currently, there are no commercial sources for the quantities that would be required for mosquito control applications.

Natural populations of predaceous cyclopoid copepods appear to limit the distribution of container breeding mosquitoes in certain tropical settings (Marten 1984). However, they have never been shown to be important predators in temperate regions or in other types of aquatic habitats. Therefore their potential for the biological control of pest and vector mosquitoes in Massachusetts appears to be nil.

3. Parasites and Pathogens

a. mermithid nematode parasites

Outside of bacteria, parasitic nematodes are the only natural parasites and pathogens that have ever achieved operational status in mosquito control. Known parasitic roundworms of mosquitoes now number over 20 species. The free-living, aquatic, preparasitic stage which hatches from the nematode egg, seeks out and penetrates the cuticle of host mosquito larvae. Larvae are usually killed in the last instar. In a few species, the mature worms are carried over in the adult mosquito and cause mortality when they exit during attempted pseudo-oviposition.

Romanomermis culicivorax (including most references to *Reesimermis nfelseni*) is the species that has been most extensively studied. Methodologies for the mass production and commercial preparation of this species have been developed and it was briefly marketed as Skeeter Doom in the late 1970'g. Low sales and problems with the shipping and shelf-life of viable eggs appear to have been the major factors which led to the marketing failure of this agent (Service 1983). Other economic drawbacks include host specificity which limits its effectiveness to only certain species (e.g., it is ineffective in cold, polluted or brackish water), and the lack of patent protection for companies investing in the production and marketing of this product. In addition, applicators need some special skill and training to effectively use this biocontrol agent. The tendency of this agent to naturally recycle once it is introduced into favorable aquatic habitats is beneficial from a control viewpoint, but it further reduces the long-term marketability and profit potential for private producers. It remains under study, however, as a recent article (Mijares et al. 1997) discussed the establishment of *R. culicivorax* in sewage settling ponds and natural ponds in Cuba.

On the biological plus side, mermithids appear to be highly compatible with a wide range of chemical pesticides and growth regulators. Moreover, they: 1) are non-specific and well suited to the life cycle of their mosquito host, 2) produce high levels of infection and mortality, 3) can be easily mass-produced and applied with standard spray equipment, and 4) offer no threat to non-target organisms or the environment.

There are species of mermithids which appear to be highly specific to spring snow-pool *Aedes* and to saltmarsh *Ae. sollicitans* (Petersen 1985). However, these worms have not been established and studied in the laboratory. Such species may have greater control potential in northern coastal states like Massachusetts than the more tropically adapted *R. culicivorax.*

Since the technology for using mermithids in mosquito control already exists, and there are numerous field trials documenting their control potential, the future availability and use of these biocontrol agents in operational programs seems to depend on changing economic and market forces (Petersen 1985).

protozoan parasites

b. Microsporidia

Virtually all mosquito species carefully examined have been found to harbor these parasites. Larvae are infected by ingesting the spore stage. Spores, which are produced at the end of the life cycle, have often proven difficult to induce and to reinfect larvae in lab cultures. Few microsporidian life cycles are well enough known to assess biocontrol potential. Life cycles vary from simple to complex and often form the basis for the non-taxonomic grouping of these protozoan parasites. The simplest forms (Type I) occur mainly in terrestrial insects and even the one aquatic species known from mosquitoes (*Nosema algerae*), does not cause mortality until, the adult stage. For this reason *N. algerae* has limited potential for reducing pest problems but may impact on disease transmission by reducing survival and fecundity. Wild strains only persist in larval populations for short periods and cause little direct mortality. Type II microsporidia have simple, asexual life cycles similar to Type I forms and they also show little promise in mosquito control (Hazard 1985). Type III forms are dimorphic, have binucleate spores, and kill mosquitoes in the larval stage. Only one species (*Hazardia milleeri*) is known from mosquitoes and it seems to have low infectivity (Hazard 1985). Type IV microsporidia include many species from mosquitoes and have the most control potential. Infected larvae are usually killed but a few females survive and carry the infection via the ovary to the next generation. However, transovarial infection ceases after a single generation. Non-ovarian modes of transmission must exist but this issue along with the possibility of sexual reproduction and alternate hosts are as yet unresolved. Additional basic research is required before any microsporidian can be considered in the biocontrol of mosquitoes (Hazard 1985).

Tetrahymena and *Lambornella* (tetrahymenid ciliates)

The lack of a resistant resting stage and difficulty in culturing these ciliated protozoa has prevented the thorough study and evaluation of this group of potential biocontrol agents. Ongoing studies of *Lambornella clarki* in California treehole *Ae. sierrensis* should help to better assess the control value of these parasites in the near future (Anderson et al. 1986).

Helicosporidium

There is still debate concerning the proper classification of this spore-forming group of parasites; some believe they are primitive Ascomycetes fungi. There are only 3 reports of natural infections in mosquitoes. They appear to infect a wide range of species but also may infect non-target insects as well. High dosages of spores are required to infect older instars in the lab. Continuous cultures of these parasites do not exist so the basic research needed to evaluate their biocontrol potential is not forthcoming.

c. Fungal Pathogens

Coelomomyces

Many forms of pathogenic fungi have been known from both larval and adult stages of mosquitoes since the 1930's. However, it was not until the discovery of the obligate alternate host (i.e., microcrustacea) in the mid-70’s that cultures and full-scale laboratory investigations were possible with *Coelomomyces* (Whisler et al. 1974, 1975). The rather complex life cycles of some species have recently been described and methods for in vivo culturing established. Before wide-scale field application can occur, mass in vitro cultivation of the infective biflagellate zygote stage needs to be developed. If *Coelomomyces*, and perhaps their copepod and ostracod intermediate hosts, are introduced into favorable habitats, the potential for natural recycling exists. However, too little is known about the host ranges and habitat requirement of most *Coelomomyces* to recommend any such introduction at the present time. Moreover, species of *Coelomomyces* do not routinely provide high and predictable levels of mosquito control. It is, premature to critically assess their potential as control agents to be used independently or as part of an integrated control program (Federici et al. 1985). Studies related to their evaluation as operational control agents have only recently been initiated and it is not likely that any *Coelomomyces* will be operational within the near future.

Lagenidium giganteum.

This mosquito-specific water mold is a very promising biological control agent, especially in fresh water and in warmer climates. This fungal pathogen can be mass produced on artificial media and can recycle in as little as 3 hours (McCray 1985). It has a resistant, dormant stage and infects a wide range of mosquito species. Unfortunately, it is not effective in polluted, brackish or colt waters. This limits its commercial value and it potential usefulness in northern and coastal states like Massachusetts (Service 1983).

Other Fungi

Fungi are among the commonest pathogens of insects and many other genera besides *Coelomomyces* and *Lagenidium* have been reported from mosquitoes. Of these, *Culicinomyces* and *Metarhizium* have received the most attention. Both groups infect a wide range of mosquito species but relatively high concentrations are required to cause infection. They can tolerate organic pollution and salinity but not high temperatures (i.e. above 30°C). These fungi can be grown on inexpensive artificial media but no resistant resting stage has been fount. Difficulty in achieving long term storage of infective stages and formulation problems remain as barriers to commercial production. Nonetheless, these fungi are a promising group of biocontrol agents which may provide new mosquito control tools in the future.

Erynia aquatica

Erynia aquatica is an Entomophthorales fungus, and is the only species of the genus known to infect the immature aquatic stages of mosquitoes. It was first discovered infecting *Ae. canadensis* and *Cs. moristans* larvae in woodland pools in Hartford County, Connecticut from late May to early June (Anderson & Ringo 1969). It has since been recovered in early May from *Ae. stimulans* in woodland pools near the village of Cambridge, New York (Molloy & Wraight 1982) and from *Ae. cantator* on May 21, 1981 in a shallow salt meadow pool in Milford, Connecticut (Andreadis & Magnarelli 1983). Most recently, is was discovered in 1995 and 1996 in a woodland pool in Bristol, Rhode Island (Christie 1997).

Steinkraus and Kramer (1989) collected *Ae. fitchii* larvae infected with *E. aquatica* from a semi-permanent woodland pool in Tompkins County, New York. They used infected pupae to successfully transmit the disease to emerging adult *Ae. aegypti,* on which resting spores of the fungus developed.

Erynia aquatica has characteristics which make it attractive as a microbial agent: it is capable of causing epizootics, has been found in both freshwater and brackish water mosquitoes and has a resting spore stage that may survive well in storage. Operating against it is the fact that it has only been found in cooler, springtime waters. One thought is that infected pupae may be removed from the original infestation site and placed in other, nearby pools. A fungus that kills in the pupal stage works against its own spread.

d. Bacterial pathogens

Bacillus thuringiensis var. *israelensis*

Bti Serotype H-14 has become an important biological larvicide following its discovery in the Negev desert in 1976. Within the last 5 years it has become widely used by the mosquito control projects in Massachusetts. It is now the larvicide of choice in many situations because of its host specificity, high and rapid mortality to many mosquitoes species, and its environmental safety. It is quite distinct from the Bt strains which infect lepidopterous insects. Its track record in controlling polluted-water *Culex* is mixed, apparently because it sinks to the bottom and the active moiety rapidly binds to organic particulates. Consequently, higher dosages are required to achieve good control in highly organic and deep-water situation. Saltmarsh mosquitoes generally require rates at the high end of the labeled application rates for effect control. Liquid, powder, granular and slow-release briquet formulations are commercially available.

Bti must be ingested to cause toxicity to filter-feeding mosquito larvae; pathology occurs in cells of the midgut wall. It is least toxic to 4th instars since they cease feeding at least 12 hours prior to pupation. The mosquito toxic ingredient of Bti preparations is the heat labile deltaentotoxin located in the proteinaceous parasporal crystalline inclusions synthesized concomitantly with the spore during sporogenesis. Once released in the environment, it biodegrades rapidly (it is usually only active 1-3 days) and this bacterium (gram negative Bacillaceae) does not recycle. This is considered the only major drawback of this highly effective mosquito pathogen but it has enhanced its commercialization (Lacey & Undeen 1986).

The biocidal activity of Bti toxin appears to be limited to larvae of certain families of nematocerous Diptera. A large number of laboratory and field tests have confirmed that all non-nematocerous, non-target organisms are virtually unaffected (Lacy 1985). All existing data indicate that the unaltered protoxin of Bti is also safe to vertebrates including humans (Lacey 1985). Further improvements in the efficacy and price competitiveness of this control agent, brought about by formulation changes and genetic engineering, are likely to occur in the near future. In addition, formulation of this agent with other compatible and perhaps synergistic agents such as juvenile hormone analogs (e.g. Altosid) is currently underway. Such mixture have two important advantages. They reduce the likelihood of mosquitoes developing resistance to either agent and, secondly, they widen the window for control since Bti is most effective against early instars and growth regulators against later instars.

Bacillus sphaericus.

Although only recently available, *B. sphaericus* may have greater control potential than Bti because of its ability to continue to recycle once it is introduced. It has many of the same beneficial attributes of Bti but all strains isolated to date are less effective against a wide range of species than is Bti. At the moment it is primarily marketed against *Culex* in high-organic waters but research is on-going in expanding its control potential.

e. Viral Pathogens

The biological control potential of both non-accluted (iridoviruses and densonucleosis viruses) and occludet (baculoviruses, cytoplasmic polyhedrosis viruses and entomopox viruses) viruses pathogenic to mosquitoes has recently been reviewed by Federicci (1985). It is sufficient here to simply paraphrase from the summary of this thorough review as follows:

Analysis of research conducted to date makes it clear that none of the viral pathogens of mosquitoes can currently be considered good candidates for mosquito management programs. The two main reasons for this assessment are that viruses discovered so far possess low infectivity for original or alternate hosts and there is no readily available method for mass production of virions. This apparent lack of control potential is most obvious when one considers that few field trails have been conducted with these agents even though the first one was discovered over 15 years ago. While it appears unlikely that viruses will be developed for mosquito control in the near future, they may prove to be extremely useful microbial agents in the long term, perhaps in 2 or 3 decades, once we learn how to manipulate them effectively. Biotechnology has the greatest potential for engineering new more useful biocontrol organisms among the viruses because of their simple molecular structure.

4. Pest Species Manipulation

A somewhat different approach to biological control is manipulation of the mosquito genome to either 1) induce reproductive failure (leading to population elimination) or 2) bring about permanent changes in the behavior or physiology of the target population so it no longer vectors disease or bites people. There are numerous theoretical mechanisms by which this could be accomplished. Following is a brief discussion of the three approaches that have been most commonly discussed and researched.

a. Sterile Insect Technique

The early and continuing success of the sterile male release program in eliminating the screwworm fly from the U.S. and Mexico has given rise to many investigations and new ideas for controlling other insects (inoculating mosquitoes) through the use of this or some other genetic technique. Except for fruit flies, this method has not yet been successfully applied to other insects in operational programs and the technique is not currently being pursued for mosquito control.

b. Incompatibility

Incompatibility resulting from a lack of fertility in sexual unions may occur due to a variety of genomic failures or due to the effort of bacteria-like symbionts to control the reproduction of host (Barr 1985). The feasibility of suppressing *Culex pipiens* through cytoplasmic incompatibility was demonstrated in a Burmese Village over 20 years ago (Laven 1967) but the practicality of this method has not been confirmed by any other field tests. Moreover, incompatibility factors have been isolated in only a few mosquito species to date.

c. Chromosomal Aberrations

There are several heritable chromosome rearrangements that can, in theory, be used to inject genetic load into a mosquito population and/or to effect a permanent change in the genetic makeup of the population. These aberrations can be used to 1) increase genetic lethal load (serility is limited to 50-80% because of the low chromosome number (three, in most mosquitoes) or 2) replace noxious species with harmless strains if appropriate viable homozygous rearrangements are available. The latter is perhaps only applicable in the case of important disease vectors. Naturally occurring aberrations can be screened for in wild populations but their frequency is greatly increased through exposure to mutagens.

Controlling mosquitoes through the use of chromosomal aberrations requires a major basic research effort and a target species that is easily colonized. This later requirement automatically eliminates many important species from consideration.

d. Competitive Displacement

The final, and somewhat abstract, strategy for controlling mosquitoes biologically is the ecologically based notion of displacing a noxious species by introducing a benign but more competitive (i.e. better adapted) exotic one. This idea has been suggested primarily to control container-breeding species like *Ae. aegypti*. However, benign mosquito species are difficult to find, as most mosquitoes that have become established (*Ae. aegypti, Ae. albopictus*) are as bad or worse than the species with which they compete (container-breeding *Culex* and *Ae. triseriatus*).

5. Other Control Approaches

a. Trap out techniques. All experience to date indicates that while various traps may be good sampling devices for adult mosquitoes, they are too inefficient and limited in their range to provide any benefit in reducing biting annoyances (Nasci et al. 1983). Work is ongoing on attractants (octanol) that would both greatly increase trap collections of mosquitoes and reduce non-targets trapped, but no products are marketed for this purpose to date.

Electrocutor traps ("Bug Zappers") continue to be a popular item, with an estimated 1.75 million sold in the United States each year (Mitchell 1992) but they are extremely non-specific (mosquitoes generally make up less than 5% of the catch, and may be harmful to other insect species. They cannot be considered a part of any mosquito-control program.

b. Repellents. Personal protection through the use of mosquito repellents is an appropriate alternative to controlling the mosquito populations before they bite. This is especially true if the periods of annoyance are infrequent and brief and where the land areas are too vast and unpopulated to economically consider control programs.

The most commonly used mosquito repellent is DEET (N,N)(diethyl-metatoluamide) which has been formulated and sold under a variety of trade names (e.g., Off, Muskol, Cutters), in a variety of concentrations and as both aerosol sprays (usually ca 15%) and lotions (up to 100%). Laboratory tests have shown that maximum repellent duration (ca. 1-2 hours) is obtained with a concentration of ca. 50% so that higher concentrations do not provide appreciable advantages. The major disadvantage o£ DEET are:

1) relatively short protection time

2) somewhat offensive odor

3) damage to some fabrics and surfaces at higher concentrations

4) high cost

5) possible hazards from heavy use

Small children frequently have skin reactions to DEET. Small children are also most likely to be the individuals that develop meurotixicological symptoms from DEET. Thirteen of 14 cases of encephalopathy (toxicity of the central nervous system), found in publicly available reports by a recent review (Osimitz and Grothaus 1995), were in children 8 years old or younger. Three of these children died, all having used "heavy" amounts of repellent, even though the repellent in each case had DEET concentrations of 20% or less. Oral ingestion may have played a role in some of the cases. Osimitz and Grothaus (1995) concluded that there is no evidence that increased DEET concentration has an effect of the severity of symptoms. They also compared reports that the Poison Control Center received for DEET (6,724 in children under 6 years old during a five-year period) to laundry detergent reports (10,789 in 1989) and household bleach (16,169 in 1989), concluding that accidental exposure, while undesirably high, is in line with, or lower than, exposure to other household chemicals.

There is one unsubstantiated report in the Russian literature of carcinogenic effects in rats at high doses.

Three other repellent materials are in common use. Dimethyl phthalate (generally sold as 6-12) is not as effective as DEET against mosquitoes but still has a share of the market. Citronella-based repellents have long been marketed as candles or in oil-burning lamps. Citronella is also available as a repellent to be sprayed in skin and clothing (Natrapel). The third material (Avon skin-so-soft) is a popular bath oil that is not marketed as a mosquito repellent but has, through word of mouth, been recognized for its as yet uncharacterized mosquito repellent affect. It is as effective as DEET but it does not persist as long. On the other hand, it is much cheaper, smells better, and apparently does not damage any fabrics or surfaces. The active ingredient(s) of skin-so-soft has not been isolated or identified to date. It also has not undergone the EPA safety testing that other repellents have because it is marketed as a beauty aid rather than a pesticide (Note: repellents are classified as pesticides by EPA).

Electronic mosquito repellent devices which are periodically marketed in the U.S. (usually by mail order houses) are completely ineffective and are not based on any biological rationale (Foster & Lutes 1985, Mitchell 1992, Curtis 1994).

C. Physical Control

1. Types of Habitat Modification

a. Open marsh water management (OMWM)

Originally developed for New Jersey salt marshes (Ferrigno 1970, Ferrigno & Jobbins 1968, Ferrigno et al. 1969), this strategy basically attempts to overcome the limitations of ditching by the incorporation of other water management strategies. In particular, champaign pools or reservoirs (which permanently hold water and sustain larvivorous fish) are created (by backhoe, dragline or rotary ditcher) in selected tidal pools or large shallow pans and are connected via small shallow ditches to surrounding mosquito breeding depressions. If old ditches are re-dug and used as reservoirs, then plugs must be inserted at the tidal end to prevent drainage. This customized approach to marsh management represents the least deleterious and most efficient nonpesticidal method for controlling saltmarsh mosquitoes and has been adapted to New England conditions (Boyes and Capotosto 1980, Hruby et al. 1985, Christie 1990). A manual outlining this method was developed by the Massachusetts Audubon Society (Hruby and Montgomery 1986) and OMWM is currently being practiced by coastal projects in Essex and Plymouth Counties in Massachusetts. As of 1996, OMWM had become the accepted technique for new salt-marsh water management work, though maintenance work remains dominated by cleaning existing ditching, as opposed to conversion to OMWM.

b. Other Modification Strategies

Mosquito control efforts in Massachusetts predate modern chemical insecticides. Early control efforts consisted of source reduction work, mostly in salt marshes (see “History of Cape Cod Mosquito Control Project, 1928-1971”). This emphasis was largely abandoned when cheap and seemingly more effective organo-chlorine insecticides became available in the early 1950's. Early control programs capitalized on cheap WPA labor but they failed to achieve the level of control that the public has come to expect of modern control programs. Nonetheless, they serve as a reminder that mosquito control, from its earliest inception, considered and practiced control alternatives to synthetic chemical pesticides.

Except for new OMWM projects in salt marshes, mosquito control source reduction work now consists primarily of maintenance work on existing culverts, storm sewers and ditches. Very little new ditch construction has taken place in recent years. Ditch cleaning, which often involves excavating spoil with a backhoe or plow, is an activity which has drawn great concern when it takes place in estuarine environments. This is because many of the old grid ditches in the saltmarsh served no real purpose for mosquito control but they must be re-cleaned periodically or they themselves become shallow breeding areas for saltmarsh mosquitoes.

c. Origination of Requests for Physical Control.

The exemption from certain regulations enjoyed by mosquito control is a two-edged sword. On the one hand, it enables mosquito control projects to more quickly respond to drainage problems. On the other hand, it makes the heading "Mosquito Control" particularly desirable for drainage projects in which mosquito control is, at best, a marginal goal. This pressure can come from property owners, public officials, or from within control projects themselves. The pressure to conduct drainage work that does not have a mosquito-control component must be resisted.

The best interests of mosquito control programs are served by conservative application of the definition of mosquito control, as over-use of the wetlands exemptions may result in the loss of those exemptions. To this end, mosquito control programs, in conjunction with state and federal wetlands protection agencies, must develop a strong set of guidelines for alterations exempt from Wetlands Protection Act.

2. Ecosystem changes of non-target biota as a result of physical controls.

a. Salt Marsh .

New England coastal wetlands have been heavily impacted by man (Shisler 1990). However, evidence concerning the negative impact of saltmarsh ditch maintenance activity is mixed. The principal concern is with disposal of the spoil on the marsh and the invasion of upland plants that can occur with even slight elevation increases (i.e. 1-2 inches) (Miller and Egler 1950, Buchsbaum 1994). Ditching also permits *Spartina alterniflora* to invade the upper marsh (dominated by *Spartina patens* and *Distichlis spicata*) along the edges of the newly created ditches. There is evidence to support the claim that this increases marsh productivity (Buchsbaum 1994).

In 1979, staff biologists from the New England Division of the U.S. Army Corps of Engineers (DeSista & Newling 1979) carried out preliminary investigation in several Massachusetts salt marshes to explore the issue of spoil deposition and upland plant invasion. In many instances they found little plant invasion despite evidence of previous spoil deposition of 2 inches or more in depth on the marsh. In a few locations with minimal tidal influence, some invasion by species such as common ragweed (*Ambrosia artemisifulia*), march elder (*Iva frutescens*), and seaside goldenrod (*Solidago semprevirens*) had occurred over time. However, they concluded that it was not obviously correlated with the spoil itself but was perhaps caused by some other factor associated with the disturbance to the marsh. They recommended the sort of long-term monitoring studies which have as yet not been carried out in Massachusetts salt marshes.

Clarke et al. (1984) studied the effect of ditching and vegetation changes on the use of the saltmarsh by birds in Rowley, Massachusetts. They concluded that bird use of the marsh was negatively impacted by mosquito control ditching. This is in contrast to the studies of Shisler & Jobbins (1977) in New Jersey marshes where increase productivity was observed in ditched marshes. Daiber (1986) noted that, where ditches drain pannes, birds that need a constant water supply (American bittern, pied-billed grebe and American coot) may decline. Also noted was a case where spoil ridges invade by *Baccharis* and *Iva* caused gulls to seek less brushy areas for nesting. Scheirer (1994) encouraged mosquito control programs to develop water management partnerships with the U. S. Fish and Wildlife Service, especially for OMWM-type marsh restorations designed to improve migrant waterfowl habitat.

In a series of investigative reports by staff biologists from the National Park Service, the environmental impact of ditching and diking of salt marshes in the Herring River basin of Cape Cod National Seashore were investigated (Soukup & Portnoy 1983, Portnoy 1984a, 1984b). These reports held that Cape Cod marsh management practices were responsible for the freshening, stagnation, acidification and high sulfate and aluminum concentration in diked marshes. These authors suggest that the destruction of a thriving eel and herring fishery in Wellfleet was the direct result of these marsh disruptions. However, the main dike across the mouth of the Herring River (from Griffin Island to the Mainland) was constructed in 1909 with the main objective of providing for agricultural use of the basin. These structures are not typical of early mosquito marsh management practices in other coastal regions in Massachusetts. The impact may be largely reversible if dikes are removed and normal tidal flow is allowed to return to these areas. OMWM tailored to the unique characteristics of these small estuaries should be explored as a way to manage the *Ae. sollicitans* populations which are likely to replace the present *Ae. cantator* populations if tidal flow and normal vegetation and salinity are restored in these marshes.

Perhaps the most damaging assessment of ditching in salt marshes was the report of Bourn and Cottam (1950) in which they blamed open ditching for converting up to 90% of the *Spartina alterniflora* marsh along the Mispillion River in Delaware to *Baccharis*. However, Provost (1977) reported that the area had returned to *Sp. alterniflora* after navigational dredging of the river had ceased and concluded that it was the dredging of the main channel, not the marsh ditching, which had permitted *Baccharis* to invade the marsh (see Daiber 1986 and Buchsbaum 1994 for reviews of this debate). Arguing against significant water-table lowering in salt marshes is the strong affinity for water exhibited by salt marsh soils. Because permeability is so low, the water table may be lowered only within a meter or so of the ditch itself (Balling and Resh 1982).

Grid ditching, even if not the marsh destroyer some claim it to be, still reduces standing water on the marsh and creates an unnatural and aesthetically unpleasing view. Open marsh water management was designed to more closely approximate the diversity of the natural marsh while eliminating the shallow pannes in which mosquitoes breed.

Wolfe (1996) reviewed the effects of OMWM on numerous tidal marsh resources. OMWM systems tended to enhance tidal exchange and salinity in marshes that were converted from grid ditching. Except where spoil piles were left (improperly) on the marsh, vegetation change was slight and favored salt-marsh species such as *Spartina patens* and *Distichlis spicata*. Small changes in elevation due to spoil deposition sometimes result in invasion by *Iva, Baccharis,* and *Phragmites*. Salt-marsh snails (*Melampus bidentatus*) have declined in some OMWM sites but not in others. Similar mixed observations have been made for marsh periwinkle (*Littorina irrorata)* and fiddler crabs (*Uca* species). Marsh fish populations are, by design, enhanced by OMWM. However, changes in species composition may occur where existing pools are deepened. Mummichogs (*Fundulus heteroclitus*)and spotfin killifish (*Fundulus luciae*) should decrease while sheepshead minnows (*Cyprinodon variegatus*), inland silversides (*Menidia menidia*) and rainwater killifish (*Lucania parva*) should increase (Talbot et al. 1986). The small reservoirs are not particularly attractive to birds and the minor changes in hydrology, flora and invertebrate fauna caused by OMWM do not cause significant changes in bird use on OMWM sites. Effects on mammals are not well documented. OMWM has had no long-term detrimental effects on water quality. As a result, Wolf concludes that, "Open Marsh Water Management is an environmentally focused management tool that is designed to be compatible with nature rather than compete with it." Of course, the technique is new enough that long-term monitoring is required to ensure that altered sites remain functional salt marshes.

b. Freshwater Wetlands (exclusive of Vernal Pools). Palustrine wetlands, including emergent, scrub-shrub and forested wetlands, are the dominant system in which Massachusetts freshwater physical control take place. In the vast majority of cases, this work consists of maintaining existing ditching designed to remove standing water from the wetland, thereby reducing mosquito-breeding habitat. For most MCPs, this type of work (source reduction) makes up a large percentage of their control effort. Though reducing standing water certainly reduces mosquito breeding, there has been little research concerning the overall effects of these alterations on the modified wetland. Ditch systems can become problems in their own right, producing mosquitoes if left unmaintained. Most of these systems were never designed specifically for mosquito control and their other, primary function, such as removing runoff from large parking lots, may cause considerable damage to the ecosystem, leaving the MCP to clean up, or at least deal with, someone else's mess.

The majority of drainage systems currently maintained by MCPs were not initially constructed by MCPs and the effort of MCPs today is almost entirely restricted to removing blockages to existing flows, rather than enlarging or straightening channels to increase flow. Most freshwater drainage is an inherited problem which requires intervention not because of mosquito-control activities but because of the activities of others. Road sand and yard waster represent two of the most common obstructions MCPs are called upon to remove from existing streams and drainage networks. New developments also can cause dramatic changes in the sediment load in streams, despite regulations designed to prevent such problems. Road sand, yard waste and increased sediment load from development can all have impacts on a stream that are as greater or greater than regular ditch maintenance.

Because MCPs are often involved in removing manmade sediments from streams, a system under appropriate ditch maintenance may function more closely to a natural system than one in which manmade wastes are allowed to accumulate unabated. The appropriate response by the MCP in such cases is not obvious because, although the problem, and its cause, may not be mosquito related, the mosquito control program may be the organization best equipped, both from and equipment and a training perspective, to rectify the situation.

Since mosquito control projects came into being in Massachusetts, the perceived values of wetlands have changed. Once shunned as disease-bearing waste lands, best suited for dumping, draining or filling, wetlands are now viewed in a much more positive way. They are important wildlife habitats, perform a myriad of water quality maintenance functions, and serve as flood control, erosion, ground-water recharge and water supply regulators (Tiner 1989). Mosquito control programs have been slow in adapting to the increased value accorded wetlands. On the one hand, long-residual and/or broad-spectrum pesticides are no longer used in wetlands in Massachusetts. On the other hand, there is real resistance to halting maintenance work in drainage networks that may be seriously damaging wetland habitat.

There has not been a great deal of work done specifically on the effects of physical control for mosquitoes on non-target organisms. Therefore the following discussion is based on the general effects that can be expected when wetland alterations are made. Care should be taken in extending these general concerns to mosquito control in Massachusetts. For example, channelization (straightening) of natural streams is not permitted in Masachusetts, where programs are required to follow the natural meanders of the stream. The three broad categories of wetlands alteration are outright loss, changes in the abiotic system and changes in the biotic community. Filling and/or draining wetlands to convert them to upland is a mosquito-control practice that has been all but eliminated in Massachusetts. There is no indication that MCPs are intentionally reducing wetland acreage in order to control mosquitoes. However, the fact that the wetlands boundary remains essentially unmoved by a mosquito-control alteration does not mean that profound alterations have not occurred.

Changes in the abiotic system and biotic community are deeply intertwined, though physical control most often causes abiotic changes which then cause biotic changes. For channels changes in flow rates, microhabitats, sediment load, sedimentation, and groundwater interactions can all occur. For wetlands (outside of channels) changes can include lost water-storage capacity, increased sedimentation and pollutant load, changes in water depth, and changes in groundwater hydrology.

When a stream is altered to improve water flow for the purpose of removing standing water, either within the stream or from adjacent wetlands, a number of changes may take place. By definition, improving water flow increases runoff. This, in turn, may decrease the surface-water storage capacity of the wetland system and decrease the capability of the wetland to retain load (suspended solids). This may increase the load of the water moving through the stream (Brown 1988). Increasing runoff into a given stream tends also to increase erosion, which further increases load (Williams & Feltmantle 1992). Not only is total flow increased, but alteration tends to increase peak flow, which is associated with reductions in faunal diversity (Hynes 1972).

The effects of increased flow and loading are many. At its most obvious, higher peak flows increase scouring of the stream bed by gravel and sand being transported by the water. Bottom dwelling animals are either affected on-site or swept downstream, leaving an impoverished community as flows return to normal (Hynes 1972). Increased flows can also remove organic matter, leaving a sandy bottom on which macrofauna is reduced (Ward 1992). As stated earlier, higher peak flows also encourage erosion, a process that can increase stream load long after sediment controls put in place during the actual drainage work are removed.

High levels of suspended solids alter the stream habitat by:

1. reducing light penetration
2. reducing primary production

3. altering the trophic structure
4. altering nutrient dynamics
5. changing thermal conditions
6. reducing oxygen levels (Ward 1992).

These effects can, in turn can have the following impacts on the stream fauna:

1. abrating respiratory epithelia
2. clogging respiratory structures
3. reducing feeding rates
4. reducing feeding efficiency
5. increasing exposure to toxins
6. reducing vision
7. inducing organisms to drift.

All of these effects can alter behavior patterns, change predator/prey interactions and change the outcome of inter and intra-specific competition (Ward 1992).

Maintenance for the purpose of reducing mosquito breeding also includes removing obstructions within streams. Tree branches and fallen trees are a particularly important part of the stream environment, providing food, living space, concealment from predators, protection from abiotic conditions and emergence sites (Ward 1992). They also provide varied microhabitats by deepening and slowing flow on the upstream side and often creating deeper pools on the downstream side. Removing these obstructions diminishes the variability of the stream ecosystem.

At the other end of the flow-rate spectrum, increasing peak flow may lead to faster drying in intermittent streams. The insect fauna (and biotic community in general) of intermittent streams does not overlap to a great extent with that of permanent streams (Ward 1992). As a general rule, this is because intermittent stream dwellers have evolved to deal with the drying down stream. Survival mechanisms include leaving the stream (swimming down stream or emerging as land-living forms), surviving in crayfish burrows or remaining pools of water, burying either at shallow depths or quite deeply into the substrate or hiding under rocks or leaflitter within or along the stream course (Ward 1992). Streams the dry more quickly, and stay drier longer, may disrupt all of these techniques as insects that emerge as adults may not have enough time to complete development (the primary example being mosquitoes themselves), remaining pools may decrease in size and number and shallow burrows and hiding sites under rocks and leaf litter may become too dry to support the fauna hiding there.

The effect of rapid drying brings up the aspect of the hyporheic zone. This is the interstitial space between the substrate particles in a stream bed. Within the hyporheic zone the macrofauna can find shelter from floods, drought and extreme temperatures, can find suitable and predictable conditions for immotile stages such as eggs, pupae and diapausing nymphs and larvae and, particularly for early instars, protection from predation. Gravel beds provide the best hyporheic zones and animals can often be found many feet down (Ward 1992). This hyporheic zone fauna can be an important source of recolonizing organisms after a stream bed is denuded (Williams & Feltmantle 1992). Excessive drying can reduce the viability of the hyporheic zone.

Sedimentation, both within stream beds and in wetlands into which streams flow, is a problem because it can alter the stream bed composition, thereby altering the fauna, and can clog interstitial spaces, thereby reducing the hyporheic zone and/or reducing groundwater recharge. Sediments can also increase exposure to pollutants as they provide additional sites for pollutant binding while suspended, and then carry the pollutants to the benthic fauna.

MCPs routinely conduct maintenance to remove sediments. Therefore, there is good reason to expect the overall effect of maintenance may be to reduce the negative impacts of sedimentation within the stream. In such cases, it would be preferential to develop systems designed to prevent the deposition of road sand into drainage systems, rather than to prevent the removal of that sand, once it has entered the system. Removing the dense, rotting masses of grass clippings that are dumped into streams by property owners should also improve overall stream quality.

Up to this point the discussion has focused on the stream itself, but freshwater wetland alterations are typically designed to change standing-water wetlands to soil-saturated wetlands (New Jersey DEP 1997). The obvious problem is that any organism that requires standing water for periods other than peak flooding, the wetland may become unusable. Mosquitoes fit this definition perfectly, but so do many other organisms. Many species of amphibians use temporary standing water for breeding and are becoming scarce as these habitats are eliminated.

Increased drainage also may have an effect on groundwater. Precipitation and inflow determine the amount of water initially available to a wetland for ground water recharge (Todd 1972). Increasing the amount of water removed from the wetland prior to percolation downwards can decrease the capacity of the wetland to recharge groundwater supplies. Not only can groundwater recharge within the wetland lowered, it can be lowered with the outflowing stream as well. During peak flows, water moves from the stream into the substrate and raises the water table (increases groundwater). As the flow declines, groundwater percolates back into the stream (if it does not, the stream dries out). By eliminating upstream reservoirs (wetlands), more water flows out of the system initially, leaving less water within the system. As water levels fall, groundwater discharge occurs sooner than might otherwise be the case. If nothing else, stream depth is liable to vary more widely after adjacent wetlands are reduced to soil saturation.

What is most needed is a comprehensive understanding of the true ecological costs of physical alterations for mosquito control. This is particularly important because, although the environmental effects of pesticides receive the lion's share of concern, it is possible that the long-term effects of physical controls may have a greater effect on the environment than does pesticide use (Buchsbaum 1994). This may be especially true today with the switch from broad-spectrum, more-persistent pesticides to methoprene and Bti.

New Jersey has recently updated it's Best Management Practices for Mosquito Control and Freshwater Wetlands Management and Massachusetts should look to such guidelines to establish a protocol for physical control in freshwater wetlands. At a minimum the common-sense requirements that all alterations be planned (not random), necessary, and desirable should be rigorously applied to all MCP water management projects regardless of whether they are defined as new or maintenance work. The North East Massachusetts MCP Standards for Ditch Maintenance (Appendix F) can be viewed as a starting point for a statewide protocol, though it fails to mention the need for sediment controls during maintenance work and leaves the MCP superintendent with wide latitude for determining the necessity of a given project. A response from the Massachusetts Audubon Society (also Appendix F) to these Standards provides additional comments which deserve consideration when a protocol is established.

c. Vernal Pools. Vernal pools form in contained depressions in which water stands for a period of several months, generally from mid- to late winter through the spring. Water either comes in the form of snow melt or spring precipitation or can be a result of a rising water table. Some pools dry down within two or three months, others may only dry when the water table is lower than normal, resulting in a pool that is semi-permanent. Regardless, a key feature of vernal pools is that they undergo periods of dry down. Vernal pools may have permanent inlets but do not have permanent outlets (Kenney 1995).

There are numerous obligate species for vernal pools, the most visible of which include fairy shrimp, the wood frog (*Rana sylvatica*) and several species of salamander (*Ambystoma* spp.).

The Massachusetts Division of Fisheries and Wildlife (Publication #15498-10-600-6-1-88C.R) has created guidelines for certifying vernal pool habitat on the grounds that many vernal pool species cannot successfully survive without vernal pools and that vernal pools are under pressure from continued development within the state. The certification program is coordinated by the Natural Heritage and Endangered Species Program (NHESP - see next section). "Automatic" protection is given to vernal pools only if they

1. occur either (a) within the 100 year inland flood plain or (b) on "isolated land subject to flooding" (as defined in the regulations at 310 CMR 10.57 (2)(b)); and

2. its existence and location has been certified by the Massachusetts Division of Fisheries and Wildlife.

Curiously, upland vernal pools are not granted the same protection but may be certified as vernal pools. The NHESP does not seek out pools to certify; it certifies submissions from the public. A guidebook for vernal pool certification (Wicked Big Puddles) is available to help those who wish to submit a vernal pool site for certification (Kenney 1995).

Mosquitoes, particularly *Ae. canadensis*, also use vernal pools for breeding. From a control perspective, vernal pools are important because, due to increasing protection, vernal pool habitat is often left undeveloped while the land adjacent to the pool is built up. As a result, many new developments surround known breeding sites. Regardless of the wisdom of developing so close to vernal pools, mosquito-control personnel are charged with controlling the mosquitoes coming from the pool.

d. Rare and Endangered Species. Hynes (1972) states three axioms of running water biotic communities:

1. The greater the diversity of the abiotic system, the greater the number of species within the system.

2. The more conditions deviate from the normal, the fewer species will be present, but those remaining will be present in greater numbers.

3. The longer a system is left undisturbed, the richer and more stable is the biotic community.

Operating under the assumption that it is rare and endangered species which are most likely to be lost from the system first, the above statements would suggest that reductions in habitat diversity, alterations from the natural state, and frequent disturbances will all work against these species. Channelization of streams reduces diversity by removing obstructions, straightening the channel and increasing flood levels. Wetlands changed from standing-water to saturated-soil regimes have been drastically changed from their natural state. Maintenance is ongoing, as is the disturbance it causes.

The key question is, however, to what extent does mosquito control contribute to the above problems. First, Massachusetts MCPs do not channelize streams, as their certification manual calls for following the existing meanders. Second, MCPs work neither in historically undisturbed, nor currently undisturbed streams. There is every reason to argue that there is no specific "natural" state that can be assigned a ditch dug by man and intermittently filled with road sand and grass clippings. Even with natural streams, the "natural" habitat in which they flow has long been altered and continues to be altered.

The Natural Heritage and Endangered Species Program (NHESP) was created in order to conserve and protect those plants and animals not hunted, fished, trapped or commercially harvested in the state. The program's highest priority is to inventory rare and endangered species and to develop conservation plans through research, management and habitat protection for those species. One such program that directly impacts mosquito control is the vernal pool certification program mentioned above.

The NHESP also reviews proposed alterations to wetlands habitats under the Wetlands Protection Act (M.G.L. c. 131, s. 40 and regulations 310 CMR 10.00). NHESP has produced a series of estimated habitat maps for rare and endangered species (Massachusetts Natural Heritage Atlas) which proponents of a given alteration are required to check. Should a project fall within an estimated habitat, NHESP will then determine if the area to be altered is actual wetland habitat for a state-listed species. The results of the NHESP determination are given to the inquiring MCP.

The Massachusetts Endangered Species Act (M.G.L. c. 131A and regulations 321 CMR 10.00) prohibits the "taking" of rare plants or animals. From a mosquito-control perspective, the most important definition of "taking" is disrupting nesting, breeding or feeding sites of animals or killing or cutting a plant. Aside from directly protecting rare or endangered species, this Act also allows areas to be designated "significant habitats." Alterations in "significant habitats" require a permit from the Division of Fisheries & Wildlife.

In Massachusetts, the species that have caused modifications in mosquito control practices are the Blue-spotted salamander (*Ambystoma laterale*), Mystic Valley amphipod (*Crangonyx aberrans*), and banded bog skimmer (*Williamsonia lintneri*). In addition, ditch maintenance in vernal pond areas has been curtailed to protect this type of habitat. Other animals for which concerns have been raised are the yellow-spotted turtle and osprey.

The presence of a threatened species need not prevent water management, however. In the East Volusia Mosquito Control District in Daytona Beach, Florida, OMWM was carried out in a salt marsh that contained the Atlantic salt marsh snake (*Nerodia clarkii taeniata*). An observer walked in front of the ditching machinery and work was halted until observed snakes left the area. In practice the snakes were difficult to spot and several were seen in the freshly cut ditches behind the ditcher. Two dead snakes were found, and assumed killed by the work. The dead snakes were handled as "incidental take" and placed on ice for delivery to the Florida Game and Fresh Water Fish Commission (Goode 1996). With an increased understanding of the ecosystems in which mosquito control takes place, mosquito control projects should improve their ability to work in areas containing endangered species with minimal impact to those species.

Under the current system mosquito-control maintenance activities are exempt from the Massachusetts Wetland Protection Act, leaving only the federal 401 Water Quality Certification Act and both the Massachusetts and federal Endangered Species Act as methods for regulating maintenance. Unfortunately, water quality, while important, does not address the issue of changing habitat and the presence or absence of a rare and endangered species has little to do with the merits of a given project.

Rare and endangered species will probably increase in their impact for several reasons. First, as data is collected on these species, additional species and additional habitats will most likely come under protection. Second, residential areas are creeping closer to wetlands areas. The net effect is that the clash between economic development and environmental protection will likely increase, with mosquito control being one component of an intense debate. Again, a more comprehensive understanding of the true ecological effects of mosquito control is required to better determine the cost/benefit ratio for different types of mosquito control.

D. Food Web Effects of Mosquito Control.

Throughout their life cycle mosquitoes are a part of the food web, both as consumer s and prey. As larvae most species feed on algae, protozoa, and organic debris (Pennak 1953). As adults they drink nectar and the females of most species take blood meals from a wide variety of animals. Larval mosquitoes are eaten by an impressive array of animals (Bates 1949) while adult mosquitoes are taken by spiders, predatory flies, odonates, bats and birds (Collins and Washino 1985). Given that mosquitoes are so thoroughly embedded in the food web, the question arises as to the effect of removing a large percentage of the mosquitoes from that food web.

At first glance, the effect would appear to be large, particularly in habitats with dense larval populations. However, mosquitoes are r-strategists, in that they produce large numbers of eggs that develop quickly (when immersed in water) to adulthood. Most pest species seek out temporary and spatially disconnected habitats for breeding and can complete a breeding cycle long before an adequate predator complex can develop. Mosquitoes are, therefore, a highly unpredictable food source for predators, and predation rates must be equally unpredictable (this section will focus on predation, as parasites and pathogens are not widespread control agents in Massachusetts). This is borne out by the fact that mosquito predators are generalists which can readily switch to other prey when mosquitoes become scarce (Collins and Washino 1985). In a study in Florida, immature mosquitoes made up over 50% of the diet of several species of saltmarsh fish (*Fundulus confluentus, Lucania parva, Gambusia a. holbrooki*). But each of these species fed on other items as well, including copepods, shrimp, other fish and even some plant material (Harrington and Harrington 1961).

One important point regarding predation and larval broods is that the concepts of handling time and satiation come in to play (Varley et al. 1973). A predator must spend a certain amount of time with each prey. Hydrophilid larvae took several minutes to feed on larvae and pupae taken in a panne in Tiverton, Rhode Island (Christie, pers. observation). Not only does it take time to catch and eat the prey, but invertebrate predators are typically not much larger than the mosquito larvae they are attacking. Satiation must play a role in limiting predator take, particularly when mosquito numbers are high.

Predators can play an important role in regulating mosquito numbers in some situations. That mosquitoes are absent from waters with fish populations is well known. Less well known is the influence of chaoborid larvae, which can severely reduce mosquito populations in vernal pools (Morrison and Andreadis 1990). In this case the larvae are present in snow-melt pools for approximately two months, so predation has time to operate as a regulating mechanism.

Although adult mosquitoes are eaten by numerous predators, it is rare that they make up an appreciable proportion of the diet of any one predator. One exception is the spider *Tetragnatha montana* for which, in Poland, mosquitoes made up 74% in June and 62% in July of all prey captured (Collins and Washino 1985). Bats and purple martins are not effective mosquito predators nor do mosquitoes form a significant part of their diet.

From a mosquito-control perspective, the mosquitoes to be controlled are, for the most part, those which have escaped predation to become predators in their own right. In the absence of scientific data supporting the necessity of mosquitoes in the diets of specific animals, removing mosquitoes from the food web by chemical, biological or physical control remains an easily justifiable activity. Even so, control personnel should take care to avoid chemical applications where mosquito larvae are not present or are present in very small numbers, should use control measures that do not harm existing predator complexes, and should limit control to areas where control is necessary, allowing natural cycles to continue in areas where human activity and the risk of disease transmission is slight. One argument made in favor of Altosid is that it does not kill the young larvae, leaving them available as food for the existing predator complex.

Up to this point, the discussion has focused on the effect of chemical control (including *Bacillus* products and IGRs) of mosquito populations on other species. Within the context of biological control, one of the primary reasons *Gambusia* are not being used in Massachusetts is the fear that they might displace native species of fish, thus altering the natural biota, not by predation but by competition for the same resource.

Physical control by water management may increase predation, as in OMWM, or may eliminate predator and prey as when wetlands are drained to soil saturation. Mosquito breeding must be thoroughly documented before new work is done. Because disturbances may displace some species, and because predator species tend to rebound more slowly than their prey, maintenance work should be conducted only when necessary.

E. No Program

Another alternative strategy to current mosquito control practice is no control. Many communities in Massachusetts have chosen this option. These town are usually outside of the enzootic EEE zone so the risk of human diseases transmitted by mosquitoes is viewed as practically nil by these communities. In addition, they are not located near salt marshes and their attendant pest mosquito problems. The mid-section of Massachusetts, where most no-control communities occur, also has a more rural character, less wetland , lower human populations, and a lower mean family income than most eastern areas with organized mosquito control programs. In general, the view of these communities is that the anticipated benefits from mosquito control do not outweigh the anticipated costs and perceived risks.

A more precise way of polling the public and confirming this opinion would be through establishing the Human Annoyance Threshold (HAT) for the town. Communities in which the HAT is below the actual annoyance level should be persuaded to choose the no control option since justification for control is lacking unless a documented disease threat exists.

In some communities, biting annoyance is created by a combination of biting insects (i.e. mosquitoes, black flies, biting midges and tabanids) which require completely different control approaches. Many people do not recognize the difference between these insects, especially in dim evening light. It is critical to accurately identify the biting insects actually responsible for the human annoyance. In general, black flies and tabanids only cause annoyance during the daytime while mosquitoes and biting midges are most annoying from 6-10 PM. The HAT level for tabanids and biting midges is likely to be less than for mosquitoes because of their more painful bites.

Perhaps part of the reason why Berkshire County communities have supported a MC program while other Western Massachusetts communities have not, lies in the fact that this region supports many summertime outdoor activities (e.g. camps, resorts, golf courses, Tanglewood, etc.). In addition, this more mountainous region has a significant black fly annoyance problem superimposed on top of the mosquito problem. Vacationers are likely to have a lower HAT than permanent residents since they are spending more time and money on outdoor recreational activities.

In addition to risk-benefit considerations, other criteria for weighing the control/no control option are 1) the feasibility of successfully reducing annoyance below the HAT level, and 2) the adequacy of community resources for reducing annoyance to acceptable levels.

Towns with large areas of mosquito-producing freshwater wetland should recognize that effective mosquito control in these habitats is difficult at best and often impossible. As indicated earlier in this report, permanent wetlands do not usually produce large numbers of pest mosquitoes but in situations where they do, the public needs to be aware that these wetlands are a valuable resource that must be protected from significant perturbation and that options for mosquito control are therefore few. Community planning boards and zoning laws can and should be used to restrict residential development and other human activities from such wetland areas.

Towns with annoyance problems but with large land areas and thinly, scattered populations must understand that the same level of mosquito control achieved in more populated communities will cost them significantly more per capita. In many such cases, the economic status of the population means that insufficient tax dollars can be generated to adequately deal with the problem.

Nantucket provides an interesting case study. Mosquito control had lapsed in the early eighties. However, by 1989 saltmarsh mosquitoes were becoming a significant problem in the west and north areas of the island. The town began applying Altosid (including aerial applications of pellets in 1992) to control the mosquitoes while. getting the requisite permits for OMWM in several west-end marshes (Madaket, Warren's Landing Eel Point). The OMWM systems were dug in January 1993 (Christie 1993). It was hoped that the OMWM alone would be sufficient to control mosquitoes but large-scale breeding continued in the north end (Pocomo) and the low tidal range has hindered the effectiveness of the OMWM as dug. As a result, some lariviciding continues. The conclusion on Nantucket is that mosquito control against saltmarsh mosquitoes must be continued at some level in order to provide residents with the summer environment they want. However, Nantucket does not target freshwater mosquitoes at all and does no adulticiding. Nantucket and Cape Cod together indicate that adulticiding is not a requirement even in high-tourist areas.

It is difficult to measure the impact of choosing the no control option. The example of towns that have left, and left and later rejoined MC projects is perhaps the only available basis for estimating public opinion concerning such impact. No documentation of annoyance levels, cases of disease, recreational dollars spent, etc., was ever attempted in these towns when they had mosquito control versus when they did not. Thus, public complaints were apparently the main indication of the impact of the no control option that was used in guiding town decision making.

In the 1986 questionnaire, only about 10% of the towns in organized projects indicated that there had been controversy relative to leaving, joining, or rejoining a project. Those that had experienced controversy indicated that 4 factors were about equally involved. These were: 1) monetary constraints, 2) concern over the effectiveness of project control programs, 3) concern over the safety of the methods used by the project, and 4) concern over the environmental impact of the control procedures. Paradoxically, 86% of these towns indicated they were unwilling to spend more money (if legally possible) to obtain more effective control and 67% indicated unwillingness to spend more money to support less hazardous control methods. However, the bias of the people filling out the questionnaire sent to each town may have influenced these responses; no town in Massachusetts has actually polled their citizens on these questions. In fact, some towns within projects have taken advantage of new provisions which allow towns to collect additional money for MC activities which projects can then only spend in these towns.

Among towns that actually withdrew from MC programs, monetary constraints played a role in 73% of these decisions, followed by environmental concerns in 32% and concern over effectiveness in 27% of these cases. Towns that contemplated withdrawing but did not do so, indicated that monetary and effectiveness considerations dominated their concern.

The number of towns in MCPs declined in the late eighties. Economic factors, not environmental concerns, were the dominant reason given for withdrawal. This trend has reversed itself significantly in the last several years. The 1990 EEE problem is probably one reason, coupled with the fact that several coastal programs tried the no-control option and found mosquito numbers rose quickly.

Many towns in the Berkshire County and South Shore projects withdrew in 1981 mainly in response to Proposition 2-1/2 monetary constraints. The remaining 8 towns in Berkshire County subsequently chose to continue as a multi-town Project (Note: the town of Lanesborough rejoined in 1986, the city of Pittsfield rejoined in 1988, and other towns are contemplating reentry). South Shore actually disbanded as a project but by 1988 most towns had joined neighboring MC projects in Norfolk and Plymouth Counties. These actions suggest that these communities were not content with the no control option that resulted from the disbanding of their former project. Towns that voluntarily withdrew from MC projects but then later rejoined a project, did so for a variety of reasons. These were in order of their importance: increased public support for MC, increased mosquito annoyance, alleviation of monetary constraints, threat of EEE, improved methods and effectiveness of the project.

The Environmental Impact Statement (Sjogren 1977) prepared for the Metropolitan Mosquito Control District in Minnesota attempted to quantify the no control option for their community. Any attempt to develop similar estimates for Massachusetts would be meaningless given the lack of appropriate baseline data.

VI. MOSQUITO CONTROL INTEGRATED PEST MANAGEMENT

A. Definition of IPM as it Relates to Mosquito Control.

1. Overview of IPM. Few ideas stir more debate in pest control than "Integrated Pest Management" (IPM). Everyone agrees it's a good idea, but there agreement ends. For some it means, "No pesticides." For others it means, "Extensive research followed by careful implementation." For others it means, "Don't spray when they aren't there and use several different chemicals when you do spray." What makes agreement so difficult is that all three definitions are, at least in part, correct.

For the purposes of this report, however, a simpler statement of IPM is in order. At its most basic IPM is:

> A system designed to reduce the negative impact of a pest species to an acceptable level while avoiding unnecessary additional problems (Virginia Cooperative Extension Service 1987).

For mosquito control the negative impacts of mosquitoes are reduction in outdoor use, particularly recreational, and disease transmission. Problems that have developed in the past are loss/degradation of valuable habitat, exposure of non-target organisms to pesticides, creation of new, sometimes worse, breeding habitat, and resistance of mosquitoes to pesticides in use. Of course, determining which of these problems is unnecessary is the crux of much debate over mosquito control.

IPM was originated as a pest control strategy for agricultural systems. It has been modified for urban systems under the name Urban Pest Management (UPM). UPM varies from IPM (modified from Olkowski et al. 1978, Horn 1992, and Christie 1994) in that:

1. UPM systems are generally more complex, particularly with regard to determining thresholds for control.
2. UPM takes place close to large numbers of people.
3. Control decisions are often made for aesthetic, not economic reasons.
4. Pests of human health require control even at small numbers.

Mosquito control falls between the classic agriculture-based IPM program and current UPM systems. Control of numerous species over a wide range of habitats is more complex than most agricultural systems (modification 1) and control work often takes place adjacent to (in the case of larviciding retention basins) or on (in the case of adulticiding) human populations (modification 2). In addition, mosquitoes, even when controlled for nuisance purposes, would be classified as pests of human health (modification 4). However, mosquito control decisions are not made for aesthetic purposes (modification 3) in a manner similar to tent caterpillars in a city park.

The important point here is not what to call mosquito control IPM or UPM or something entirely different (the term integrated mosquito management has been proposed (Anonymous 1995) but rather to make it clear that one cannot pick up bodily a system designed for agricultural systems and transplant it into mosquito control without accepting that modifications have to be made. That being said, the second important point is that the difficulty in arriving at a scientifically based, economically and environmentally sound control program should not be used as an excuse to avoid implementing mosquito integrated pest management.

2. Integrated Pest Management for Mosquitoes. Before an IPM program can be put in place, a strong organization must be in place. There is a huge difference between tossing some pesticide at possible breeding sites and conducting a full-fledged IPM program. The organization must be adequately funded, adequately trained and provided with the materials to do the job correctly. At a minimum expertise in mosquito biology, wetlands ecology, and program administration are required.

Adequate staffing and resources are only the first steps in creating an IPM program. The main step is in creating the analytical process whereby control decisions are made, evaluated and modified. This process can be divided into four steps: 1) Surveillance and Monitoring, 2) Establishing Thresholds for Action, 3) Prevention and Control and 4) Evaluation.

a. Surveillance and Monitoring (including identification). The initial step in IPM is to survey the existing pest population and monitor its occurrence over time. For mosquitoes, adult populations are monitored for their direct impact on people whereas larval populations are monitored for their potential impact after they emerge as adults. For adult populations, monitoring is used to determine if adulticiding is required and to identify the species of mosquito in a given area so that future larval control efforts can be directed at the appropriate breeding sites. Larval populations are monitored to determine if larviciding is required and/or if physical or biological controls are working. Larval counts also aid in determining what areas are candidates for water management. Monitoring should also take place post-control, in order to evaluate efficacy of various control measures.

Mosquitoes collected during monitoring must be identified, to the extent possible, to species. For adult mosquitoes, the species of adult will give a clue as to where larval monitoring should be focused. For larvae, enough non-pest species exist that field staff should be able to sight identify most of the common species to genera, primarily to avoid larviciding a non-pest species.

The habitats in which breeding occurs or in which the adult mosquitoes are most numerous must also be identified. Wetlands should be mapped. With the recent rise in the number of drainage basins in new developments, an important aspect of mosquito control is to maintain an up-to-date list of all such basins and work with local building officials to discourage constructing mosquito-breeding basins.

A third component of monitoring is to classify the area in which control is to take place by human usage. Unless funding is not a constraint, the goal of surveillance and monitoring should be to produce a site list prioritized by the level of mosquito breeding and its proximity to humans.

b. Establishing Thresholds for Action. The goal of IPM is to keep pest levels below the Economic Injury Level (EIL). This is the level where the economic loss from pest damage exceeds the cost of control. In mosquito control, this is the Human Annoyance (or Disease) Threshold (HAT) and represents the highest biting density (or Disease Incidence) that most citizens in a community find tolerable. Intolerance is usually exemplified by people moving indoors, putting on repellent, leaving a campground etc.. HAT is generally the biting level above which most people prefer to pay to have the level reduced than put up with the annoyance. This level will vary from community to community and may be influenced by the species biting (Sjogren 1977), the time of day when annoyance occurs, and the duration of the period when HAT is exceeded.

In agricultural IPM programs, a 2nd pest density, the Economic Threshold (ET) is established and monitored by frequent and systematic sampling of the pest population. This is the so-called action level. It is the pest density that, if left unchecked, will result in the Economic Injury Level (EIL) being reached. It is a computer-assisted predictive level, (lower than the EIL) and is based on previous experience, populations of beneficials, time of year, etc. It is difficult to translate this management concept into mosquito control practice because the populations responsible for biting annoyance (adult females) differ from those that need to be monitored and controlled (larvae). Biting is not restricted to areas with the larval habitats and it is difficult to assess the future biting impact of any given larval population.

During the surveillance and monitoring phase, workers need to establish thresholds for the various control options they have. Thresholds may be established based on those found in the literature but will generally require local modification. Standard thresholds for adulticiding are generally given as complaint calls for a given area, landing counts (mosquitoes landing on an observer per minute) or light trap counts (number of human-biting mosquitoes collected per night). Standard thresholds for larviciding and/or water management are based on dip counts.

Thresholds need not be expressed in terms of existing mosquito populations. In the case of existing programs, the threshold for drainage maintenance will most likely be based on some variation from the existing cross-section of the system or some measure of water flow as compared to a previously established norm. Prevention cannot be based on existing mosquito populations but must be based on the potential for populations to develop.

Thresholds for action are influenced by economic factors. Only programs with sufficient operating funds can fully exploit the flexible control strategies generally found in a full IPM program. Programs strapped for funds may have no, or very high, thresholds for open marsh water management, because the high initial cost cannot be borne by the program.

Political realities also influence thresholds. Local populations vary widely in their acceptance of various control measures. In Massachusetts there are projects that adulticide on the basis of a single request and there is one project (Cape Cod) that does not adulticide at all. Human population density and behavior patterns also influence thresholds for action. Where budgets are limiting, funds will be earmarked for areas in which the most people will benefit. Seashore communities dependent on summer tourists will generally demand higher levels of control, hence, lower thresholds for action, than will thinly populated rural areas.

Finally, environmental factors are also included in establishing thresholds. Control measures that have little impact on non-target organisms can be conducted at lower thresholds than can control measures that have large impacts on non-targets. In addition, thresholds for action will be influenced by the sensitivity of the location in which control is to be conducted. An on-going example in Massachusetts is the use of Altosid (methoprene) in endangered-species areas. In Suffolk County Bti use is permitted, methoprene is not. Should Bti become significantly more costly than methoprene, the threshold (larvae per dip) for larviciding in the affected areas will most likely be raised.

In summation, the choice of control measures to use, and the extent to which a given control measure is used, is determined by the pest species and population, the environment in which the pest population is located, and human factors expressed in political and economic terms. Determining which control options are available and how much funding will be allocated to each, coupled with an understanding of the pest population, should allow action thresholds to be created.

c. Prevention and Control. As a general rule, prevention refers to maintaining a pest population below an action threshold for control, whereas control refers to bringing a pest population back down under the threshold for control. The line between the two, however, is blurred enough that there is little conceptual reason to separate them. Clearing a blocked ditch so that larvae are flushed out is a short-term control measure with long-term preventative effects.

Source reduction is the primary prevention technique for mosquito control. Maintaining water flow through drainage networks is the primary freshwater mosquito control technique while ditching (previously) and open marsh water management (currently) are designed to eliminate the isolated, shallow pannes in which salt-marsh mosquitoes breed. Programs that do not stress source reduction cannot make long-term reductions in mosquito populations.

That being said, there are cases where source reduction is not possible. The most obvious are areas where source reduction would impact an endangered species or where the type of source reduction necessary would severely impact the wetland resource. In Massachusetts any alteration in such an area must undergo NHESP review. Less obvious but equally real are cases where property owners deny permission for source reduction projects or where the breeding area is simply too large for source reduction to be economically feasible.

Public education is a second vital component of prevention. An educated public should be more willing to cooperate in eliminating man-made breeding habitats, should better understand the trade-offs between the various available control techniques, and should be more willing to fund more expensive approaches if the expense can be justified by a better long-term benefit. A side benefit from public education is that lines of communication are usually strengthened, so that the economic and political aspects of mosquito control, areas often controlled by non-mosquito-control personnel, bear a stronger relationship to the realities of mosquito control.

Control, in the strict sense of killing mosquitoes, is dominated by chemical use. For adult mosquitoes, no current control alternative to pesticides exists. However, options exist for larval control. Biological control using mosquitofish is possible.

Expanding on the concept of control to understand that what is being controlled is the negative impact of mosquitoes, rather than mosquitoes themselves, then all efforts designed to reduce human exposure to mosquitoes constitute control. Public awareness becomes a vital component. This does not mean teaching people to live with mosquito bites. It does mean teaching people how to make informed decisions about mosquito control.

Thresholds are vital to the control process because only through thresholds can a rational response be made to unusual circumstances. A quality IPM program cannot "fail" in the strict sense because it has control techniques available for each step in pest population increase (or, in the case of a disease threat, each increase in the risk of contracting the disease). Source reduction is adequate when mosquito breeding is absent or low. Larviciding is triggered by increasing larval numbers. Localized adulticiding is triggered when adult populations pass a given threshold. Finally, aerial adulticiding is available when populations explode and/or the disease threat is high.

d. Evaluation. Each control step is evaluated for efficacy and future actions modified to improve control or reduce negative impacts. Field evaluation will generally use the same monitoring techniques described above and the important criteria will be changes in the mosquito population and/or environment. Over time, a steady state should develop where realistic thresholds trigger effective responses.

B. Aspects of IPM currently in place in Massachusetts mosquito control programs.

1. IPM Questionnaire.

Along with the general questionnaire sent to the projects in 1996, a separate page concerning IPM was included. In it, projects were requested to provide a definition of IPM and then either agree or disagree with a series of statements about IPM (Tables 15 and 16).

Table 15. Project responses to IPM Questionnaire as given.

Response	Agree	Disagree	No
14. Mosquito breeding outside the Program has an impact on adult mosquito populations within the Program.	7	1	
1. The Program already practices IPM.	6	1	1
4. Quantifying human annoyance is difficult	6	2	
2. The wide range of breeding habitats to be monitored makes implementing IPM difficult.	2	6	
3. The wide range of areas in which adult mosquitoes are a problem makes implementing IPM difficult.	3	4	1
5. Control techniques and options are more often determined by a vocal minority rather than the community average.	5	3	
6. Light trap catches are influenced by too many factors unrelated to mosquito population densities to be used as a reliable indicator of actual problems.	2	6	
7. Current funding provides a rough measure of a community's perceived need for mosquito control.	3	5	
8. Personnel shortages prevent collection of data required for IPM decisions.	4	4	
9. Knowledge gaps prevent implementation of IPM.	2	6	
10. The wide range of species of mosquitoes to be controlled makes implementing IPM difficult.	3	5	
12. Predicting adult mosquito populations from larval monitoring is not sufficiently accurate.	4	4	
13. Waiting until adult mosquitoes are biting is too late to initiate control.	4	4	
11. IPM is not possible in mosquito control.	0	8	

The most encouraging aspect of the answers is that none of the eight projects responding felt that IPM was not possible in mosquito control (Statement 11) and six of the eight felt they were already practicing some form of IPM (S1). On a less optimistic note, there was strong feeling that quantifying human annoyance is difficult (S4). Of the two (Cape Cod and East Middlesex) that did not think quantifying human annoyance is difficult, Cape Cod is dominated by the summer tourist season and is probably is not very hard to figure out whether or not mosquitoes should be controlled, the answer being, "Yes!" An additional concern when attempting to establish HATs is that most of the projects felt that vocal minorities have more say in mosquito control than does the community average (S5). There is little question that the HAT concept, while theoretically of value, may be based on incorrect assumptions about the driving forces behind control decisions.

Equally troubling from a control perspective is that most projects felt that mosquito breeding outside their

Table 16. Project responses to IPM Questionnaire sorted from highest number of "agree" responses to lowest.

Response	Agree	Disagree	No

14.	Mosquito breeding outside the Program has an impact on adult mosquito populations within the Program.	7	1	
1.	The Program already practices IPM.	6	1	1
4.	Quantifying human annoyance is difficult	6	2	
5.	Control techniques and options are more often determined by a vocal minority rather than the community average.	5	3	
8.	Personnel shortages prevent collection of data required for IPM decisions.	4	4	
12.	Predicting adult mosquito populations from larval monitoring is not sufficiently accurate.	4	4	
13.	Waiting until adult mosquitoes are biting is too late to initiate control.	4	4	
3.	The wide range of areas in which adult mosquitoes are a problem makes implementing IPM difficult.	3	4	1
7.	Current funding provides a rough measure of a community's perceived need for mosquito control.	3	5	
10.	The wide range of species of mosquitoes to be controlled makes implementing IPM difficult.	3	5	
2.	The wide range of breeding habitats to be monitored makes implementing IPM difficult.	2	6	
6.	Light trap catches are influenced by too many factors unrelated to mosquito population densities to be used as a reliable indicator of actual problems.	2	6	
9.	Knowledge gaps prevent implementation of IPM.	2	6	
11.	IPM is not possible in mosquito control.	0	8	

district has an impact on adult mosquito populations within their district (S14). The only project that did not was Cape Cod, which is more isolated than are the other projects. IPM programs that stress water management of larval populations must be flexible enough to allow projects to control adults mosquitoes coming in from other areas.

Looking at some specifics by project, Norfolk and Essex both agree with the three statements (S2, S3, and S10) relating to the wide range of mosquito habitats. Though these programs have both salt-marsh and freshwater components, their distribution of effort is not markedly different from Plymouth or Suffolk Counties, which disagreed with all three statements. Norfolk and Essex also were the two projects that agreed with the statement that, "Knowledge gaps prevent implementation of IPM" (S9). As both Norfolk and Essex MCPs are active in pushing for stronger, more ecologically sound mosquito control, their responses may be less an indication of their dissatisfaction with IPM and mosquito control and more an indication of their desire to see mosquito control IPM improved.

2. Mosquito Control IPM as practiced in Massachusetts today.

The strategy of IPM as developed for agricultural ecosystems is an ecologically-based concept (Axtell 1979). It has yet to be fully applied to mosquito management programs. IPM is a strategy for managing insect populations not a method for controlling them. It is more than integrated control which is simply the combining of several control methods. Mosquito control has a long history of integrating different control methods.

The general feeling among most MC practitioners is that any significant larval population within flight range of residential areas will probably result in some human annoyance and therefore should be controlled. Few MC programs in the U.S.A. have developed annoyance threshold levels for their communities. No Project in Massachusetts has undertaken such an effort. In the Metropolitan MC District in Minneapolis/St. Paul, it was found that the HAT was 2 bites/5 minutes between 7-9 PM on typical summer evening. Thus, the minimum goal of this District is to keep the human biting rate at or below 1 bite/5 minutes. This number is so low, however, that few projects are likely reach it consistently throughout their district. Therefore, whether or not a given breeding site is larvicided is more a function of economics than of absolute mosquito numbers.

Although many MC programs regularly monitor adult population levels (with light traps and landing counts) they do it to evaluate larval control effectiveness and the need for adulticiding; not to determine when immediate larval control is needed as in the case of agricultural IPM programs. However, light trap counts, landing rates and complaint calls are used to create a general picture of the need for mosquito control and projects with long-term experience develop larviciding plans based on this historical data.

It would be beneficial if techniques for predicting future adult biting annoyance from larval counts could be developed. One way this could be accomplished by marking different larval populations (for example with Geimsa stain) and then assessing the subsequent contribution of marked females to the population biting humans in neighboring areas (Fish & Joslyn 1984, Joslyn et al. 1985). A simpler technique is to mark adults with a fluorescent dust, release them at the breeding site, and attempt to recover them in adjacent biting areas (Morris, et al. 1991). This can show which areas are being affected by which breeding areas. The drawback to these types of is the need to do it for each species in question and, due to the large number of site-specific variables, for many breeding sites. Regardless, studies like this would require a research element not present in the current Massachusetts system.

Assessment of the cost/benefits resulting from outdoor recreational activities have been dealt with extensively in the literature (Pierce & Napier 1977, Beardsley 1971, Moeller et al. 1976). The theoretical basis for most of these analyses is found in general welfare theory (Pierce 1971, Prest & Turvey 1965, Walsh & Williams 1969). When applied to the assessment of economic benefits, these analyses represent attempts to establish the consumer surplus" (Blaug 1968). This surplus represents the consumers willingness to pay" (WIP) for a specific service or facility e.g., a mosquito-free campground or park. Once determined, the WIP is used as a proxy for benefits emanating from the service (Mishan 1976). John et al. (1987) established the WIP for a Texas community to be $22.44 per household ($18.96 per renter household). Once the benefits and costs of mosquito control are assessed, it is possible to establish Economic Thresholds (e.g., the mosquito density at which the cost of control is equal to the value (estimated benefits) forthcoming from the controls (Edens & Cooper 1974, Edens 1977).

A major concern in all of these cost/benefit analyses is that they compare dollar costs of various control techniques or discuss consumer willingness to pay but they do not address ecological costs associated with mosquito control. Due to the lower and more specific toxicities of newer pesticides, water management may not always be less ecologically damaging than pesticide application.

There is no study to date of the costs and benefits of Massachusetts mosquito control programs. There is good reason to believe, even if such studies were done, that the results would reflect local, current thought, as opposed to some underlying “true” cost/benefit for mosquito control. Variables that would affect perceived cost/benefit include relative economic strength of the local community and of the state, recent weather patterns and their influence on mosquito breeding, the rate and direction of development within the community, and the techniques available for mosquito control. Regardless of the underlying variability of any cost/benefit analysis, working towards an understanding of the costs and benefits of mosquito control is desirable. The following information would aid in such work:

1) Establish human annoyance thresholds (HAT)
2) Document how human activity patterns relate to HAT and economic factors
3) Determine cost/benefit analysis of control (willingness to pay)
4) Correlate HAT with a standard non-biting sampling method (e.g. light trap)
5) Correlate densities of immatures with future levels of biting annoyance

6) Establish the ecological costs of various control techniques.

The cost/benefit of various control options (e.g., permanent vs. temporary control) also has been evaluated in recent papers (Ofiara & Allison 1986a, 1986b) but this should not be confused with the cost/benefit of control programs.

3. Improving Physical Control.

Reducing pesticide use is not a primary goal of IPM (Robinson 1996). Reducing unnecessary pesticide applications and improving the effectiveness of pesticide applications are goals, and improving our knowledge of how a system works often results in pesticide-use reduction, but there is nothing in the concept of IPM that mandates reducing pesticide use. Indeed, at Essex County, when they established a landing count rate of 1 per five minutes for adulticiding, they found that the total area that qualified for adulticiding jumped dramatically (Walter Montgomery, personal communication). That being said, pesticide use remains an issue and improving non-chemical controls is a desirable goal.

Most organized MC projects in Massachusetts engage in source reduction activity. Current source-reduction efforts generally consist of cleaning and repairing ditches and other water control structures built previously rather than with the construction of new structures. New construction is limited by State and Federal wetland protection laws and regulations. Also, the economics of source reduction programs is an important consideration. The higher initial cost of this semi-permanent control strategy must be amortized over the multiple years of anticipated benefit. It cannot be implemented at all when limited annual budgets prevent MCPs from acquiring the large up-front capitol sums that are needed for major source reduction projects. Another shortcoming of the current regulations, as they apply to mosquito control, is they fail to adequately differentiate between natural and manmade wetlands.

One major advance already underway is vastly improved mapping through Geographic Information Systems (GIS). GIS wetlands mapping can both aid mosquito control agencies in determining control priorities but can be used by mosquito control agencies to integrate their work with other land-use agencies (Guthe 1993). Very detailed maps can also be made when planning water management projects (Gettman 1995).

a. Saltmarsh management

There are two major strategies for managing tidal waters to achieve control of saltmarsh mosquitoes: (1) long-term flooding or impoundment of the high marsh to prevent mosquito egg laying and encourage larvivorous fish, or (2) drainage of the high marsh to prevent water from standing for the 6+ days required for the completion of mosquito larval development. Some combination or modification of these two might be considered as a third strategy. Permanent or seasonal impounding of the entire high marsh is not a viable option in New England's grassy salt marshes with wide tidal fluctuation (Provost 1969).

Early source reduction work in grassy salt marshes consisted of grid ditches, initially dug by hand. .Everyone concerned now seems to agree that such a blanket approach to saltmarsh ditching is overly destructive and less effective than more customized designs though the actual impacts have been debated (Bourn & Cottam 1950, Lesser et al. 1976, Provost 1977, Daiber 1986, Buchsbaum 1994). This approach is no longer practiced or recommended, but many of these old, square-bottomed ditches still criss-cross Massachusetts salt marshes. Many have become silted-in shallow depressions in which mosquitoes breed. To avoid this, some MC projects continue to clean and maintain at least some of the old grid ditches.

Contour ditching grew out of the realization that grid ditches often fail to flush with the tides and therefore, unless continuously maintained, they eventually silt in and form breeding. Contour ditches are more strategically placed and follow the natural topography of the marsh. Contour ditching schemes are essentially integrated extensions of natural tidal creeks and they better take into account the hydrodynamics of tidal marshes. Although they are a more intelligent approach to ditch design, they are still ineffective in preventing mosquito breeding in many shallow pans and isolated, irregular depressions which characterize the upper part of many Massachusetts salt marshes.

An obvious alternative to maintaining grid or contour ditching would be to upgrade the grid-ditch systems to OMWM systems. In a Rhode Island salt marsh such a conversion consisted of creating a reservoir within an existing ditch, cleaning out those sections of ditch that functioned as connectors from the reservoir to breeding pannes, and using the spoil to fill in ditching that was not serving a mosquito-control function. As a result, breeding densities of hundreds per dip were reduced to virtually none and larviciding practically eliminated (Christie, personal communication). This type of work is occurring in Massachusetts but could probably be increased.

b. Fresh water management

Natural Wetlands. Over the past decade there has grown up a tremendous force for the preservation of all wetlands, the “no-net-loss” policy. This policy is based on three assumptions:

1) each and every wetland is of infinite value

2) that all wetlands are of equal value

3) that any actions or other properties sacrificed to maintain a wetland must have less value than the wetland itself. (Gates 1995).

The challenge for mosquito control programs is to ensure that a more balanced set of assumptions comes to the fore as our understanding of wetlands, mosquitoes, and vector control increases. No IPM program for mosquito control can be adequately developed if the areas in which control takes place are off limits to manipulation. Just as mosquito-control personnel must become more aware of the ecological costs of mosquito control, so too must advocates of wetlands preservation become more aware of the benefits of mosquito control.

Most permanent wetlands offer few options for water management. Draining or filling natural wetlands are no longer considered acceptable practices. Extensive existing drainage networks are currently maintained by the Mosquito Control Projects but new ditching is rarely permitted. Most existing systems were not originally dug with mosquito control in mind. Unfortunately, a ditch system, once in place, almost invariably breeds mosquitoes if it is not maintained. A primary goal for mosquito-control programs and state agencies should develop criteria for continued drainage maintenance, using the New Jersey guidelines (New Jersey DEP 1997) and the North East Massachusetts Mosquito Control and Wetlands Management District "Standards for Ditch Maintenance" as starting points.

The prospect for source reduction activity in the thousands of acres of wooded swamps common throughout the eastern third of Massachusetts is slim. The primary vector mosquito, *Cs. melanura*, produced in these swamps is essentially an after dark, passerine bird feeder, and is unlikely to transmit EEE to humans and horses (Nasci & Edman 1981a, Morris et al. 1980). Therefore, any effort to control this mosquito is perhaps misplaced, though some success has been had with aerial applications of Altosid pellets (Henley 1992). If the vector(s) of EEE virus to mammals were known, control efforts directed against this mosquito would be a more logical and efficient way to interrupt disease transmission during threatened epidemics. The most likely candidates for such attention are *Cq. perturbans, Ae. vexans,* and *Ae. canadensis*.

Vernal pools are both a valuable resource and a reliable source of mosquitoes. Their size makes them more amenable to habitat modification but their value as nurseries for amphibians and other semi-aquatic animals makes their preservation important. In rare cases, however, ditching (when possible) or filling small woodland pools in close proximity to human populations may provide sufficient benefits to outweigh the loss of some of these temporary aquatic habitats. Vernal-pool certification by NHESP will, over time, bring under protection of the Division of Fisheries and Wildlife those vernal pools which should be left undisturbed. Most vernal pools slowly fill in naturally while new ones are constantly being created in the root cavities created by blown over trees. Massachusetts forests are currently maturing so 'blowdowns' and new vernal pools may be increasing.

Populations of tree-hole *Ae. triseriatus* seldom reach serious densities in Massachusetts at present but this could change. Because this species is a daytime biter, adapts readily to discarded tires, and is a potential vector of La Crosse encephalitis, it bears careful monitoring. The city of La Crosse in Wisconsin has mounted an effective campaign to nearly eliminate human cases of LAC encephalitis by simply removing old tires and other small water-holding containers and filling in tree holes near residential areas (Parry 1983). This model for source reduction of tree-hole mosquitoes is undoubtedly the most effective way to presently deal with *Ae. triseriatus* in areas where it becomes a localized problem species.

Reservoirs and dug ponds. The majority of small permanent ponds and lakes in Massachusetts are man-made. They were created by dredging natural seepage areas or by damming streams. Many Massachusetts reservoirs are old, having been built to provide power and water for adjacent factories built between the middle of the 19th century and the depression years of this century. Some have become badly silted and eutrophic. Nearly all of these bodies of water create some mosquito habitat, at least along vegetated shorelines and in shallow upper reaches distal to the dam. *Anopheles* and *Culex* are the principal mosquitoes associated with these wetlands and, when cattail or water willow invade along the shoreline, *Cq. perturbans* become established as well. Also, small permanent ponds or reservoirs within wooded habitats often hatch large broods of univoltine Aedes along leaf-packed borders during spring flooding.

Older dams seldom have flexible water level control structures. Thus, well-established principles for managing mosquitoes in impounded waters (Edman 1964) can not be applied in most Massachusetts reservoirs. All new and rebuilt structures should include adequate control capabilities so that water level management can become a mosquito control option in all impoundments in the future. The main features of water level control plans are: (1) maximum pool levels when flood-water *Aedes* are laying eggs, (2) gradual summer drawdown with weekly surcharges to strand floating debris and keep water out of the shoreline vegetation that protects *Culex* and *Anopheles* larvae from wave action and predators, and (3) during the spring egg hatch period, keep pool levels from rising above the levels maintained during the previous year's univoltine *Aedes* egg-laying period.

Grass and scrub marshes created by drainage disruption. Most serious pest/vector problems associated with these habitats are created in situations where vegetation favorable to the cattail mosquito, *Cq. perturbans* has invaded the marsh. This mosquito is difficult to control by conventional larvicides, is an aggressive biter of humans and domestic animals, and may play a role in EEE epidemics. Spring *Aedes*, and summer Anopheles and *Cx. salinarius* problems may be associated with these marsh habitats as well. Also, a univoltine bird feeder, *Cs. moristans*, which may play a role in enzootic cycles of EEE virus (Morris and Zimmerman 1981), breed principally in this category of wetland.

There are two potential habitat management strategies for eliminating breeding associated with these wetlands and neither is popularly practiced. One involves removing the vegetation which supports breeding (e.g., cattails). This can be done with a dragline provided the vegetation is still restricted to the pond border. Alternatively, selective herbiciding or hand removal when invasive plants like cattails first become established along the shore may be effective in some situations. A second management strategy is to correct the drainage disruption which created the wetland situation in the first place. This may be as simple as installing or lowering a culvert. In contrast, it may be so complex and expensive that it is not a viable option. When feasible, restoring natural drainage will permanently eliminate the wetland. This may be considered unacceptable despite the fact that these wetlands are man-made and of limited life expectancy. The builders of roads, railroads, and power or pipe lines are responsible for the majority of these wetlands. Expecting contractors to retroactively address, at great expense, the public health and nuisance problems that they have created is perhaps unrealistic. However, all new construction which involves significant changes in topography and natural drainage should be reviewed by an agency such as the SRMCB to assess impact on water flow and creation of new wetlands which may produce pest/vector mosquitoes.

Roadside ditches and tire ruts. A major source of reflood *Aedes* are ditches that fail to completely drain because of a lack of culverts or culverts that are located above the level of the ditch bottom. Heavy equipment and tractor tires leave permanent ruts in soft turf which is another major source of reflood breeding sites associated with ditches and low-lying fields. Both of these categories of man-made wetlands can be prevented by proper engineering, construction, and maintenance practices. Where these breeding sites already exist, they can be permanently eliminated by appropriate lowering of culverts and regrading work. Tapered cement aprons at both ends of culverts and cement linings in the bottom of roadside ditches in residential areas with poor drainage characteristics can also assist in preventing the creation of these breeding sites. Municipal and state road crews should be cautioned against mowing when the sod is too soft to fully support mowing equipment without creating depression in the ditch bottom.

Storm catch detention and retention basins, ornamental pools, tires, and other man-made containers. Good sanitary practices promoted through homeowner education can eliminate most of the water-holding vessels which support container-breeding mosquitoes. The policy of many landfills to charge extra for accepting used rubber tires and appliances has created undesirable stockpiles in many backyards or illegal dumping along isolated roadsides. Tires can be eliminated as breeding sources by cutting 3-4 large holes on either side, but those most likely to dump tires illegally are least likely to care about creating breeding habitat. Tire dumps create a special problem that can best be dealt with through recycling plants which are now being built in many areas. Retreading operations frequently stockpile large numbers of used tires that are awaiting processing. If tires are stored in open sunlit area, they will not be colonized by *Ae. triseriatus*. *Culex pipiens*, which will colonize sunlit containers and underground catch basins are not a major pest or vector problem in Massachusetts. *Culex salinarius* is the only *Culex* frequently taken in mid to late summer human biting collections in the Northeast and it does not normally breed in catch basins or other containers. The urban autogenous form of *Cx. pipiens* (i.e. *molestus*) reportedly bites humans (Spielman 1973) but outdoor pest populations of this form are not well documented in the Northeast. In any event, well designed and regularly cleaned catch basins should not retain runoff water. Cities in Massachusetts with old sewer systems still contain many catch basins which produce *Culex*. The actual pest status of mosquitoes produced in catch basins should be well established by each community prior to control considerations. New detention and retention basins are frequently built around new malls and similar large construction site to manage rainwater and protect nearby wetlands from runoff pollution and siltation. In many cases these basins are becoming a mosquito problem (*Culex, Anopheles, Aedes,* and even *Coquillettidia*). Better design and maintenance could help to alleviate this growing problem.

About 12 years ago the Asian tiger mosquito, *Ae. albopictus*, was accidentally introduced into Texas, presumably via used tires from northern Asia (Moore 1986). Since its introduction, this day-active, man-biting pest and potential vector species has spread into 17 states including several in the North. It has been found in Maryland and may appear in Massachusetts. Biting densities of 30 per minute already have been reported in

Texas, Louisiana and Illinois. This species is most common in tires but will occupy a variety of man-made containers. Its control is likely to become an important priority in the Northeast within a few years.

VII. STANDARDS FOR MOSQUITO CONTROL

A. Standards for Monitoring and Control: Pesticide applications in an IPM program require monitoring insect populations and comparing data with pre-established thresholds for treatment. In addition, post-treatment evaluation is required to ensure the treatment worked as planned and did not have unintended side-effects.

1. Larval Populations: The primary technique for larval population counts is the dip count. It is hard to standardize dipping technique but, for the purposes of this document, it is assumed that dips are taken in undisturbed pools (the field person is aware that disturbing the water and/or casting a shadow over the water will cause mosquitoes to dive, thereby lowering counts) known by the field personnel to be typical of the breeding area being monitored. For large-scale work, dipping will be done at permanent, marked (or easily located) dip stations. For small sites such as drainage basins and woodland pools, dips will be taken at random throughout the site. Up to twenty dips per site will be taken unless the count for treatment and/or water management is exceeded with a smaller number of dips. Specifics for various types of work are given in Table 17.

a. Larval Identification. Field identification of larvae to genus is desirable. The following genera should be recognizable most of the time: *Aedes, Anopheles, Coquillettidea, Culex, Culiseta, Psorophora,* and *Uranetaenia*. Programs should rear out sufficient numbers of larvae (or identify larvae to species) to allow correlation between adult mosquito species and larval populations. Because there may be situations where treatment will depend on the species (as opposed to the genus) present, programs are encouraged to have a staff member trained in larval (4th instar) identification

b. Pre-control Larval Monitoring. Larval populations are monitored to determine whether or not control is required and, if so, whether short-term or long-term control is preferred. Criteria for water management in salt marshes are given in more detail in Appendix D. Projects should develop their own criteria for freshwater water management work, though some guidelines are given below under standards for physical control.

Table 17. Specifics for monitoring larval (& pupal) populations of mosquitoes for determining control.

	No Treatment	Pesticide Application	Water management	# Sites for large-scale work
Salt Marsh	<1 per 10 dips	1+ per 10 dips	5+ per dip[a]	1 dip station per 250 acres
Freshwater				
Ground	<1 per 5 dips	1+ per 5 dips	Variable	Not applicable
Aerial	<1 per 10 dips	1+ per 10 dips	Not applicable	1 dip station per 250 acres

[a]Numerous additional factors go into determining water management options for OMWM.

c. Post-control or post-alteration monitoring will be conducted as follows:

Treatment Technique	Evaluation Sites	Time Period	Number of Dips
Aerial applications	each dip station	within two business days.	Ten dips
Ground applications	one of every ten sites	within two business days	Ten dips
Water management	each dip station	for two years post-alteration	Three dips

d. Additional Water Management Requirements. Projects have an obligation to ensure that all alterations function as intended without adverse effects on the environment. Post-alteration work for water management (Appendix 4 for OMWM) will also monitor vegetative re-growth, changes in fauna and notes on whether or not the hydrology of the site is as intended.

e. Pre-hatch Work. On occasion, pre-hatch treatment is desirable. In such cases, the project should have historical data that establishes a pattern of breeding at a given site. Pre-treatment work is limited to Category IV larvicides.

2. Adult Populations. No adulticiding program will be conducted on a routine, pre-scheduled basis (i.e. once per week, regardless).

a. Monitoring for Adulticiding

Monitoring Mechanism	Rate to trigger adulticiding
Light traps	Human-biting mosquito counts exceed five per night
Landing counts	Landing count rates exceed one per minute
Complaint calls	When complaint calls exceed two per geographical area (this area will vary but assume approximately one square mile)

b. Considerations for adulticiding. Adulticide applications for mosquito control require particular care as they are generally made with rather broad-spectrum pesticides (for example, resmethrin is of concern near fish waters) in areas of high human use. Pesticide aerosols, while an effective technique for using small amounts of pesticide to impact large numbers of mosquitoes, also increase concerns over drift into non-target areas such as apiaries and organic farms. As is always the case, reading and following the pesticide label is essential. Also, adulticide operators should have a map of no-treatment zones with them on their routes and they should be aware of variations in weather conditions (high wind) that would affect, or even cancel, a treatment.

c. Further notes on complaint calls. Because different people complain at different mosquito population levels, program personnel will conduct landing counts and/or place light traps within adulticide zones at intervals throughout the season to determine what mosquito population levels are triggering what levels of complaint calls. Chronic complaint callers should be checked by conducting landing counts and/or hanging light traps at the location of the complainer.

d. Adult Identification. Light trap mosquitoes should be sorted and up to 100 individuals (randomly selected from the larger pool) should be identified, where possible, to species. If trap counts are being used to monitor water management work, species identification (particularly of *Aedes*) is more critical than if traps are being used for adulticide monitoring.

At least ten mosquitoes from each landing count should be identified to species.

Complaint callers should be asked the time of day at which biting occurs.

e. Post-Adulticide Monitoring. Although determining the exact effect of a given adulticide application is difficult, projects should increase their efforts to understand the impact of adulticiding on mosquitoes. Projects should cross-reference complaint calls with adulticide applications and record the number of calls coming in the week before an application and in the following week (this work may be done during the winter for the previous season). In addition, projects should conduct before and after landing counts and/or light-trap counts for ten percent of their adulticide applications. Landing counts should be taken within 48 hours pre- and post-application at the same location both times. Light trap samples should be from the same trap and for the same time period before and after treatment. Where possible, non-treated areas similar to the treated area should be checked to determine population trends outside the spray zone.

Projects should keep a log of complaint calls received post-treatment Such complaints may be of non-target effects such as fish or bird kills, or of human exposure to the treatment. While establishing a link between an adulticide application and a specific problem is very difficult, such complaints may provide insight into the efficacy of the application or may alert control projects to problems with spray equipment, treatment timing and/or treatment area.

C. Standards for Physical Control. Altering or eliminating mosquito breeding sites range from proper disposal of tires through analyzing drainage systems to creating entire new open marsh water management systems.

All mosquito control programs should create a map of their area of responsibility on which they have roughly demarcated endangered species estimated habitats and significant habitats as listed in the Natural Heritage Atlas. This should be referred to before any maintenance or new work is done and specific maps within the Atlas checked when work is taking place near such an area. Any work with such an area, must go through NHESP.

For this section Physical Control refers specifically to alterations to breeding habitat to prevent mosquitoes from maturing to adulthood. Physical Control is divided further into three types:

Source Elimination: Completely eliminating the breeding site not just the mosquito breeding. Source elimination is generally limited to breeding habitats created by humans in non-wetland areas.

Source Maintenance: Maintaining potential breeding sources in such a way that mosquitoes cannot become a problem.

Source Reduction: Reducing the ability of an area to breed mosquitoes. It differs from source maintenance in that the existing habitat is breeding mosquitoes whereas, if a maintenance program is running as designed, mosquito breeding should not occur. Once a source reduction project is completed, it will, in most cases, require at least some source maintenance in order not to return to being a mosquito-breeding habitat.

Although the three types of Physical Control blend into one another, there is value in recognizing the difference, particularly between maintenance and reduction. Here the critical issue is the need to document mosquito breeding. While unwarranted ditching is not desirable, neither is it desirable to prevent maintenance of existing ditching to the point where mosquito breeding begins in an area that has been mosquito free in the past. It is important to stress that no mosquito-control activity that would result in the permanent loss of true wetland (as opposed to temporarily flooded areas resulting from human mismanagement) can be accepted as a standard practice.

1. Source Elimination.

a. Tires. All mosquito-control programs should have a system in place for contacting departments of public works within the project so that the tires can be removed. Where tires are being intentionally stored, projects should attempt to contact the property owner and explain the breeding potential of the tire dump. Projects are not responsible for ensuring compliance with tire-disposal regulations; their sole responsibility is education of property owners and notification of appropriate local authorities.

b. Blocked drainage. In this situation, the assumptions are that the stagnant water would not be present if not for the blockage and that the drainage in question has not been part of an on-going maintenance program (see source maintenance below). In this case, mosquito breeding must be documented within the blocked ditching for mosquito control programs to re-open the ditch (without mosquito breeding the ditch may be re-opened by Highway or Public Works Departments for drainage reasons).

c. Residential problems. Such situations would include pools, refuse dumps, tire tracks, and other localized, man-made problems. As is the case with tire removal, projects can only advise property owners of the breeding potential and/or notify the appropriate authorities of a problem.

d. Drainage basin design. A primary tenet of IPM is to avoid creating pest problems through good planning. Projects are strongly recommended to make available to local agencies the specifications for drainage basin design located in Appendix 5. Projects should evaluate various basin designs for breeding potential and should educate local officials about the problems basins can cause.

2. Source Maintenance

a. Stormwater runoff and ditch maintenance. A primary goal of any mosquito control program is to monitor existing drainage to ensure that it is working as designed. Within existing drainage, any blockage may be removed regardless of mosquito breeding. As an example of the type of guidelines projects should use for this type of work, the standards for the North East Massachusetts Mosquito and Marsh Restoration Project are given in Appendix F.

Record keeping for maintenance purposes should be improved. Projects should maintain at their headquarters a list of all drainage that is monitored and maintained. This list should include location and approximate cross-section and length. Projects should also maintain a record of when and where maintenance was done. In instances where ditching has not been maintained, and no historical documentation of maintenance exists, the projects should request a review of the proposed work by DEP's Water Quality Certification program to ensure compliance.

In the long run, projects should develop priority lists for ditch maintenance based on the potential for mosquito breeding, the proximity of human activity, the ecological cost in reduced wetland benefits from the area being drained, and the relative value or scarcity of the wetlands resource affected. Maintenance should be based on breeding potential and ecological factors.

Drainage basin maintenance is also included within this area. Some basins that do not produce mosquitoes when maintained properly, will become breeding sources if left unmaintained. Projects should conduct yearly checks of drainage basins to ensure that pooling within the basin is not increasing to a point where breeding may occur. In deeper basins, invasion by cattail or emergent grasses might also create breeding habitat.

Basin ownership and maintenance responsibility are often difficult to determine. Mosquito Control Programs need to remind the appropriate authorities that basin maintenance is an important issue and should be monitored by the Building Inspector's office or other responsible agency.

b. Salt-marsh Ditching. It is generally not recommended that the open ditch systems be maintained as is. however, projects will self-determine the need for maintenance of existing ditching versus conversion to OMWM, understanding that conversion is preferred.

c. Waste Disposal. Projects are not responsible for waste disposal but they can and should monitor areas known for problems with either tire dumping and/or improper general waste disposal, particularly where it blocks drainage. The purpose of this work is not to get projects involved in policing dump sites, but rather to get them to move from a passive strategy of treating known tire piles to an active strategy of eliminating such areas and preventing their return.

3. Source Reduction.

a. Open Marsh Water Management. Open Marsh Water Management (OMWM) is the preferred technique for salt-marsh source reduction. When done properly, OMWM can result in virtual elimination of breeding without any loss of wetland. Although each project with salt marsh will develop its own standards, the standards of the North East Massachusetts Mosquito Control and Wetlands Management District are included as Appendix 4 as guidelines for establishing an OMWM system that will comply with all state and federal regulations.

New open tidal ditch systems are not recommended except as an integral part of an OMWM system.

b. Freshwater wetlands. Source reduction in freshwater systems, exclusive of existing drainage networks, does not have an equivalent to OMWM in salt marshes. At this time there can be no standards for water management within freshwater systems except that any such work must be evaluated by the appropriate authorities on a case-by-case basis.

An additional consideration is wetlands replication, the process by which existing wetlands may be altered and new wetlands created. While mosquito control projects should not be the authors of such work, they will be involved in monitoring such areas. Further, reclassifying some areas as wetlands replication sites may well alter the extent to which water management work and/or larviciding can or should be done. For this reason, projects should be made aware of all wetlands replication projects. As with drainage basin design, projects should likewise develop a working relationship with town Zoning Boards and Building Inspectors so that mosquito control programs are included in the review process for wetlands restoration, replication or creation projects.

c. Cattail control. In order to prevent increases in *Coquillettidea perturbans,* projects should discourage the creation of deep-water (two feet plus) cattail marshes (Drainage basins) in residential areas. Failing in that, projects should request that such marshes be designed so that water may be drained from the marsh for a period of several weeks in late summer.

D. Standards for Biological Control.

1. Larvivorous fish. OMWM is dependent on native fish immigrating into the newly created ditch and reservoir system. Projects should explore the idea of stocking native fish species in deep-water drainage basins.

2. Other biological control agents. Exclusive of the Bti and *Bacillus sphaericus* products (listed here under pesticides), there are no current biological control agents available for use for mosquito control in Massachusetts other than larvivorous fish. Mosquito control programs in Massachusetts are not research institutions and cannot be expected to develop biological control agents without extensive research support. Should research uncover possible control agents, projects are encouraged to experiment with them.

E. Standards for public notification, public awareness and education.

1. Public Notification.

Projects must comply with regulations for aerial applications of pesticides.

For truck-mounted adulticiding, projects should notify the public through the print media, between March 1st and May 1st of each year, as to the areas that may be treated, the pesticide to be used and a number to contact for more information or to request exclusion from treatment.

All projects should maintain, either at their headquarters or at a designated public library, a copy of this GEIR and copies of the labels and MSDSs of all the pesticides they use. it is further recommended that they include copies of any educational materials they have put out.

2. Public Awareness and Education. As education is a primary aspect of an IPM program, projects are encouraged to develop educational flyers covering such aspects of their work as pesticide use, water

management, and property-owner mosquito control. Flyers may either be developed in-house or be obtained from the state or other agencies. Examples of educational materials may be found in Appendix 7.

3. Staff Development. Aside from the pesticide applicator recertification requirements, programs are urged to provide opportunities for staff to increase their knowledge about mosquitoes, wetland, and mosquito control. Membership in professional organizations, accessing information through university Libraries or the Internet, and developing good working relationships with federal, state and local officials whose tasks overlap that of mosquito control are all good ways to improve the knowledge and performance of staff.

F. Standards for EEE monitoring and DPH liaison.

1. Role of Programs in EEE Surveillance.

The MA DPH in cooperation with the Executive office of Environmental Affairs (EOEA) and the regional mosquito control districts of eastern Massachusetts developed the "Vector Control Plan to Prevent Eastern Equine Encephalitis (1991, currently being revised). This plan outlines and defines policy for vector control of mosquitoes that transmit the EEE virus and provides guidance for the coordination of state, regional, and local efforts during EEE outbreaks, This plan requires the active cooperation of MCDs in the EEE Risk Area. At clearly defined levels of EEE risk, based upon surveillance data collected by DPH, MCDs are asked to assist DPH in assessing vector species abundance levels and control options in their communities. The cooperative efforts of the MCDs working with DPH helps effect targeted, species-specific vector control when warranted. At the Level of EEE Public Health Emergency (see Appendix B), the MCDs work in conjunction with DPH to carry out all phases of the control effort.

2. Standard Operating Procedures during EEE problem.

When surveillance data points to increasing levels of EEE risk, DPH notifies the SRMCB and regional MCD superintendents. The EEE Surveillance Program informs MCD superintendents of isolations of EEE in their districts and the districts, in turn, provide feedback to DPH regarding population and life stage indices for critical mosquito species. At certain defined interim levels of risk as outlined in the "Vector Control Plan," MCDs may be asked to increase their ground control larvicide and/or adulticide applications in response to increased EEE virus activity. The SRMCB is responsible for contracting with appropriate mosquito control applicators in the event that aerial EEE vector control is recommended by DPH.

VIII. SUMMARY AND RECOMMENDATIONS

A. Legal, Organizational and Fiscal Aspects of Massachusetts Mosquito Control

The organizational structure and funding for Massachusetts mosquito control programs, be they regional or town based, rests predominately at the level of town government, although the state legislative bodies have a direct influences over eight of the nine MCPs' annual budgets (only East Middlesex is not so affected). In contrast, the overseer of mosquito-control activity in Massachusetts is the State Reclamation and Mosquito Control Board. This is a loose arrangement for delivering a public service that is best applied at a regional level. Lack of control effort in one town can greatly effect the efficiency of control efforts in neighboring towns.

Enabling legislation has been written in a patchwork manner so that there is currently little consistency from project to project. For example, towns in Barnstable County (and formerly in Berkshire) are all members of their respective regional MC project and no individual community may withdraw from the program without changing the legislation as did Chap. 119 of the Acts of 1982 in the case of Berkshire County. This provides an assurance of fiscal and organizational stability that is lacking in other programs. For example, the Essex County and Central Massachusetts projects both went through considerable upheavals in membership between 1988 and 1993. Fortunately, the other projects have remained remarkably stable over the past decade. Maintaining and improving stability, both in membership and funding, is a desirable goal.

This uncertain fiscal picture is further compounded by the fact that all MC projects in Massachusetts are seriously under-funded. In other states, with progressive MC programs, the per capita expenditure varies from $2 upward. In Massachusetts, it averages about $0.50 (based on $2 per household of 4 people). In addition, many other states provide supplemental state funds to encourage non-chemical control efforts and for supportive research and educational activities. No such state support exists in Massachusetts. When supplemental state support has come, it has been for chemical adulticiding in the wake of EEE threats.

To a large extent, funding dictates the control approaches that can be pursued. IPM, source reduction, 1arval control, and adult control represent the four major options in their order of decreasing cost and efficiency. Thus, poorly funded programs are forced into more reliance on less efficient and more controversial techniques. Larger, better-funded, and stable regional projects can invest in better paid and trained employees, better surveillance and public education programs, and expensive equipment such as helicopters which can broaden the options for safer and more efficient larval control (e.g., granular larviciding with Bti and methoprene).

Given the fact that several different state agencies are concerned with mosquito control activities, the current system of interagency responsibility for overseeing MC activities (i.e., State Reclamation and Mosquito Control Board representing 3 different state agencies) is perhaps the best compromise arrangement. On the other hand, the level of general support services that projects and towns receive from this Board seems to be inadequate.

Recommendations

That new and comprehensive enabling legislation be drafted, reviewed, appropriately revised, and passed into law, which will bring all MC control activity in Massachusetts under the same organizational, fiscal and operational guidelines. This legislation should provide for the following:

1. The State Reclamation and Mosquito Control should have the following personnel:
   a. An Executive Director @ approximately $45,000 per year
   b. An Engineer @ approximately $35,000 per year
   c. An Entomologist @ approximately $35,000 per year

   Not only would this staffing permit the state to conduct research into mosquito control, it would provide a team for rapid response to EEE threats in communities that are not members of established MCPs. This staff would also provide services such as incorporating DEP stormwater management guidelines into Massachusetts MCP Upland Water management operational procedures.
2. An operations budget, above and beyond the normal needs of the SRCMB, for research and development. A minimum of $50,000 per year is suggested.
3. A competitive grant fund (funded by the state, administered by the Executive Director of SRMCB and advised by an ad hoc panel of outside experts) to support IPM related research and delivery programs within the state mosquito control enterprise. This should provide support for studies such as: cost/benefit analysis of mosquito-control programs; development of human annoyance thresholds (HAT); improved methods for monitoring and predicting mosquito population levels; development, evaluation, and implementation o£ new, non-chemical mosquito management techniques (e.g., open marsh management and biological control); management of pesticide resistance, drift and other use exposures; impact of MC activities on surface and ground water,

and on non-target organisms; and the biology and role of selected species in disease transmission.

4. The SRMCB should establish a committee to work with their staff to develop best management practices (BMPs) for all aspects of mosquito control, the results of their work being used to update the GEIR on a regular basis. The committee should include four mosquito-control superintendents, four representatives of environmental agencies (federal, state or private) and one at-large member to serve as chairperson. Their first order of business should be to develop a set of BMPs for freshwater drainage maintenance for mosquito control. These BMPs should establish strict definitions for projects in which the mosquito control exemption from the Wetlands Protection Act may be applied.

5. MCPs must have the authority to deny requests for maintenance work that does not have a mosquito-control component. Because these requests are often made by the same persons or municipalities which provide funding to the MCPs, the SRMCB must be willing to act as an appeals board, to which a request for work may be sent by an applicant in the event the mosquito control program denies the request.

6. Limit mosquito control activity to regionally based regional mosquito control programs which can be organized by the appropriate public vote. The SRMCB should organize the regional based mosquito control programs and appoint project or district commissioners. The SRMCB should select Commissioners from candidates proposed by authorized Boards/individuals from the cities and towns of the mosquito control projects or districts.

7. A flexible and appropriate system of tax assessment which allows for budgets that are adequate to provide for the implementation of the most contemporary and least risky strategies for controlling mosquitoes.

8. A legal system whereby all major zoning and construction plans in the Commonwealth are reviewed by the executive director of SRMCB and the appropriate county MC director for their potential impact on mosquito populations and human health.

B. Operational Aspects of Massachusetts Mosquito Control

Operational programs in Massachusetts could legally be using chemicals (approved by EPA and the Massachusetts Pesticide Board) that are significantly more hazardous than those used in current practice. This suggests that knowledge and sensitivity for the environment and human safety are generally being considered by the existing control programs. As already indicated, funding levels seldom allow projects to follow the optimum operational course. Despite these fiscal constraints, projects have significantly changed their operational methods in recent years toward more source reduction work such as the Open Marsh Water Management projects in Essex, Norfolk and Plymouth Counties. Most projects also use more selective and environmentally compatible larvicides such as Bti and methoprene.

The operational recommendations that follow are predicated on additional and adequate funding being available for implementation.

<u>Recommendations</u>

1. All MC Projects should build their programs around the IPM strategy of keeping human annoyance below threshold levels as given in the Standards of this GEIR.
2. Control methodology should be source reduction whenever possible and larvicidal control when it is not. Projects should work closely with the DEP water quality certification program and the Natural Heritage Endangered Species Program to minimize negative impacts of source reduction to wetland habitat and/or rare or endangered species. The most target-selective and environmentally compatible larvicides (e.g., Bti, methoprene) should be used whenever possible regardless of cost considerations.
3. Saltmarsh mosquito control efforts should emphasize OMWM. All OMWM proposals should include plans for filling many of the old grid ditches in Massachusetts salt marshes which do not function in a productive way and which must regularly be cleaned in order to prevent breeding in the ditches themselves. This will gradually eliminate the controversy over the continuing need to clean these ditches and the problem of what to do with the resulting spoil that is created.
4. Document location, length, and cross-section(s) of all drainage systems maintained by the project and have that information available in an easily understood format for public inspection. Exemption from the permitting process extents only to those drainage systems for which adequate historical records of maintenance work exist.
5. The SRMCB should create a list of pesticides approved for mosquito control in Massachusetts. Adulticides should be from Categories III and IV and larvicides should be from Category IV.

6. Adulticiding should only be carried out in emergency situations involving disease threats or pest densities which consistently exceed the human annoyance threshold.

7. For large-scale adulticiding, only ULV-cold fogging should be used. For spot treatment around recreation areas or other areas where public events are to be held, portable mistblowers using permethrin as a residual pesticide can be used.

8. Aerial applications should be restricted to granular formulations in areas where drift could be a significant problem. Sometimes some drift is desirable so as to reduce the chance of gaps between application swathes. In such cases a liquid formulation may be a better choice. At this time liquid formulations are also significantly cheaper, making larger applications, and more effective control, easier. Increased use of helicopters for aerial larviciding in coordination with the use of drift-suppression agents and technologies should be encouraged (particularly for enhanced larval control in inaccessible habitats such as salt marshes, wooded swamps, vernal pools, etc.).

9. Projects should file a post-treatment report for aerial applications with the Pesticide Bureau which gives location and acreage actually treated. The pre-application forms do not always accurately represent what actually happened.

10. Chemical-use reporting needs to be monitored to ensure uniformity and accuracy in reporting. Previous reports contained such problems as no units are given on the 1993 through 1995 Cape Cod report for Bactimos (BTI), two different EPA registration numbers for Bactimos are given in the 1993 Cape Cod and Central Massachusetts MCPs reports, and briquets are variously reported in terms of number of briquets, pounds of briquets or pounds of active ingredient. The Pesticide Bureau should insist that yearly chemical-use reports be filled out according to standardized procedures. Reports should be checked as they come in to ensure that standardized reporting procedures are followed.

11. All pesticide storage areas should be equipped with smoke, fire and security systems. A standard procedure should be developed for the disposal of all insecticidal materials used in Massachusetts for mosquito control. The State Pesticide Board should encourage manufacturers of such products to market reusable containers. A standard procedure should be developed for the clean-up of

accidental spills of insecticides. Proper use of absorbent materials and the disposal of such materials are necessary. Proper attire during formulation and application of insecticides should be made mandatory for all individuals involved in these processes.

C. Research Needs

There is a need in the mosquito control process in Massachusetts for a strong, operationally focused, research effort in freshwater wetlands, exclusive of chemical application techniques. This is not to condemn current research efforts, for we know more about EEE mosquitoes than ever before, have improved saltmarsh mosquito control dramatically, and have made improvements in both chemicals used and methods of chemical use over the past decade. But there is a need for research to assess the environmental impacts and efficacy of the current MCP programs relative to the freshwater environment.

Additional research on topics such as long-term effects of OMWM, economically viable control of *Cq. perturbans*, and mosquito control in endangered species habitats also require attention.

<u>Recommendations</u>

1. For water management practices, monitor impacts on animals on a case-by-case basis, depending on the site and establish vegetation transects to document changes in wetland vegetation.
2. Develop a unified data base that documents mosquito populations on an ongoing basis from regular monitoring sites. Establish state standards for monitoring mosquitoes and provide training to mosquito control project staff in data collection and management.
3. Conduct comparative studies with different management approaches (e.g. pesticide applications vs. water management).
4. Develop a Geographic Information System (GIS) with known breeding sites and areas of historical water management activities.
5. Qualify sites on the basis of need for control, based on breeding (potential or actual), mosquito species, proximity to human activity, level and type of human activity, and type of wetland habitat affected.
6. Create an ongoing research partnership with NHESP to document wetland types, etc.. Mosquito Control Projects have knowledge and expertise about wetlands that could be invaluable to NHESP.

IX. WRITTEN COMMENTS ON GEIR

NOTE: CONTACT THE STATE RECLAMATION AND MOSQUITO CONTROL BOARD TO OBTAIN COPIES OF THESE DOCUMENTS

A. Comments on Notice of Project Change (1996).

B. Comments on Spring 1997, Rough Draft.

C. Comments on Final Rough Draft (1997-98).

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APPENDIX A

GENERAL ENVIRONMENTAL IMPACT REPORT

1996 QUESTIONNAIRE
MASSACHUSETTS MOSQUITO CONTROL PROGRAMS

NOTE: CONTACT THE STATE RECLAMATION AND MOSQUITO CONTROL BOARD TO OBTAIN COPIES OF THIS DOCUMENT.

APPENDIX B

DPH EEE RISK ASSESSMENT, RISK CATEGORIES, STRATEGY FOR VECTOR CONTROL
(from the Vector Control Plan to Prevent EEE)

VI. RISK ASSESSMENT

The potential risk for EEE disease in humans is categorized into one of four levels according to an assessment of EEE surveillance data from the current and previous year. The risk levels are (1)Low (2)Moderate (3)High and (4)Public Health Emergency. Under Risk Levels 2, 3 and 4, the characterization of risk includes a definition of areas of concern. The concept of "area of concern" is important in defining the magnitude of the EEE risk and selecting appropriate intervention options. There are three components within the conceptual construct of area of concern: study area, risk area and treatment area.

(1) The study area is the geographical area where most human and equine EEE cases in Massachusetts have occurred. This area is shown in Figure 3 and includes Plymouth, Norfolk, Suffolk, Bristol, Middlesex and Essex Counties. Personal protection measures are emphasized in this area through a public information campaign that intensifies at each level of risk.

(2) The risk area is the geographical area where most of the human EEE cases have occurred. This area is shown in Figure 4 and includes Plymouth, Bristol and Norfolk Counties, and parts of Middlesex and Suffolk Counties. Vector control efforts may be implemented by state agencies or Regional Mosquito Control Districts within this area. Vector control efforts may be extended outside of this area, if surveillance data indicate the probability of multiple human EEE cases occurring outside the area of historical disease prevalence.

(3) Treatment areas are defined by EEE surveillance data and are used to guide vector control efforts. The basic cell is defined by a mosquito trap site and is approximately 100,000 acres. These treatment cells are calculated to be the set of "best-fit" polygons that represent the areas around trap sites. The area for treatment will be defined by the GIS polygon inclusive of all towns with more than 20% of their area within the unit. Vector control intervention will be dependent upon viral isolation from mosquito pools trapped at the DPH site. The treatment area for a positive EEE virus isolation from a horse or human is defined by a circle approximately 2 miles in radius around the case. Within a treatment area, larviciding is recommended in areas where significant

levels of vector species larvae are present, and treatment would be expected to reduce adult emergences in proximity to large numbers of people. Adulticiding of a treatment cell is recommended if predetermined risk indices are met and significant numbers of vector species adults are present.

At a Moderate or High level of EEE risk, vector control is considered within an area following identification of EEE virus in the environment. Following a positive finding supplemental surveillance is done to assess the need for a vector control intervention. Additional trapping will be implemented in the treatment area to determine the age structures and population abundance of vector species. Larval surveys may also be initiated after significant rainfall events.

EEE occurs disproportionately by area within eastern Massachusetts. The human cases of EEE by county have been 25 in Plymouth, 19 in Norfolk, 13 in Middlesex, 9 in Suffolk, 5 in Bristol, 1 in Essex, 1 in Barnstable, and 1 in Hampden. A disease prevention strategy must respond to this disproportionate distribution of risk by providing supplemental mosquito control funding (and/or state or federal assistance delivered through independent contractors) for high risk areas and by coordinating efforts among Mosquito Control Districts that share common risk areas. The epicenter of EEE appears to be the contiguous area where Plymouth, Norfolk and Bristol Counties join. This area should be the primary target of coordinated mosquito control efforts under the direction of a state office. In the event that fiscal, staff, and equipment resources available to regional mosquito control districts are insufficient, the state must be prepared to assist in the effective control of mosquitoes to help prevent or minimize human EEE cases.

RISK CATEGORIES

(1) LOW - A LOW LEVEL OF EEE RISK exists if all of the following conditions are met:

Current Season

1. EEE virus isolates in *Cs.melanura* <10
2. Population of *Cs. melanura* below long-term mean

Previous Season

1. No human or horse cases
2. *Cs. melanura* below long-term mean
3. EEE virus isolates <20

At this level surveillance activities are routine and supplemental control efforts are not recommended. Mosquito control efforts should be standard in accordance with established plans for integrated pest management (IPM). IPM is an ecologically based strategy for managing insect populations with the goal of keeping pest levels below predetermined threshold levels. Mosquito Control District (MCD) IPM programs may include source reduction, ground or truck spray adulticide, larvicide, and other control activities in response to human annoyance thresholds (HATs) as determined by the MCDs operating under the State Reclamation and Mosquito Control Board.

(2) MODERATE - A MODERATE LEVEL OF EEE RISK exists if any of the following conditions exist:

Current Season

1. EEE virus isolates from *Cs. melanura* >10
2. *Cs. melanura* populations approaching long-term mean
3. 1-2 presumptive or confirmed horse cases

Previous Season

1. 1-2 human cases or 2-4 horse cases
2. *Cs.melanura* population above the long-term mean
3. EEE virus isolates from *Cs. melanura* >20

At this level, mosquito control interventions should be directed only against those species suspected as epidemic vectors (capable of EEE virus transmission to humans). Regional mosquito control efforts should be intensified only in EEE virus positive treatment areas. These efforts may include larviciding and ground or truck spray adulticiding based upon surveillance data that indicates significant larval and/or adult populations of bridge vector species.

(3) HIGH - A HIGH LEVEL OF EEE RISK exists if any of the following conditions exist:

Current Season

1. Confirmation of 1 human case
2. 3 or more presumptive or confirmed horse cases
3. *Cs. melanura* population above the long term mean and MIR in Cs.melanura >1
4. EEE virus isolate from bridge vector species

Previous Season

1. 2 or more confirmed human cases or 5 or more presumptive or confirmed horse cases.

These indices trigger intensive surveillance of bridge vector species and recommendations for state-funded vector control interventions which may include ground or targeted aerial larviciding and/or adulticiding. Treatments would be undertaken only in EEE virus positive treatment areas, defined by EEE virus isolates and horse or human cases, as surveillance of bridge vector populations indicate.

(4) PUBLIC HEALTH EMERGENCY - DPH will forward a recommendation immediately to the Governor's Office to declare a PUBLIC HEALTH EMERGENCY in the event that any of the following conditions exist:

Current Season

1. 2 human cases are confirmed
2. More than 10 horse cases are confirmed

Surveillance data indicating that multiple human cases of EEE will occur without intervention

These criteria will be considered sufficient for a recommendation that an emergency be declared, if they occur at a time when seasonal and biological conditions present a continuing high risk of EEE human disease. The declaration of an Emergency may trigger state supported mosquito control efforts using wide area aerial application of mosquito larvicide or adulticide. A recommendation for a wide area aerial adulticide application will be made only if surveillance data indicate a risk of multiple human cases and biological conditions are favorable for continuing risk. When such control strategies are recommended, treatment areas will be defined by DPH surveillance data. Areas targeted for aerial pesticide application will immediately be notified and all media sources utilized to alert residents to the timing and scope of the application. Environmental monitoring will be done before and after treatment and rare and endangered species habitat excluded from the spray zone in affected areas. In addition a 500-1000 foot setback will be observed when spraying around water bodies. The objective of this option is to cause a significant reduction in all species capable of EEE transmission. This intervention is successful if the target species are temporarily reduced thereby interrupting the amplification of the virus within its avian reservoir. The timing of this late season option is critical and is intended to be a one-time intervention.

VII. STRATEGY FOR VECTOR CONTROL

A vector control plan must be safe, economical, minimize environmental effects, and minimize the risk of human EEE disease. To achieve these ends, the plan must be, to the maximum extent possible, geographically and vector species specific. Vector control measures are chosen according to species, seasonal and climatic conditions, and vector life stage indices.

Three options will be available for vector control: larviciding; targeted small scale adulticiding; and wide-area aerial adulticiding; with specific activities chosen by analysis of surveillance data. Treatment areas will be defined by mosquito trap sites and/or human/equine case locations. Within a treatment area, the use of larviciding or adulticiding interventions will be guided by additional field information and surveillance data to limit the area of intervention to the extent possible, taking into account the uncertainty of risk data. All state supplemented vector control interventions will be done under the authority of Regulation 304-CMR. Section 50.08 (3)(a).

The number of mosquito species that potentially could serve as epizootic vectors of EEE is extensive; however the three species most often thought to be responsible for human and equine infection are *Coquillettidia perturbans*, *Aedes vexans* and *Aedes sollicitans* (Tsai 1991). Recent studies suggest that *Anopheles* species and *Culex salinarius* should also be considered as epidemic EEE vectors (Edman et al 1993, Vaidyanathan et al. 1997). An historical analysis of the epidemidology of EEE in Massachusetts and mosquito abundance and isolation data indicate that *Ae. vexans*, *Ae. canadensis* and *Cq. perturbans* are likely vectors involved in human disease transmission in Massachusetts. *Ae. sollicitans* may also be a vector for cases located closer to the coast, and may be targeted in areas where known human and/or equine cases have occurred.

Cq. perturbans, a permanent water species, breeds in cattail marsh areas, common in the disturbed sections of wetlands. This species has one generation per year, emerging by mid June and reaching peak populations by early to mid July. An aggressive human biter, *Cq. perturbans* presents a difficult control problem because its larvae develop attached to the roots of emergent vegetation in permanent marsh areas. The insect growth regulator methoprene in the form of slow release Altosid formulations has proven to provide effective larval control of this mosquito (Sjogren et al. 1986). This chemical is relatively nonpersistent in the environment and exhibits morphological rather than direct toxic action by interfering with larval development.

Aedes vexans, *Aedes sollicitans*, and *Aedes canadensis*, are reflood mosquitoes whose abundance levels are directly related to rainfall and floodwater or moon tide events sufficient to flood intermittently flooded oviposition areas. All of these species may exhibit peak populations mid to late summer concurrent with peak EEE virus activity in birds and may be treated at the larval stage using the biological control product, *Bacillus thuringiensis* var. *israelensis* (Bti). The success of such applications, may be hampered, however, by the small treatment window available due to rapid larval development and by the difficulty of application through the dense canopy and thick underbrush of late summer. Bti is a natural microbial agent toxic to most mosquito and blackfly larvae. It is non-toxic to bees but some mortality to other Diptera has occurred at mosquito-control application rates. In all EEE vector interventions standardized larval surveys will be conducted pre and post application.

Aedes vexans is the most predominant summer reflood mosquito in Massachusetts. The appearance of this species is dependent on the frequency and spacing of major rains. Broods have been observed from the latter part of June throughout the summer and into the fall. Although the window for effective larval treatment is narrow due to the rapid development of this species, *Bti* applications have been used successfully for control.

Aedes sollicitans breeds in the high salt marsh that is normally only flooded by moon tides at the full and new moon. *Aedes sollicitans* is an aggressive biter know to travel great distances from its breeding habitat. This species can be effectively controlled with *Bti* and treatment is made easier by the predictability of its life cycles. *Aedes canadensis* is primarily a univoltine species that appears from late spring through mid summer. A second brood can develop in early fall if rainfall is sufficient. These mosquitoes develop in temporarily flooded woodland depressions and vernal pools that are often inaccessible, particularly late in the summer, due to heavy underbrush making ground control difficult if not impossible to accomplish. Due to the heavy tree canopy and dense underbrush of this habitat, aerial larval control of *Aedes canadensis* is also very difficult.

Anopheles mosquitoes inhabit permanent water, and may be found along the edges of slow moving streams. In the latter part of the summer they may also be found in temporary pools and puddles caused by summer rainfall. *Culex salinarius* is classified as a permanent water species. This species is multivoltine with peak populations occurring late in summer. *Cx. salinarius* is an active human biter and although mammalophagic, it is more likely than other potential epidemic species to feed on birds thus increasing its chances of a playing a role in EEE virus transmission (Vaidyanathan et al 1997). The larvicide *Bacillus sphaericus* has been found to be effective against *Culex* species. *Bacillus sphaericus* is a naturally occurring bacterium with the same mode of action as Bti but with an even more narrow toxicity range. This larvicide is more effective than Bti in the highly organic water favored by *Culex* species. The spores of this bacterium are slowly removed from the water column and *B. sphaericus* may undergo limited recycling in certain environments thereby increasing its availability to target organisms. Granular formulations of *B. sphaericus* have been found to work effectively against Anopheles species (Arrendondo et al. 1990). Altosid formulations have also been used successfully as larval control agents.

Small-area, targeted, ground or aerial adulticiding with ULV malathion or resmethrin may also be utilized if specific risk conditions are met. This effort will be aimed at all potential vector species in the target area where population and life stage studies indicate treatment is required. Wide-scale aerial adulticiding may only be employed during a public health emergency if it is determined that use of such treatment is needed to prevent further human disease transmission.

An effective adulticide provides a sufficient reduction in vector species such that there is insufficient time for reinfection of a subsequent brood of vector species before the end of the mosquito season. Late season risk following a wide area intervention is usually limited by lack of virus availability in avian species, the low probability of significant numbers of infectious human biting mosquitoes surviving, and cooler weather that limits the activity of mosquitoes.

All state supplemented aerial adulticide treatments will use ULV malathion. A comprehensive review of aerial applications of insecticide for mosquito control concludes that ULV applications are efficacious, cost effective and can be used effectively over dense foliage or open housing (Mount et al. 1996). Malathion has been chosen because of its effectiveness against adult mosquitoes and its relative safety for humans and other vertebrates (Edman and Clark 1990). The efficacy of all adulticiding treatments will be determined by a comparison of pre and post-spray DPH trap site mosquito abundance levels.

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APPENDIX C

GENERAL ENVIRONMENTAL IMPACT REPORT

PESTICIDE LABELS AND MSDS
MASSACHUSETTS MOSQUITO CONTROL PROGRAMS

NOTE: CONTACT THE STATE RECLAMATION AND MOSQUITO CONTROL BOARD TO OBTAIN COPIES OF THIS DOCUMENT.

APPENDIX D

GENERAL ENVIRONMENTAL IMPACT REPORT

NORTHEAST MASSACHUSETTS MCP STANDARDS FOR OPEN MARSH WATER MANAGEMENT

NOTE: CONTACT THE NORTHEAST MASSACHUSETTS MOSQUITO CONTROL AND WETLANDS MANGAMENT DISTRICT TO OBTAIN COPIES OF THIS DOCUMENT.

APPENDIX E

STORMWATER MANAGEMENT

The following is a brief summary of information relevant to mosquito control found in the three state publications:

Stormwater Management. Volume One: Stormwater Policy Handbook. (March 1997)

Stormwater Management. Volume Two: Stormwater Technical Handbook. (March 1997)

Both prepared by the Massachusetts Department of Environmental Protection and the Office of Coastal Zone Management.

Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas.

Prepared by the Franklin, Hampden and Hampshire Conservation Districts and available through the Department of Environmental Protection.

These documents should be referenced directly for more detailed information.

The two concerns addressed by these publications are water quality (pollutants) and water quantity (flood control). They are primarily concerned with preventing pollutants from flowing into waterways and wetland systems, and with controlling runoff from developed sites. For mosquito control, therefore, the regulations are generally not directly applicable (except in rare cases of new construction) but come into play when MCPs are asked to conduct mosquito control within these constructed systems. This results in the odd situation where Best Management Practices for stormwater management are not evaluated for their mosquito-breeding potential. However, failing to address mosquito control in the design phase may result in a larger-than-necessary number of stormwater management systems that contribute to mosquito problems. In endemic eastern equine encephalitis areas, creating additional breeding habitat for bridge (bird-to-human) vectors such as *Cq. perturbans* or *Ae. vexans* is unwise. Wet (Retention) Basins and Constructed [Stormwater] Wetlands may do precisely that.

A significant limitation of the handbooks for mosquito control is that they discuss new construction of manmade systems only. Maintenance of existing and/or natural systems is not discussed. The Erosion and Sediment Control Guidelines should be referred to for information about working in and around existing drainage though even here the issue of maintenance within the existing channel is not discussed.

Four issues regarding stormwater management exist for MCPs and are addressed in order of importance (most important first).

1. The expectation that MCPs will maintain drainage systems even when MCP actions did not cause the problem (road sand into a stream).

Standard #9 of the "Stormwater Management Form" (page 1-11 of the Policy Handbook), relates to the Operation/maintenance plan for control designs. Although this particular form is optional, the requirement for a maintenance plan should not be. Where MCPs will be expected to monitor for mosquito breeding, they should have access to the maintenance plan for the stormwater system in question and should be able to request maintenance on-site where mosquito breeding is caused by a breakdown in the system's operation. Suggested maintenance requirements for each BMP are given in the Technical Handbook. MCPs should also be able to request system alterations in the event a system is continually breeding mosquitoes.

Where maintenance responsibility is clear-cut, maintenance work should be done by the responsible party. Unfortunately, the vast majority of drainage channels have no official maintenance plan and MCPs have routinely assumed or been assigned responsibility for maintenance. In these cases, MCPs should, wherever possible, adhere to the maintenance requirements as given for the BMP that most closely describes the system in question. In most cases this will be the Drainage Channel.

2. The erosion and sediment control standards relating to (exempted) maintenance work done by MCPs.

Despite the fact that MCP maintenance work is exempted from the Wetlands Protection Act, the best interests of the MCPs are served by minimizing disruption during maintenance work. Temporary erosion and sediment controls should be used when necessary. Vegetation bordering the channels should be left as undisturbed as possible. Again BMPs for maintenance in existing systems should be developed.

3. System design and the extent to which mosquito breeding is considered prior to construction.

BMPs for stormwater management in urban and suburban areas must include some consideration of mosquito-breeding potential. That the current publication does not is an indication of the need to improve communication between mosquito control and other agencies involved in stormwater management. The best place to practice mosquito control in manmade drainage systems is in the design phase. Clearly there is cause for concern over the BMP Constructed [Stormwater] Wetlands, where pools ranging from 6 to 18 inches deep are <u>desired</u>.

4. New construction by MCPs.

New drainage construction is not exempted from the Wetlands Protection Act and MCPs should refer to the policy and technical handbooks when designing any new work.

APPENDIX F

GENERAL ENVIRONMENTAL IMPACT REPORT

NORTHEAST MASSACHUSETTS MCP STANDARDS FOR DITCH MANAGEMENT

NOTE: CONTACT THE NORTHEAST MASSACHUSETTS MOSQUITO CONTROL AND WETLANDS MANGAMENT DISTRICT TO OBTAIN COPIES OF THIS DOCUMENT.

APPENDIX G

GENERAL ENVIRONMENTAL IMPACT REPORT

EDUCATIONAL FLYERS REGARDING MASSACHUSETTS MOSQUITO CONTROL PROGRAMS

NOTE: CONTACT THE STATE RECLAMATION AND MOSQUITO CONTROL BOARD TO OBTAIN COPIES OF THIS DOCUMENT.

APPENDIX H

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BS, Entomology, Cornell University, Ithaca, NY — Jan. 1981

Continuing Education:
Courses in Environmental Planning and Community Development, Dept. of Community Planning, URI — 1987-88

EXPERIENCE: Director of the **Portsmouth** Vector Control Program (14 years), and of mosquito control programs for **Tiverton** (13 years), **Warren** (11 years), **Bristol** (9 years), **Lincoln** (8 years), and **Westerly** (5 years). Currently assisting **Warwick** Mosquito Control Program (12 years).

Mosquito Control Consultant for **Nantucket**, **MA** 1990 - 1993, 1996 - 1998.

Have designed and marketed elementary-school-level classes in Entomology.

Assisting **Warwick** in implementation of city-wide integrated pest management program 1993-1995.

MEMBER:	American Mosquito Control Association	13 Years
	Northeastern Mosquito Control Association	13 Years
	Member, Board of Directors:	1994-1997
	Entomological Society of America	7 Years

EDITORIAL EXPERIENCE: Editor: Northeaster. The newsletter of the Northeastern Mosquito Control Association.

SELECTED PUBLICATIONS: Christie, G. D. 1995. Guidelines for the use of pesticides on city-owned property. Warwick, RI. 54 pp.

Christie, G. D. 1993. Business and political skills in mosquito control. Wing Beats. 4(3): 17-18.

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Christie, G. D. 1990. Salt marsh mosquito control in Portsmouth, Rhode Island. J. Am. Mosq. Control Assoc. 6: 144-147.

MOSQUITO CONTROL TALKS (all talks at the Annual Meeting of the Northeastern Mosquito Control Association unless otherwise noted)

1996 Information on a Fungal pathogen of *Aedes canadensis* in Vernal Pools.
Mosquito Control through Marsh Restoration in Portsmouth, RI
1995 Killer Pathogen, Probably Fungus, appears in Bristol, Rhode Island
1994 Community-level Application of IPM for Medically Important Arthropods
65th Annual meeting, Eastern Branch, Entomological Society of America
1993 When the Edge Meets the Middle: Mosquito Breeding during Intermittent Tides
Open Marsh Water Management on Nantucket
1992 Reaching out for Resource Tools and Development
Altosid Pellets in Nantucket
1991 Report on Mosquito Control in Rhode Island
Monitoring Mosquito Populations for Eastern Equine Encephalitis in 1991 in Rhode Island
1990 Encephalitis in Tiverton, Rhode Island
1989 Open Marsh Water Management in Portsmouth, RI
55th Annual Meeting, American Mosquito Control Association
1987 Private [business] Mosquito Control Endeavors
1986 Overview of Mosquito Control in Portsmouth, RI.

METHOPRENE

A review of the impacts of the insect growth regulator methoprene on non-target aquatic organisms in fish bearing waters (Ver. 2.0)

For the Massachusetts Pesticide Board Subcommittee
By Steven Antunes-Kenyon and Gerard Kennedy.
Massachusetts Pesticide Bureau, Department of Food and Agriculture,
251 Causeway Street, Boston, MA 02114-2151
www.massdfa.org
August, 2001

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This document reviews the environmental impacts of the insect growth regulator methoprene, when used for midge and mosquito control, on non-target aquatic species in fish bearing waters. Increased reports of specific malformations in amphibians over the past decade, confusing regulatory decisions at the state and federal level regarding the use of methoprene, and the general public concerns which have been expressed about methoprene use led the Massachusetts Pesticide Board Subcommittee to direct the Massachusetts Pesticide Bureau to conduct this review.

Methoprene is an insect growth regulator, which is highly effective as a control agent for mosquitoes. It interferes with maturation and reproduction in insects by mimicking the activity of natural juvenile insect hormone. Chemically it is considered to be a member of the terpenoid family of chemicals. Technical methoprene is soluble in water at 1.39 ppm and very soluble in common organic solvents.

Methoprene, for use in mosquito and midge control is sold under the trade name "Altosid®". Wellmark International manufactures and distributes the Altosid® line. Among the commercially available Altosid® products are slow release formulations such as briquets, which release the active ingredient continually when wet as they erode over periods ranging from 21 days to 150 days. Altosid® is widely used in Massachusetts as a mosquito larvicide in municipal West Nile Virus prevention strategies.

Methoprene is rapidly degraded under field conditions. The biological activity of aqueous solutions of methoprene is affected by sunlight, temperature, and microbial action. The metabolism of methoprene by aquatic microorganisms is extensive. The most abundant breakdown product in aqueous solution is methoxycitronellal (9%). While methoprene degrades rapidly in the field, the persistence in water is determined, ultimately however, by the formulation and method of application. The XR briquet releases small amounts of methoprene as it degrades over a period of 150 days. While the briquet has been shown to physically persist in water for eighteen months, no data is available to indicate biological activity for this time period.

Although methoprene is most toxic to insects of the order Diptera, it is also toxic to a range of insects from 12 orders, including Diptera, Lepidoptera and Coleoptera. In all cases reviewed, mosquitoes and midges show the greatest susceptibility to methoprene. Toxicological studies reviewed observed variable susceptibilities by non-target aquatic invertebrates to methoprene. Short-term toxicity studies on insects indicate that most non-target insects, including those predacious to mosquitoes, are not likely to be adversely impacted by labeled applications of methoprene. While a number of studies on the grass shrimp and daphnia magna raise concerns, the majority of studies reviewed suggest that there is not likely to be an impact on crustaceans at expected environmental concentrations. However, research is ongoing in this area, particularly on lobsters.

The United States Environmental Protection Agency (EPA) has registered all commercially available Altosid® formulations of methoprene for use in fish bearing waters. However, the 1991 EPA RED factsheet continued to state until recently, that the pesticide is acutely toxic to estuarine and marine invertebrates. The factsheet was updated in June 2001 to remove this statement.

At the state regulatory level, however, inconsistencies remain regarding the use of methoprene. New York, due to concerns about the teratogenicity of methoprene breakdown products, continues to prohibit the application of sustained-release formulations to fish bearing waters. Maryland limits the uses of methoprene on a case-by-case basis through its pesticide aquatic application permitting process. While Altosid® is registered for use in fish bearing waters in all other states, a number of states have placed limitations on the application of methoprene products, along with dozens of other pesticides, to waters containing endangered species.

The overall findings of the review are:

- We have found no evidence to suggest that the labeled application of methoprene for mosquito and midge control will lead to amphibian malformations.

- Studies reviewed observed variable susceptibilities of crustaceans to methoprene. At this time, it is difficult to draw final conclusions regarding the safety of methoprene for crustaceans until further research is completed and available for review. The weight of evidence reviewed, however, suggests that impacts upon crustraceans are not likely at expected environmental concentrations.

- Because the half life of methoprene is quite short , the use of the liquid larvicide is unlikely to create any adverse impacts. Possible exceptions are repeated applications, or the use of methoprene slow release formulations in shallow, poorly flushed waters. The data gap for chronic exposure to small quantities of methoprene over the long term, particularly in a poorly flushed medium, prevents conclusions from being drawn about the long term effects of the 150 day slow release formulation.

- While some impact on non-target organisms (especially in aquatic communities) could be expected, the effects of methoprene application would be less harmful than those caused by most mosquitocidal pesticides. Methoprene has longer persistence than *Bti* after application, but also causes greater impact on non-target organisms. Despite this, there is no indication in the literature of permanent disruption to ecosystems after methoprene application.

1. INTRODUCTION

The purpose of this report is to review and evaluate the environmental impacts of the insect growth regulator methoprene[1], when used for midge and mosquito control, on non-target aquatic species in fish bearing waters. The Massachusetts Pesticide Bureau on behalf of the Massachusetts Pesticide Board Subcommittee is conducting the review. The subcommittee requested the review in response to a letter from an environmental group[2] which asks that the subcommittee "revoke the use of Methoprene based pesticides in bodies of water containing fish and shell fish." Among the claims in the letter are that: "Methoprene when exposed to sun-light and water breaks down into retinoids that causes deformities in frogs, fish and other aquatic invertebrates"; "ten states have banned the use of Methoprene in bodies of water containing fish"; and the material safety data sheet on two methoprene based pesticides state that it is toxic to aquatic invertebrates.

While several of the assertions in the letter are inaccurate, there *have* been increased reports of specific malformations in amphibians over the past decade that have raised public concerns about the possible causes. Observed deformities include missing limbs and digits and central nervous system malformations (Ankley, 1998). Speculation as to the causes has focused on ultraviolet light, a parasitic flatworm and biochemicals, such as retinoids, methoprene and derivatives of methoprene. Methoprene has also been implicated as a causative agent of a lobster die-off in Long Island Sound in 1999.

Regulatory decisions at the state and federal level have also muddied the waters regarding the issue of methoprene use. While methoprene is registered for use in all 50 states, two slow release formulations are presently prohibited from use in fish bearing waters in New York. Maryland places conditions on the use of methoprene on a case-by-case basis. Furthermore a number of states have placed limitations on the use of methoprene (along with dozens of other commonly used pesticides) in waters containing endangered species. Additional confusion has been added due to conflicting information between the federal label provisions for Altosid® use and 1991 EPA methoprene factsheet[3], The factsheet stated that "methoprene is highly acutely toxic to estuarine invertebrates", while the label contains no such information. The factsheet was updated in June 2001 to reflect the fact that concerns about toxicity to estuarine invertebrates have been alleviated as a result of the submission of studies which indicate minimal chronic risks[4].

Given the attention methoprene has received as a potential causative agent of amphibian deformities, the apparent inconsistencies among federal and state regulators regarding its use patterns, and the general public concerns which have been expressed regarding its use, it is important for the Pesticide Board Subcommittee to have a clear understanding of the issues. This review of methoprene will assist the subcommittee in its decision making by reviewing the scientific literature as it pertains to the toxicity of methoprene to non-target aquatic organisms and to the predicted fate and transport of methoprene in aquatic systems. It also presents:

- an analysis of the conflicting information from EPA regarding methoprene use,
- a discussion of how methoprene is regulated in other states, and
- a brief comparison of alternative methods of control.

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[1] Methoprene for mosquito or midge control purposes is sold under the trade name ALTOSID®.
[2] Preserve Our Pond. December 15, 2000. Letter to the Director of Regulatory Services
[3] 1991 Environmental Protection Agency Reregistration Eligibility Document (RED)
[4] 2001 Environmental Protection Agency Reregistration Eligibility Document (RED)

2. BACKGROUND

Methoprene is an insect growth regulator which is highly effective as a control agent for mosquitoes. It interferes with maturation and reproduction in insects by mimicking the activity of natural juvenile insect hormone. Chemically it is considered to be a terpenoid. The most notable commercially available formulations are the slow release pellet and briquet products which release methoprene continually as they erode over periods up to 150 days.

Methoprene is an insect growth regulator that has been registered as a general use pesticide by EPA since 1975. Methoprene has no significant adverse toxicological effects in any human health effects screening studies and has been classified as a slightly to practically nontoxic compound by EPA, which ranks it in "toxicity class IV" (EPA, 1991). It is considered to be a biochemical pesticide because, rather than controlling insects through direct toxicity, it disrupts the insect's lifecycle and prevents it from reaching maturity and reproducing. Because it is effective in controlling the larval stage of insects, it is widely used as a larvicide (EXTOXNET, 1996). Methoprene has been extensively tested against *Aedes* mosquitoes and shown to be highly effective, both in fresh and salt water (Glare, 1999). In aquatic areas, it is used to control mosquitoes, and several types of flies, moths, beetles and fleas. It is also registered for use on a number of foods including meat, milk, eggs, mushrooms, peanuts, rice, and cereals.

As a potent insect growth regulator (IGR), methoprene interferes with maturation and reproduction in insects by mimicking the activity of natural juvenile insect hormone [5](Wright, 1976). During development, insects undergo changes at specific times, for example pupation, which are mediated by endogenous hormones, such as juvenile insect hormone. Juvenile insect hormone, expressed at certain specific times, leads to metamorphosis. However, if present at other times, the presence of juvenile insect hormone leads to suppression of adult characteristics. These abnormalities are observed during molt into the pupae or adult stages of growth. For example the feet of treated mosquito may be stuck to the molted skin or covering (exuvia) of the pupae causing failure of the newly formed adult to emerge from the water. Insects and crustacea whose metamorphosis is regulated by a juvenile insect hormone and a molting hormone could be sensitive to methoprene during development. Animals lacking juvenile insect hormone should not be sensitive. The activity of methoprene should not be confused with that of chitin inhibitors[6] such as diflubenzuron.

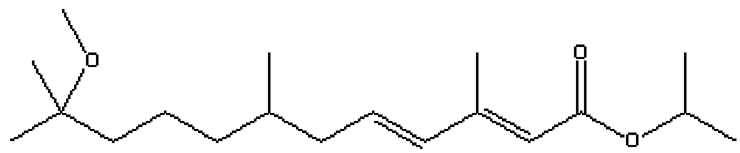
Insect growth regulators, such as methoprene, interfere with insect development causing death or reproductive failure at a specific time in the life cycle, usually not the stage treated. Glare states that: "the extent and character of the response varies between insects, but generally it is the last instars of the larval or nymph form, or pupae, which are most affected" (Glare, 1999). For example, mosquito larvae are the target stage for methoprene, but the effect is not seen until lack of adult emergence.

[5] **juvenile hormone,** also called ECDYSONE, a hormone in insects, secreted by glands near the brain, that controls the retention of juvenile characters in larval stages. The hormone affects the process of molting, the periodic shedding of the outer skeleton during development, and in adults it is necessary for normal egg production in females *(Enclycopaedia Britannica Online)*

[6] Chitin-inhibitors such as Dimilin (diflubenzuron) have a much broader effect on non-target organisms (Glare, 1999).

Chemical and Physical Properties
S- Methoprene (Isopropyl (2E,4E)-11- Methoxy- 3,7,11- trimethyl-2,4-dodecadienoate) is a pale yellow liquid with a fruity odor. Its chemical structure is typical of the family of chemicals known as terpenoids:

Figure One: Isopropyl (2E,4E)-11-methoxy-3,7,11-trimethyl-2,4-dodecadienoate;



Source: www.chemfinder.com

Many terpenoids are naturally occurring and include vitamin A, camphors, citronell and limonene. Table One shows some of the basic physical and chemical properties of methoprene. The chemical structure of methoprene is very similar to natural juvenile insect hormone. Both chemicals are long chain esters containing only carbon, hydrogen and oxygen and have similar molecular weights.

Table One: Physical and Chemical Properties of S-Methoprene. (The Pesticide Manual, 2000 and Wellmark International)

Molecular Weight	310.50	***Vapor Pressure*** *(RS- Methoprene)*	2.37 X 10^{-5} mm Hg at 25° C
Molecular Formula	$C_{19} H_{34} O_3$	***Specific Gravity***	0.921 (25° C)
Form	Pale yellow liquid with a fruity odor	***Solubility In water***	1.39 ppm
Boiling Point	> 262 25° C ° C	***Stability in water***	Stable in water; sensitive to UV light

Commercial Availability
Methoprene, for use in mosquito and midge control is sold under the trade name "Altosid®". Wellmark International manufactures and distributes the Altosid® line. Among the commercially available Altosid® products are slow release formulations such as briquets, which release the active ingredient continually when wet as they erode over periods ranging from 21 days to 150 days. Application rates vary depending on the type of habitat, water depth and water quality. Maximum application rates are shown in Table Two. All of the Altosid® products are formulated with the resolved S-methoprene enantiomer except for the 30 day briquet which contains both the R and the S enantiomers.

Table Two: Altosid® Product Line

ALTOSID ® PRODUCT	EPA #	% ACTIVE INGREDIENT[7]	APPLICATION RATE	RELEASE PERIOD
LIQUID LARVICIDE	2724-392	5%	3 to 4 fl.oz/ A	5 – 7 days
LIQUID LARVICIDE	2724-446	20 %	0.75 – 1 fl oz/ A	5- 7 days
ALTOSID® SBG	2724-489	0.2%	5-10 lbs per acre	5- 10 days
BRIQUETS *	2724-375	8.62%	1 to 4	30 days
BRIQUET XR*	2724-421	2.1%	1 briquet/ 100 sq ft to 1 briquet/ 200 sq.ft for non flow shallow (<2 feet) areas.	150 days
PELLETS*	2724-448	4.25 %	2.5 – 10 lbs per acre	30 days
GRANULES XR*	2724-451	1.5 %	5- 10 lbs per acre	21 days

***SLOW RELEASE SOLIDS**

[7] Information on the “inert” ingredients is proprietary and not available.

3. TOXICOLOGICAL PROFILE
(a) Amphibians, (b) Insects, (c) Crustaceans, (d) Oysters, (e) Fish.

(a) Amphibian*s*
The global decline in amphibian populations and recent increases in reported amphibian malformations has led to a surge in amphibian research and the development of more than one plausible theory for its explanation. The severity and types of malformations found in nature vary widely; however, a great majority of them are found in the hindlimbs and include extra (supernumary) limbs, skin webbings, and missing legs (Ankley, 1998). The theory that certain breakdown products of methoprene might mimic the action of retinoids and cause malformations in amphibian populations is partially supported by research that discovered how methoprenic acid (t-MA) can stimulate gene transcription in vertebrates. In fact these findings appear to build on the studies showing an increase in limb deformities from methoprene treated mouse embryos (Harmon, 1995*)*.

Upon close examination of a number of studies related to these issues, it appears that the theory implicating methoprene or its naturally occurring breakdown products and their alleged affects on the retinoic acid pathway of development is highly questionable and largely without merit.

- **Methoprenic acid (t-MA) is not a naturally occurring compound (Harmon, 1995)**

- **The lowest concentrations of sunlight exposed methoprene shown to cause any malformation was 7.5 µL/L (ppm), which is some 1,700 times the level found under typical application rates of Altosid® (La Clair, 1998)**

- **Studies by La Clair were unable to produce the most commonly seen malformations, such as supernumary limbs, skin webbings, and missing legs. Severe eye malformations and other cranial and facial defects were the primary observations in La Clair's work (La Clair, 1998)**

- **There is greater evidence that recent increases in malformed amphibians may be explained by increases in exposure to unsafe levels of UV light and increases in the rate of amphibians infection by parasitic trematodes.**

Methoprene has received considerable attention as a possible causative agent of the increase in amphibian malformations over the past decade (Ankley et al 1998). The growing number of reported malformations are primarily from the amphibian **order Anura** (frogs and toads); however, a number of reports also include the **order Caudata** (salamanders). A high prevalence of hindlimb deformities has been recorded in wild-caught green frogs (*Rana clamitans*), northern leopard frogs (Rana pipiens), American toads (Bufo americanus) and bullfrogs (Rana catesbeiana) from agricultural lands (Ouellet, 1997). Other amphibians species exhibiting gross malformations include gray tree frogs (*Hyla versicolor*), mink frogs (*Rana septentrionalis*), wood frogs (*Rana sylvatica*), spring peepers (*Hyla crucifer*), Pacific tree frogs (*Hyla regilla*), long toed salamanders (*Ambystoma macrodactylum*), and spotted salamanders (*Ambystoma maculatum*) (La Clair, 1998). Based on these and other anecdotal reports, most researchers consider the malformations to be at levels that are above "normal".

Some of the common external abnormalities observed in the field include the following:

- Extra limbs (supernumary limbs or polymelia)
- Missing limbs or limb segments (ectromelia)
- Limbs located in an unusual place (ectopic limbs)
- Extra digits or toes (polydactyly)
- Missing or misplaced eyes
- Skin webbing (cutaneous fusion)
- Missing part or all of one or more digits or toes (ectrodactyly)

Due to the aquatic developmental stages of amphibians and their associated gill and transdermal respiration mechanisms, potential exposure to and absorption of xenobiotics, such as juvenile hormone, may occur at the embryonic, larval and metamorphic stages. Some researchers are looking at the retinoic acid pathway as a target of teratogenic activity.

Retinoids, such as retinoic acid, are biochemical metabolites of Vitamin A, which regulate gene expression and appear to play a role in vertebrate limb development (Thaller, 1993). The retinoic acids modulate gene expression by binding to nuclear retinoic acid receptors (RAR) and retinoid X receptors (RXR), forming complexes which then act on DNA sequences known as hormone response elements (Harmon, 1995). In excess, retinoids can be teratogenic, causing serious birth defects in humans. All-*trans*-retinoic acid (t-RA) is known to have profound effects on cellular differentiation, pattern formation, and embryonic development (Yang, 1991). La Clair reports that certain concentrations of t-RA cause nervous system and craniofacial malformations [8]. According to Sessions *et.al.* some of the more commonly seen malformations in the field, supernumary limbs, can also be experimentally induced in tadpoles by treatment with retinoic acid (Sessions, 1999).

Methoprene and its derivatives share structural and behavioral similarities with the retinoids. There is evidence that *trans*-S-methoprenic acid, a laboratory breakdown product of methoprene, can mimic the behavior of t-RA. Trans-S-methoprenic acid (t-MA) has been shown to stimulate gene transcription in vertebrates by binding to a cellular retinoid receptor. The researchers concluded that the discovery of t-MA activity may explain the reported teratogenic effects of high doses of methoprene that have been observed during mouse embryogenesis. Effects observed from these embryogenesis studies included limb deformities similar to the effects of retinoids (Harmon, 1995).

La Clair *et.al.* report that, at extremely high levels, methoprenic acid was found to dramatically interfere with normal amphibian development. Exposure to methoprene causes little mortality and malformation to *Xenopus laevis* embryos at concentrations below 15 µL/L (ppm). However, a mixture of methoprene and its photodegradation products caused malformations at concentrations of 7.5 µL/L[9] (ppm), a concentration some 1,700 times the level found under typical applications. Results of additional experiments using chemically synthesized pure t-MA show significant levels of deformities at 2.5 µL/L (ppm) and complete malformation at 15 µL/L (ppm). The photolysis of t-MA showed increased malformations at 7.5 µL/L (ppm) and obvious mortality at 10 µL/L (ppm)

[8] 96 hour whole embryo developmental toxicity study: Frog Embryo Teratogenesis Assay-*Xenopus* (FETAX)
[9] 1 µL/L is equal to 1 part per million (ppm). The unit µL/L is a ppm weight/weight description of concentration based on the followng: ppm (w/w) = (g of analyte in sample / g of sample) x 10^6.

There are several flaws in La Clair's work. The concentrations of test compounds used in his studies do not remotely mirror those found under typical conditions. The lowest dose of sunlight exposed methoprene show to cause any malformation was 7.5 µL/L (ppm). As La Clair points out in his discussion, when correctly applied to a 1 hectare (he) (2.49 acres) pond with an average depth of 0.25 m, the concentration of S-methoprene lies between 0.0044 and 0.0060 µL/L (ppm). Furthermore, although the theoretical hydrolysis product t-MA was shown to be of higher developmental toxicity to *Xenopus laevis* than its parent compound, it is not found in nature and cannot be studied outside of the laboratory. Lastly, the studies by La Clair were unable to produce the most commonly seen malformations, such as supernumary limbs, skin webbings, and missing legs. Severe eye malformations and other cranial and facial defects were the primary observations in La Clair's work.

In a U.S. EPA study presented as a poster abstract at the 2001 Society of Toxicology Annual Meeting, Degitz *et.al.* describe their findings of the developmental toxicity of methoprene and its degradation products in the African clawed frog (*Xenopus laevis).* In 96-hour *in vivo* assays (FETAX) methoprene, methoprene acid, methoprene epoxide, 7-methoxycitronellal and 7-methoxycitronellic acid were tested for their ability to cause malformations at concentrations ranging from 0.1 µl/L (ppm) to 30 µl/L (ppm).

Results from the above study demonstrate the potential for methoprene acid to cause craniofacial malformations at exceedingly high concentrations [$\geq$1.25 µl/L (ppm)]. Methoprene epoxide and 7-methoxycitronellal also induced malformations but only at concentrations $\geq$5 µl/L (ppm). The authors conclude that methoprene and its metabolites are not potent developmental toxicants to the African clawed frog (*Xenopus laevis).* They further found that methoprene concentrations in their experiments were 3-orders of magnitude higher than expected environmental concentrations based on typical field application rates of Altosid® (0.01 ppm) and that concerns or methoprene-mediated developmental toxicity may be unwarranted.

Another study looked at the effects of ultraviolet light and methoprene on the survival and development of embryos of Northern leopard frogs (*Rana pipiens*). Ankely *et. al.* exposed newly fertilized eggs of Northern leopard frogs (*Rana pipiens*) to several different concentrations of methoprene both in the presence and absence of UV light. The concentrations of methoprene ranged from 0 to 488 µg/L (ppb).[10] Methoprene treatment at the four lowest test concentrations did not result in increased mortality or developmental abnormalities in Northern leopard frogs, either in the absence or presence of UV light. However, all of the embryos from the high methoprene treatments were grossly deformed, exhibiting severe axial distortions, as well as craniofacial and abnormalities in the tail or posterior. By day 16 all organisms in high methoprene treatment, both in the absence and presence of UV light, were dead. Interestingly, exposure to the pesticide did not cause any limb malformations, which is the effect that is generally reported in wild amphibian populations. More than half of the frogs which were exposed to UV light for 24 days developed hindlimb malformations, irrespective of whether methoprene was present. These malformations included missing limbs segments and missing or reduced digits. Despite being similar to those seen in deformed frogs in the wild, the UV light did not cause the full range of malformations observed in the field. While the conclusions to the study were uncertain, the researchers did suggest that UV light should be considered as a plausible factor contributing to amphibian malformations in field stations.

[10] Concentration ranges are based on min. and max. from 2 sample days.

Possible links between the increased amphibian infection rates by parasitic trematodes has also been implicated in the surge of observed amphibian malformations. One of the leading papers on amphibian malformations was completed in 1990 and specifically examined one explanation for naturally occurring extra (supernumary) limbs in amphibians. This work has led the investigation of how a parasitic flat worm (trematode) uses amphibians as intermediate hosts. The cercarial larval stage of the trematode attacks amphibians, penetrating the skin to form cysts (metacercariae). The cysts are preferentially localized in the developing hind limb regions of both salamanders and frogs (Sessions, 1990).

One recent study from the literature shows how severe limb abnormalities were induced at high frequencies in Pacific tree frogs (*Hyla regilla*) exposed to cercariae of a trematode parasite (*Ribeiroia sp.*). The abnormalities closely matched those observed at field collection sites, and elevations in parasite density led to an increase in malformation frequency and a decline in the survival of tadpoles (Johnson, 1999).

(b) Insects

Although methoprene is most toxic to insects of the order Diptera, it is also toxic to a range of other insects from 12 orders, including Hemiptera, Lepidoptera and Coleoptera. The lethal dose required to kill common mosquitoes is generally around 1 part per billion (ppb). In all cases reviewed mosquitoes and midges show the greatest susceptibility to methoprene (Miura, 1973 and Lawler, 2000). The short-term toxicity studies reviewed indicate that most non-target insects, including those predacious to mosquitoes, are not likely to be adversely impacted by labeled applications of Altosid®. This finding is due to the fact that expected environmental concentrations are significantly lower than acute toxicity endpoints for most aquatic non-target insects.

In nature, insect predators are an important natural control agent of insect pests such as mosquitoes. Consequently, it is important to evaluate methoprene use for effects against such biological agents.

In a short-term study the effects of ZR-515 [(RS)-methoprene] were tested on a number of non-target insects. A series of five methoprene concentrations were utilized for the laboratory studies. Water boatman *(C. decolor)* and backswimmers *(N. unifasciata)* were maintained in metal barrels treated with 10% ZR-515 and containing 0.1 ppm (RS)-methoprene. The following insects were included in these studies performed in the laboratory, in outdoor artificial containers, and in the field:

- damselfly nymphs *(Argia sp.)*
- dragonfly nymphs *(Orthemis sp.)*
- mayfly nymphs *(Callibactis sp.)*
- water boatman nymphs and adults *(Corisella decolor sp.)*
- backswimmer nymphs and adults *(Notonecta unifasciata sp.)*
- diving beetle adults *(Laccophilus sp.)*
- water scavenger beetle larvae and adults *(Helophorus sp. and Hydrophilus triangularis sp.)*, *(Tropistcrus lateralis sp.)*
- whirligig beetle adults *(Gyrinus punctellus)*
- flower fly larvae *(Xylota sp.)*
- shorefly larvae *(Brachydcutera argentata)*
- midge largae *(Chironomum stigmaterus)*
- mothfly larvae *(Pericoma sp.)*

Results of acute toxicity tests with ZR-515 (technical) performed in the laboratory with non-target predatory insects and mosquitoes are presented below:

Table Three: Risk Quotients for Select Insects (Miura, 1973).

Animal	State of growth	Number of tests	Number Animals per container	Test Duration (hours)	LC_{50} (ppm)	Acute RQ[11] (EEC/LC_{50})[12]
Water boatman *(Corisella decolor sp.)*	Adults	4	10	24-96	1.65	0.006
Backswimmers *(N. unifasciata)*	Nymphs	4	10	24	1.20	0.008
Diving beetles *Laccophilus sp.*	Adults	3	10	48-72	2.00	0.005
Mosquitoes *Ochlerotatus nigromaculis*	Larvae	9	25	96-120	8×10^{-6}	1,250

The maximum expected environmental concentrations of methoprene from labeled application rates is 10 µg/L (ppb) or 0.01 mg/L (ppm). In the above study backswimmers appear to be the most sensitive species with an acute median lethality (LC_{50}) of 1.20 mg/L (ppm). In addition to the fact that the acute toxicity endpoint for the most sensitive species in this study is some 100 times the EEC, the calculated risk quotients for all organisms indicate minimal acute risks of toxicity. This study also helps to illustrate that mosquitoes (*Ochlerotatus nigromaculis)* are significantly more sensitive to methoprene than other non-target insects (Miura, 1973).

Lawler *et.al.* studied the effects of sustained-release methoprene and a combined formulation (Duplex) of liquid methoprene and *Bti* on insects in salt marshes. Although, methoprene concentrations in treated water were not measured, these materials were applied at maximum label application rates. The authors expressed concern for the development of resistance as a result of the use of sustained-release formulations; however, they found no evidence that Altosid® Pellets or the Duplex mixture affected the survival of water boatman[13] *(Trichocorixa reticulata).* Caged juvenile water boatman matured at the same rates in treated and control sites and there were no apparent malformations. The relative insensitivity of water boatman *(Trichocorixa reticulata)* to methoprene demonstrated in this study supports the above findings by Miura and Takahashi (Lawler, 2000).

Methoprene was reported to have no deleterious effect on backswimmers[14] (*Notonecta unifasciata)* and (*Buenoa scimitar)*, when used to control mosquitoes in California. A different study from California however, showed that repeated applications of 100 µg/L (ppb) methoprene to experimental ponds eliminated larva of the diving beetle[15] (*Laccophilus* sp.). These adverse effects represented a loss of 84% of the predator biomass during one period. Dragon fly and

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[11] Risk Quotient (RQ): The estimated environmental concentration / median lethal dose (LC_{50}); The lower the Risk Quotient (RQ) the less risk.
[12] According to Ross *et.al.* 10 µg/L (ppb) or 0.01 mg/L (ppm) is the Expected environmental concentrations from the application of ALTOSID Liquid Larvicide at 4 fluid oz. /acre (293 ml/ha) (Ross, 1994).
[13] The **order Hemiptera** includes aquatic predators known as water boatman from the **family Corixidae**.
[14] The **order Hemiptera** includes aquatic predators known as backswimmers from the **family Notonectidae**.
[15] The **order Coleoptera** includes aquatic predators knows as diving beetles from the **family Dytiscidae**.

damsel fly naiads[16] formed the second major group of predators during the study; these preyed heavily on mosquitoes and ostracods[17] and were not affected by Altosid®. In another study, two larval predators, damselfly naiads *(Enallagma* sp.) and diving beetles appeared not to be affected by the Altosid® applications against mosquitoes in Florida (Glare 1999).

The short-term effects of methoprene and *Bti* on non-target insects were studied by Hershey *et. al.* using temporary pond in Wright County Minnesota, Minnesota. Methoprene was applied as Altosid® extended release 150-day briquets. No significant differences were observed between the control site and the methoprene treatment site in populations of water scavenger beetles[18] or predacious diving beetles (Hershey, 1995).

In a later, study Hershey *et.al.* studied the effects of *Bti* and methoprene applied for three consecutive years on non-target aquatic invertebrate communities of 27 wetland ecosystems in Wright County Minnesota. The authors state that in their sampling the following six **orders** were identified: **Diptera, Collembola, Bivalvia, Isopods, Annelida, and Gastropoda**. Of the 179 genera of aquatic species collected, 101 were from the **order Diptera** and 57 species of the Diptera were midges from the **family Chironomidae**. Hershey *et. al.* state that the reduction in predators on methoprene-treated sites, including both dipteran and non-dipteran may have been due to a combination of direct toxicity and changes in the food web. Community diversity was altered, whereby there was an overall reduction in species richness and an increase in the dominance of select species. Hershey concludes that observing these negative impacts on the invertebrate community, such as food web effects, requires that researchers reconsider the results of short-term tests showing no such adverse impacts (Hershey, 1998). While the authors maintain that the application was apparently consistent with the pesticide label, no information was provided on the methoprene concentrations found in the treated water.

(c) Crustaceans

Much concern has been raised regarding the potential for methoprene's use in larviciding activities to have an impact on crustaceans, such as shrimp, crabs and lobsters. These concerns are due to their shared evolutionary past and the resultant similarities in biology, as exemplified by the aquatic developmental cycles of insects in the order Diptera (mosquitoes and midges) to that of their distant relatives in the order Crustacea. These concerns have been further fueled by high profile incidents such as the 1999 Long Island Sound lobster die-off.

Most of the studies reviewed which looked at shrimp, Atlantic oysters, amphipods, copepods and mud crabs appear to indicate that adverse effects are not likely at or near the 10 ppb expected environmental concentrations. However the work done by EPA biologist Charles McKenney on grass shrimp and mysid shrimp suggest that there may indeed be reason for concerns at levels as low as 8 ppb and 2ppb.

Lobsters

Common in the media are reports that there might be an association between the 1999 lobster die-off in western Long Island Sound and the aerial application of the mosquito adulticide malathion or the use of methoprene in catch basins. According to the New York Times, however,

[16] The **order Odonata** includes damselflies and dragonflies, whose aquatic immature stage of development (naiads), are predaceous on mosquito larvae.
[17] Ostracods are crustaceans that have their entire body enclosed in the carapace, and resemble tiny clams.
[18] The **order Coleoptera** includes aquatic predators knows as water scavenger beetles from the **family Hydrophilidae.**

researchers have been skeptical of the pesticide theory, noting that while the lobster die-off peaked in the fall of 1999, it began in 1998, the summer before pesticide spraying began (October 29, 2000). During the same time period, there were unexplained mortalities of blue crabs and spider crabs in the sound and a continuing loss of sea urchins ranging from Massachusetts to Nova Scotia. This event also fell on the heels of another major lobster mortality event that occurred in Maine in 1997-98.

The New York Times also reports that 1,100 lobsterman from Long Island Sound have filed a lawsuit against five pesticide manufacturers, seeking $125 million in damages. The cause or causes of the "1999 Long Island Sound lobster die-off" are presently not well understood. Some scientists suspect that multiple factors may have played a role. The following is list of the possible factors, which may have played a role in the declining health of lobsters:

- Pollution stirred up from dredging materials such as PCB's, heavy metals and nitrates
- Unusually large outbreak of a deadly marine-born parasite[19]
- Shell disease[20]
- Aerial and ground spraying of pesticides for mosquito control[21]
- Low dissolved oxygen levels
- Excessive harvesting of lobsters in past years[22]
- Increased water temperature

According to the Sea Grant's Long Island Sound Lobster Initiative, University of Connecticut scientist Dr. Richard French and his colleagues have received grants totaling over $108,000 to perform a comprehensive study of the health of the lobsters in the sound. According to a March 31, 2001 New York Times article, University of Connecticut biologist Dr. Hans Laufer and seven colleagues will receive nearly $250,000 to conduct research into the possible link between the Long Island Sound lobster deaths and pesticides used to kill mosquitoes in the fight against West Nile Virus.

Mud Crab

Celestial and McKenney, 1994 studied the effects of methoprene on larval development of the mud crab (*Rhithropanopeus harrisii*). Larval development consists of four distinct zoeal stages and one megalopa stage prior to the first crab stage. The many similarities between this organism's aquatic development stage and that of mosquitoes make it a suitable non-target estuarine crustacean for such studies.

Larvae were treated with 0.1, 1.0, 10.0, 100.0, and 1,000.0 µg/L (ppb) methoprene. At methoprene concentrations of 1,000 µg/L (ppb) no larvae survived to megalopae. Significant reductions were found in survival at 100 µg/L (ppb) from hatch to megalops stage and from megalops stage to first crab stage. At concentrations less than 100 µg/L (ppb), no significant

[19] Dr. Richard French, a University of Connecticut pathologist found a one celled protozoan parasite, known as a paramoeba, which known to kill crabs and sea urchins, attacking the lobster's nervous system, causing limp lobster syndrome.

[20] Shell disease is a generic name for a variety of lesions found on shells of crustaceans.

[21] Ground and/or aerial adulticide applications related to WNV were made only in 1999 using malathion, sumithrin, and/or resmethrin.

[22] CT and NY officials estimated that there were more than 500,000 lobster pots in LIS in 1999. According to the National Marine Fisheries Service (NMFS), the lobster industry in New York hit a peak in 1996, with 9.4 million pounds caught, worth nearly $33 million, and stayed strong through 1998 , with 8.5 million pounds worth $29.8 million.

reductions were found in survival through developmental stages nor in survival among the same developmental stages across exposure concentrations.

In a study performed at the Duke University Marine Laboratory mud crab larvae were exposed to a maximum of 1,000 ppb methoprene. At optimal salinities for the mud crab (*Rhithropanopeus harrisii*) no effects were demonstrated in terms of molt frequency, duration of molt and molting time at concentrations $\leq$100 ppb. Waters with extreme salinities for the mud crab caused significant stress to the crab and thus increased its sensitivity (Costlow, 1977). This finding is later expanded upon in a later publication by Costlow where he found that reduced salinities caused 100% mortality in zoeal stages of the mud crab (*Rhithropanopeus harrisii*); however, when mud crabs were exposed to methoprene at 1,000 ppb but at salinities of 20 and 35 parts per thousand (ptt) survival was unaffected (Costlow, 1979). Based upon these findings it appears that salinity levels used in crab toxicity studies may play a critical role in the sensitivity of the test crustacean to various concentrations of methoprene.

Seawater salinity levels are typically 35.5 ppt fluctuate by about 4 %. Estuarine organism tend to be more tolerant of varying salinities; however it is possible that concentrations below 20 ppt would be too extreme for crabs and inappropriate for the study the methoprene toxicity in conditions typical of the crab habitat.

According the Massachusetts Division of Marine Fisheries tolerance to varying salinity concentrations in seawater is dependent upon a number of factors such as species, gender, season and temperature. Male blue crabs for example will move further into the mouth of the estuary than females where the salinity concentration will be lower. Female blue crabs will however, move further out towards and beyond the terminal part of the estuary. The recommended salinity range for maintaining American lobsters is 29-35 ppt (Bruce Estrella, Personal Communication).

In yet another study the mud crab (*Rhithropanopeus harrisii)* susceptibility to methoprene was again studied in the laboratory using 10, 100, and 1,000 ppb of methoprene with various salinity 5-35 ppt and temperature (20-35^{0} C), these authors found a significant reduction in the survival of zoeal larvae with increasing methoprene concentrations at almost all temperature/salinity combinations. One thousand parts per billion (1,000 ppb) completely arrested further development. At under 100 ppb little effect on metamorphosis was noted (Glare, 1999).

Blue Crab

Horst and Walker, 1999 studied the effects of methoprene on morphogenesis and shell formation of the blue crab (*Callinectes sapidus*). In this study samples of post-molt female crabs were used to isolate exoskeleton labeling to study protein and chitin synthesis; stage 2-4 embryos were used to study uptake of methoprene and development in the presence of methoprene; and megalopae (post larvae) were utilized for molting characteristics. The four components of this study and their findings are as follows:

- *Electron Microscopy Study of Internal Cellular Organellar Organization*
  Upon examination via electron microscopy, treatment at 1,500 ppb methoprene caused profound ultrastructural changes in the cuticular epithelial cells (exoskeleton) of postmolt adult blue crabs studied in vitro; these changes included loss of secretory organelles as well as swelling (distention) and air sacs (blebs) of the outer membrane of the nuclear envelope.

- *Radiolabel Explant Tissue to Study Protein and Chitin Synthesis*
  For protein and chitin synthesis, explant post-molt carapace cultures were treated with 1,500 ppb methoprene for 8–22 hours including a 2 hour label with either [^{35}S]-methionine or [^{3}H]-glucosamine. The authors demonstrate an approximate 50% reduced synthesis of radiolabeled proteins in cuticle new growth and a contrasting >400% increased synthesis of radiolabeled proteins in the epithelial cells.

- *Hatchability and Survivability of Embryos and Methoprene Uptake*
  Stage 2-4 embryos were treated with 300 – 1,500 ppb methoprene under static conditions for up to 11 days prior to performing morbidity/mortality and hatchability analysis. Treatment with 5750 ppb, 1,500 ppb or 300 ppb methoprene resulted in 61%, 25%, or 54% hatching rate respectively compared to approximately 75% in controls.

- *Megalopae Morbidity and Mortality*
  Megalopae (post-larvae) were continuously exposed to 500 µg/L (ppb). After 10 days, 80% mortality in methoprene treated megalopae is observed compared to 25% mortality in control animals.

The authors state that at concentrations likely to be seen in the environment, methoprene produced morbidity and mortality. This statement however is inaccurate and misleading. Exposures of 300 to 1,500 ppb methoprene are far greater than typical field use rates which do not exceed expected environmental concentrations of 10 ppb (Ross, 1994). In addition, without additional supportive data, the *in-vitro* (outside the whole living organism) part of this study examining impacts on protein synthesis is not indicative of findings from whole animal toxicity studies.

Earlier laboratory research indicates that at salinities of 20 and 35 parts per thousand (ptt), 100% mortality of megalopa stage of blue crab (*Callinectes sapidus*) was observed when animals were exposed to 10,000 µg/L (ppb). In the same range of salinities survival was reduced to 40% when animals were exposed to 1,000 µg/L (ppb) (Costlow, 1979). As mentioned earlier the expected environmental concentrations of methoprene from labeled applications is 10 µg/L (ppb). Thus the toxicity of methoprene to the blue crab at concentrations of 10,000 µg/L (ppb) and 1,000 µg/L (ppb) are not indicative of potential effects at expected environmental concentrations.

Shrimp
A laboratory study was completed for Zoecon Corporation examining the acute toxicity of Altosid® technical (90.7%) to the estuarine grass shrimp *(Palaemonetes pugio).* Altosid® was not found to be acutely toxic to grass shrimp at nominal concentrations up to 10 ppm (Bionomics EG&G, Inc. 1975).

In a 1992 the acute toxicity of (S)-methoprene to the mysid shrimp (*Mysidopsis bahia*) was studied for Zoecon Corporation by Springborn Laboratories, Inc. Wareham, Massachusetts. Twenty mysid shrimp per treatment group were exposed to mean measured concentrations of technical (S)-methoprene at 150, 84, 35, 17, and 10 µg/L (ppb) under flow-through conditions. At test termination (96-hours), a mortality rate of 85 and 25% was observed among organisms exposed to the 150 and 84 µg/L (ppb) mean measured test concentrations, respectively. Sublethal effects (e.g., lethargy, losss of equilibrium) were also observed among several of the surviving mysids exposed to these two test concentrations. No mortality or sublethal effects were observed among mysids exposed to the remaining concentrations tested [35 - 10 µg/L (ppb)]. The calculated LC_{50} values are >150, >150, and 110 µg/L (ppb) for 24-hours, 48-hours, 72-hours and 96-hours respectively. The No Observed Effect Concentration (NOEC) established for this study was determined to be 35 µg/L (ppb). The risk quotient (RQ) value calculated in **Table Four** (below) indicates minimal risk of acute toxicity to shrimp (Machado, 1992).

Table Four: Risk Quotients for Mysid Shrimp (*Mysidopsis bahia*) and tadpole shrimp *(Triops longicuadatus)* (Machado, 1992 and Miura, 1973).

Animal	State of growth	Number of tests	Number Animals per container	Test Duration (hours)	LC_{50} (ppm)	Acute RQ[23] (EEC/LC_{50})[24]
mysid shrimp (*Mysidopsis bahia*)	juvenile	2	20	24	>150	6.6×10^{-5}
Tadpole shrimp *(Triops longicuadatus)*	1.2 cm immature	8	10	24-96	5.00	0.002
clam shrimps *(Eulimnadia sp.)*	Mixed	3	10	24	1.00	0.01

In 1996 chronic toxicity of (S)-methoprene to the mysid shrimp (*Mysidopsis bahia*) was studied for Zoecon Corporation by Springborn Laboratories, Inc. Wareham, Massachusetts. The Lowest Observed Effect Concentration (LOEC) established for this study was determined to be 25 µg/L (ppb).The No Observed Effect Concentration (NOEC) established for this study was determined to be 14 µg/L (ppb). The Maximum Acceptable-Toxicant Concentration (MATC)[25] was calculated to be >14 µg/L (ppb) and <25 µg/L (ppb) or the mean of 19 µg/L (ppb) methoprene (Sousa, 1996).

McKenney and Mathews from the U.S. EPA studied the larval development of the estuarine grass shrimp *(Palaemonetes pugio)* exposed to methoprene. In this laboratory study larvae were reared in nominal concentrations of 0.1, 1, 10, 100, and 1,000 µg/L (ppb) of either isomer, (R,S)-methoprene or (S)-methoprene. No grass shrimp larvae survived completion of metamorphosis with exposure to 1,000 µg/L (ppb) regardless of the isomer used. Larval survival was significantly reduced by exposure to 100 µg/L (ppb) (RS)-methoprene but not by this concentration of (S)-methoprene. No significant difference was revealed, however, in ability to inhibit metamorphosis between these two isomeric types across the broad range of exposure concentrations from 0.1 to 1,000 µg/L (ppb). Methoprene exposure did not alter either the duration of total larval development or the total number of larval stages prior to metamorphosis *(McKenney, 1990).*

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[23] Risk Quotient (RQ): The estimated environmental concentration / median lethal dose (LC_{50}); The lower the Risk Quotient (RQ) the less risk.

[24] According to Ross *et.al.* 10 µg/L (ppb) or 0.01 mg/L (ppm) is the Expected environmental concentrations from the application of ALTOSID Liquid Larvicide at 4 fluid oz. /acre (293 ml/ha) (Ross, 1994).

[25] Maximum Acceptable Toxicant Concentration (MATC) is the hypothetical toxic threshold concentration lying in a range bounded at the lower by the highest tested concentration having no observed effect (NOEC) and at the high end by the lowest concentration having a significant toxic effect (LOEC) in a life cycle (full chronic) or partial life cycle (partial chronic) test. This may be represented as NOEC < MATC < LOEC. Calculation of MATC requires quantitative life cycle toxicity data on the effects of a material on survival, growth, and reproduction.

McKenney and Celestial from the U.S. EPA studied the growth and metabolism of the estuarine grass shrimp *(Palaemonetes pugio)* exposed to methoprene. According to the researchers, exposure to methoprene at concentrations ≥8 μg/L (ppb) through larval development inhibited successful completion of metamorphosis. Methoprene retarded growth in early larval stages and post-larvae, but enhanced growth in pre-metamorphic larvae. Respiration rates of early larvae were elevated by methoprene, but not so in older larvae or post-larvae. Lower net growth efficiency in methoprene-exposed early larvae suggests that increased metabolic demands reduced assimilated energy available for growth. Responses of developing grass shrimp larvae to methoprene are characteristic of those of insects to juvenile hormone (McKenney, 1992).

In other laboratory studies, McKenney and Celestial studied the survival, growth and reproduction of estuarine mysid shrimp *(Mysidopsis bahia*[26]*)* exposed to (S)-methoprene through a whole life cycle. According to the authors, total lethality occurred among all juvenile mysids exposed to 125 μg/L (ppb) for 4 days. Mysids reared at the sublethal concentration of 62 μg/L (ppb) weighed significantly less than unexposed mysids as they matured after 15 days of exposure. Release of the first brood was significantly delayed by as much as 3 days in mysids exposed to low μg/L (ppb) concentrations. The total number of young produced by groups of mysids during their first brood was significantly reduced when mysids were reared in methoprene concentrations ≥8 μg/L (ppb). The most sensitive response of mysids to methoprene exposure was a significant reduction in the number of young produced per female in concentrations ≥2 μg/L (ppb) *(McKenney, 1996).*

Water Fleas

In a study examining the acute and chronic effect of (S)-methoprene (Altosid®) on water fleas[27] (*Moina macrocopa*) the 24- and 48-hour LC_{50} values were calculated to be 510 and 340 μg/L (ppb) respectively. Water flea survival, longevity, and fecundity were reduced at 50 μg/L (ppb) and higher concentrations. At 5 and 10 μg/L (ppb) longevity, and fecundity increased slightly as compared to controls. The authors state that if environmental concentrations do not exceed 50 μg/L (ppb), which is likely the case, application of this insecticide is unlikely to cause detrimental effects on natural water flea populations. They conclude that the reproductive stimulation of methoprene on the water flea, as observed at 5 and 10 μg/L (ppb), is consistent with the following hypothesis: that juvenile hormone analogs, such as methoprene may affect reproduction and development in crustaceans because methyl farnesoate, a juvenile hormone endogenous to crustaceans, is believed to play a regulatory role in these processes and has a chemical structure similar to that of the insect juvenile hormone (Chu, 1997).

In another study, the short-term effects of ZR-515 [(RS)-methoprene] were tested on the *Daphnia magna* and *Cyclops sp.* in the laboratory and in outdoor artificial containers. *Daphnia magna* and *Cyclops sp.* were maintained in aquariums treated with 10% Flowable liquid formulation (slow release) of ZR-515 and contained 0.1 ppm (RS)-methoprene. According to the authors *Daphnia sp.* showed the least tolerance to technical ZR-515 in the laboratory tests with 24-hr LC_{50} value of 0.90 ppm. The calculated risk quotient values in **Table Five** (below) indicate minimal risks for acute toxicity to water fleas (Miura, 1973).

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[26] *Mysidopsis bahia* has been shown to be one of the most sensitive members of the estuarine community to a variety of pesticides.

[27] Water fleas are crustaceans from the **order Cladocera** that are sometimes extremely abundant in freshwater pools. *Moina* appear in high concentrations in pools, ponds, lakes, ditches, slow-moving streams, and swamps where organic material is decomposing and are ideally suited for feeding freshwater fish fry.

Copepods

Copepods are one of the most abundant animals on the planet. Most are saltwater plankton, living their entire lives in the open ocean without ever touching the bottom or surface. Copepods also live on the sea bottom, in fresh water, as parasites on fish, or in caves. Copepods are important components of the food chain in aquatic systems and some species are predatory on mosquito larvae. In the previously discussed Miura and Takahashi 1973 study, the authors calculated an LC_{50} value 4.60 mg/L (ppm) for copepods *(Cyclops sp.).* The calculated risk quotient values in **Table Five** (below) indicate minimal risks for acute toxicity to copepods (Miura, 1973). Subsequent studies by Schaefer *et al.* also found no effect of methoprene (Altosid®) on water fleas *(Daphnia* and *Moina* spp.) and a variety of copepods (Glare, 1999).

Table Five: Risk Quotients for Water Fleas *(Daphnia magna sp.)* and Copepods *(Cyclops sp.)* (Miura, 1973).

Animal	**State of growth**	**Number of tests**	**Number Animals per container**	**Test Duration (hours)**	**LC_{50} (ppm)**	**Acute RQ (EEC/LC_{50})**
Water Fleas *(Daphnia magna sp.)*	Mixed	3	30+	24	0.90	0.011
Copepods *(Cyclops sp.)*	Mixed	3	30+	24	4.60	0.002

Amphipods

Amphipods are considered an important food constituent of fish and some share their breeding places with mosquitoes. In an acute toxicity study with the amphipod (*Gammarus Aequicauda)* serial dilutions of technical Altosid® (65.8%) were prepared. Ten animals per concentration were utilized and LC_{50} and LC_{90} values were calculated **(Table Six)**.

Table Six: Risk Quotients for Amphipods (*Gammarus Aequicauda)* (Gradoni, 1976).

Stage	**LC_{50} (ppm)**	**LC_{90} (ppm)**	**Test Duration (hours)**	**Acute RQ (EEC/LC_{50})[28]**
Adult females	2.15	4.10	96	0.004
Adult males	1.95	7.80	96	0.005
Young	0.32	1.05	24	0.031

Based on the LC_{50} values above, it appears that the young amphipods are 6-7 times more sensitive to methoprene than adult amphipods of the same species; however calculated risk quotient values indicate minimal concerns for acute toxicity (Gradoni, 1976).

(d) Atlantic Oyster (Phylum, Mollusca)

In a 1972 the acute toxicity of (R,S)-methoprene (technical ZR-515, 69.7% active ingredient) to the Atlantic oysters *(Crassostrea virginica)* was studied for Zoecon Corporation by Bionomics

[28] According to Ross *et.al.* 10 µg/L (ppb) or 0.01 mg/L (ppm) is the Expected environmental concentrations from the application of ALTOSID® Liquid Larvicide at 4 fluid oz. /acre (293 ml/ha) (Ross, 1994).

Inc., later known as Springborn Laboratories, Inc. The goal of the study was to determine a 48-hour median tolerance limit (48-hr TL_{50}), which is defined as the concentration of the chemical in water which causes 50% response under the test conditions during a 48-hour interval.

The response observed in these studies was normal embryonic development. For observations on development of embryos, fertilized eggs were introduced into the test container soon after release. Quantitative samples were taken 48 hours later to determine the percentage of the fertilized eggs that had developed to a normal morphological stage (i.e. straight-hinged veliger larvae).

The predicted 48-hour TL_{50} (i.e. concentration of Altosid® which inhibited normal development 50% of the developing oyster larvae) was 0.247 mg/L (ppm). No effect on normal embryonic development was observed among oyster larvae exposed to Altosid® at 0.075 mg/L (ppm) for 48-hours (Sleight, 1972).

(e) Fish

According to the June 2001 Update of the 1991 EPA Registration Eligibility Document, methoprene poses minimal chronic and acute risks to freshwater fish. Table Seven provides a summary of toxicity endpoints to fish.

The EPA 1991 R.E.D. summarized available fish studies concluding that methoprene is moderately toxic to warm water, freshwater fish and slightly toxic to coldwater, freshwater fish. Exposure of fish to methoprene has produced LC_{50} values ranging from 3.3 mg/L (ppm) for trout to >100 mg/L (ppm) for channel catfish *(Ictalurus punctatu*s). Acute fish toxicity would not be expected during control programs as the concentration of methoprene in water at any one time is unlikely to exceed 10 µg/L (ppb) (Ross 1994). It should also be noted that some of the experimental work examining methoprene toxicity to fish used special solvents, such as dimethyl-formamide, to increase methoprene's solubility in water. Solvents are not used in Altosid® formulations and the solubility of methoprene is approximately 1.39 mg/L (ppm) (Glare, 1999).

Table Seven: Toxicity of Methoprene to Various Aquatic Organisms (Hicks, 2001).

AI	WARM WATER FISH LC_{50} (MEDIAN LETHAL CONCENTRATION)	COLD WATER FISH LC_{50}	ESTUARINE AND MARINE TOXICITY	FRESHWATER INVERTEBRATES
Methoprene [3]	Bluegill sunfish: 96hr LC_{50} 1,520ppb [3] 96 hr TL_{50} (median threshold limit) = 4,600 ppb (static) [2] LC_{50} > 370 ppb [3] Channel catfish: TL_{50} > 100,000 ppb (static) [54] Fathead minnow: LEL (Lowest Effective Level) = 84 ppb [22b] NOEL = 48 ppb [22b]	Rainbow trout: 96 hr LC_{50} > 50,000 ppb[3] Juvenile Rainbow trout: LC_{50} = 106,000 ppb [54] LC_{50} = 760 ppb [22b] LC_{50} = 106,000 [54] Trout: TL_{50} = 4,400 ppb (static) [54] TL_{50}= 106,000 ppb (static aerated) [54] Coho salmon LC 50 = 86,000 ppb [54]	Mud crab: ↓ gametes in @ 1,300 ppb [3] Adult grass shrimp: Slightly toxic [3] not acutely toxic [41] Juvenile grass shrimp and larval mud-crabs: Very highly toxic [1] not acutely toxic Gammarus aequicauda: 96 hr LC_{50} = 2,150 ppb (females) [54, 22d] 96 hr LC_{50} = 1,950 ppb (males) [54, 22d] Mysid Shrimp: 96 hr LC_{50} = 110 ppb [22b] 28 day MATC = > 98 ppb [22b] Oyster (larvae): 48 hr LC_{50} = 247 ppb [22b] Oyster shell deposition 96 hr = 1,400 ppb [22b]	Daphnia; 48 hr EC_{50} 89 ppb [3] 42 day MATC 27 - 51 ppb [3] 48 hr EC_{50} = 360 ppb [22b] 42 day MATC 51 ppb [22b]

[3] EPA (1991) R.E.D. Methoprene.
[22b] Sandoz (1996) Submission of Environmental Toxicity and Release Data to EPA.
[22d] Grandoni, L., Bettini, S. and Majors, G. 1976. *Toxicity of Altosid® to the Crustacean: Gammarus aequicauda*. Mosquito News, Vol. 36(3):294-297.
[41] Wellmark (2001) Comments on March 5,2001 Maine draft report by Hicks, Lebelle:
[54] Vershcueren, K. Handbook of Environmental Data on Organic Chemicals. 2nd Ed. Van Nostrand Reinhold Press, NY, 1983.

4. ENVIRONMENTAL FATE AND TRANSPORT

Methoprene is rapidly degraded under field conditions. The biological activity of aqueous solutions of methoprene has been shown to be affected by sunlight, temperature, and microbial action. The metabolism of methoprene by aquatic microorganisms is extensive, with methoxycitronellic acid being the major microbial breakdown product. The most abundant photoproduct in aqueous solution is methoxycitronellal (9%). While methoprene degrades rapidly in the field, the persistence in water is determined, ultimately however, by the formulation and method of application. The XR briquet releases small amounts of methoprene as it degrades over a period of 150 days. While the briquet has been shown to physically persist in water for eighteen months, no data is available to indicate biological activity for this time period.

Stability in water

Methoprene is extremely stable to hydrolysis (Schooley, 1975). The principal modes of degradation in water are photodegradation and degradation by aquatic microorganisms (EXTOXNET, 1996). Quistad has shown in the laboratory that the photolysis half life of methoprene in water is less than one day (Quistad, 1975). In field trials, aqueous solutions of methoprene formulated as an emulsifiable concentrate were found to have a half life of only about two hours (Schaeffer, 1973). Treatment of a ten percent flowable liquid (slow release) formulation in water showed almost no detectable residues after 24 hours, although biological activity persisted for several days (Schaeffer, 1973). Studies under conditions that approximate the natural environment and the use rates of methoprene for mosquito control, have demonstrated half lives in pond water of about 30 and 40 hours at initial concentrations of 0.001 ppm and 0.01 ppm respectively (Schooley, 1975). Measuring the methoprene concentration in the field is difficult due to its rapid rate of dissipation.

Because of its rapid rate of degradation, several formulations of methoprene have been developed which extend the active life of methoprene in water. As shown in Table Two, these formulations include slow release solids such as briquets, pellets and granules. While these slow release formulations provide excellent control of mosquito larvae, they have been shown to physically degrade over a period of as long as eighteen months (Boxmeyer, 1997).

Methoprene, formulated as slow release Altosid® briquets in a Minnesota study was found under field conditions to degrade on average to 19% of its weight within 150 days of immersion in water. The briquet however, took eighteen months to completely degrade. No information in the study was provided to indicate whether the briquet continued to be biologically activity for eighteen months (Boxmeyer, 1997).

However, Ross *et al* of Zoecon Corporation maintain that methoprene has a short environmental persistence when applied in sustained release formulations. In an experiment to measure the methoprene concentrations present over time in aquatic microcosms treated with the liquid larvicide and with sustained release Altosid® formulations – Altosid® Briquets (AB), XR Briquets, and Pellets-, no sample collected in the experiment contained a residue in excess of 10 µg/L (ppb)[29]. In fact, 85% of the residues in the 186 samples analyzed were less than 1 µg/L (ppb). Water samples were taken at various intervals over a 35 day period. The study found that the highest methoprene concentrations from the use of Altosid® liquid larvicide, 2.2 µg/L(ppb), is produced at days 1 and 3 post application. The 30 day briquets (AB) and the 30 day pellets

[29] The expected environmental concentrations of methoprene produced by the application of ALTOSID® Liquid Larvacide at the maximum rate of 4 floz/0.5 acre feet of water is 10 µg/L (ppb).

produce peak methoprene concentrations of 4 μg/L(ppb) and 2μg/L(ppb) at seven days. For the 150 day briquets (XR), the concentration remained consistently around the 0.2 μg/L(ppb) level for the 35 day study peaking at 0.7 μg/L(ppb) at day two (Ross *et al*, 1994).

In its 1991 RED, EPA expressed concern over the use of the slow release formulation because it causes estuarine organisms to be exposed to methoprene over an extended period of time (EPA, 1991). And in fact, New York state has limited the use of the 150 day briquet based upon similar concerns. Studies submitted by Wellmark International subsequent to the 1991 RED have led to the removal of any such language from the federal label. However New York continues to prohibit the use of the slow release formulation under specific circumstances. This issue is discussed in more detail in the following section which addresses the varying approaches taken at the state and federal level to regulate methoprene use.

Aquatic Microorganisms
Schooley *et al* report that the metabolism of methoprene by aquatic microorganisms is extensive and appears to occur more rapidly than the competing photo-initiated decomposition of methoprene in solution (Schooley, 1975). The major microbial product is 7-methoxy-3, 7 dimethyloctanoic acid (methoxycitronellic acid). However the contribution to degradation of each process under field conditions is likely to be determined by the specific environmental conditions.

Light
Methoprene degrades rapidly in sunlight, both in water and on inert surfaces (Scheaffer, 1973, EPA, 1991). It undergoes photolytic degradation to a large number of photoproducts all of which are present in relatively low yield (< 10 %) (Quistad, 1975). After one week of irradiation, an aqueous solution of methoprene yielded four major photoproducts. The most abundant photoproduct was 7-methoxycitronellal (9%). The other products included methoxycitronellic acid (7%), an epoxide of methoprene (4%), and a methyl ketone (4%). At least 46 other products were detected, with none representing more than a 2% yield. Unreacted methoprene was not detected after two weeks of exposure to sunshine (Quistad, 1975).

Methoprene is also susceptible to photoisomerization of the 2-ene double bond to various mixtures of photoisomers. Schaeefer has reported that sunlight reduces the biological activity of methoprene (Schaefer, 1973). This is due to the fact that the *2E, 4E* isomer is readily converted to the biologically less active *2Z,4E* isomer in solution (Quistad, 1975). The *2Z,4E* isomer is approximately 1000 times less active on mosquito larvae. Interestingly, a 1:1 isomeric ratio of *2Z,4E* to *2E,4E* was consistently observed after field exposure of methoprene to sunlight. Consequently, a non-degradative loss of about half the biological activity of methoprene should result from photoisomerization. With slow release formulations, however, biological potency is maintained over longer periods.

Temperature
Schaefer has determined that temperature has a definite effect. At 12°C, a solution of methoprene averaged 21% of the initial concentration after 8 hours. For a solution where the water temperature reached 39°C , the concentration was reduced to 1.3% after the same exposure. While high temperatures do have an effect, Schaefer concluded that sunlight appears to be a much more important factor accounting for a rapid decline in concentration in laboratory experiments (Schaeffer, 1973).

6. GOVERNMENT REGULATION

USEPA has registered all commercially available Altosid® formulations of methoprene for use in fish bearing waters. However, the 1991 EPA RED factsheet states that methoprene is highly acutely toxic to estuarine invertebrates. EPA has recently updated this R.E.D. (June 2001), concluding that:

- **all ecological concerns contained in the 1991 R.E.D. factsheet related to toxicity to estuarine invertebrates have been alleviated as a result of the submission of studies which indicate a minimal chronic risk to Mysid Shrimp, and**
- **all methoprene end–use products have completed the registration process.**

New York prohibits the application of sustained-release formulations to fish bearing waters. Maryland imposes conditions on the application of methoprene to water bodies on a case by case basis. While Altosid® is registered for use in fish bearing waters in all other states, a number of states have placed limitations on the application of methoprene products, along with dozens of other pesticides, to waters containing endangered species.

Federal Government

Conflicting messages from EPA regarding the use of methoprene in aquatic environments have confused the issue of methoprene use in fish bearing waters. The 1991 EPA Registration Eligibility Decision (R.E.D.) factsheet stated that "the ecological effects studies on methoprene suggest that use of the briquet or slow-release formulation in estuarine areas may cause undue risks to estuarine invertebrates, since the pesticide is highly toxic to these organisms." However the label contains no such language and methoprene is routinely used for insect control in aquatic environments. The reasons for this discrepancy arise out of the complexities inherent to the federal pesticide product registration process. However in June 2001, EPA issued an updated R.E.D. factsheet which concludes that:

- the studies available to EPA indicate that the biochemical insect growth regulator Methoprene is of low toxicity and poses very little hazard to people and other non-target species,
- ecological concerns contained in the 1991 Methoprene R.E.D. factsheet related to toxicity to estuarine invertebrates have been alleviated as a result of the submission of the estuarine invertebrate life cycle toxicity study in 1996, which indicated minimal chronic risk to Mysid Shrimp,
- all Methoprene end-use products completed the reregistration process in 1997 and all reregistration data requirements and label changes have been completed.

The issue is further complicated because New York state continues to require that the slow release formulations bear the label with the statement prohibiting applications to fish bearing waters. Maryland imposes conditions on methoprene use, specific to the resource, through a pesticide aquatic application process. Several other states have placed limitations on the application of methoprene (along with dozens of other commonly used pesticides) to waters containing endangered species. The registration status of methoprene in several states, including New York, is further discussed in the following section.

New York

New York is the only state that currently requires Wellmark International to distribute and sell their slow-release formulations with amended labels, unique to New York, which prohibit any applications to fish-bearing waters. Based upon a recent risk assessment of the slow release formulations conducted by the Department of Environmental Conservation (DEC), a decision has been made to maintain this prohibition.

According to Tim Sinnott, Ecotoxicology and Standard Unit Leader (Personal communication, July, 2001), DEC has determined that methoprene itself is not acutely toxic to fish and amphibian species tested at concentrations likely to be encountered in the environment following a labeled application. However, the DEC risk assessment expressed concerns that certain methoprene degradates could potentially be teratogenic to amphibians. In addition, the Boxmeyer study (described on page 15) which reported that Altosid® briquets degraded over an eighteen month time period fueled further concerns among environmental risk managers in New York regarding the persistence of methoprene's degradation products. These concerns centered on the teratogenic compounds that could potentially be continuously generated as a result of the sustained release of methoprene over time into a water body. Because the briquet degrades over such a long period, DEC also expressed concerns that the briquet could over winter potentially becoming active again in the early spring at a time when amphibians and fish typically spawn. These findings provided the DEC with enough concerns about the long term effects to recommend that the amended label for the slow release formulations should remain unchanged. While they have no definitive evidence that methoprene degradates are teratogenic, the outcome of the risk assessment was such that they felt that they could not rule out the possibility (of teratogenicity) based upon the data reviewed.

The use of methoprene, including sustained-release formulations, is an integral part of the New York's Routine Comprehensive Arthropod-borne Disease Surveillance and Control Program. According to this program, Altosid® briquets and Altosid® granules will be applied to non-seepage storm drains or catch basins. Non-seepage drains are basins that do not allow the water to drain into the ground. Seepage basins that allow the water to eventually seep into the ground will be treated with VectoLex (*Bacillus sphaericus*). This plan also states their intention to apply VectoLex (*Bacillus sphaericus*) and VectoBac (*Bti*) to freshwater ponds, lakes, and numerous other areas determined to be sensitive natural resources. This plan does allow the option of applying the Altosid® Liquid Larvicide formulation of methoprene to such sensitive natural areas on a site by site basis.

New York's Division of Fish, Wildlife and Marine Resources further recommends that the extended release briquet should not be used in waters inhabited by endangered species.

New Jersey

New Jersey has one of the most comprehensive mosquito control programs in the Northeast and reports that no restrictions beyond the label exist on the use of any Altosid® products. County projects, which use Altosid® Liquid Larvicide as their primary larvicide on salt marshes, report that it provides excellent control of mosquito emergence.

Maryland

Maryland does not have a direct prohibition on the use of sustained release formulations to fish bearing waters. Instead, Maryland imposes specific conditions and restrictions on methoprene use, on a case by case basis, through the Toxic Materials Permitting process of the Department of the Environment. These conditions are based upon a recommendation to the Department of the Environment (DOE) from the Department of Natural Resources (DNR). MDE has reviewed data that show methoprene can impact certain non-target organisms, but they recognize that the concentration and duration of exposure to cause these effects are far greater than will occur following application of methoprene for mosquito control per label directions (Personal Communication, Cyrus R. Lesser, Chief Mosquito Control Section, MDA).

An example of typical conditions, drawn from Maryland Toxic Permits TMP-01-127 which was issued on March 2, 2001, includes the following points:

- There shall be no direct application of methoprene to Use III waters, headwater tributaries, or contiguous wetlands. Between March 1 and June 15, there shall be no direct application of methoprene to documented anadromous finfish spawning areas or their contiguous wetlands.

- Use of residual formulations of methoprene is restricted to storm water detention facilities and isolated woodland pools, neither of which is within or immediately next to estuarine aquatic habitat areas (including marshes).

- **Specific areas of Concern:** There shall be no direct application of methoprene to wetlands or conveyances directly contiguous to the tidal marsh along Deep Creek, just north of Franklin Manor.

Placing limitations on methoprene use in Maryland is a source of contention between the Maryland Department of Agriculture (DOA) and the Department of Natural Resources.

Maine
Altosid® products are registered for use in all New England states. However, whereas each state has a different arbovirus or mosquito control program, registration of a larvicide does not necessarily equate to use. Maine for example does not have an organized mosquito control program. Applications of any larvicide including *Bti, Bs,* and methoprene to a salt marsh require a pollution discharge permit from the Maine Department of Environmental Protection (DEP). Beyond the permitting process there are no additional restrictions on the registration of methoprene in Maine. Maine has restrictions on the application of any material to water that is not contained and enters into another body of water or may be used by the public. DEP does not normally give out any permits for application of pesticides to bodies of water that empty into a pond, lake, or river. Without such a permit only registered materials may be applied to water bodies that are contained on an individual's property and do not connect to other bodies of water.

New Hampshire
Although there are no additional restrictions on the registration of Altosid® products in the state of New Hampshire, a permit from the New Hampshire Department of Agriculture's, Division of Pesticide Control is required to apply a pesticide to or within 25 feet of any body of water, including vernal pools. Although permits are issued on a case by case basis, there is a limited number of municipalities such as Hampton, Hampton Beach, and Rye which have organized mosquito control programs that require permits for season long applications of larvicides such as Altosid® to saltwater marsh areas and catch basins. Several factors must be present however, prior to the issuance of such permits. For example, municipalities must work in cooperation with someone who is certified to use pesticides and is specially trained in pest identification and surveillance techniques.

Vermont
Any application of a pesticide to water requires a permit from the Vermont Division of Water Quality. In Vermont however, the Department of Agriculture provides permits for any larvicide/ mosquito related applications. Vermont has one organized mosquito control district involving

four towns. Recent studies in Lake Champlain have documented the occurrence of malformed *Rana pipiens*. As a result of these malformations methoprene applications will be restricted and may be made only on a case by case basis as approved by the Department of Agriculture. Permits will be granted for the application of Altosid® Briquets to catchbasins and vernal pools. According to John Turmal 99% of mosquito control applications use *Bti*. In 2000, EPA issued a request for applications under the Regional Applied Research Effort (RARE) program to conduct investigations into the possible causes of amphibian malformations in Lake Champlain.

Rhode Island
There are no additional restrictions on the use of methoprene in the state of Rhode Island. The program in Rhode Island provides oversight and training to communities and shares mosquito control activities, such as larviciding, with hired commercial applicators and certified individuals working for municipalities.

Connecticut
Beyond the label language, there are no additional restrictions on the use of methoprene in Connecticut. However, any application of a chemical to water for control of aquatic organisms in state waters, including catch basins, requires a permit. Biological pest control agents such as *Bti* and *Bs* are exempt from this permitting process. Connecticut's organized mosquito control program is held within its Department of Environmental Protection. The activities of pesticide related activities of the DEP are exempt from the permitting process. According to Roger Wolff of DEP, Altosid® products are used for salt marsh mosquito control along the coast of Connecticut (Personal Communication, July 2001).

Florida
Methoprene is widely used in the state of Florida where there are no additional restrictions on its use. The low toxicity of Altosid® to non-target organisms, makes it the preferred product for use in Florida's State and Federal Parks. However according to Dr. Jonathan Hornby of Applied Science and Technology, Abate (temephos) is currently the main larvicide used in many of Florida's salt marsh lands due to its relatively low cost. Altosid® however, is used extensively in pastures, retention ponds and other areas due to restrictions on the Abate label.

In work yet to be completed and published Florida officials observed increased emergence of their primary saltwater mosquito pest *(Ochlerotatus taeniorhynchus)* after using Altosid® XR Briquets over a four year period. As the location of this study site was off shore, the island conditions provided the opportunity to study the effectiveness of Altosid® on this species without the migration of outside species and their genes into the study population. The location provided an optimal natural setting for studying the potential development of resistance. Florida officials have not observed mosquito resistance from their use of temephos (Personal Communication, Bryan Smith, Larviciding Field Supervisor and Jonathan Hornby, Ph.D. Div. Head Applied Science and Technology, Lee County, Florida).

Other States
Several states such as, Alabama, Arkansas, Kentucky, Mississippi, Nebraska, Nevada, Oklahoma and Virginia have at the time of writing placed limitations on the application of methoprene to waters containing endangered species. However, all of these states have placed similar limitations on the use of dozens of pesticides – 63 active ingredients in the case of Hinds County, Mississippi- in the vicinity of waters containing endangered species. The limitations vary considerably from state to state. In Hinds County, Mississippi, the limitation on methoprene use amounts to a recommendation to read some general information about reducing runoff and drift.

In Lee County Virginia, methoprene cannot be applied within 20 yards of the water's edge or within 100 yards for aerial applications. Similar restrictions apply to benomyl, captan, carbaryl, chlorpyrifos, diazinon and a dozen additional pesticides.

8. CONCLUSIONS

Methoprene is one of the most effective tools available for midge and mosquito control. It is used in Massachusetts, most notably, to control mosquito larvae in catch basins as part of municipal West Nile Virus prevention strategies. However it has come under considerable scrutiny over the past few years due to its suspected role as a causative agent in amphibian deformities. It has been further implicated in a die off of lobsters in Long Island Sound in 1999. Despite the fact that it has been registered for use since 1996 on all water bodies, doubts persist about its long term effects among the scientific community and some state regulators. Our findings can be summarized as follows:

- We have found no evidence to suggest that the labeled application of methoprene for mosquito and midge control will lead to amphibian malformations. Methoprene and its breakdown products are not retinoid compounds. Methoprene *has* been shown in the laboratory to break down into methoprenic acid which can mimic retinoid activity, and cause deformities in frogs at extraordinarily high levels. However, methoprenic acid is not found in the natural environment. There is far greater body of evidence that suggests that parasitic trematodes and ultra violet light may be more likely causative agents.

- Studies reviewed observed variable susceptibilities of crustaceans to methoprene. Several short term studies indicated no effect from methoprene on aquatic invertebrate crustaceans such as the Blue Crab, the Mud Crab, Shrimp and some varieties of Copepods. However, short term studies on the fresh water crustacean Daphnia Magna provide cause for concern. A longer term chronic study fuels concerns for the potential toxicity of methoprene, at levels which might be expected from a labeled application, to Grass Shrimp Larvae. At this time, it is difficult to draw final conclusions regarding the safety of methoprene for crustaceans until further research is completed and available for review. The weight of evidence reviewed, however, suggests that impacts upon crustraceans are not likely at expected environmental concentrations.

- Because the half life of methoprene is quite short, the use of the liquid larvicide is unlikely to create any adverse impacts. Possible exceptions are repeated applications, or the use of methoprene slow release formulations in shallow, poorly flushed waters. Water sampling show that minute concentrations (~0.2 ppb) of methoprene result from the use of this briquet over a 35 day period. The highest concentration (0.7 ppb) is found at day two. However, the briquet is formulated to remain active for at least 150 days. It has been shown to be physically present for up to 18 months. It is unlikely to present any adverse effects in a well flushed water body. However, the data gap for chronic exposure to small quantities of methoprene over the long term, particularly in a poorly flushed medium, prevents conclusions from being drawn about the long term effects of this formulation.

- While some impact on non-target aquatic organisms could be expected, it is clear that the effects of methoprene applications are less harmful than those caused by most mosquitocidal pesticides. Methoprene has longer persistence than *Bti* after application, but also causes greater impact on non-target organisms. Despite this, there is no indication in the literature of permanent disruption to ecosystems after methoprene application.

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APPENDIX A : COMPARISON OF METHOPRENE TO ALTERNATIVE LARVICIDES

"When considering the environmental safety of methoprene use, it is important to compare efficacy with other agents. The efficacy of methoprene in comparison to other mosquitocidal agents has been examined by several researchers in both laboratory and field situations. Methoprene has consistently proved to be one of the most effective insect growth regulators against mosquitoes and is usually more efficacious than biological control agents" *(Glare, 1999).*

"Methoprene has a broader host range than biological control agents of mosquitoes, such as *Bt*i, *B. sphaericus* and *Lagenidium giganteum.* However, it is far more specific than widely used chemical controls such as temephos. While the list of susceptible insects is extensive for methoprene, many reported susceptible organisms require doses that greatly exceed the field application rate. Several researchers have suggested that methoprene can be specific to Diptera in field situations, which would be likely to include some beneficial dipteran species. The non-target effects observed after methoprene use include some reduction in benthic communities and direct, but low toxicity to fish, however such communities appear to recover quickly" *(Glare, 1999).*

Bacillus thuringiensis israelensis (Bti)

Bti is a naturally occurring soil bacterium that produces a proteinaceous crystalline inclusions containing toxins that damage the gut of some insects. Bti is approved for control of larval mosquitoes, black flies, and some midges. Bti has been found to be non-toxic to many beneficial predatory insects. "Bti is generally toxic to only nematocerous[30] Diptera, and, as with other Bt larvicides, toxicity to the target group requires both ingestion of the toxic crystals associated with the spores and the appropriate pH conditions in the gut. Laboratory and field studies have shown that Bti is toxic to some larval chironomids, but many factors reduce its toxicity to chironomids in the environment. In black fly control studies conducted in streams, limited short-term effects on insect drift, but not on mortality, have been observed for some Ephemeroptera and Trichoptera" *(Hershey, 1998).*

Most formulations for use in mosquito control are known by the trade name Vectobac®. Altosid® and *Bti* have been used together for many years and this combination is usually referred to as a Duplex mixture. Duplex has been shown to control all species of mosquitoes. The two control agents are usually applied in ratios of 12:1 to 6:1 of *Bt*i:Altosid®. When a 6:1 ratio is applied at 1 pint/acre, effective control can be maintained for about 10 days *(Glare, 1999).*

The presence of pollutants, salinity, organic and inorganic particles can all reduce the efficacy of *Bti* efficacy. Pollution apparently results in less *Bti* being ingested, resulting in reduced efficacy. The presence of free chlorine in the water can inhibit or destroy the endotoxin. The presence of soil significantly reduces larval mortality, probably by assisting sedimentation and unavailability of *Bti*. The efficacy of spore-crystal formulations of *Bti* against mosquito larvae (*Cx. quinquefasciatus* and *Ae. Aegypti)* in the laboratory decreased when aqueous environments contained a concentration of soil or clay particles greater than or equal to 0.5 mg/ml. In another study, sludge from soil decreased the effectiveness of *Bti* more than decomposing organic matter, inorganic mud or silica gel. *(Glare, 1998).*

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[30] Nematocera is a suborder of the genus Diptera and includes insects that are small, slender and midge-like in appearance. Mosquitoes are an example of nematocerous Diptera.

It is difficult to compare the toxicity of *Bti* to chemical controls such as methoprene and temephos. *Bt* concentrations are measured in international units, which factor in the potency of each batch and toxicity study results are reported in terms of colony forming units (CFU). The situation is similar for *B. spaericus.* See Table Seven for a list of *Bti* aquatic toxicity endpoint values to aquatic organisms.

Temephos

Temephos is a non-systemic organophosphorus insecticide and the only chemical from this class that is used to control mosquito, midge, and black fly larvae. It is used in lakes, ponds, and wetlands in formulations known by the trade name Abate. The toxicity of temephos to aquatic organisms varies widely with species. Some species for example are more susceptible to methoprene than temephos. Methoprene however, is far more specific than temephos, which effects a much broader range of aquatic insects *(Glare, 1999)*.

Insects appear to develop resistance to temephos more rapidly than to methoprene, another issue in choice of agents for use in vector management. The long residual activity of temephos can make it attractive for specialized uses such as container treatment (which contributes to the development of resistance). This needs to be compared with methoprene, which also has long residual activity in protected (from sunlight) environments *(Glare, 1999)*. A further problem with organophosphates is the likelihood of withdrawal from the market in the future, due to concerns raised by the Food Quality Protection Act such as cumulative toxicity to compounds exhibiting a common mechanism of toxicity.

See Table Seven for a list of temephos aquatic toxicity endpoint values to aquatic organisms.

Bacillus sphaericus

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. Most formulations for use in mosquito control are known by the trade name VectoLex®. Mosquito larvae ingest the bacteria, and as with *Bt*i, 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.

Poly Ethoxylated Alcohols and Monomolecular Films

Monomolecular films (MMF) or poly ethoxylated alcohols (POE) are manufactured by the reaction of alcohols with ethylene oxide. When these materials are applied to bodies of water they form a thin film on the surface. This film reduces the surface tension of the water and mosquito larvae and pupae are unable to attach to the surface, which they must do in order to breathe. This film may also block their breathing tubes. 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.
At application rates up to 0.5 Gal/Surface Acre, Agnique® MMF Mosquito Larvicide and Pupicide is registered for use in semi-permanent or permanent fresh potable and irrigation water. It is also registered for use in salt water habitats with no, low, moderate or high concentrations of emergent or surface vegetation. Examples of these systems include: salt marshes, ponds, storm water retention/detention basins, roadside ditches, grassy swales, potholes, fields, reservoirs, irrigated croplands, etc..

Other use sites include semi-permanent or permanent polluted water habitats containing no, low, moderate, or high concentration of algal mats, emergent or surface vegetation and/or organic/inorganic debris.

Table Eight Aquatic Toxicity of Mosquito Larvicides (Hicks, 2001)				
Active Ingredient	**Warm water fish LC_{50}** **(Median Lethal Concentration)**	**Cold water fish LC_{50}**	**Estuarine and Marine Toxicity**	**Freshwater Invertebrates**
Bti [1]	Bluegill Sunfish; Aqueous $LC_{50;}$ 8.9 x 10^{9} to 1.6 x 10^{10} colony forming units per liter (cfu/l) [1] Oral LC_{50} > 4.3 x 10^{9} to 1. 3 x 10^{10} cfu/gram food [1]	Trout; Aqueous LC_{50}; > 8.7 x 10^{9} to > 1.4 x 10^{10} cfu/l [1] Oral LC_{50} > 5.3 x 10^{9} to 1. 7 x 10^{10} cfu/gram food [1]	Grass shrimp; No Observable Effect Level (NOEL) > 2 x 10^{10} cfu/g food [1] NOEL > 4.2 x 10^{10} cfu/g food [1] Sheepshead minnow; NOEL > 2 x 10^{10} cfu/g food [1] LC_{50} > 7.2 x 10^{9} cfu/g food [1] Oral LC_{50} > 2 x 10^{10} cfu/g [1] Copepod NOEL = 50 mg/kg (sediment) [1]	Daphnia 21 Day (EC_{50}) Median Effective Concentration = 5,000 - 50,000 parts per billion (ppb) = ug/L [1]
B.sphaericus [2]	ND = No Data	ND	ND	ND
Methoprene [3]	Bluegill sunfish: 96hr LC_{50} 1,520ppb [3] 96 hr TL_{50} (median threshold limit) = 4,600 ppb (static) [2] LC_{50} > 370 ppb [3] Channel catfish: TL_{50} > 100,000 ppb (static) [54] Fathead minnow: LEL (Lowest Effective Level) = 84 ppb [22b] NOEL = 48 ppb [22b]	Rainbow trout: 96 hr LC_{50} > 50,000 ppb[3] Juvenile Rainbow trout: LC_{50} = 106,000 ppb [54] LC_{50} = 760 ppb [22b] LC_{50} = 106,000 [54] Trout: TL_{50} = 4,400 ppb (static) [54] TL_{50}= 106,000 ppb (static aerated) [54] Coho salmon LC 50 = 86,000 ppb [54]	Mud crab: ↓ gametes in @ 1,300 ppb [3] Adult grass shrimp: Slightly toxic [3] not acutely toxic [41] Juvenile grass shrimp and larval mud-crabs: Very highly toxic [1] not acutely toxic Gammarus aequicauda: 96 hr LC_{50} = 2,150 ppb (females) [54, 22d] 96 hr LC_{50} = 1,950 ppb (males) [54, 22d] Mysid Shrimp: 96 hr LC_{50} = 110 ppb [22b] 28 day MATC = > 98 ppb [22b] Oyster (larvae): 48 hr LC_{50} = 247 ppb [22b] Oyster shell deposition 96 hr = 1,400 ppb [22b]	Daphnia; 48 hr EC_{50} 89 ppb [3] 42 day MATC 27 - 51 ppb [3] 48 hr EC_{50} = 360 ppb [22b] 42 day MATC 51 ppb [22b]

Table Eight Aquatic Toxicity of Mosquito Larvicides (Hicks, 2001)				
Active Ingredient	**Warm water fish LC_{50}** **(Median Lethal Concentration)**	**Cold water fish LC_{50}**	**Estuarine and Marine Toxicity**	**Freshwater Invertebrates**
POE MMF [5]	Bluegill sunfish: LC_{50} = 290,000 ppb [34]	Rainbow trout: LC_{50} = 98,000 ppb [34]		*Daphnia*: LC_{50} = 1,900 ppb [34]
Temephos (Abate) [4] EC	Bluegill Sunfish; 96 hr LC_{50} = 21,800 ppb Technical Grade Active Ingredient (TGAI) [4, 33] 96 hr LC_{50} = 1,140 ppb Emulsifiable concentrate 43% (EC)[4, 33] Fathead minnow: 31,100 ppb [33] Channel catfish: 10,000 ppb [33] 3,230 (EC 46%) [33] Largemouth bass: 1,440 ppb (EC 46%) [33]	Rainbow trout; 96 hr LC_{50} = 3,490 ppb (TGAI) [4, 33] 96 hr LC_{50} = 580 ppb (EC) [4] 160 ppb (EC) [33] Cut throat trout: 1,279 ppb [33] Brook trout 12,800 ppb [33] 5,000 ppb (WP 50%) [33] Lake trout 3,650 ppb [33] Coho salmon 350 ppb (EC 46%) [33] Atlantic salmon 21,000 ppb [33] 6,700 ppb (EC 46%) [33]	Eastern oyster; 96 hr EC_{50} = 220 ppb (TGAI) [4] 96 hr EC_{50} = 170 ppb (EC) [4] Pink Shrimp; 48hr EC_{50}= 5.3 ppb (EC) [4] *Gammarus lacustris* 80 ppb [33]	Daphnia 48 hr LC_{50} = 0.011 ppb (EC) [4] 48 hr LC_{50} = 0.54 ppb Granular %5 (G) [4] Scud; 48 hr LC_{50} = 820 ppb (TGAI) [4] Stonefly; 48 hr LC_{50} = 10 ppb (TGAI) [4]

[1] EPA (1998) R.E.D. Bacillus thuringiensis variety *israelensis* (Bti).
[2] Bacillus sphaericus.
[3] EPA (1991) R.E.D. Methoprene.
[4] EPA (1999) ERED Reregistration Chapter for Temephos.
[22b] Sandoz (1996) Submission of Environmental Toxicity and Release Data to EPA.
[22d] Grandoni, L., Bettini, S. and Majors, G. 1976. *Toxicity of Altosid to the Crustacean: Gammarus aequicauda*. Mosquito News, Vol. 36(3):294-297.
[33] Hazardous Substances Data Base (2001) for Temephos: (http://toxnet.nlm.nih.gov)
[41] Wellmark (2001) Comments on March 5,2001 Maine draft report by Hicks, Lebelle:
[54] Vershcueren, K. Handbook of Environmental Data on Organic Chemicals. 2nd Ed. Van Nostrand Reinhold Press, NY, 1983.

APPENDIX B: JUNE 2001 EPA UPDATE OF THE MARCH 1991 METHOPRENE R.E.D. FACTSHEET

http://www.epa.gov/pesticides/biopesticides/factsheets/fs105401.pdf

PUBLIC HEALTH FACT SHEET

Mosquitoes in Massachusetts

Massachusetts Department of Public Health, 305 South Street, Jamaica Plain, MA 02130

Are there different kinds of mosquitoes?

Yes. About 3000 different kinds (also called "species") of mosquitoes have been identified worldwide, with more than 150 different mosquito species found in North America. Fifty-one different species of mosquitoes have been identified in Massachusetts.

Where are mosquitoes usually found?

Most adults spend the day in damp, shady areas where they can find protection from the sun; some of them will even hide in your house. Mosquitoes need water to lay their eggs in and plants to hide in so they are usually found around water and plants. Mosquito eggs are laid on water or damp soil where the young mosquitoes grow and develop.

Different mosquitoes prefer different kinds of water. Some use natural sources of water such as swamps or ponds and others prefer water in swimming and wading pools, old tires, watering cans, flower pots, trash cans, etc. When the young mosquito turns into an adult, it leaves the water and flies away.

How long do mosquitoes live?

Most female mosquitoes live for less than 2 weeks and most male mosquitoes live for less than a week. However, when the conditions are right, some mosquitoes will live up to 8 weeks. The life cycle of all mosquitoes includes four different stages: egg, larva, pupa, and adult. Adult mosquitoes are the only ones that fly.

Why do mosquitoes bite?

Only female mosquitoes bite to suck blood. The female uses the blood to make eggs. Male and female mosquitoes use plant nectars and fruit juices as their main source of food.

Do all female mosquitoes bite humans?

No. Different species of mosquitoes like different types of blood. Some mosquitoes feed on animals like frogs, turtles and birds. Other species kinds bite mammals, including horses and humans. Some will bite both birds and mammals including humans. These mosquito species play an important role in spreading disease between birds and other mammals, including humans. *Diseases that normally are found in birds can be transmitted to humans (and some other mammals, like horses) by mosquitoes that bite both birds and mammals.*

When am I most likely to be bitten by a mosquito?

You can be bitten at any time. Different species of mosquitoes are active at different times of the day. Most mosquito species are active from just before dusk, through the night until dawn.

> ***Did you know*?**
> Some species of mosquitoes can fly 1.5 miles per hour.

How does a mosquito find an animal or human to bite?

Female mosquitoes are attracted to the gas (carbon dioxide) that humans and other animals breathe out. Mosquitoes can follow a stream of carbon dioxide from as far as 50 feet away. Mosquitoes are also attracted to substances like lactic acid on your skin, which your body produces in greater amounts when exercising.

Mosquitoes may also be attracted to certain scents or fragrances and are more attracted to dark colors than light colors.

Why are mosquito bites a concern?

Some mosquitoes carry germs that can make people and some animals sick. Mosquitoes can transmit viruses when they bite. In Massachusetts, the diseases linked to mosquitoes are West Nile virus (WNV) and eastern equine encephalitis (EEE) virus.

Do all mosquitoes spread germs to people?

No. In fact, most mosquito bites will only result in itching or skin irritation. However, some species found in Massachusetts carry viruses that can cause illness. Information about common kinds of mosquitoes that are most likely to spread disease in Massachusetts is shown below.

Mosquito Species Name	When are they most active?	Where do they live and what kind of water do they like?	What types of animals do they bite?	What time of year are they most common?
Aedes vexans	Dusk/dawn, night	River floodplains and Salt-marshes – temporary flooded areas	Mammals/humans	Summer and early fall
Coquillettidia perturbans	Dusk/dawn, night	Woodlands – cat-tail marshes	Birds Mammals/humans	Summer
Culex pipiens	Dusk/dawn, night	Urban areas – artificial containers	Birds, Occasionally mammals/humans	Summer and early fall
Culex restuans	Dusk/dawn, night	Urban areas – natural and artificial containers	Birds, Occasionally mammals/humans	Spring, summer and fall
Culex salinarius	Dusk/dawn, night	Salt-marshes – brackish and freshwater wetlands	Reptiles Birds Mammals/humans	Summer
Culiseta melanura	Dusk/dawn, night	Woodlands – white cedar and red maple swamps	Birds, Occasionally mammals/humans	Spring and summer
Ochlerotatus canadensis	Dusk/dawn, day	Woodlands – woodland pools	Birds Mammals/humans	Late spring through summer
Ochlerotatus japonicus	Day	Urban areas – natural and artificial containers	Mammals/humans	Summer through fall

Where can I get more information?

- **For information on diseases spread by mosquitoes and how to prevent them:** contact the MDPH, Division of Epidemiology and Immunization at 617-983-6800 or visit the MDPH Arbovirus website at www.mass.gov/dph/cdc/wnv/wnv1.htm.

- **For information on mosquito repellents:** review the MDPH Public Health Fact Sheet on Mosquito Repellents online at www.mass.gov/dph/epi . If you can't go online, contact the MDPH at (617) 983-6800 for a hard copy.

- **For information on mosquito control in your city or town**: The State Reclamation and Mosquito Control Board (SRMCB) within the Massachusetts Department of Agricultural Resources oversees mosquito control in Massachusetts (http://www.mass.gov/agr/mosquito/). The SRMCB can be contacted at 617-626-1777. There are nine established mosquito control districts in the state that provide service to many cities and towns. Information for each district can be found at www.mass.gov/agr/mosquito/districts.htm. Also, you can contact your local board of health concerning mosquito problems.

This fact sheet was developed in conjunction with the State Reclamation and Mosquito Control Board and the Massachusetts Mosquito Control Projects.
July, 2008

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Mosquito Misting Systems Position Statement

With the recent emergence of West Nile Virus (WNV) and concerns about mosquito borne illness in general, a growing industry has emerged offering various solutions to control mosquitoes. In particular, mosquito-misting systems have been promoted as both a commercial and residential solution to mosquito problems.

According to Pest Control Technology News dated October 21, 2005, “these systems are typically installed in the eaves of residential and commercial properties and dispense a fine mist of adulticides during the time of day in which mosquitoes are active. Their purpose is to reduce the population of mosquitoes in the area immediately adjacent to the treatment.” Also, the news item further stated “that since the emergence of the technology, state and federal regulators have expressed a number of regulatory concerns about the systems, including advertising claims made by the companies that manufacture, distribute and install the systems, concerns about human exposure to the pesticides dispensed by the systems, effects on non-target species, increased resistance to adulticides, licensing, certification and training of individuals selling and installing the systems and issues related to the storage and disposal of pesticides dispensed by the systems.”

The State Reclamation and Mosquito Control Board (SRMCB) has considered the issue of Mosquito Misting Systems (MMS) and the concerns expressed about them. Our position is in agreement with the position held by the American Mosquito Control Association (AMCA) and the concerns of others such as Pesticide Regulatory Officials.

In particular, the SRMCB cites the following statement by Roger S. Nasci, Ph.D. President of the American Mosquito Control Association (AMCA) in a letter dated June 29, 2004 to Director James J. Jones of the Office of Pesticide Programs in Washington, D.C.

“In summary the AMCA position is that the automated interval misting systems are not consistent with sound practices to promote public and environmental health and should be discouraged. We request the USEPA support this position and take appropriate action to limit the use of these products for mosquito control.”

The SRMCB recognizes and supports the use of pesticides to suppress mosquitoes when based on an Integrated Mosquito Management (IMM), it does not support the indiscriminate and unmonitored use of pesticides to reduce mosquito populations.

At this time, the SRMCB view these systems as contrary to Integrated Mosquito Management (IMM) and regional approach to mosquito suppression. Further, the SRMCB question the effectiveness of such systems from the perspective of annoyance alleviation and reduction of risks associated with mosquito-borne diseases.

If and when research indicates that these systems are effective or regulatory restrictions are applied, the SRMCB could revise its policy. Until such time, the SRMCB, as the agency responsible for overseeing mosquito control in Massachusetts, does not support, recommend, nor approve the use of mosquito misting systems to control mosquitoes in Massachusetts.

Voted and Approved on November 7, 2005

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Adult Mosquito Control Pesticide Label Compliance Policy Pertaining to the Protection of Bees of the State Reclamation and Mosquito Control Board

Introduction

New requirements for the protection of bees have been added to the labeling of Anvil 10+10 ULV, a product commonly used for adult mosquito control in Massachusetts, as well as other products registered for adult mosquito control. These requirements have made it necessary to develop a policy that balances the environmental risks to bees from applications made to control adult mosquitoes and the need to protect the public from the threat of mosquito-borne diseases.

New Label Language

The new labeling precautions, with one exception, prohibit applications to blooming crops or weeds *when bees are actively visiting the treatment area*. The exception is when applications are made to prevent or control a threat to public and/or animal health determined by a state, tribal or local health or vector control agency on the basis of documented evidence of disease causing agents in vector mosquitoes or the occurrence of mosquito borne disease in animal or human populations, or if specifically approved by the state or tribe during a natural recovery effort.

Objective

The following policy and parameters as outlined defines the exception for Massachusetts conditions and meets the objective of compliance with these new label changes. In addition, the policy provides a basis for mosquito control activities approved and carried out under the aegis of the State Reclamation and Mosquito Control Board (SRMCB).

This policy utilizes the Massachusetts Department of Public Health (MDPH) State Arbovirus Surveillance and Response Plan. The MDPH state State Arbovirus Surveillance and Response Plan characterizes the severity of risk of arbovirus and probability of human outbreak. The MDPH State Arbovirus Surveillance and Response Plan can be found at the following link:
http://www.mass.gov/dph/wnv/arbovirus_surveillance_plan.pdf

Policy

Whether the mosquito control applications are deemed necessary for the purpose of annoyance alleviation or public health, the intent of the labeling is to ensure that mosquito control professionals take into account bee activity. Honey bees, bumble bees, and solitary bees do not forage at night or during very cool weather. Insecticides applied during the day at optimal temperatures inadvertently to melliferous (honey bearing) bloom can cause severe pollinator losses. Therefore, the optimal time to perform mosquito adulticide treatments, whether truck mounted, backpack, mist blower, hydraulic sprayer, etc., should occur after sunset or prior to sunrise, in order to minimize and avoid bee losses. Given that peak flight and ovipositioning behaviors of many mosquito species of concern occur during this interval, such times are ideal to perform adult control applications. More information may be obtained by reviewing the report titled Adult Mosquito Control Intervention Parameters, May 25, 2006 (see link below).
http://www.mass.gov/agr/mosquito/docs/Spray_Efficacy_Workgroup.pdf

Therefore, it is the Board's policy that any control intervention targeting adult mosquitoes (aerosol or foliar) shall be documented and commenced <u>no sooner than sunset and conclude no later than sunrise</u>, since bee mortality is not expected during this time interval. Under one exception, the above policy and label restriction is removed under the following conditions.

When targeting species of concern and potential vectors of arbovirus, standard, locally established adult mosquito control efforts--including aerosol and foliar, <u>may commence prior to sunset and continue after sunrise</u> when conditions are appropriate to achieve efficacy and in accord with all other labeling directions and restrictions. The above exception applies when the following criteria are met:

- When the risk category for the focal area is defined by the MDPH State Arbovirus Surveillance and Response Plan as level 3 (moderate probability of human outbreak) and the adult mosquito control intervention, either aerosol/space ULV or foliar/barrier application, is approved or requested in writing by the local Board of Health via letter, facsimile, e-mail, etc.; *or*
- When the risk category for the focal area is defined by the MDPH State Arbovirus Surveillance and Response Plan as level 4 (high probability of human outbreak) or 5 (critical probability of human outbreak); or
- When specifically requested or directed by the SRMCB when risk benefit analysis favors the application of pesticides.

Note: The SRMCB can revise this policy as new information becomes available about labeling requirements in order to update and conform to those changes.

Policy approved and voted on August 20, 2007