Commonwealth of Massachusetts
STATE RECLAMATION AND MOSQUITO CONTROL BOARD

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2013 VECTOR MANAGEMENT PLAN

Introduction: The U.S. Centers for Disease Control and Prevention (CDC) declared that the 1999 introduction of West Nile Virus (WNV) into the United States tested the preparedness of public health agencies to identify and respond quickly to outbreaks of vector-borne disease. The CDC concluded that "mosquito control is the most effective way to prevent transmission of West Nile" and that "the most effective and economical way to control mosquitoes is…through locally funded abatement programs"(1).

Unique among state agencies are Massachusetts **Mosquito Control Projects and Districts** (MCP/D) in that they are **accountable directly to subscribing member communities**. It is the needs and concerns of member communities that drive MCP/D operational policy and strategies. This has been the operational "mantra" of the Northeast Massachusetts Mosquito Control District for twenty years. There are currently thirty-two cities and towns that subscribe to the District.

As the needs of our communities change and evolve, so have the services we provide. With the invasion and establishments of new arthropod-borne viruses ("arboviruses") in our communities since 2000, we have transformed our primary operational strategy from control of nuisance mosquito to protecting public health. The World Health Organization's (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (2). Thus, it is not an exaggeration to say that high numbers of mosquitoes is not just a nuisance, but an issue of health! Furthermore, the Federal Insecticide, Fungicide and Rodenticide Act defines "vector" as "any organism capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including mosquitoes…" (3). Therefore, by this definition, all mosquitoes are potential vectors and all mosquito control activities are conducted in the interest of public health.

West Nile virus first appeared in Essex County in 2000 and since then, almost 200 detections of this virus have been recorded in tested samples of county mosquitoes; there have been five cases of serious virus-generated illness requiring hospitalization in county residents. Eastern Equine Encephalitis virus, once a rarity north of Boston, has been detected five of the past nine years in the District and it claimed its first two District mortalities in 2012 (Georgetown & Amesbury). Some may contend that number of fatalities caused by arboviruses is too small to warrant attention. However, with the knowledge, personnel, and technology readily available at a relatively small cost, **it is worth the effort** to protect the lives of our more vulnerable citizens engaged in innocent everyday outdoor activities. It has been documented (4) that for the protection of the public's health, the costs for mosquito control and its emphasis on prevention of disease far outweighs the costs (and suffering) of treatment of the sick and distress.

The purpose of this Vector Management Plan (VMP), updated for 2013, is to summarize our mosquito control and arbovirus surveillance strategies. This 2013 VMP also outlines our specific responses to arboviruses, and how our limited resources will be directed effectively and efficiently toward implementing these responses.

Regional Adult Mosquito Surveillance: The District operates its surveillance of mosquito populations based on protocols established by the CDC and Massachusetts Department of Public Health (MDPH). The District maintains historical trapping stations (HTS) in all thirty-two subscribing municipalities at the same locations for an entire season every year. There is at least one HTS in each subscribing municipality and each HTS has two different surveillance traps (see Figure 1). The stations are usually located at a secure municipal-owned facility, with access to electrical power, in the general vicinity of major population centers. The traps operate from early May through the beginning of October, running twice a week with each collection cycle lasting twenty-four hours. Mosquito-filled trapping receptacles are retrieved by District personnel at the end of each collection cycle and **all** collected mosquitoes are identified and tallied. Fifty-one species of mosquitoes are known to breed, develop, and survive in Massachusetts.

The first of the two traps is the CO_2-baited "New Jersey trap" (Figure 2). To attract mosquitoes, carbon-dioxide (the same chemical as in our exhaled breath) is released from a pressurized cylinder into a hose located at the top of the trap. The mosquitoes approach the hose's opening, then are drawn inside the cylinder by an internal fan, and are forced into a hanging container or "basket" found below. With this trap, the principal human-biting and disease-carrying species in a community are identified and monitored. Because the traps are placed at the same locations every year, population trends can be studied and compared between years, as well as during the year.

Figure 1. Historical Trapping Station

Figure 2. "New Jersey Trap"

Figure 3. Reiter-Cummings Gravid Trap

The other is the Reiter-Cummings gravid trap (Figure 3), our principal West Nile virus detection tool. This trap is designed to attract container-breeding mosquitoes in which two of these, ***Culex pipiens*** and ***Cx. restuans*** are the key carriers of West Nile virus (hereafter, "WNV") in the District. This trap is baited with a rank-smelling hay-infusion-filled water, held in a pan below the trap, to attract female mosquitoes. These blood-fed females come to lay their eggs on the water's surface and when they approach the trap's underside opening, they are drawn inside. The contents are collected, identified, tallied, and WNV-vector species are separated and sent to the state labs to be tested for the presence of viruses.

When necessary, additional battery-operated gravid traps are deployed in areas with disturbing ***Culex*** population trends and in communities with recent histories of WNV. ***Cx. pipiens*** & ***Cx. restuans*** breed proficiently in heavily urbanized areas so additional gravid traps will be set on an "as need" basis in these more congested urbanize areas. In the short term, these additional trappings provide us with more data on ***Culex*** population distributions and densities in these communities; over the long term, better historical information is obtained to study trends on vector populations and viral activity. See Figure 4 for a photograph of ***Cx. pipiens***, also known as the Northern House Mosquito.

Our third surveillance trap is the Resting box. Due to the behavior and habitats preferred by yet another species of disease-carrying vector, resting boxes are not placed at the HTS. Instead, resting boxes are situated in the vicinity of cedar and maple swamps where ***Culiseta melanura*** (Figure 5) resides. ***Cs. melanura*** is the principal vector of Eastern Equine Encephalitis virus (hereafter, EEEV). Resting boxes are designed to simulate the tree holes and cavities these mosquitoes normally rest in during the day after they feed on blood. Resting boxes (Figure 6) are visited twice weekly from June through the end of September; the contents are collected, identified, tallied, and ***Cs. melanura***, and the closely related ***Cs. morsitans***, are separated to be later tested for the presence of viruses.

Figure 4. Adult ***Culex pipiens***
(CDC: PHIL: 4464)

Figure 5. Adult ***Culiseta melanura***

An "epicenter" of EEEV activity has developed in southeastern New Hampshire and now monitoring for EEEV-vectors has become another component of our surveillance program. Since 2005, we have maintained resting box stations in fixed historic locations in District communities bordering southeastern New Hampshire. These include Methuen, Haverhill, Merrimac, Amesbury, and Salisbury; ten stations (two in each town) are located along this "line" with eight boxes in each station. Since 2006, resting box stations have also been set in Boxford, Topsfield, Hamilton, Newbury, and Wenham in response to EEEV infections in mosquitoes, horses, alpacas, or humans in these communities. New stations may be established in Georgetown in 2013. Additional boxes are ready for deployment and stations have been selected in more communities if resting box surveillance must be expanded. Because ***Cs. melanura*** can also transmit WNV, resting box surveillance has enhanced our WNV monitoring, as demonstrated this past year.

Whereas ***Cs. melanura*** rarely bites humans, they bite and infect local birds which, in turn serve as blood-meal sources for other mosquito species. These other EEEV-infected species can then bite humans. These additional species with the potential of infecting humans are known as "bridge vectors". To determine whether infected bridge vectors are present, portable CDC-CO_2 traps (Figure 7) are placed at resting boxes locations when infected ***Cs. melanura*** mosquitoes have been collected. These traps collect other species which upon identification, are tested. Knowing the "infection status" of bridge vectors in EEEV-known habitats can result in more effective targeted adulticiding responses.

Figure 6. Recycled fiber pulp “Resting Boxes” (left back view; right front view)

Figure 7. CO_2-baited CDC trap

Risk Communications and Public Relations: Dissemination of mosquito and arbovirus information is paramount to any mosquito control operation. With the speed which information, as well as rumors and even disinformation, can be conveyed in all public informational media, it is crucial that Boards of Health and subscribing municipality residents are kept correctly informed. To that end, the District continues to improve its communication regarding mosquito species, potential arboviral threats, and details of larviciding and adulticiding operations.

At the end of every winter, the District sends detailed “Best Management Practice Plans” (BMP’s) to each District subscribing municipality (Figure 8). Each BMP includes summaries of the previous year’s mosquito and arbovirus activities, descriptions of suggested and agreed-upon control operations. Every spring, the District conducts a “Mosquito/Arbovirus Surveillance Workshop” (at Endicott Park in Danvers; Figure 9), for health agents and Boards of Health members of District communities. This workshop informs on the potential mosquito and arboviral threats and how the District plans to combat these threats. The District operates a website (http://www.northeastmassmosquito.com; Figure 10) with all relevant information on mosquitoes, arboviruses, and operations. Also, when necessary, “District Bulletins” (Figure 11) or e-mails are prepared periodically and sent electronically to all subscribing Boards of Health describing current and potential mosquito and arboviral issues and warning, as well as current control operations. And finally, our phone lines remain open at all times and while we are often unable to respond immediately, being that we are all in the field, **we do return all calls** in as timely a fashion possible!

Emergent Exotic and Recent Immigrant Mosquito Species: The possibility of exotic mosquito species becoming established in our area cannot be dismissed. Thus, as we monitor our local mosquitoes, we are sensitive to the appearance of new species. Within the past ten years, we have seen the appearance and rapid spread of an exotic species, ***Aëdes japonicus***, the "Japanese Rock Pool Mosquito", throughout our District (Figure 12). While this species is a competent disease vector in other areas, there is little to suggest it is currently a major disease vector in the Northeast.

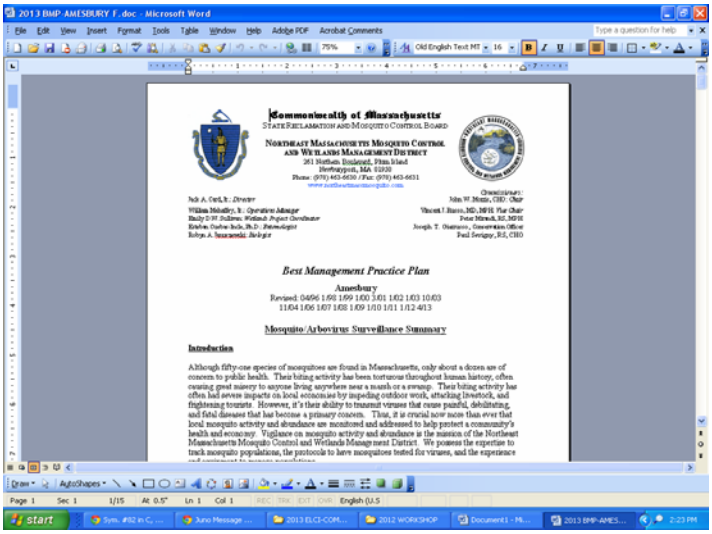


Figure 8. First page of Amesbury's 2013 BMP

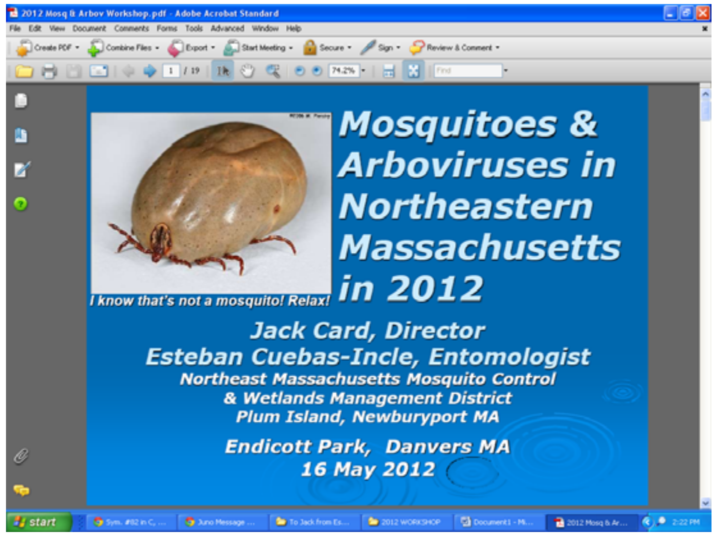


Figure 9. 2012 Arbovirus Surveillance Workshop

Figure 10. Home page of NE MA MCD website

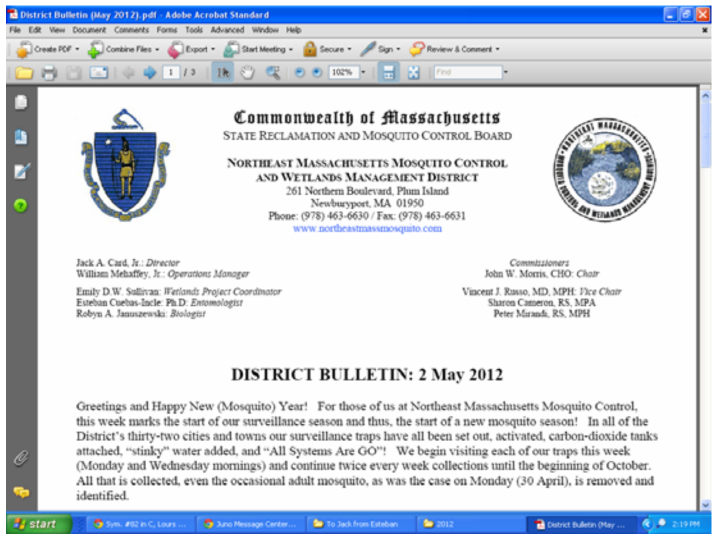


Figure 11. First page of "District Bulletin" sent in 2012

Figure 12. Japanese Rock Pool Mosquito (***Aëdes japonicus***)

Figure 13. Asian Tiger Mosquito (***Aëdes albopictus***)

Both Photographs copyright: Steve A. Marshall Published on *The Diptera Site* (http://diptera.myspecies.info)

Another competent disease vector and notorious daytime human-biting species is ***Aëdes albopictus***, the "Asian Tiger Mosquito" (Figure 13); it could the next exotic species to become established in northeast Massachusetts. Originally from northeast Asia, it has spread rapidly throughout the temperate regions of the world (5) through the importation of used automobile tires. Discarded water-filled tires simulate tree-holes where this species tends to lay its eggs. It was first found in the U.S. in Houston in 1985 and has spread nationwide as far north as Connecticut; it has become the dominant mosquito species in New Jersey. ***Aë. albopictus*** is a great concern to public health because of its ability to transmit many arboviruses that cause serious disease in humans including Chikungunya and Dengue (discussed below). ***Aë. albopictus*** has been collected in Bristol County on repeated occasions throughout the 2011 and 2012 (6) in tire-collection facilities. It may soon become established there and spread throughout eastern Massachusetts.

In 2007, District personnel collected specimens believed to be ***Aë. albopictus*** and attempts were made in 2008 to collect additional specimens and locate breeding sites. Towards this endeavor, the District deployed a new type of surveillance trap, "BG Sentinel trap" to enhance collection. However, no ***Aë. albopictus*** were collected. (In fact, it was these same BGS traps that were loaned to Bristol County MCP in which they collected their ***Aë. albopictus***!) Nonetheless, we continue surveying for ***Aë. albopictus*** in facilities that hold used/discarded tires.

Virus Testing: Specimens of the principal WNV- and EEEV-vectors from our trap collections are sent weekly to Arbovirus Surveillance Laboratories of the Department of Public Health in Jamaica Plain in Boston, to be tested for the presence of encephalitis viruses (http://www.mass.gov/eohhs/docs/dph/laboratory-sciences/sli-manual-tests-services.pdf). On average, 50 pools of mosquitoes are sent each week to the State Labs. We are currently investigating the options of testing other common mosquito species for all arboviruses reported in New England. The arbovirus laboratory of the Connecticut Agricultural Experiment Station in New Haven CT (http://www.ct.gov/caes/cwp/view.asp?a=3882&q=455644) have the facilities and experience to engage in this enhanced testing if we wish to contract them.

Emergent Virus: The threat of mosquito-borne disease is on the rise world-wide (7, 8). The potential for invasion, transmission, and establishment of new arboviruses in the United States is on the increase. The possible invasion of exotic vector-borne disease into our District can no longer be disregarded nor deemed as heresy. After the introduction/establishment of West Nile Virus in 2000 and emergence of EEEV in 2005, potential viral threats in the District must now be seriously considered and even anticipated.

The most recent new arboviral concern is Dengue virus (DENV). It was thought that, except for occasional imported cases, Dengue had vanished from the U.S. There were localized outbreaks near the Texas-Mexican border in the late 1990's and in Hawaii in 2000. However, the threat level was raised considerably when a New York resident visiting Key West, Florida contracted Dengue in September 2009. By December 2010, there have been 55 confirmed cases of locally-acquired Dengue in Key West (9). Six cases of locally-acquired Dengue were confirmed in Florida for 2011 (10) and four more in 2012. Containment of viral transmission is not easily facilitated when at the same time there are 133 imported cases of Dengue (infections of patients when traveling outside the US) in 2011 and 100 more in 2012. With the vectors readily present in Florida, ***Aë. aegypti*** and ***Aë. albopictus***, it will not take much for the virus to be easily transmitted from an imported case to a resident (Figure 14).

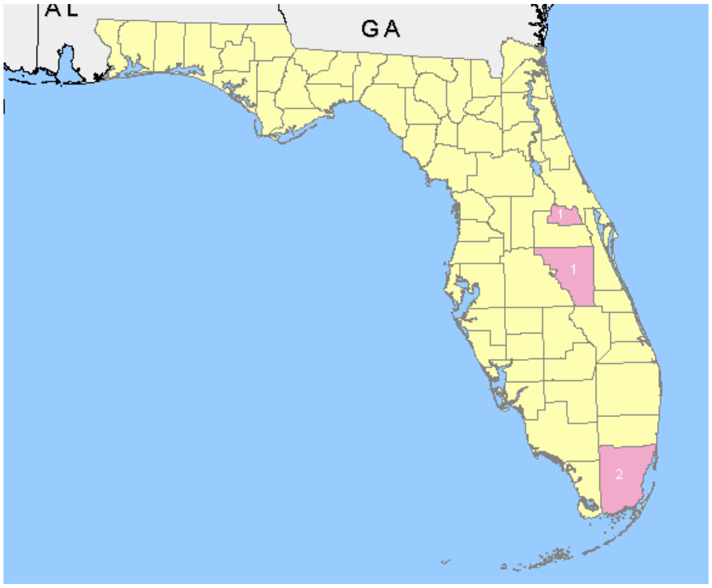


Figure 14a. Cumulative 2012 Data of locally-acquired Dengue in Florida as of 3 am, Dec 11, 2012 (http://diseasemaps.usgs.gov/dep_fl_human.html)

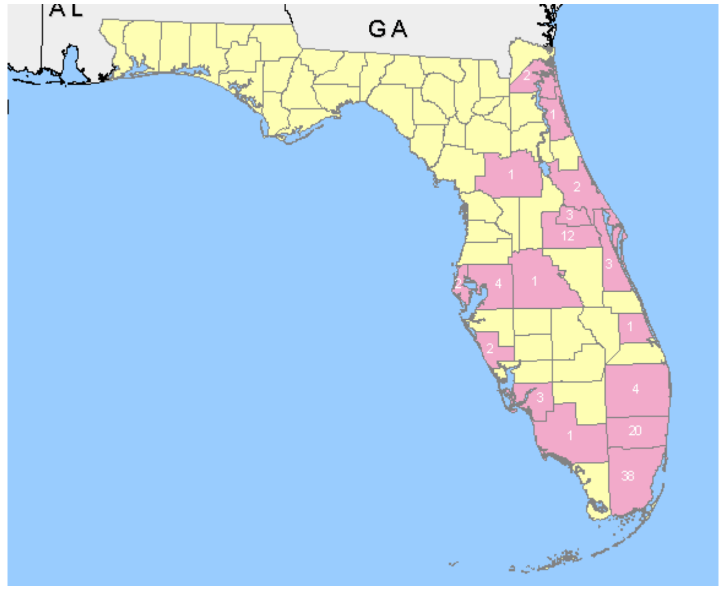


Figure 14b. Cumulative 2012 Data of imported Dengue cases in Florida as of 3 am, Dec 11, 2012

DENV is the greatest mosquito-borne virus circulating in the world today, affecting anywhere from 50 to 100 million people annually in about 100 countries (11). While Dengue is a disease of the tropics to the sub-tropics, the virus could mutate to a form that can be easily acquired and transmitted by temperate mosquitoes. If ***Aë. albopictus*** becomes established in Massachusetts, it can acquire DENV from an infected returning traveler, and transmit the virus locally, causing a public health havoc. See Figure 15 for recent records of imported cases of Dengue in New England. Symptoms of Dengue symptoms include high fever, severe headache, severe pain behind the eyes, joint pain, muscle and bone pain, rash, and mild bleeding (12). A more dangerous manifes-tation of this disease is Dengue hemorrhagic fever, which after the fever declines, persistent vomiting, severe abdominal pain, and difficulty in breathing may ensue. This can be followed by excessive bleeding into the body cavities leading to circulatory failure and shock, followed by death. There is no specific medication for prevention or treatment of a Dengue infection.

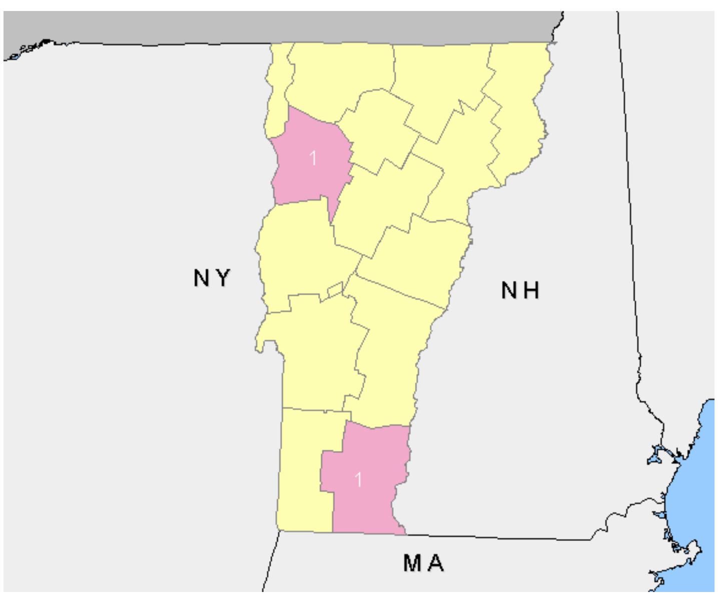


Figure 15a. Cases of imported Dengue in Vermont in 2011 (data as of 3 am, Dec 14, 2011) (http://www.cdc.gov/ncidod/dvbid/westnile/USGS_frame.html)

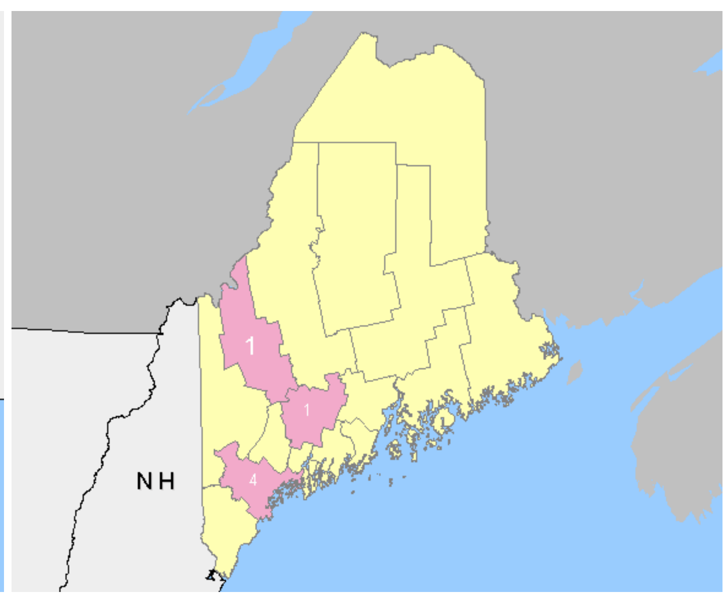


Figure 15b. Cases of imported Dengue in Maine in 2010 (data as of 3 am, May 09, 2011)

According to Dr. Jean-Paul Mutebi of the CDC, there are currently three circulating international arboviruses with the greatest potential of establishing themselves in the U.S. These are the viruses causing Chikungunya, Rift Valley Fever, and Japanese Encephalitis (7, 8). Mosquito species that can easily spread these viruses are all found in abundance in the U.S.; most of these species are found in New England as well (7, 8).

After Dengue, the arboviral disease that can become most easily established in the U.S. is Chikungunya. While Chikungunya is rarely fatal, it has the potential to infect large numbers of people very quickly. It is a debilitating illness, causing excessive and prolonged fatigue and extreme pain in joints lasting up to several weeks (13). In 2005 and 2006, Chikungunya sickened almost one third of the 800,000 inhabitants of the French island of La Reunion, off the east African coast (14). There is still a Chikungunya pandemic in South Asia and along the Indian Ocean basin (and with nearly 2 million people infected).

Even more alarming was the outbreak of Chikungunya in northern Italy in September of 2007 (with over 200 cases); the Italian epidemic is the first known outbreak of this virus outside the tropics (15). The Chikungunya virus (CHIKV) was vectored by a new strain of ***Aë. albopictus*** adapted to competently transmit CHIKV. Since 2006, there have been over 100 imported cases of Chikungunya in the U.S. (8) demonstrating the potential for imported cases to serve as sources of CHIKV for domestic ***Aë. albopictus*** to acquire and transmit. Since New Jersey is experiencing an “explosion” of ***Aë. albopictus***, with a large percentage of residents who travel to Chikungunya-endemic regions, do not be surprised if you read in the near future that a locally-acquired Chikungunya outbreak has broken out in New Jersey!

Rift Valley fever virus (RVFV) causes a fast-developing (“acute”) fever that affects livestock animals and humans (16). Whereas RVF is devastating to livestock, the degree of virulence will vary among humans. Many infected persons will not exhibit symptoms, but others may develop fever, generalized weakness, back pain, dizziness and extreme weight loss. Some will manifest liver abnormalities while a small percentage may suffer hemorrhagic fever (17). Approximately 1% to 10% of affected patients may have some permanent vision loss. Approximately 1% of RVF-infected humans die of the disease. There is no established treatment for infected patients and there is neither a cure nor a vaccine currently available.

RVF was first identified in 1931 and has historically been confined primarily in eastern and southern Africa; there was a recent outbreak in South Africa with 172 human cases and 15 deaths (8). However, in 2000, there was an outbreak far north in the Arabian Peninsula and there has been concerns of RVF spreading into North America ever since. The virus is transmitted primarily by floodwater mosquitoes (***Aëdes*** species). While no mosquitoes have been found in the U.S. infected with RVFV, common species such as ***Aë. vexans*** and ***Cx. pipiens***, have demonstrated the capacity to transmit RVFV (18, 19).

Infection with Japanese encephalitis virus (JEV) causes signs and symptoms similar to those caused by West Nile Virus (discussed below). The case fatality rate averages about 30%. It is the leading cause of encephalitis in Asia averaging between 30,000 to 50,000 cases annually; children are most at risk to infection (19). Although its principal vectors are not found in the U.S., ***Aë. japonicus*** has been shown to transmit JEV (20) and as discussed earlier, this species has become prevalent in Massachusetts.

We will continue to monitor for these potential threats. Our partnerships with the State Labs and Connecticut Agricultural Experiment Station and affiliations with mosquito control associations provide us with the necessary expertise to assist us in developing and implementing intervention strategies if and when required.

Endemic virus: West Nile Virus

***Introduction**:* West Nile Virus (WNV) was introduced to New York City in 1999 and within five years had spread to all 48 continental US states! It was first isolated in Essex County in 2000, and is now endemic throughout eastern MA, particularly in the Boston metropolitan area. Since its first appearance in North America, WNV has caused significant illness to almost 37,000 persons in the United States (Table 1; Table 2 shows WNV cases/fatalities in Massachusetts). Whereas it is estimated that about 80% of all West Nile virus infections in humans are not symptomatic, approximately 20% of infections are manifested as some form of fever; less than 1% of the remaining infections display varying degrees of serious neurological ailments. These neurological diseases include acute febrile paralysis, encephalitis, and meningitis resulting in death to about 9% of all neurological cases. Of the almost 16,000 neuroinvasive cases since 1999, there have almost 1,500 deaths. Descriptions of all neurological manifestation of West Nile infections can be found at the Iowa State University Center of Food Security and Public Health website: http://www.cfsph.iastate.edu/Factsheets/pdfs/west_nile_fever.pdf.

WNV, primarily an avian virus, has been far deadlier to birds with dramatic declines in seven species (22) and many avian populations have yet to recover.

Table 1. Total Number of Human WNV Cases/Fatalities in USA 1999-2012[1]

Year	Neuroinvasive	Non-Neuroinvasive	Other Clinical/Unspecified	Total	Fatalities
1999	59	3	0	62	7
2000	19	2	0	21	2
2001	64	2	0	66	9
2002	2,946	1,160	50	4,156	284
2003	2,866	6,830	166	9,862	264
2004	1,142	1,269	128	2,539	100
2005	1,294	1,607	99	3,000	119
2006	1,459	2,616	194	4,269	177
2007	1,217	2,350	63	3,630	115
2008	687	624	45	1,356	44
2009	373	322	25	720	30
2010	629	392	0	1,021	45
2011	458	209	0	667	42
2012	2,734	2,653	0	5,387	243
Totals	15,947	20,039	770	36,756	1,481

1: as of 11 Dec 2012 as reported by the CDC; 2012 cases may increase subsequently (www.cdc.gov/ncidod/dvbid/westnile/surv&control.htm)
2: CDC now classified all encephalitis, meningitis, and acute febrile paralysis cases as "Neuroinvasive Disease"
3: CDC now classified all related fevers as "Non-neuroinvasive Disease Cases"

Table 2. Total Number of Human WNV Cases/Fatalities in Massachusetts 2001-2012[1]

Year	Neuroinvasive (2)	Non-Neuroinvasive (3)	Other Clinical/Unspecified	Total	Fatalities
2001	3	0	0	3	1
2002	19	4	0	23	3
2003	12	5	0	17	1
2004	0	0	0	0	0
2005	4	2	0	6	1
2006	2	1	0	3	0
2007	3	3	0	6	0
2008	1	0	0	1	0
2009	0	0	0	0	0
2010	6	1	0	7	1
2011	4	1	0	5	1
2012	27	6	0	33	1
Totals	81	23	0	104	9

1: as of 11 Dec 2012 as reported by the CDC; 2012 cases may increase subsequently (www.cdc.gov/ncidod/dvbid/westnile/surv&control.htm)

2: CDC now classified all encephalitis, meningitis, and acute febrile paralysis cases as "Neuroinvasive Disease"

3: CDC now classified all related fevers as "Non-neuroinvasive Disease Cases"

It was thought that WNV-associated neurological ailments were short-lived and affected only a small percentage of those infected. However, recent studies suggest that neurological disorders may be more prolonged and serious, affecting more victims than originally thought (23, 24)**.** Another recent study has shown that renal disease can be manifested in patients several years after infection with WNV and whom were have thought to have recovered (25).

It was also assumed that after its initial spread, WNV would decrease in prevalence in both bird and human populations, since there would be too few susceptible hosts to maintain and amplify the virus. It was theorized that the virus would "become dormant", "disappear into the landscape", and not appear again for several years or decades, in the manner exhibited historically by EEEV. So you can imagine the surprise when the numbers of WNV-infected mosquito samples ("pools") in Massachusetts began to increase in 2010 and continued to increase further in 2011 and 2012 (Table 3). There were human infections in the District in 2010 and 2011 (Revere and Peabody) manifested as meningoencephalitis and meningitis respectively. Both patients "recovered", but the extent of their recovery has not been disclosed.

Mosquitoes of the species ***Culex pipiens*** are primarily responsible for the transmission of WNV to birds and humans in endemic areas in the northeast US (26); ***Cx. restuans*** is also responsible for the virus's spread, but this species almost exclusively bites birds. These species develop in "high-organic content" water that accumulate in containers and large water-holding structures which are in far greater abundance in urbanized areas. Therefore, the District has developed strategies to combat the vector mosquitoes by first attacking where they "breed" to reduce both adult emergence and disrupt the bird-to-mosquito-to-bird WNV cycle. If efforts to reduce/eliminate larvae are not fully successful, then operations to reduce adult populations during periods of high WNV-risk to humans are recommended and effected. These strategies are outlined below:

Table 3. Summary of Arbovirus-infected mosquito pools in Massachusetts (2000-12)[1]

Year	Total number of + WNV pools			Total number of + EEEV pools	
	Statewide	NEMA District		Statewide	NEMA District
2000	4	0		16	0
2001	25	4		12	0
2002	68	14		1	0
2003	48	2		9	0
2004	15	4		39	0
2005	99	11		45	2
2006	43	5		157	11
2007	65	14[(2)]		31	0
2008	135	10		13	0
2009	26	2		54	13
2010	121	21		65	0
2011	275	56[(3)]		80	0
2012	307	48[(4)]		267	14[(4)]
Totals.....	**1231**	**191**		**789**	**40**

(1) = as of 12 December 2012 (http://www.mass.gov/eohhs/gov/departments/dph/programs/id/epidemiology/researchers/public-health-cdc-arbovirus-surveillance.html)
(2) = Not including two infected pools from Manchester
(3) = Not including two infected pools from Lawrence
(4) = Includes two pools that also positive for both arboviruses

Catch Basin Treatments: Spraying against infected adult mosquitoes is the short-term approach for immediate risk reduction. However, the preferred long-term and more cost-effective strategy is to eliminate larvae before they become adults. While ***Culex*** mosquitoes can develop in a variety of freshwater habitats, the greatest concentration of ***Culex*** breeding in the District is in the estimated 80,000 catch basins (Figure 16). The basins are well utilized for breeding by the two principal urban ***Culex*** mosquitoes, ***Cx. pipiens*** and ***Cx. restuans***. These species breed in highly organic or polluted water that collect in catch basins, storm water structures (including retention ponds; Figure 17), and discarded tires, clogged gutters, bird baths, and the like (Figures 18-20).

Figure 16. Catch Basin (http://www.neponset.org)

Figure 17. Retention pond. (http://dunwoodyusa.blogspot.com)

Figure 18. Discarded tire yard (Middleton)

Figure 19. Clogged rain gutter filled with water (http://www.moonworkshome.com)

Treating of catch basins consist of the application of either bacteria or "growth regulators". The bacteria are effective towards killing exclusively mosquito larvae; the "growth regulator" retards or completely ceases development of larvae into adults. Short term surveillance data showed an 80% reduction in ***Culex*** species in communities where basins are treated as compared to communities with untreated basins. In a study conducted in Portsmouth NH in 2007 by Municipal Pest Management Services Inc., there was a 75% reduction in mosquitoes breeding in treated catch basins compared to untreated basin and 92% of the species breeding in the basins were ***Cx. pipiens/restuans*** (27). It is preferred that basins be treated in the late spring or early summer to maximize the effects of the larvicidal agents. However, this is not always possible in all towns. Applications of larvicides are often delayed until basins are emptied of debris by municipalities. Basins filled with organic debris will diminish the effect of the larvicides to the extent they may be rendered useless.

Figure 20. Bird bath filled with debris & water (Amesbury)

Long term surveillance data has shown that the continued annual treatment of basins has gradually and significantly decreased ***Culex*** populations throughout the District in normal rainfall years. Fewer ***Culex*** adults transmitting virus translates to reduced risk of WNV infection to District residents. Early-season basin-treatment strategy will continue as best as possible in 2013. Droughts present special problems. How WNV-vector breeding is enhanced as well as how our operations are affected by droughts will be discussed below.

The order of catch basin larvicidal treatments for 2013 will be prioritized as follows. First to be treated will be those basins in District municipalities mostly along the District's northern sector (including Andover, Methuen, Haverhill, Merrimac, Amesbury, Salisbury, Newburyport, Groveland, and Boxford). Treatments of basins in these communities will begin in May. Basins will be next treated across the central (including Ipswich, Wenham, and Manchester) and southern sectors (including Swampscott, Saugus, Nahant, Revere, and Winthrop). Time, availability of material, and extent of other District operations will determine when the remainder of basins will be treated.

Waste Water Treatment Facilities Inspection: An additional "preemptive strategy" is to inspect and treat, where necessary, all wastewater treatment facilities, when requested. This way, actual or potential ***Culex*** breeding can be reduced or eliminated. District personnel are authorized, under the provisions of Chapter 252 Section 4 of the General Laws of the Commonwealth, to enter upon lands for the purpose of inspections for mosquito breeding.

However, we do not and cannot penalize any persons or agencies for providing breeding habitats. We are **not** a regulatory agency. It is not our intention to cause any imposition to the management of wastewater facilities. Instead, we wish to be a resource of information and technology to assist facility managers to prevent and/or abate mosquito breeding to the mutual benefit of the facility, the community, and mosquito control.

Property Inspection: Socioeconomics often plays an important role in mosquito control and associated public health risk. This is evident by a study conducted in California in 2007 in which there was a 276% increase in the number of human WNV cases in association with a 300% increase in home foreclosures (28). Within most foreclosed properties in Bakersfield (Kern County, CA) were neglected swimming pools which led to increased breeding and population increases of ***Cx. pipiens/restuans***; see Figure 21.

Figure 21. Abandoned swimming pool with collapsed cover collecting water & debris (Topsfield).

Figure 22. Abandoned home property with containers of all types scattered about and collecting water (West Newbury).

In recent years we have received requests from Boards of Health to inspect abandoned properties (Figure 22). Given the current economic climate and likelihood of properties still being abandoned, the District in 2013 will continue to approach aggressively to property inspections. In the course of our routine activities, we will be "on the lookout" and inspect and report on the status of such properties to your Board. In the long term, we will offer any support that may be appropriate to resolve mosquito problems related to such properties. In the short term, with the support of the Boards of Health, we will implement the necessary control measures to mitigate any immediate mosquito problem associated with such properties.

Selective Ground Adulticiding: As a final measure to reduce the risk to WNV infections, the District may recommend selective and targeted adulticiding applications to reduce ***Culex*** populations when WNV-infected mosquitoes are discovered. The District uses "Ultra Low Volume" (ULV) for ground adulticiding applications which dispense minute amounts of pesticides over a large area (Figure 23). Due to the nature of the pesticides employed, ground-based adulticiding is done at night. The District may recommend a selected or "targeted" application within a municipality (several streets or a neighborhood) based on the following criteria: two or more WNV-mosquito isolations in close proximity; one or more human cases of WNV. On occasions, when WNV has yet been recovered but ***Culex*** populations are seen increasing at higher-than-usual rates, we will recommend that adulticiding operations be commenced. These operations would only be recommended only during high WNV-transmission periods (late July through September) in communities with historical WNV activity.

Ground Adulticiding Exemption: Following what was begun in 2011, we are making the following request to all Boards of Health. Residents who want their property excluded from **all pesticide applications** (including larviciding as well as adulticiding) must comply with the legal process to exempt their property (333 CMR Section 13.03; see http://www.mass.gov/agr/legal/regs/333_CMR_13.00.pdf). The process consists of the property owner sending a certified letter with the request to the town or city clerk prior to **March 1st** of each year**.** No exclusions will be allowed after March 1st, if towns adopt this policy, nor will property owners be allowed to make such a request by telephone. The deadline of March 1st is to insure that residents requesting exemptions are not subjected to springtime larviciding operations, as well as truck-spraying later in the season if adulticiding is mandated. It also takes time to process the requests into the computer systems on board the trucks. There is no option of selecting what control operations are exempted.

Figure 23. Truck spray at night

Figure 24. Truck applying barrier treatment.

Truck-spraying is done routinely in many communities without issue and has been so for decades. However, in communities that only allow spraying as a virus-intervention measure, it has become "a new event" often causing undue concern among residents in those communities. The announcement of spraying often triggers responses from residents unfamiliar with the process, resulting in requests to exclude their property. The abundance of calls made prior to an area-wide operation often causes an administrative nightmare in trying to keep track of all the no-spray requests. Calls would continue sometimes up to the minute the spraying commences, making the logistics in effecting the operation extremely difficult.

The District anticipates that those Boards of Health of communities that allow virus-intervention-only truck-sprays agree that this policy change is a necessary and prudent step. If the Boards agree on this change, the

District recommends that each Board hold a public hearing prior to March 1 to announce their intention to adopt such a policy and give those residents who wish to legally exclude their property ample notice to do so.

Barrier Treatment: While ULV is a cost-effective means of reducing mosquito populations on a large scale, it only affects those mosquitoes active at the time of the application; repeated applications are sometimes necessary to sustain population reduction. To reduce the need for repeated applications and provide more sustained relief from mosquitoes in high public use areas, the District may recommend a smaller scale "barrier spray treatment". This application would be made to public use areas such as schools (applications to schools must be in compliance with MGL Ch. 85), playgrounds, athletic fields, etc. (Figure 24) A barrier spray may reduce mosquito presence for up to two or more weeks. The District strongly recommends member municipalities take advantage of this service when needed.

Special Circumstance: Droughts. During intense drought seasons, "all bets are off" regarding normal development and distributions of ***Cx. pipiens/restuans.*** Prolonged droughts together with periods of intense heat result in "explosions" of these species, as was seen in our District in 2010. Patterns of heavy rainfall followed by stretches of intense heat lasting weeks will also result in greater than normal populations of these species, as exhibited in 2011.

What is going on? Whereas the availability of standing water diminishes during droughts and most mosquito species suffers significant population losses, the "breeding" habits of ***Cx. pipiens/restuans*** allow them to take advantage of conditions provided by droughts. Recall that these species breed in waters of "high organic content". Artificial containers filled with such water are catch basins, as mentioned earlier. You would think that that these basins in urbanized areas become dry during a drought. However, people continue to water their lawns and wash their cars during droughts. All the excess runoff from these activities keeps catch basins filled. If basins have been treated with most larvicides, breeding should be kept in check. If the basins are property of a municipality, and we have records of their locations, they will be treated. However, on private properties, we may not know of their existence and thus, they remain untreated and become a continual source of ***Culex*** mosquitoes throughout the season.

Cx. pipiens/restuans mosquitoes do not breed in great abundance in wetlands and definitely do not in any moving water. However during a drought, large expanses of water become smaller, shallower, and more concentrated with more organic debris, presenting ***Culex*** mosquitoes with more breeding habitats to exploit. With more development going on in more habitats, their populations surge. There are also fewer predators present (especially fish) as wetlands dry and the survivorship of the developing larvae is dramatically increased. While mosquitoes do not breed in moving water, these bodies gradually slow and decrease in volume during droughts. Either in the very slow moving water or more likely, along the puddles and pools formed at the edges (usually filled with organic debris; see Figure 25), more breeding sites are available for ***Culex*** to utilize.

Any large body of water dries, containers and tires dumped into these bodies (as trash) when full of water now become exposed (Figure 26). Being filled with polluted water, these also become ideal breeding sites for ***Culex***. Debris-filled empty holes and depressions (either naturally-occurring or artificial) can become filled with water in a sudden downpour and become instant breeding habitats for these species. What all this means is that breeding areas for "urbanized" ***Culex*** mosquitoes are always in abundance, even in the middle of the worst drought! Unfortunately, all these unexpected breeding areas cannot all be treated, even by mosquito control projects with unlimited budgets! This is why the control of ***Cx. pipiens/restuans*** populations is extremely difficult during a drought. This is also why human WNV-infections are at their highest during a drought.

Figure 25**.** Powow River (Amesbury) during June 2010 drought.

Figure 26. Drying pond in Newburyport in August 2010 exposing debris and containers originally found under water.

Special Circumstance: Beaver Dams. In recent years, beavers have made a comeback in population and environmental impact in northeastern Massachusetts. Because the impoundments beavers construct often result in large stretches of standing water, there has been great debate as to whether these impoundments create more areas to be used by mosquitoes for their reproduction. Research has been done looking at changes in local mosquito fauna (species diversity and populations) and results have been so far inconclusive. Butts (29, 30, 31) reported declines in populations and in some cases reduction in species diversity in beaver pond habitats in central New York State; Wilson (32) concluded that there was no evidence that the presence of beavers will increase overall mosquito populations in Connecticut however, their presence influenced what types of mosquitoes were present.
On the other hand, in Warren County New Jersey, steady increases in permanent- and flood- water mosquito species and populations have been noted since the appearance of a beaver dam and the subsequent flooding (33). Although sampling for mosquitoes in the "open water" of beaver ponds may not have demonstrated increases in mosquito populations, what has not been thoroughly explored is the role of "edge breeding", those areas subjected to periodic receding and re-flooding, together with dense aquatic vegetation found there. How inundated forests could become development sites for cryptic breeding EEEV vectors has not been investigated. Nor how the abundance of dead decaying trees in flooded forest swamp pools contribute to breeding of WNV vectors has not been studied either.

We will continue to monitor beaver pond habitats with the hope to identify whether and where arbovirus vectors may be taking advantage of these habitats to enhance their populations and improve their status as public health nemeses.

Endemic virus: Eastern Equine Encephalitis Virus

Introduction: Prior to 2004 there were never serious concerns about Eastern Equine Encephalitis in Essex County. EEEV seemed to be restricted to southeast Massachusetts and its vector, the Cedar Swamp mosquito, ***Culiseta melanura***, seemed to thrive in the expansive habitat of the great cedar swamps found there. No such huge cedar swamps are found in northeast Massachusetts nor was ***Cs. melanura*** ever collected here in any abundance. Then in 2004 and 2005 came reports of EEEV-infected mosquitoes, birds, horses, and humans from southeast New Hampshire, just over the border from Essex County. And the more EEEV that was reported in New Hampshire, the more the virus began to "spill over" into our District beginning in 2005 (Tables 4a & b). Infected mosquitoes were collected from one or more of our border towns annually from 2005 through 2009

(Figure 29). While no EEEV-infected mosquitoes were collected in 2010 and 2011, we believed that EEEV has become an endemic public health threat in our area. And our fears were realized in 2012 when EEEV was detected in seven municipalities, three of them never having reported with EEEV until last year. Furthermore, most of these detections were in towns at a distance away from the New Hampshire border. And, these infections were in mosquitoes whose numbers were lower than usual due to the summer-long drought.

EEE infections manifest symptoms similar to West Nile encephalitis and while the human infection rate is lower, the fatality rates are much higher, about 33%. Also, the recovery rates from EEE disease are longer and most often are incomplete when compare to recovery from West Nile-associated ailments. EEEV seems to attack the young as readily as the elderly unlike WNE which the elderly are far more susceptible (34).

EEEV was first discovered in horses hence, the basis for the name "Equine Encephalitis". The name "equine" stuck even after it was later discovered that this was the same virus that caused the same encephalitis in humans. Humans and horses are "dead-end hosts", meaning that the virus cannot be transmitted from infected horses or humans (34). Like WNV, EEEV is an avian virus, transmitted from bird-to-bird principally by ***Cs. melanura***. While ***Cs. melanura*** mosquitoes are primarily responsible the amplification of virus in bird populations, they typically do not bite humans. It is other mosquito species, with wider host preferences, when infected (after biting infected birds) can transmit EEEV to humans; these species, as discussed earlier, are termed "bridges vectors". Nonetheless, it is our judgment that while risks to humans directly from infected ***Cs. melanura*** are extremely low, we will continue to take preemptive protective operations directly against ***Cs. melanura*** when infected mosquitoes are detected. Lack of early intervention activity can result in accelerated EEEV amplification into other species which can increase human risk to infection later in the season.

Tables 4a & b. EEEV detections in Massachusetts: 2001-2012.

Table 4a. Statewide totals of EEEV detections: 2001-2012.

Year	# infected mosquito "pools"	horse infections	human infections//deaths
2001	**12**	**0**	**1 // 0**
2002	**1**	**0**	**0**
2003	**9**	**4**	**0**
2004	**39**	**7** (1)	**4 // 2**
2005	**45**	**4** (2)	**4 // 2**
2006	**157**	**6** (3)	**5 // 2**
2007	**31**	**0**	**0**
2008	**13**	**1**	**1** (4) **// 1**
2009	**54**	**1** (5)	**0**
2010	**65**	**4**	**1**
2011	**80**	**1**	**1** (6)
2012	**267**	**6**	**7 // 2**

Table 4b. EEEV infections in Southeastern MA (Bristol, Norfolk, & Plymouth counties) and Essex County: 2001-2012.

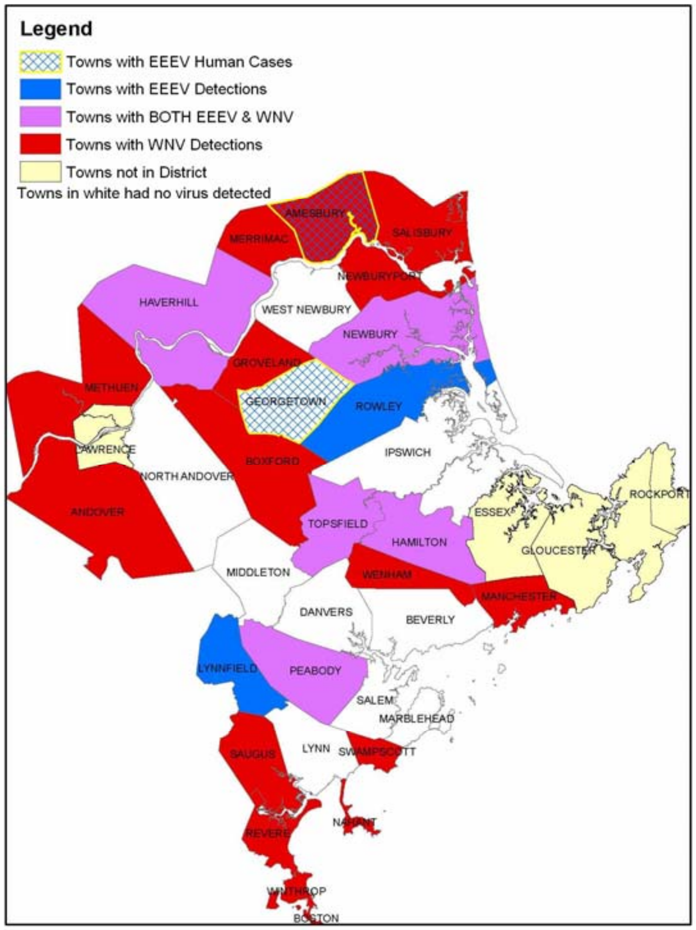
	Southeastern Massachusetts			Essex County		
Year	# infected mosquito "pools"	horse infections	human infections//deaths	# infected mosquito "pools"	horse infections	human infections//deaths
2001	**12**	**0**	**1 // 0**	**0**	**0**	**0**
2002	**1**	**0**	**0**	**0**	**0**	**0**
2003	**9**	**3**	**0**	**0**	**0**	**0**
2004	**37**	**4**	**4 // 2**	**0**	**1** (2)	**0**
2005	**40**	**1**	**4 // 2**	**2**	**2**	**0**
2006	**157**	**6**	**5 // 2**	**11**	**0**	**0**
2007	**31**	**0**	**0**	**0**	**0**	**0**
2008	**13**	**1**	**0**	**0**	**0**	**1** (4) **// 1**
2009	**26**	**(cow)**	**0**	**13**	**(alpaca)**	**0**
2010	**64**	**2**	**1 // 0**	**0**	**0**	**0**
2011	**74**	**0**	**2** (6) **// 1**	**0**	**0**	**0**
2012	**237**	**3** (7)	**2 // 0**	**14**	**2**	**2 // 2**

1: also an emu & alpaca
2: also an emu
3: also a llama & harbor seal
4: resident of Newburyport but acquired infection in either NH or ME
5: alpaca & cow
6: including resident of Missouri acquired infection while vacationing in MA
7: also an alpaca

Southeast Massachusetts, the original "hotbed" for EEEV activity in New England, continues to experience serious problems with EEEV. In 2010, the much-higher-than-normal detections in both enzootic and bridge vectors culminating in an aerial adulticiding application in August. In 2011, detections of virus in mosquitoes were elevated again, but the state elected not to order an aerial operation. As can be seen in Tables 4a and b, Southeastern Massachusetts exhibited record numbers of EEEV-infected mosquito pools as well as infected animals and human cases. Last year, the Department of Public Health deemed the EEEV threat more dangerous to the state's residents with at least eight different species of mosquitoes infected with EEEV. The state authorized two fixed-wing adulticidal air sprays over much of Bristol and Plymouth counties in July and August.

Whereas only WNV was encountered in the District in 2011, in 2012 both WNV and EEEV were detected in abundance and distribution (see Figure 27). The unprecedented District-wide viral activity resulted in extensive larvicidal and adulticidal responses to a degree also unprecedented. Sadly, there were two fatalities in the District caused by EEEV (in Georgetown and Amesbury). There were also two animal fatalities resulting from EEEV, both horses (Georgetown and Essex; Essex is not a subscribing municipality). Although it was suspected that WNV presence was going to be high due to the dry and hot summer experienced, the presence and spread of EEEV in the District was a greater surprise, being that EEEV-vector populations were unusually low and no EEEV was reported in southeastern New Hampshire for most of the summer.

Figure 27. NE MA Mosquito Control District Municipalities reporting WNV and EEEV infections in 2012



The extremely low presence of floodwater mosquitoes in late summer may have been the principal reason why EEEV was not as prevalent in Essex County as compared to Plymouth and Bristol counties. These mosquitoes, principally ***Aëdes vexans*** and ***Aë. canadensis***, are also notorious human-biting mosquitoes and can effectively transmit EEEV. Had their populations in Essex County achieved the levels found south of Boston, there would have been more human disease cases here!

Habitat Surveillance: Predictive models of EEEV cycles and distributions are apparently no longer reliable as is EEEV activity can no longer be estimated by high populations of ***Cs. melanura***. It was seen in 2012 in several resting box sites that lower than usual populations of ***Cs. melanura*** can be found to transmit EEEV. Monitoring their populations to help in predicting EEEV activity has been troublesome due to the locations where this species breeds and develops. ***Cs. melanura*** is one of only a few mosquitoes that survive the winter in the larval stage. Instead of open water, they develop inside flooded root meshes, holes and tunnels ("crypts") under trunks of trees and in tree hummocks in Atlantic white cedar and red maple swamps (Figure 28 & 29). These habitats are in relative abundant in northeast MA, although they exist as isolated pockets and are difficult to access. Since 2004, we have been searching for ***Cs. melanura*** habitat to monitor in winters. Trying to find ***Cs. melanura*** larvae breeding in crypts is very much like trying to find a needle in a hay stack; to date we have been unsuccessful in locating such sites with consistency. During the winters, we continue to narrow our search for ***Cs. melanura*** breeding to areas within a one mile radius of our surveillance stations in communities bordering NH and in the Hamilton/Topsfield area. The objective is to find these breeding locations from which we can monitor larval populations through the winter; the expectation is to make better projections of what may happen in the following seasons and prepare batter for intervention.

Figure 28. "Inside the Atlantic White Cedar Swamp Trail"
(http://www.paulscharffphotography.com)

Figure 29. "Breeding" habitat of ***Cs. melanura***.
(http://www.co.oswego.ny.us/info/news/2012/061112-1.html)

Selective Ground Adulticiding: Because of the elusive nature of ***Cs. melanura*** larval development, larviciding is not a viable option as a manageable preemptive strategy. Therefore, the District may recommend selective and targeted adulticiding applications to reduce ***Cs. melanura*** populations in an effort to break the mosquito-to-bird transmission phase of the virus cycle. Historically, when horse and human infections are reported, truck-spray operations are initiated. But by this time, these interventions are late and their effectiveness in reducing risk are limited at best. Therefore to reduce risk, adulticiding operations will be recommended to a municipality when any one of following criteria are met: above average ***Cs. melanura*** populations; one EEEV detection in ***Cs. melanura*** mosquitoes; one EEEV isolations in horses; one human EEE cases. As with WNV intervention, the District uses Ultra Low Volume (ULV) for ground adulticiding applications.

Barrier Treatment: The discussion of barrier application in the attempt to reduce exposure to WNV-infected mosquitoes also applies to reduce exposure to EEEV-infected mosquitoes.

Emergency Response Aerial Adulticiding Plan: In the event that the infection risk level escalates to a point that ground adulticiding is insufficient to reduce that risk, an emergency aerial adulticiding application may be warranted. The effectiveness of aerial adulticiding operations have been documented (35). Fixed-winged aircraft would be employed to release adulticides over targeted areas. For this aerial application to be implemented, a consensus must be reached by the District, the State Reclamation and Mosquito Control Board (SRB), the Massachusetts Department of Health (MDPH), an independent advisory board, and lastly a declaration of a Public Health Emergency from the Governor is required.

Typically, once the decision is made, the need for action is immediate and the window of opportunity is short. It is imperative that the complex logistics of executing the aerial application are already in place even before a consensus is achieved. The Emergency Response Aerial Adulticiding Plan is outlined as follows:

1. The District has already in place, and continually revises, a Global Positioning Satellite (GPS) mapping program that designates areas to be excluded from an aerial adulticide operation. These include reservoirs, endangered species areas, etc. The areas to be sprayed would be determined by the current

mosquito and risk data and circumstances. These data can be quickly downloaded into an aircraft's navigation system to then direct the aircraft to areas to be sprayed and areas to be avoided.

2. The District has (and annually revises) Memorandums of Understanding (MOU) with the Lawrence and Beverly airports. In the event that an aerial adulticiding operation is essential, Lawrence airport would be closest to the likely target area to be the staging area for the operations. In the event Lawrence airport is unavailable or the target area has broadened, then the Beverly airport would be used.

3. Through the state's procurement program, contracts are already in place for the acquisition of aircraft and pesticides. If events warrant, it is the District that will communicate directly with aircraft and pesticide contractors, airport staff, and other relevant personnel to secure the necessary equipment and materials for our use.

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