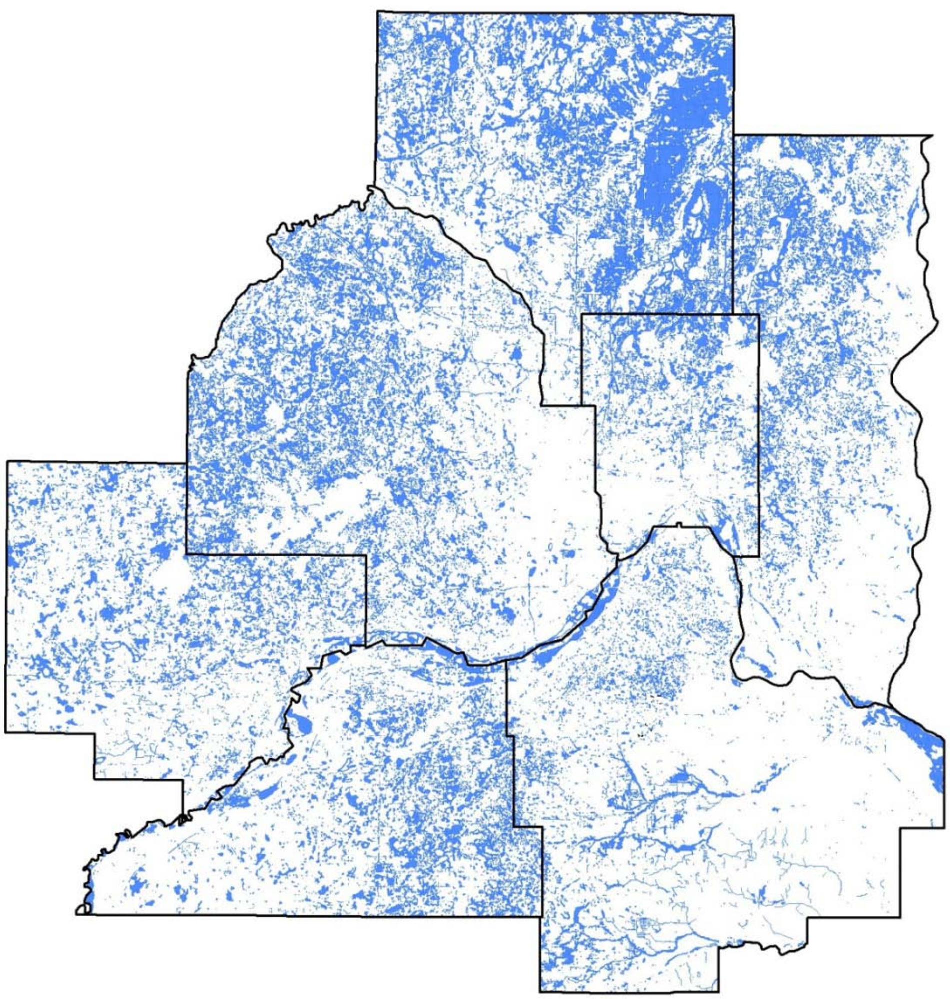
2012 Operational Review & Plans for 2013

Annual Report to the Technical Advisory Board

Metropolitan Mosquito Control District



Metro Counties Government Center ~ 2099 University Avenue West ~ St. Paul, MN 55104-3431
www.mmcd.org

Metropolitan Mosquito Control District

Mission

The Metropolitan Mosquito Control District's mission is to promote health and well-being by protecting the public from disease and annoyance caused by mosquitoes, black flies, and ticks in an environmentally sensitive manner.

Governance

The Metropolitan Mosquito Control District, established in 1958, controls mosquitoes and gnats and monitors ticks in the metropolitan counties of Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington. The District operates under the eighteen-member Metropolitan Mosquito Control Commission (MMCC), composed of county commissioners from the participating counties. An executive director is responsible for the operation of the program and reports to the MMCC.

Metropolitan Mosquito Control Commission 2013

Julie Braastad	Anoka County
Rhonda Sivarajah	Anoka County
Robyn West	Anoka County
James Ische	Carver County
Tom Workman	Carver County
Thomas Egan	Dakota County
Mike Slavik	Dakota County
Liz Workman	Dakota County
Jan Callison	Hennepin County
Jeff Johnson	Hennepin County
Randy Johnson	Hennepin County
Blake Huffman	Ramsey County
Mary Jo McGuire	Ramsey County
Janice Rettman	Ramsey County
Dave Menden	Scott County
Tom Wolf	Scott County
Gary Kriesel	Washington Co.
Fran Miron	Washington Co.

Technical Advisory Board

The MMCC formed the TAB in 1981 to provide annual, independent review of the field control programs, to enhance inter-agency cooperation, and to facilitate compliance with Minnesota State Statute 473.716.

Technical Advisory Board Members 2012-2013

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Mark Abrahamson	Mn Dept. of Agriculture
Donald Baumgartner	US EPA
Steve Hennes	Mn Pollution Control Agency
Gary Montz	Mn Dept. of Natural Resources
John Moriarty	Three Rivers Park District
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Susan Palchick	Hennepin Co. Comm. Health
Robert Sherman	Independent Statistician
Vicki Sherry	US Fish & Wildlife Service
Sarma Straumanis	Mn Dept. of Transportation

Metropolitan Mosquito Control District Contributing Staff

Jim Stark	Executive Director
Stephen Manweiler	Director of Operations/Tech. Serv.
Sandy Brogren	Entomologist
Diann Crane	Asst. Entomologist
Janet Jarnefeld	Technical Services/Tick
Kirk Johnson	Vector Ecologist
Carey LaMere	Technical Services
Mike McLean	Public Affairs
Nancy Read	Technical Services Coordinator
Mark Smith	Tech. Serv./Control Materials
John Walz	Technical Services/Black Fly

METROPOLITAN MOSQUITO CONTROL DISTRICT

Website: www.mmcd.org

Metro Counties Government Center
2099 University Avenue West
Saint Paul, MN 55104-3431

Phone: 651-645-9149
FAX: 651-645-3246
TTY use Minnesota Relay Service

May 06, 2013

Dear Reader:

The following report is the Metropolitan Mosquito Control District's (MMCD) 2012 Operational Review and Plans for 2013. It outlines program operations based on the policies set forth by the Metropolitan Mosquito Control Commission (MMCC), MMCD's governing board of 18 elected county commissioners.

The report has been reviewed by the Commission's Technical Advisory Board (TAB). TAB's charge is to comment on and make recommendations for improvements in the District's operations on an annual basis. The minutes and recommendations from the TAB meeting in February 2013 are included in this report.

Roger Moon, TAB's current Chair, reviewed the report and presented recommendations to MMCC at their April 2013 meeting. The Commission approved the MMCD 2012 Operational Review and Plans for 2013, and thanked the TAB for their work.

Please contact me if you would like additional information about MMCD and its operations.

Sincerely,

James R. Stark

James R. Stark
Executive Director
Metropolitan Mosquito Control District
2099 University Ave West
St Paul, MN 55104
(651) 643-8363
jimstark@mmcd.org

UNIVERSITY OF MINNESOTA

Twin Cities Campus

Department of Entomology
College of Food, Agricultural and Natural Resource Sciences

219 Hodson Hall
1980 Folwell Avenue
St. Paul, MN 55108
612-624-3636
Fax: 612-625-5299
www.entomology.umn.edu

Commissioner James Ische, Chair
Metropolitan Mosquito Control Commission
2099 University Avenue West
St. Paul, MN 55104

Dear Commissioner Ische,

The Technical Advisory Board (TAB) met on February 14, 2013 to review and discuss MMCD operations in 2012 and plans for 2013. Since the Board's formation in 1981, the member representatives have met at least once per year to provide independent review of field control programs and to enhance inter-agency cooperation.

After an excellent interchange of questions and information between the TAB and MMCD staff, the TAB approved the following resolutions.

1. That the chair of the TAB send a letter to Clarke regarding non-target studies on Natular, asking for support and additional data to address the TAB's concerns about chronic toxicity.

2. That MMCD work with a subgroup of TAB members to draft plans for non-target impact studies of Natular G30 in vernal pools, including choice of organisms for study.

3. That MMCD work with a subgroup of TAB members to discuss issues related to changes in dead bird surveillance, and have that group present a summary to MMCD for consideration.

4. That the TAB commends Larry Gillette for his many years of service, his advocacy for the environment and social responsibility, and for his active participation on the TAB.

Sincerely,

Roger D. Moon

Roger D. Moon
Chair, Technical Advisory Board
Professor of Entomology, University of Minnesota

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Executive Summary

The Metropolitan Mosquito Control District (MMCD or the District) strives to provide cost-effective service in an environmentally sound manner. This report presents MMCD staff efforts to accomplish that goal during 2012 through mosquito, black fly and tick surveillance, disease monitoring, mosquito and black fly control, new product testing, data management, and public information.

In 2012, MMCD continued to work on ways to improve control within the District through strategies designed to stretch each dollar of funding. Cost-effective strategies will help MMCD minimize the impact of budget limitations on service delivery. In 2013, MMCD will continue to review all aspects of its integrated mosquito management program while complying with the National Pollutant Discharge Elimination System (NPDES) and other regulatory requirements.

The 2012 season was characterized by an extremely early spring followed by a wet early summer and ended with a very dry August and September. March 2012 was the warmest on record. The warm weather caused advanced phenology, including mosquito production, by 3 to 4 weeks.

Surveillance

Altogether, 2012 saw one large District-wide spring mosquito brood, four large summer broods and another seven small-medium sized broods which occurred in various parts of the District. Adult mosquito levels rose in mid-June through mid-July and decreased thereafter.

Of special note this season was the identification of larval specimens of *Culex erraticus*, a rare species in the District. The only other larval collection of this species was taken in 1961. Six collections contained *Cx. erraticus* this season, all from Washington and Scott counties. This species is a competent vector of eastern equine encephalitis and a suspected maintenance vector of West Nile virus.

The District continued to sample the distribution of ticks in the metro area and preliminary indications are that *Ixodes scapularis* continued to become more wide-spread in the District.

Disease

2012 saw a resurgence in mosquito-borne disease cases in the upper-Midwest, as well as other parts of the U.S. Seventy West Nile virus cases were reported in Minnesota including 15 in District residents. La Crosse encephalitis (LAC) also made a comeback in Minnesota. The four children diagnosed with LAC were residents of Carver, Scott, Stearns and Wright counties. Three of the four were either District residents or were possibly exposed to the virus in the District. Prior to 2012, LAC was last reported in the District in 2005. Staff follows up on LAC case reports with extensive monitoring and site clean-up and treatment where appropriate.

Statewide 2012 human tick-borne disease information is not yet available from the Minnesota Department of Health (MDH). In 2011, however, the third highest Lyme (1201) and highest ever human anaplasmosis cases (782) occurred. MMCD's long-term tick distribution study continued

in 2012. Preliminary indications suggest record numbers of small mammals infested with *Ixodes scapularis* occurred in 2012. To help educate the public about risk of tick-borne illness, MMCD developed a "Tick Risk Meter" which was updated regularly on www.mmcd.org and on the MMCD's Facebook page.

Control

Due to the large geographic area of the metropolitan region, the District has always considered larval control its most cost-effective mosquito control strategy. As part of an overall operating budget reduction started in 2011 some shifts were made in treatment thresholds and control materials used in different situations to reduce cost. However, wet conditions early in 2012 rapidly consumed most of the budget for helicopters and materials and we asked the Commission for access to reserve funds (as in 2002, 2010, and 2011). With the dry conditions after mid-August we did not actually use any reserve funds. Overall, there were more acres of larvicides applied to wetlands than in 2011, and fewer acres of adulticides applied throughout the District.

For black fly control, liquid *Bti* treatments were used to control large river and small stream-breeding black fly larvae in 2012. The amount of *Bti* used in 2012 to treat large rivers was slightly above the yearly average used between 1997 and 2011 but the amount used to treat small streams in 2012 was well below the yearly average due to the lack of snow available for melting into streams and rivers.

Product and Equipment Testing

Quality assurance processes focused on product evaluations, equipment, and waste reduction. Before being used operationally, all products must complete an internal certification process that consists of tests to demonstrate how to use the product to effectively control mosquitoes. The District continued certification testing of two larvicides and two new adulticides. The larvicides and adulticides have been tested in different control situations in the past. The goal is to determine whether different larvicides can control two or more target mosquitoes in multiple control situations. One adulticide was tested as an alternative ULV material and the other as an alternative barrier material. These additional control materials will provide MMCD with more tools to use in operations.

Data Management and Public Information

The District values data-based decision making and is continually improving data and mapping systems. Calls, e-mails, and other contacts from citizens are important ways to identify areas of high service demand. Direct citizen input also supports disease control through requests for tire disposal and dead bird reporting. MMCD also tallies and responds to citizen complaints and requests for limited or no treatment. In 2012, staff continued an array of education efforts including school presentations and information booths at city and county open houses and fairs. Total requests made through the District's call tracking system for adult mosquito treatment in 2012 were at a four-year high with the bulk of the requests coming prior to mid-July. Requests to pick up discarded tires were also up considerably. In 2012, staff and contractors continued a major upgrade of MMCD's field data entry system to convert to a web and mobile platform.

Chapter 1 Mosquito Surveillance

2012 Highlights

- Rainstorms produced five major mosquito broods
- Early warm, dry spring. Wet May and June. Hot, dry summer
- Major mosquito peak occurred in July
- Identified 27,813 larval samples
- High populations of rare species *Anopheles quadrimaculatus* and *Culex erraticus*
- First larval collections of *Culex erraticus* since 1961
- *Aedes albopictus* found in two District communities

2013 Plans

- Evaluate placement of CO_2, gravid, and New Jersey traps
- Continue to monitor and study *Ae. japonicus*
- Maintain surveillance for *Ae. albopictus* and remain aware of other potential invasive species
- Continue to refine *Cs. melanura* surveillance

Background

The Metropolitan Mosquito Control District (MMCD or the District) conducts larval and adult mosquito surveillance to determine levels of mosquitoes present, measure annoyance, and to detect the presence of disease vector species. A variety of surveillance strategies are used since different mosquito species have different habits and habitat preferences. The District strives to obtain a complete picture of the mosquito population by weekly monitoring of host-seeking, resting, egg laying, and larval mosquitoes. By knowing which species are present in an area, and at what levels, the District can effectively direct its control measures.

There are 51 known mosquito species in Minnesota, all with a variety of host preferences. About 45 of these species occur in the District, 20 of which are human-biting. Other species prefer to feed on birds, large mammals, reptiles, or amphibians. Mosquitoes differ in their peak activity periods and in how strongly they are attracted to humans or trap baits (e.g., light or CO_2). Therefore, a variety of adult mosquito collection methods is used in order to capture targeted species.

The District focuses on four major groups of human-biting mosquito species: spring *Aedes*, summer *Aedes*, *Coquillettidia perturbans*, and disease vectors. Snowmelt induces spring *Aedes* (fourteen species) eggs to hatch in March and April and adults emerge in late April to early May. They have one generation each season and adults can live for three months. Rainfall prompts the summer *Aedes* (five species) to begin hatching in early May. They can have several generations throughout the summer and adults can live up to two weeks. *Coquillettidia perturbans*, the cattail mosquito, develops in cattail marshes and has one generation per year, peaking in early July. Disease vectors include *Aedes triseriatus*, *Culiseta melanura*, and *Culex* mosquitoes (four species). Adults are evident in early summer and they can produce multiple generations per year. Appendix A contains a species list and detailed descriptions of the mosquitoes occurring in the District.

2012 Surveillance

Rainfall

Rainfall surveillance is an important tool used to estimate the amount of larval production and to determine where to dispatch work crews following a rain event. Generally, an inch or more of rain can produce a hatch of floodwater mosquitoes. Since its beginning, the District has operated a network of rain gauges from May to September.

In 2012, MMCD joined the Community Collaborative Rain, Hail, and Snow (CoCoRaHS) network, a group of thousands of volunteers throughout the country who input their precipitation data into one database. MMCD recognized that by joining this network we would be able to eliminate some MMCD gauges that were difficult to monitor, fill gaps with observers in CoCoRaHS, and share data in a timely manner. Data from 165 gauges were used for summaries in this document.

Average rainfall in the District from May 1 through September 30, 2012 was 16.98 inches – 2.48 inches below the 53-year District average of 19.46 inches. Spring started dry, followed by frequent rains from April through mid June (Figure 1.1). Precipitation decreased by late June and was significantly lower in August and September.

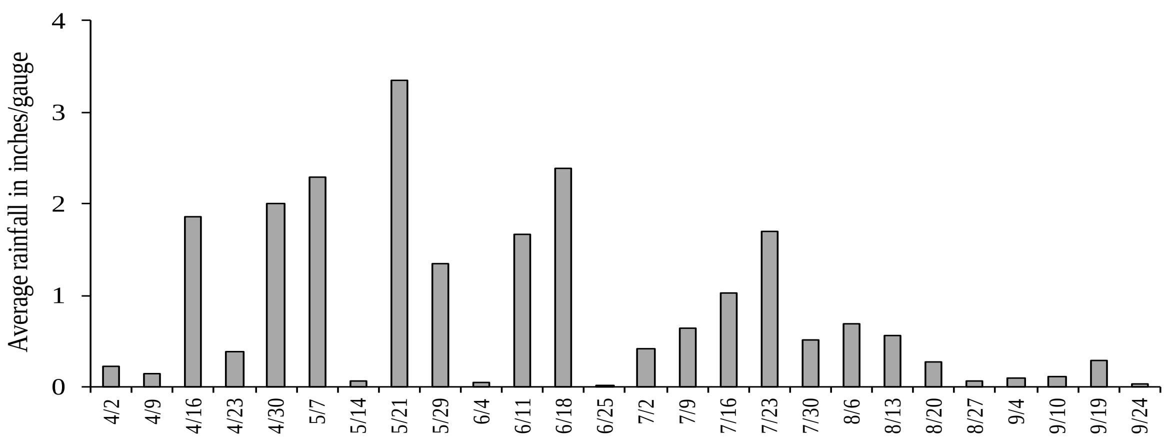


Figure 1.1 Average rainfall amounts per gauge per week (Saturday – Friday), 2012. Date labels represents the Monday of each week.

Typically, spring *Aedes* mosquitoes larvae develop over a period of months (mid-March to early May), and summer species develop over a period of days (7-10). Water temperature can influence how quickly larvae develop in sites. Figure 1.2 displays the monthly departures from normal for temperature and rainfall in 2012 (source: National Weather Service, Twin Cities Station).

March 2012 was an extraordinary month! It ended as the warmest in history. The warm weather caused early loss of soil frost, some of the earliest ever ice-out dates in many Minnesota lakes, the highest dewpoints ever measured in the month of March, the earliest date for an 80° F reading (March 17 at MSP airport station), and advanced phenology by 3 to 4 weeks. The departure from normal temperature at the MSP station was 15.5° F. March was a dry and windy month as well, with wind speeds over 30 mph on several days.

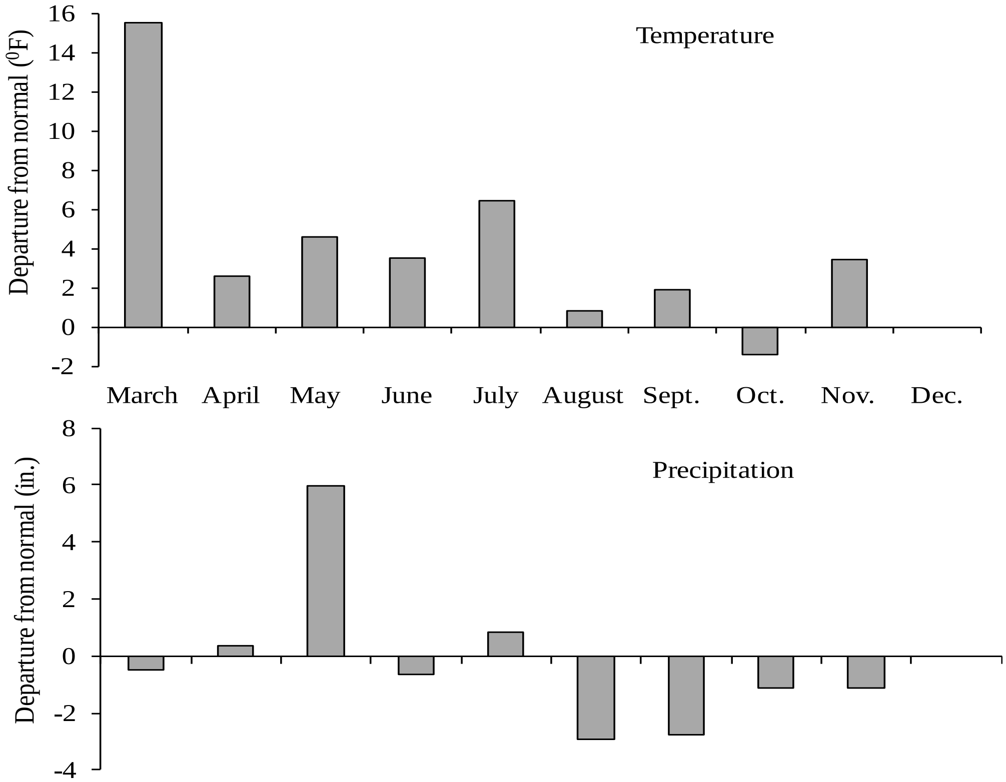


Figure 1.2 Monthly departures from normal for temperature and precipitation March-December, 2012 (source: National Weather Service, Twin Cities Station).

We experienced 11 rainfall events that were sufficient to produce broods of mosquitoes. The size of the brood is determined by the amount of area in the District affected by rainfall, the amount of rainfall received, and the amount of mosquito production that resulted. In 2012, we had one large spring brood, four large District-wide broods and another seven small-medium sized broods occurred in various parts of the District.

The dry, warm March weather, along with the lack of snow during the winter months, resulted in low water levels in spring *Aedes* larval sites. Our first larval sample was taken on March 13, the earliest in history. Cold rains in April caused spring *Aedes* larvae to hatch. Warm, heavy thunderstorms in May came on the heels of the spring brood, causing the summer species to hatch. May 2012 was the fourth wettest of all time, with over half the days receiving measurable rainfall (16-18 days). There was one large brood in June and July then mostly dry the rest of the season. Figure 1.3 depicts the geographic distribution and magnitude of weekly (Saturday-Friday) rainfall received in District gauges from April through September 2012.

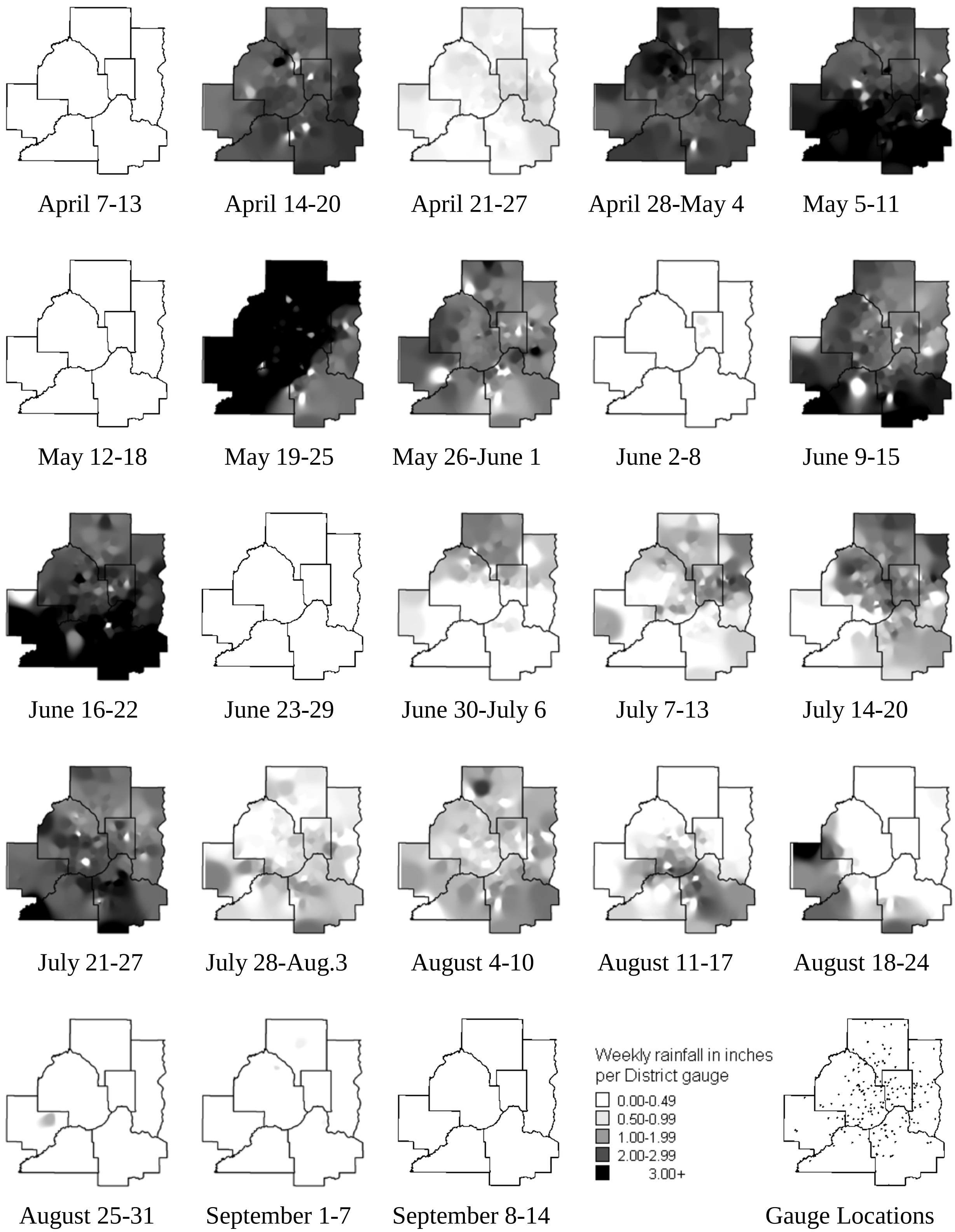


Figure 1.3 Weekly rainfall in inches per District gauge, 2012. The number of gauges varied from 116-146. A map of the rain gauge locations is included. Inverse distance weighting was the algorithm used for shading of maps.

Larval Collections

Larval mosquito inspections are done to determine if targeted species are present at threshold levels or to obtain species history in breeding sites. A variety of habitats is inspected to monitor the diverse fauna. Habitats include wetlands for *Aedes* and *Culex*; catch basins and stormwater structures for *Cx. pipiens* and *Cx. restuans*; cattail marshes for *Cq. perturbans*; tamarack bogs for *Cs. melanura*; and containers, tires, and tree holes for *Ae. triseriatus*, *Ae. albopictus*, and *Ae. japonicus*. The majority of larval collections are taken from floodwater sites using a standard 4-inch dipper. Threshold levels are determined by counting the number of larvae in each dip. Larvae are placed in sample vials and sent to the Entomology Lab for species identification. In 2012, lab staff identified 27,813 larval collections, the third highest ever collected, and 47% higher than average for the last 20 years (Fig. 1.4). To accelerate the identification of samples from sites to be treated by helicopter, larvae are identified to genus only, except for *Culex* larvae, which are identified to species to differentiate vectors. Staff process lower priority samples as time permits and those are identified to species.

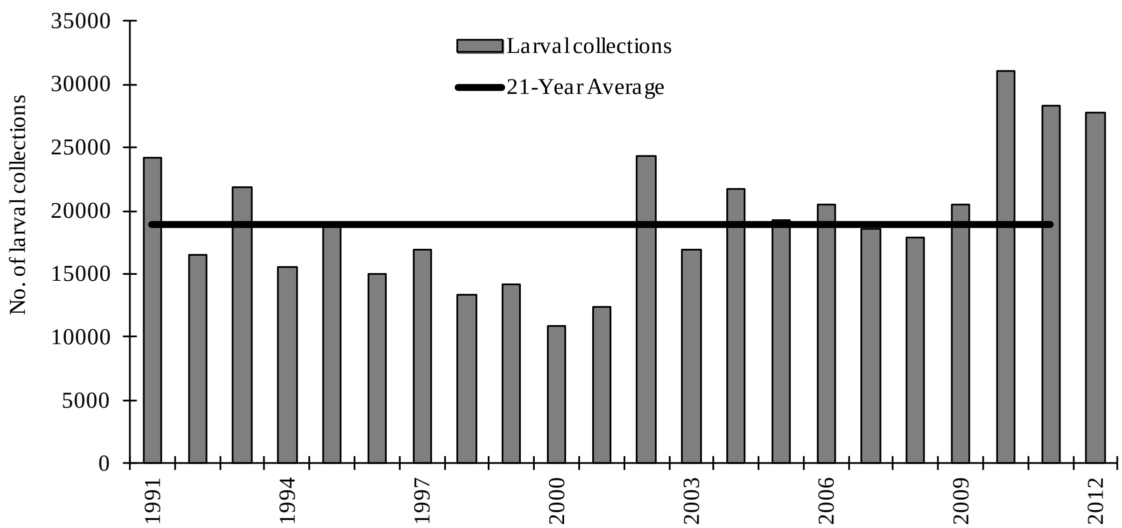


Figure 1.4 Yearly total larval collections, 1991-2012, and 21-year average.

The results of the 15,657 samples identified to species, calculated as the percent of samples in which the species was present is shown in Table 1.1. Most larval sampling takes place in natural wetlands but a significant amount of sampling is done in catch basins, stormwater structures, and other man-made features (e.g., swimming pools, culverts, artificial ponds). Those results are displayed separately (shaded column) from the natural wetlands results in Table 1.1.

The most frequently collected species from natural breeding areas was *Culiseta inornata,* occurring in 44.3% of the samples (Table 1.1). It is unusual for any species to outnumber our typical first place species, *Ae. vexans,* which came in second at 38.1%.

Table 1.1 Percent of samples where larval species occurred in wetland collections by facility and District total, and the District total for structure samples, 2012; the total number of samples processed to species is in parentheses.

	Percent of samples where species occurred by facility							
Species	North (1,724)	East (3,861)	South Rosemount (3,208)	South Jordan (2,037)	West Plymouth (1,841)	West Maple Grove (1,479)	Wetland Total (14,150)	Structures Total (1,507)
Aedes abserratus	0.3	0.4	0.2	<	0.9	<	0.3	
aurifer	<	<					<	
canadensis		0.2	0.6	0.3	0.3		0.3	
*cataphylla**								
cinereus	11.5	9.2	2.8	4.2	6.6	4.5	6.5	0.3
communis								
dorsalis		<	<	<	0.1	<	<	
euedes								
excrucians	2.7	3.6	2.1	2.3	4.4	2.2	2.9	
fitchii	1.0	2.1	1.4	0.8	1.0	0.5	1.3	
flavescens								
hendersoni								<
implicatus	0.2	<	<	<	0.1		<	
intrudens								
japonicus	0.2	<	<				<	4.2
nigromaculis			<	<			<	
punctor	0.4	0.3	0.2	<	0.8		0.3	
riparius	0.3	<	<	0.1	0.5	0.9	0.3	
spencerii						<	<	
sticticus	1.2	0.2	<	0.1	0.2	<	0.3	
stimulans	2.3	3.3	2.1	3.5	5.8	1.4	3.1	<
provocans		0.1	0.1		<	0.1	<	
triseriatus	0.1			<	<	<	<	1.7
trivittatus	3.6	3.5	4.4	5.5	4.3	1.8	3.9	0.5
vexans	42.2	36.5	38.1	30.3	48.7	35.3	38.1	13.9
Ae. species	13.7	20.6	27.9	11.7	18.4	16.2	19.4	3.1
Anopheles earlei	<	<	<				<	
punctipennis	0.3	1.5	0.2	<	0.5	0.2	0.6	1.6
quadrimaculatus	1.4	1.9	0.3	1.4	0.5	0.3	1.1	0.5
walkeri	0.1	<	<	<			<	
An. species	4.8	6.0	0.8	3.5	1.6	2.0	3.3	4.0
Culex erraticus		<		0.1			<	
pipiens	2.5	2.6	0.8	1.0	1.0	6.8	2.2	49.1
restuans	5.6	4.9	3.3	4.5	5.8	5.2	4.7	57.3
salinarius	0.1	0.4	<	0.1	0.1	0.2	0.2	0.5
tarsalis	1.5	0.7	0.5	2.3	0.6	1.6	1.1	2.7
territans	23.5	22.8	6.2	19.1	9.9	14.5	16.0	17.7
Cx. species	2.7	1.7	1.0	1.6	1.5	3.5	1.8	42.2
Culiseta inornata	36.8	41.0	50.9	46.2	42.7	46.9	44.3	6.3
melanura								
minnesotae	0.8	0.9	0.4	<	0.4	0.3	0.5	<
morsitans		0.3	<				<	
Cs. species	1.7	3.0	1.1	0.7	0.8	0.8	1.6	0.2
Ps. columbiae								
ferox	<	0.2	<	0.3	0.1		0.1	
horrida	<	<					<	
Ps. species	<	<	0.2	0.3	0.3	<	0.2	<
Ur.sapphirina	9.6	8.5	1.4	7.9	2.7	5.7	5.9	2.7

< = percent of total is less than 0.1%

* 1^{st} known occurrence in Minnesota was in 2008

Culex territans, which prefers cold-blooded hosts, was in third place. *Aedes cinereus* came in fourth and the fifth place winner was *Uranotaenia sapphirina*, another cold-blooded host mosquito. Spring *Aedes* are usually in the top five but their occurrence was reduced by the lack of snow melt to flood their eggs. Only two of the top five species in larval collections were targeted species. *Culex tarsalis*, a disease vector, occurred in only 1.1% of samples, ranking 10th.

A few mosquitoes can be identified to species in the first instar stage, but most cannot. The high amount of "*Aedes* species" and "*Culex* species" is normal and represents first instar larvae that are not identifiable to species.

Culex pipiens and *Cx. restuans* are the dominant species developing in catch basins and other stormwater structures. *Culex restuans* was found in 57.3% of the structure samples and *Cx. pipiens* in 49.1% (Table 1.1). *Aedes* species sometimes develop in stormwater structures and were identified in 13.9% of the larval samples. However, surveillance for *Culex* species often occurs after the *Aedes* have emerged from the sites. A detailed discussion of the larval *Culex* surveillance in structures can be found in Chapter 2: Vector-borne Disease.

Larval air sites are sampled prior to treatment to determine if the larvae are targeted species, at threshold level, and at an age susceptible to treatment. The percentage of under threshold samples in the spring brood of 2012 was twice as high as in 2011 (Fig. 1.5). The major cause of this was unusually high populations of a nontarget species, *Cs. inornata*. A typical summer brood has a low percentage of under threshold sites and a lower occurrence of *Cs. inornata*.

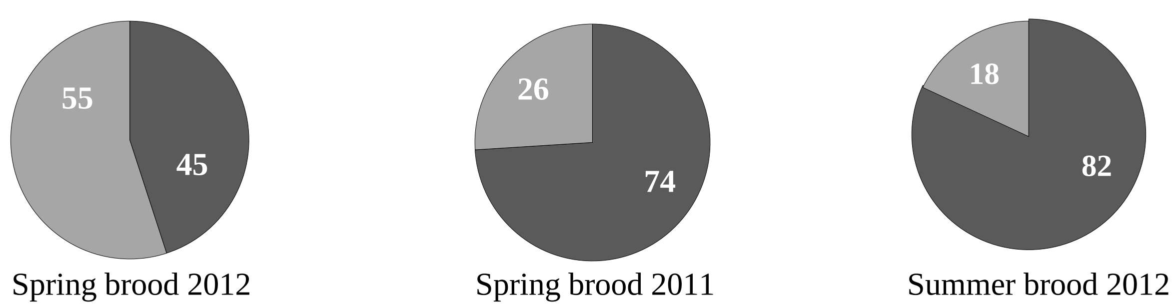


Figure 1.5 Percent of under threshold ( ) and over threshold ( ) air larval samples during spring brood 2012 vs. spring 2011 and summer 2012.

The most exciting event in the Entomology Lab this season was identifying larval specimens of *Culex erraticus*, a rare species in the District. The only other larval collection of this species was taken in 1961. Six collections contained *Cx. erraticus* this season, all from Washington and Scott counties. This species is a competent vector of eastern equine encephalitis and a suspected maintenance vector of West Nile virus. More discussion of *Cx. erraticus* occurrence follows in the adult mosquito section.

Adult Mosquito Collections

As stated earlier, the District employs a variety of surveillance strategies to target different behaviors of adult mosquitoes. Sweep nets are used to survey the mosquitoes attracted to a human host. We use carbon dioxide-baited (CO_2) traps with small lights to monitor host-seeking, phototactic species. New Jersey (NJ) light traps monitor only phototactic mosquitoes. A hand-held aspirator captures mosquitoes resting in the understory of wooded areas in the daytime. Gravid traps use liquid bait to attract and capture egg-laying *Culex* and *Aedes* species and ovitraps are used to collect eggs of container-inhabiting vector species (i.e., *Ae. triseriatus, Ae. japonicus, Ae. albopictus*). The information obtained from sampling is used to direct control activities and to monitor vector populations and disease activity (i.e., specimens collected are tested for disease). Treatment thresholds are discussed in Chapter 3: Mosquito Control.

Monday Night Network The sweep net and CO_2 trap data reported here are weekly collections referred to as the Monday night network. Employees took 2-minute sweep net collections and/or set overnight CO_2 traps in their yards every Monday night from May - September. To achieve a District-wide distribution of CO_2 traps, other locations such as parks or wood lots are chosen for surveillance as well. Figure 1.6 shows the CO_2 trap locations and their uses (i.e., general monitoring, virus testing, eastern equine encephalitis (EEE) vector monitoring). CO_2 traps operated for 21 weeks, starting one week earlier than the sweeps and continuing three weeks later.

To reduce expenses, the number of sweep locations was reduced from 204 in 2010 to 126 in 2011. Data indicated that reducing the number of sweep collections can save money without affecting data quality. In 2012, we had 115 locations (Fig. 1.6) which is less than 2011, but within our goal of 100-130 locations. Sweeps were taken for 17 weeks.

CO_2 Traps | Sweep Nets

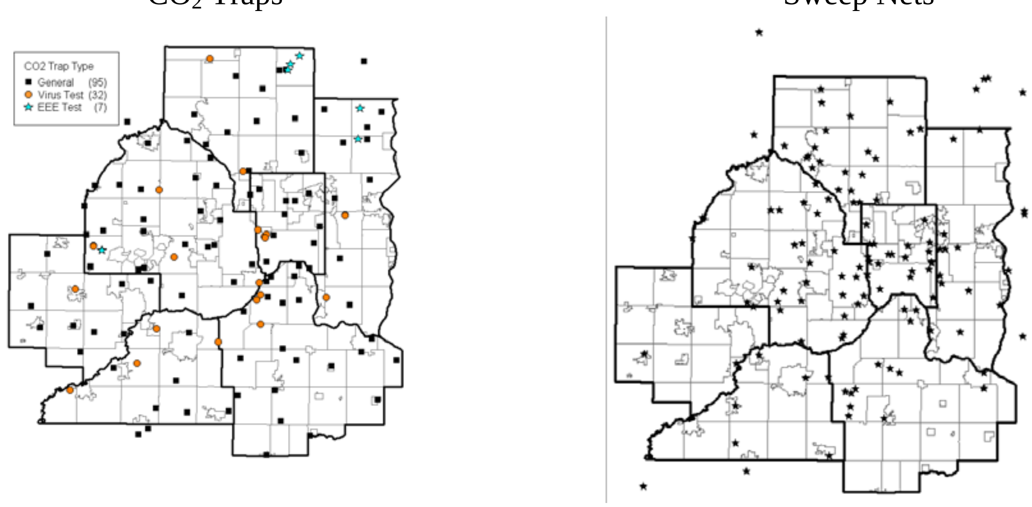


Figure 1.6 Locations of weekly CO_2 traps and sweep net locations used to monitor general mosquito populations and disease vectors (virus test and EEE test), 2012.

Most of the mosquitoes collected are identified to species, but in some cases, species are grouped together to expedite sample processing. *Aedes* mosquitoes are grouped by their seasonal occurrence (spring, summer). Others are grouped because species-level separation is very difficult (e.g., *Ae. absserratus/punctor*, *Cx. pipiens/restuans*). Generally, the most abundant species captured in sweep nets and CO_2 traps are the summer *Aedes*, *Cq. perturbans*, and spring *Aedes*. *Culex tarsalis*, unlike the other *Culex* species that prefer birds as hosts, is also attracted to mammals and is important in the transmission of West Nile virus (WNV) to humans.

Sweep Net The District uses sweep net collections to monitor human annoyance during the peak mosquito activity period, which is 35-40 minutes after sunset for most mosquito species. The number of collectors varied from 65-106 per evening.

Staff took 1,396 collections containing 3,489 mosquitoes. In 2012, the average number of summer *Aedes* collected in the evening sweep net collections was higher than in the past four years, but still below the 10-year average (Table 1.2). Populations of *Cq. perturbans* were more than double the 10-yr average. Spring *Aedes* were the lowest since 2000 and ten times lower than the 10-yr average. In 2012, spring weather conditions were very dry, resulting in the lowest spring *Aedes* populations in 10 years (Fig. 1.7). *Culex tarsalis*, which are infrequently collected in sweep net samples, were at average levels in 2012.

Table 1.2 Average number of mosquitoes collected per evening sweep net collection within the District, 2008-2012 and 10-year average, 2002-2011 (±SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2008	0.50	0.20	0.57	0.003
2009	0.20	0.20	0.15	0.003
2010	1.10	0.10	0.13	0.009
2011	1.54	0.38	0.23	0.007
2012	1.63	0.75	0.02	0.004
10-yr Avg.	1.74 (±0.18)	0.30 (±0.02)	0.15 (±0.02)	0.041 (±0.010)

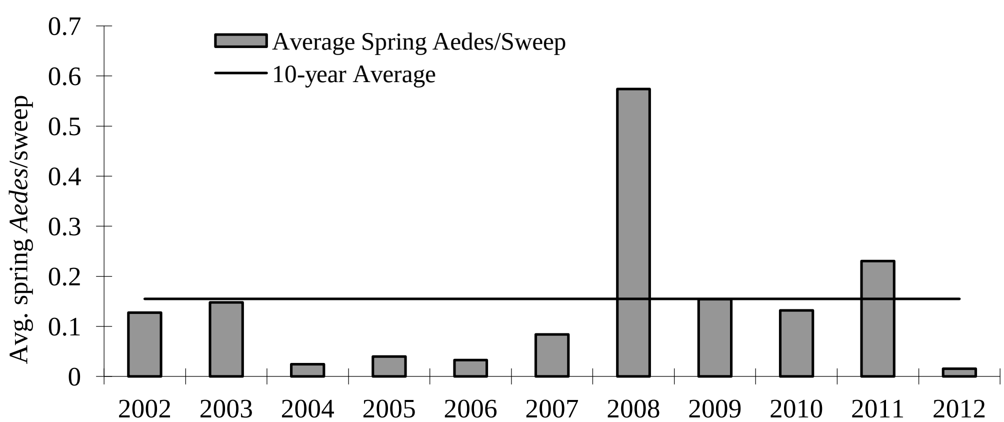


Figure 1.7 Average spring *Aedes* per sweep net 2002-2012 vs. 10-year average.

CO_2 Trap CO_2 traps baited with dry ice are used to monitor host-seeking mosquitoes and the presence of disease vector species. The standard placement for these traps is approximately 5 ft off the ground, the level where *Aedes* mosquitoes fly. In 2012, we operated 134 traps at 121 locations to allow maximum coverage of the District. At 13 locations, additional traps were placed ~25 ft above ground in the tree canopy to collect *Culex* species, which are active where birds are resting. All *Culex* specimens collected from the elevated trap locations and 14 standard placement locations are tested for WNV; however, *Cx. tarsalis* from all locations are tested. Six trap locations in the network, one also with an elevated trap, have historically captured *Cs. melanura*, and are used to monitor this vector's populations (Figure 1.6).

A total of 2,345 trap collections taken contained 691,524 mosquitoes. The total number of traps operated per night varied from 100-110. Summer *Aedes* was the predominant species collected in CO_2 traps, and was slightly above the 10-year average (Table 1.3). Fewer spring *Aedes* were captured than last year and were well below the 10-year average. *Coquillettidia perturbans* populations dropped from 2012 but remained above average. *Culex tarsalis* numbers were below the 10-year average and are discussed later in the vector surveillance section of this chapter.

Table 1.3 Average numbers of mosquitoes collected in CO_2 traps within the District, 2008-2012 and 10-year average, (2002-2011) (±SE)

Year	Summer *Aedes*	*Cq. perturbans*	Spring *Aedes*	*Cx. tarsalis*
2008	60.5	31.2	21.3	1.3
2009	28.4	30.4	7.2	0.8
2010	191.4	15.3	9.4	4.6
2011	181.0	110.0	5.1	1.4
2012	215.8	68.0	2.3	1.0
10-yr Avg.	204.0 (±53.0)	53.4 (±10.4)	8.7 (±1.6)	2.3 (±0.5)

Geographic Distribution The weekly geographic distributions of the three major groups of nuisance mosquitoes (i.e., spring *Aedes*, summer *Aedes*, and *Cq. perturbans*) collected in CO_2 traps are displayed in Figures 1.8, 1.9, and 1.10. The computer software extrapolates the data between collection points, so some dark areas are the result of one collection without another close by. What little populations of spring *Aedes* we had were confined to a few locations on the outer edges of the District or in localized areas (Figure 1.8). The trap collections of summer *Aedes* remained above threshold throughout the District in June and July, with some locally high populations in August (Figure 1.9). *Coquillettidia perturbans* populations occurred in their usual hot spots in the northern counties and near the District borders of Carver, Scott, and SW Hennepin counties (Figure 1.10).

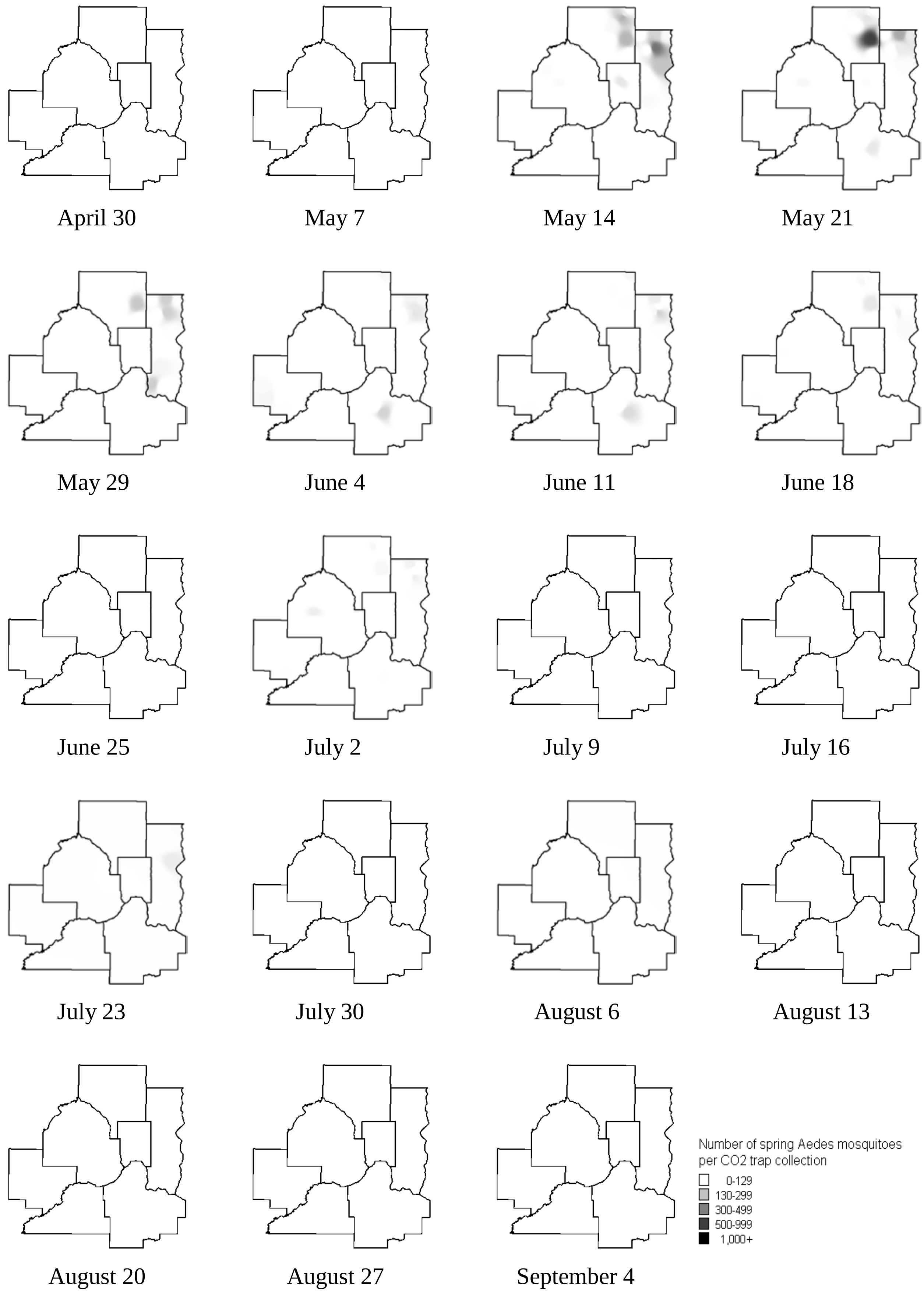


Figure 1.8 Number of spring *Aedes* in District low (5 ft) CO_2 trap collections, 2012. The number of traps operated per night varied from 100-110. Inverse distance weighting was the algorithm used for shading of maps.

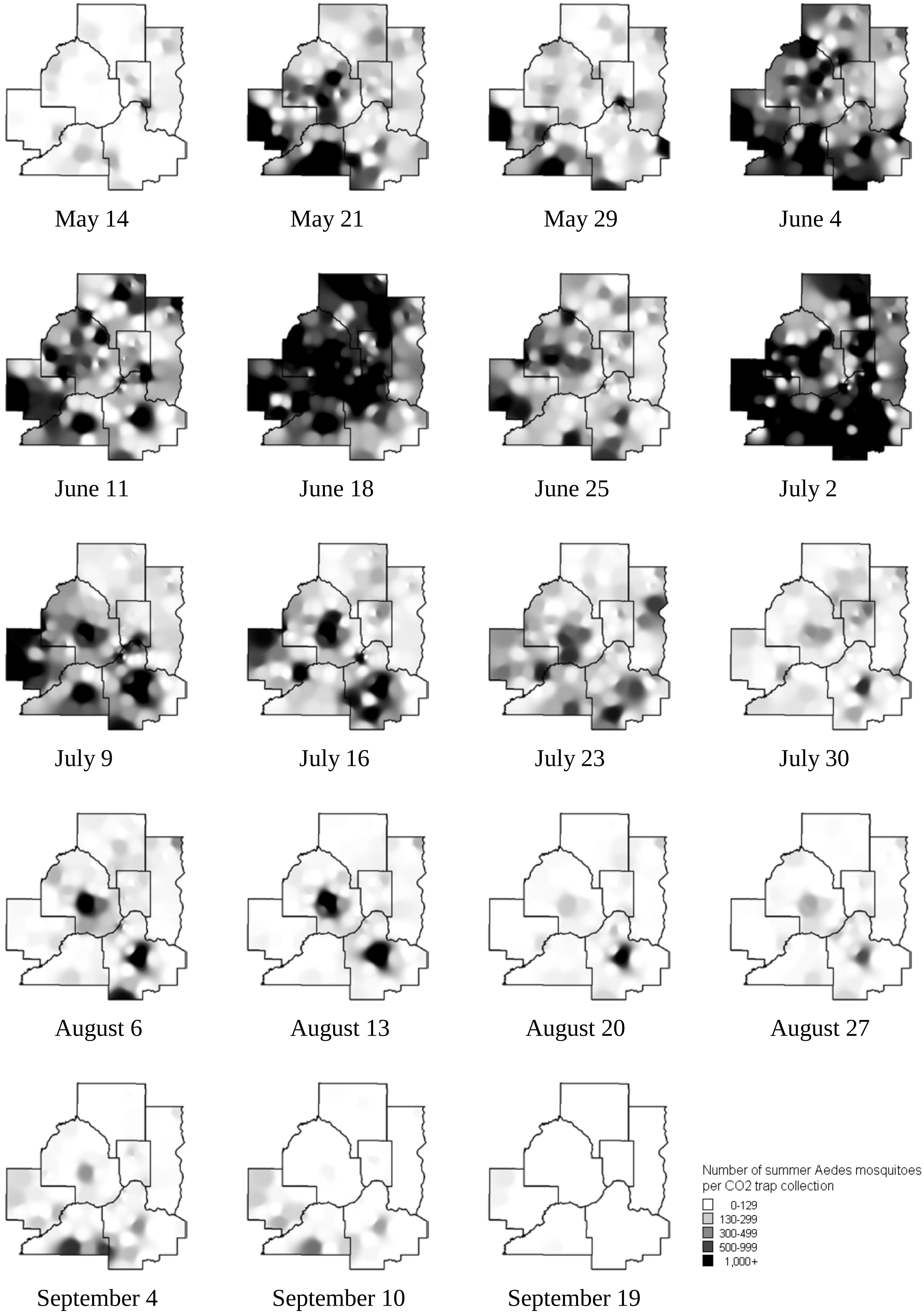


Figure 1.9 Number of summer *Aedes* in District low (5 ft) CO_2 trap collections, 2012. The number of traps operated per night varied from 100-110. Inverse distance weighting was the algorithm used for shading of maps.

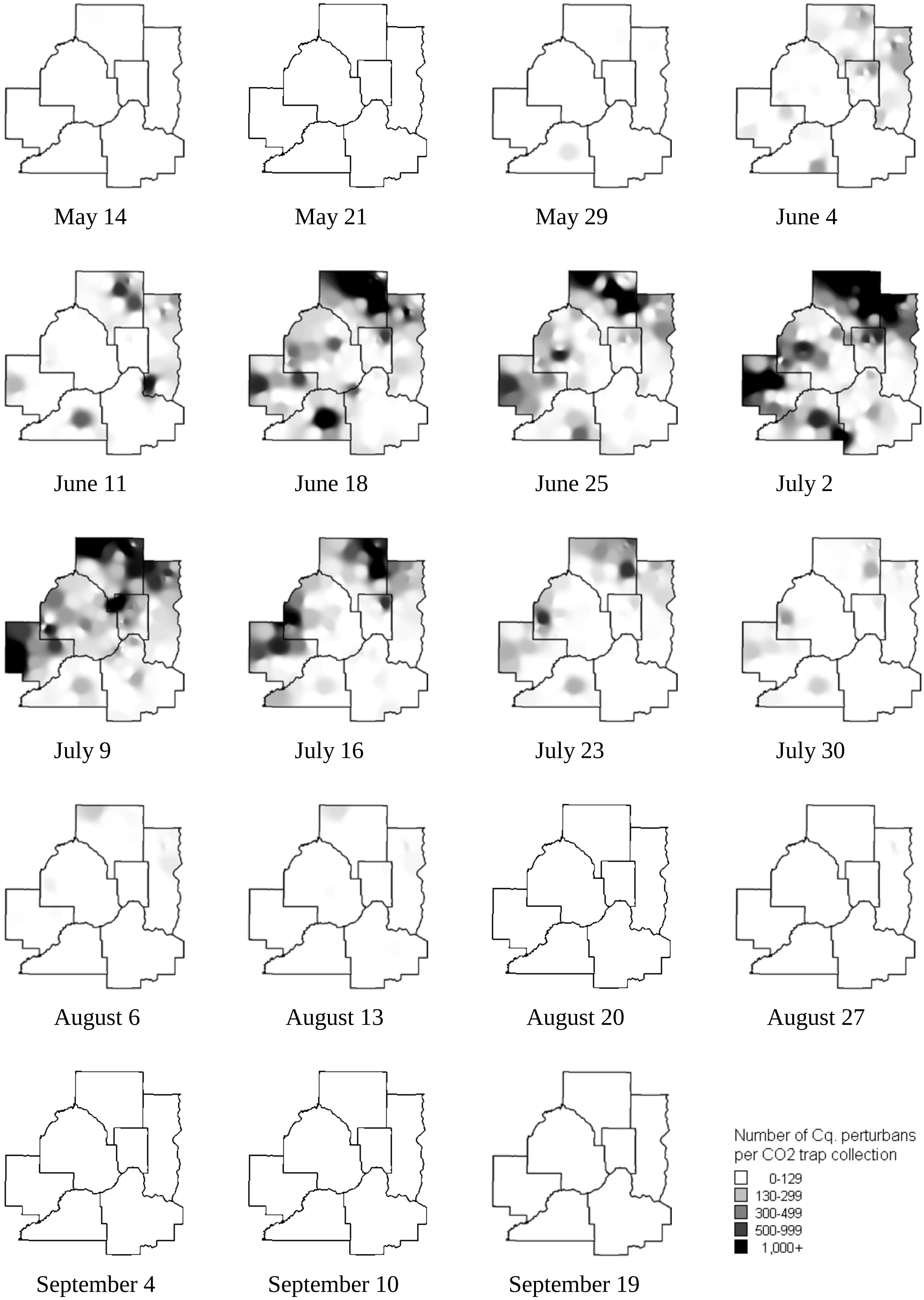


Figure 1.10 Number of *Cq. perturbans* in District low (5 ft) CO_2 trap collections, 2012. The number of traps operated per night varied from 100-110. Inverse distance weighting was the algorithm used for shading of maps.

Seasonal Distribution As described earlier, spring *Aedes,* summer *Aedes,* and *Cq. perturbans* have different patterns of occurrence during the season based on their phenology and the surveillance method used. Additionally, temperatures can affect mosquito flight activity. There was only one sampling night this season when the temperature was below the minimum (55°F) for mosquito activity (Fig. 1.11). Nights in July and August were very warm – in the 70s and 80s.

Figure 1.12 shows the seasonal distribution of the three major groups of mosquitoes from mid-May through early September, detected by sweep netting and CO_2 traps. The detection of spring *Aedes* in the sweeps was short-lived with emergence and peak on May 21, then disappearing by June 18. Sweeps were cancelled on May 28 due to wind and cold temperatures. CO_2 traps detected the spring *Aedes* peak on May 14, a week earlier than the sweeps, and continued to collect them until the end of July.

Summer *Aedes* populations fluctuated up and down on the way to their peak on July 2 and declined the rest of the season. *Coquillettidia perturbans* populations also peaked the week of July 2 and died off by the end of August. The end date for the sweep net collections is earlier than the CO_2 traps due to the availability of seasonal staff to perform the sweep collections.

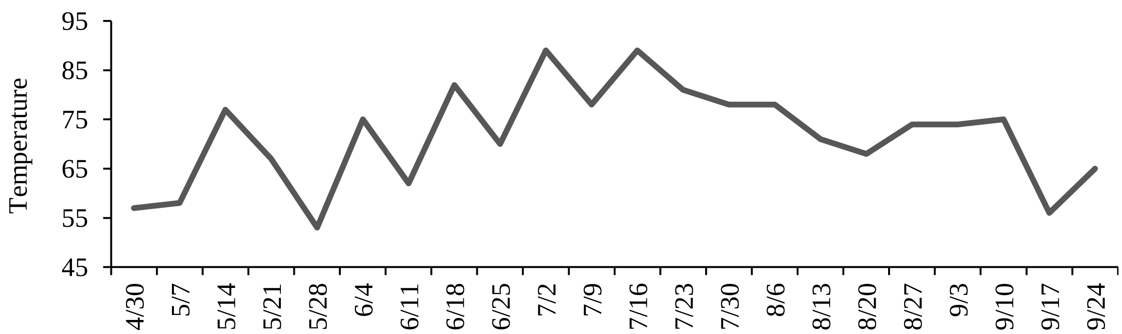


Figure 1.11 Temperature at 9:00 P.M. on Monday night surveillance dates.

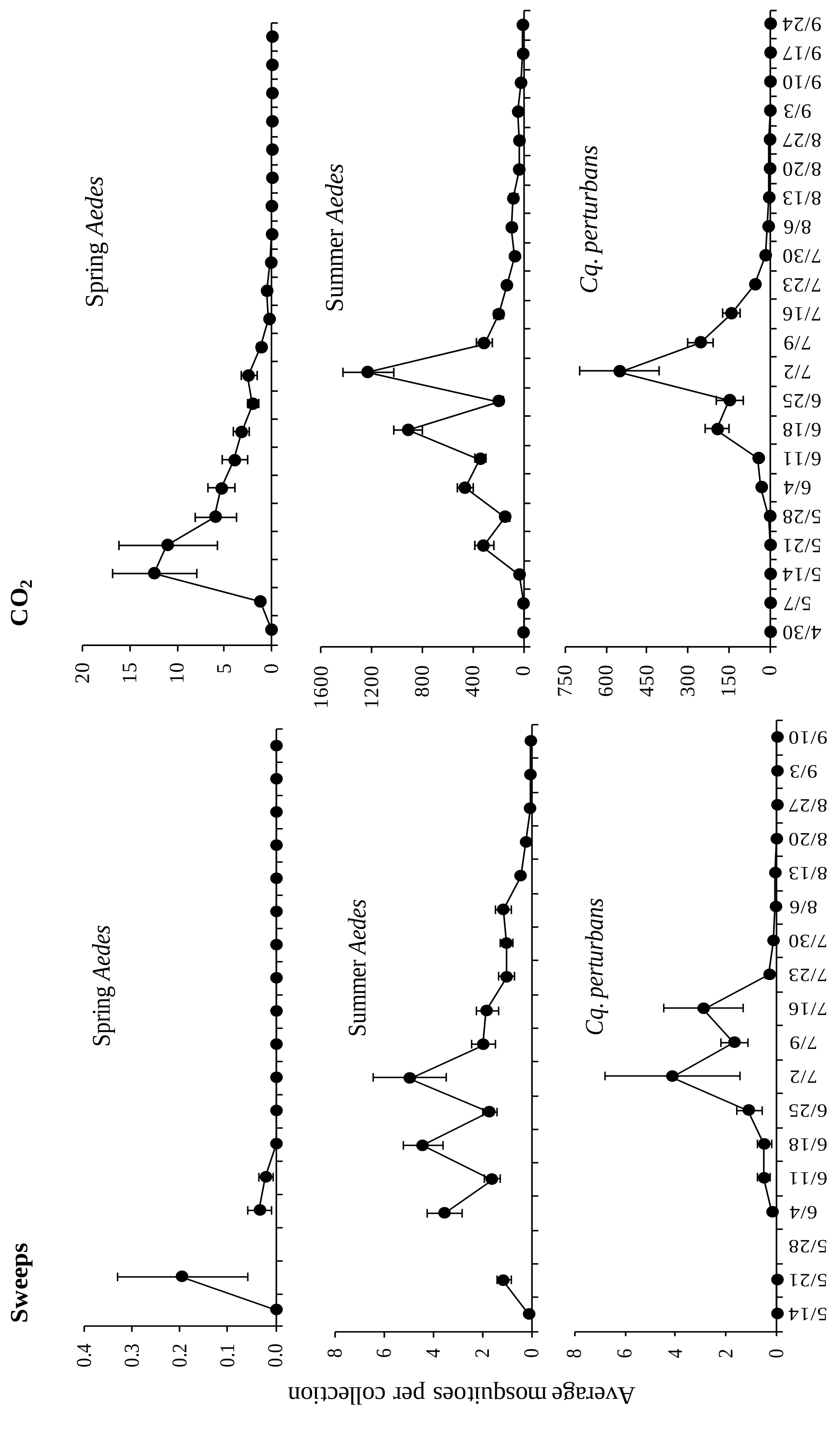


Figure 1.12 Average number of spring *Aedes*, summer *Aedes*, and *Cq. perturbans* per sweep net and CO_2 trap, 2012. Bars equal $\pm$ 1 standard error of the mean.

New Jersey (NJ) Traps For many years, mosquito control districts used the NJ light trap as their standard surveillance tool. The trap uses a 25-watt light bulb to attract mosquitoes and many other insects as well, making the samples messy and time-consuming to process. The number of traps used by the District has varied over the years; in the early 1980s, the District operated 29 traps. After a western equine encephalitis (WEE) outbreak in 1983, the District reduced the number to seven to alleviate the regular workload due to the shift toward disease vector processing.

The number of traps and locations has fluctuated since then. The District currently operates seven NJ light traps at the following locations: trap 1 in St. Paul, trap 9 in Lake Elmo, trap 13 in Jordan, trap 16 in Lino Lakes, trap CA1 in the Carlos Avery State Wildlife Management Area, trap AV at the Minnesota Zoo in Apple Valley, and trap MN in Minnetrista (Figure 1.13). Trapping occurs nightly for 20 weeks from May to September and staff identify all adult female mosquitoes to species. Traps 1, 9, 13, and 16 have operated each year since 1965. A comparison of the major species collected from 1965-2012 from those four traps is shown in Appendix B.

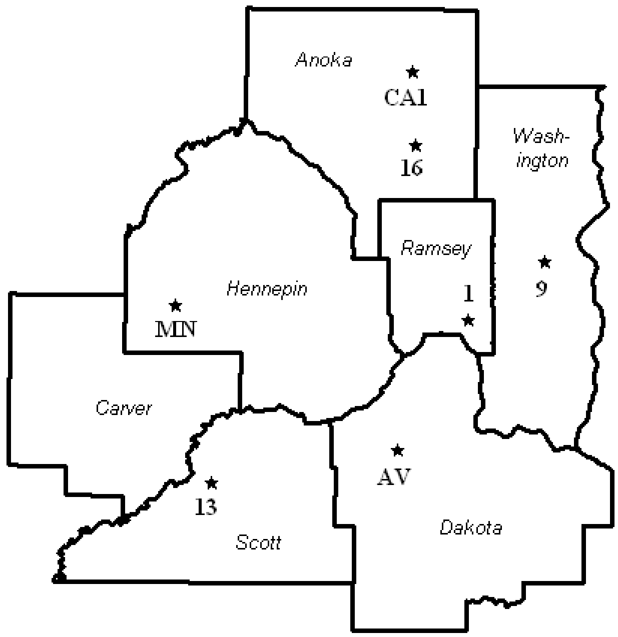


Figure 1.13 NJ light trap locations, 2012

The most numerous species collected in NJ traps was *Ae. vexans*, whose total was 64% of all female mosquitoes captured (Table 1.4). The Minnetrista trap contributed 60% and the Carlos Avery trap comprised 25% of all *Ae. vexans* captured. *Coquillettidia perturbans* ranked second and comprised 28% of the females captured (the Carlos Avery trap, which contains many acres of untreatable cattail habitat, contributed ¾ of the overall *Cq. perturbans* collected). Unexpectedly, *An. quadrimaculatus* ranked third. More discussion of this species follows in the next section. *Uranotaenia sapphirina*, a nonhuman-biting species, is readily attracted by light and captured fourth place. Finishing off the top five was *Anopheles walkeri*. Typically, the spring *Aedes* species combination of *Ae. abserratus* and *Ae. punctor* (*Ae. abs/punct*) are in the top five but they came in sixth place.

The first collection of *Ae. japonicus* in a NJ light trap was in 2009 (Minnetrista). Since then, *Ae. japonicus* has increased in frequency of occurrence and is found in 5 of the 7 NJ traps.

Table 1.4 Total number and frequency of occurrence for each species collected in NJ light traps, May 5 – September 21, 2012

	Trap Code, Location, and Number of Collections							Summary Statistics		
	1	9	13	16	CA1	AV	MN	Season		
	St. Paul	Lk. Elmo	Jordan	Lino Lakes	Carlos	Apple Valley	Minnetrista	Total	% Female	Avg per
Species	137	138	137	138	134	139	140	963	Total	Night
Ae. abserratus	0	0	0	0	139	0	0	139	0.09%	0.14
aurifer	0	0	0	0	0	0	0	0	0.00%	0.00
canadensis	0	0	0	0	4	0	0	4	0.00%	0.00
cinereus	3	3	0	9	204	2	50	271	0.18%	0.28
dorsalis	0	0	0	0	0	0	0	0	0.00%	0.00
excrucians	0	3	0	0	77	0	24	104	0.07%	0.11
fitchii	0	2	0	1	1	0	0	4	0.00%	0.00
flavescens	0	0	0	0	0	0	0	0	0.00%	0.00
implicatus	0	0	0	0	0	0	0	0	0.00%	0.00
japonicus	1	12	0	2	2	0	21	38	0.03%	0.04
nigromaculus	0	0	0	0	0	0	0	0	0.00%	0.00
punctor	0	0	0	0	62	0	0	62	0.04%	0.06
riparius	0	0	0	0	8	0	1	9	0.01%	0.01
spenceri	0	0	0	0	0	0	0	0	0.00%	0.00
sticticus	2	2	75	1	120	0	1	201	0.14%	0.21
stimulans	0	5	0	0	0	0	3	8	0.01%	0.01
provocans	0	0	0	0	0	0	0	0	0.00%	0.00
triseriatus	3	20	0	6	1	0	87	117	0.08%	0.12
trivittatus	10	38	63	3	33	42	63	252	0.17%	0.26
vexans	2,820	2,235	2,066	4,482	23,594	1,996	56,682	93,875	63.73%	97.48
abserratus/punctor	0	1	0	3	490	1	8	503	0.34%	0.52
Aedes species	64	52	21	56	377	107	1,540	2,217	1.51%	2.30
Spring *Aedes*	0	3	0	4	38	0	70	115	0.08%	0.12
Summer *Aedes*	1	0	0	0	16	1	0	18	0.01%	0.02
An. barberi	0	0	0	0	0	0	0	0	0.00%	0.00
earlei	0	0	0	0	0	0	0	0	0.00%	0.00
punctipennis	8	62	4	12	141	3	416	646	0.44%	0.67
quadrimaculatus	60	528	34	37	473	7	648	1,787	1.21%	1.86
walkeri	1	7	3	19	505	0	248	783	0.53%	0.81
An. species	6	39	3	6	80	2	102	238	0.16%	0.25
Cx. erraticus	4	3	1	1	1	0	0	10	0.01%	0.01
pipiens	0	1	0	0	1	0	0	2	0.00%	0.00
restuans	25	29	3	24	20	15	57	173	0.12%	0.18
salinarius	2	4	1	4	13	0	24	48	0.03%	0.05
tarsalis	10	3	1	8	22	3	17	64	0.04%	0.07
territans	9	83	4	29	138	8	318	589	0.40%	0.61
Cx. species	25	22	1	8	15	7	43	121	0.08%	0.13
Cx. pipiens/restuans	122	46	3	19	42	31	91	354	0.24%	0.37
Cs. inornata	83	56	6	31	96	39	207	518	0.35%	0.54
melanura	0	1	0	0	5	0	0	6	0.00%	0.01
minnesotae	1	1	0	18	72	0	13	105	0.07%	0.11
morsitans	8	2	0	0	42	0	7	59	0.04%	0.06
Cs. species	1	0	0	5	2	0	1	9	0.01%	0.01
Cq. perturbans	233	179	50	1,742	31,819	34	7,613	41,670	28.29%	43.27
Or. signifera	1	0	0	0	0	0	0	1	0.00%	0.00
Ps. ciliata	0	0	0	0	0	0	0	0	0.00%	0.00
horrida	0	0	0	0	0	0	0	0	0.00%	0.00
Ps. species	0	0	0	0	1	0	0	1	0.00%	0.00
Ur. sapphirina	76	664	14	118	165	13	597	1,647	1.12%	1.71
Unidentifiable	11	8	3	9	35	4	468	538	0.37%	0.56
Female Total	3,590	4,114	2,356	6,657	58,854	2,315	69,420	147,306	100.00%	152.97
Male Total	996	2,792	568	1,205	7,921	184	16,380	30,046		
Grand Total	4,586	6,906	2,924	7,862	66,775	2,499	85,800	177,352		

Rare Detections *Culex erraticus* is considered rare in the District. Adults were first detected by New Jersey traps in1988, occurred sporadically since then in low numbers, and in recent years have been collected in CO_2 traps more frequently (Fig. 1.14). This summer, Lab staff were quite excited to collect them in record numbers throughout the District. This species is a competent vector of eastern equine encephalitis and a suspected maintenance vector of West Nile virus. Its range is southern United States with the District at its northern edge. Since it is usually extremely rare, it has not been targeted for control.

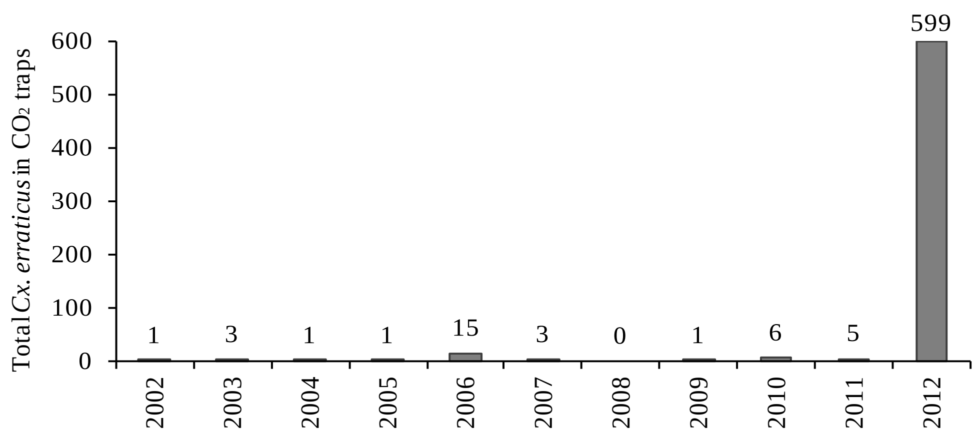


Fig. 1.14 Yearly total of *Culex erraticus* in CO_2 traps, 2002-2012.

Anopheles quadrimaculatus is notable because it is capable of transmitting malaria. They are known to bite humans, but are not directly targeted for larval control. Historically, it is rare in the District, but in recent years, it has occurred in traps throughout the District more frequently than in the past (Fig. 1.15). Prior to 2002, *Anopheles* specimens in CO_2 traps were not identified to species, so it may have been undocumented. Since 2002, *An. quadrimaculatus* has appeared with increasing frequency, reaching the highest amount ever in 2012.

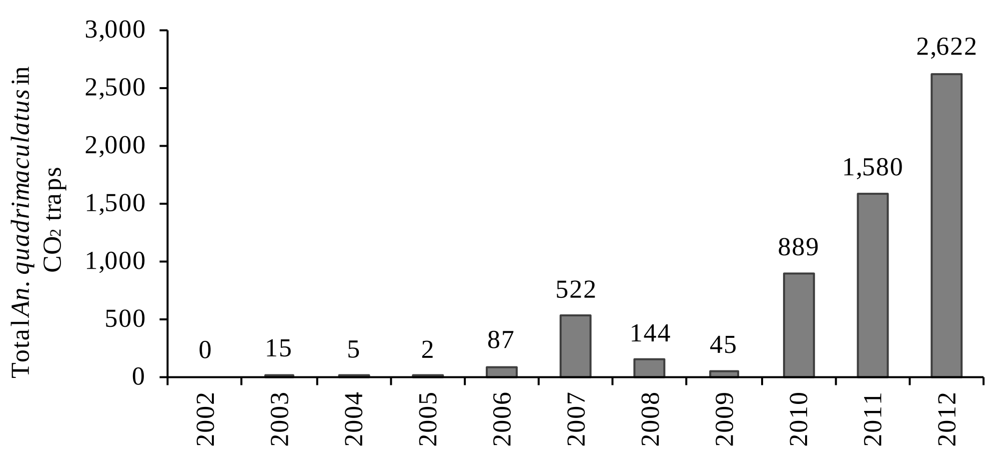


Fig. 1.15 Yearly total *Anopheles quadrimaculatus* in CO_2 traps, 2002-2012.

Targeted Vector Mosquito Surveillance

Aedes triseriatus Staff use a mechanical aspirator to sample the understory for resting mosquitoes in the daytime. This method is used primarily for *Ae. triseriatus*, the La Crosse encephalitis (LAC) vector, which can be difficult to capture by other methods. Sampling began during the week of May 21 and continued through the first week of September. The peak rate of capture of 1.9 *Ae. triseriatus* per sample occurred during the week of June 25 (Figure 1.16). Surveillance results indicated the *Ae. triseriatus* population closely followed the pattern that is typical of the last decade. Collections fluctuated during the early, rainier part of the season, but generally increased until the end of June. Fluctuations continued through July. In August and September, we observed the general population decline that is typical of that time of year.

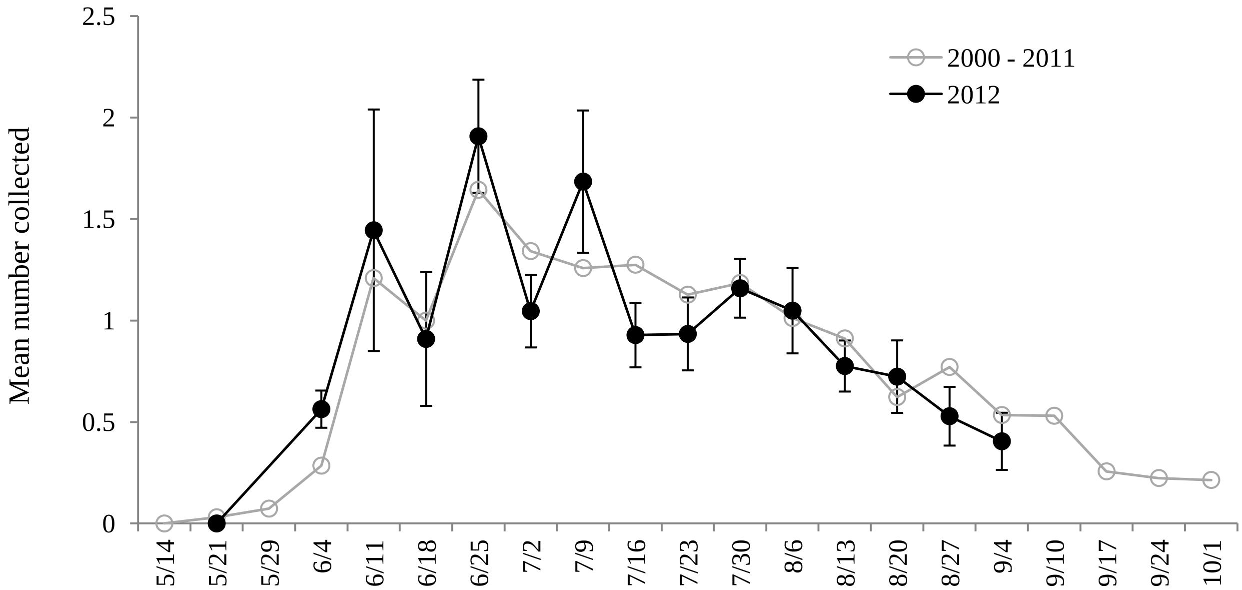


Figure 1.16 Mean number of *Ae. triseriatus* adults in aspirator samples plotted by week in 2012 compared to mean captures for the corresponding weeks of 2000-2011. Dates listed are the Monday of each week. Error bars equal ± 1 standard error of the mean.

Culiseta melanura *Culiseta melanura*, the enzootic vector of eastern equine encephalitis (EEE), feeds primarily on birds. Locally, the most common larval habitat is spruce-tamarack bog or other acidic habitat. Larvae are sometimes found in caverns in sphagnum moss supported by tree-roots. Overwintering is in the larval stage with adults emerging in late spring. There are multiple generations per year, and the late summer cohort supplies the next year's first generation. Most adults disperse a short distance from their larval habitat, although a few may fly in excess of five miles from their larval habitat.

District staff monitored adult *Cs. melanura* at ten locations using 11 CO_2 traps; four new locations were added in 2012. Five sites are in Anoka County, four sites are in Washington County, and one site is in Hennepin County. *Culiseta melanura* have been collected from each location in the past. Two traps are placed at the Hennepin County location – one at ground level and one elevated 20 ft into the tree canopy, where many bird species roost at night.

Surveillance throughout the 2011 season documented unusually high numbers of *Cs. melanura* spread out over much of the District. In 2012 far fewer *Cs. melanura* were collected. Each of the 11 traps set to monitor *Culiseta melanura* collected at least one specimen in 2012. However, only 118 *Cs. melanura* were collected in 56 of 214 trap placements. In 2011, 697 *Cs. melanura* were collected by 142 trap placements.

The first *Cs. melanura* adults were collected in a CO_2 trap on May 21 (Figure 1.17). The population of the first generation to emerge remained low with a maximum capture of 0.56 per trap. The July 16 and September 10 collections were the highest of the season with means of 1.7 and 1.6 respectively.

A logical expectation for the 2012 *Cs. melanura* population might have been for numbers similar or even in excess of 2011 observations. However, dry conditions persisted in the late summer and autumn of 2011 and there was little snow during the winter. The resulting drawdown of water levels in bogs populated by overwintering *Cs. melanura* larvae likely impacted the size of the initial 2012 generation.

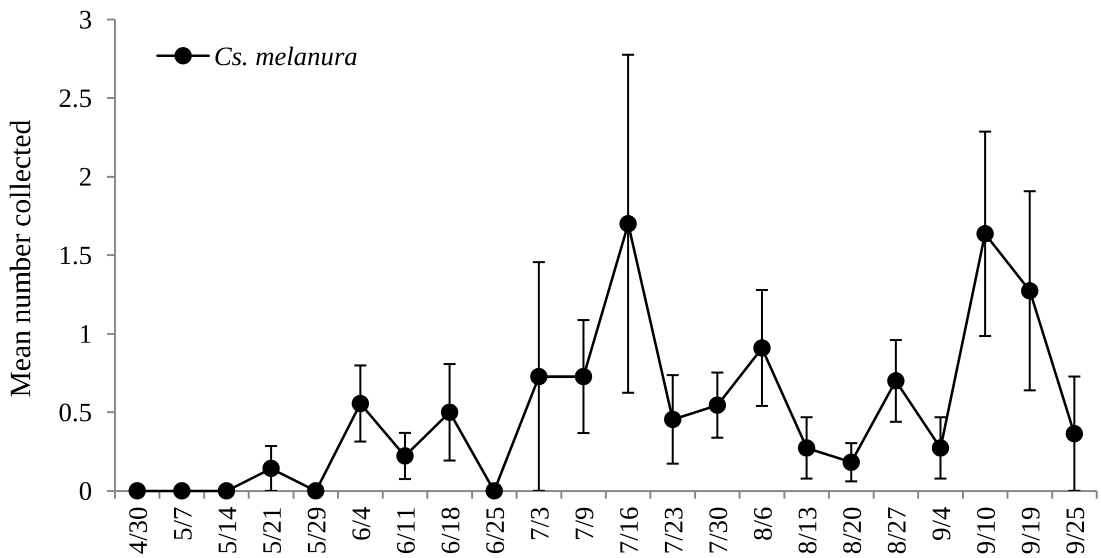


Figure 1.17 Mean number of *Cs. melanura* adults in CO_2 traps from selected sites, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

District staff collected 631 *Cs. melanura* in 410 aspirator collections targeting the species in wooded areas near bog habitats. Collections were greatest in August with means in three consecutive weeks of 4.0, 3.6, and 4.2 per sample (Figure 1.18).

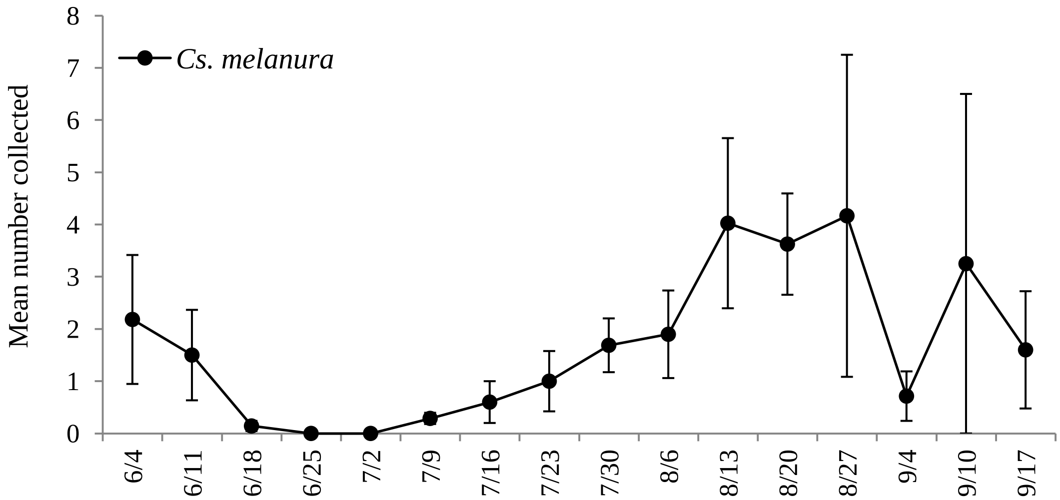


Figure 1.18 Mean aspirator collections of *Cs. melanura*, 2012. Error bars equal ± 1 standard error of the mean.

Culiseta melanura develop in a narrow range of aquatic habitats in the District, and larvae are difficult to collect. In April, May and June of 2012, 39 sites were inspected for *Cs. melanura*. Mosquito samples were collected from 20 sites and six contained *Cs. melanura* larvae.

***Culex* Surveillance** *Culex* species are important for the amplification and transmission of WNV and WEE virus in our area. The District uses CO_2 traps to monitor host-seeking *Culex* mosquitoes and gravid traps to monitor egg-laying *Culex* mosquitoes. Many *Culex* specimens collected in the network were tested for WNV. Concentrations of *Culex* in the District as detected through gravid trap monitoring are displayed in Figure 1.19.

Culex tarsalis is the most likely WNV vector to humans in our area. *Culex tarsalis* specimens from Monday night CO_2 traps were tested for WNV in 2012 (see Chapter 2, page 37, Table 2.4). Capture rates for *Cx. tarsalis* in CO_2 traps were low to moderate during the 2012 season (Figure 1.20). The *Cx. tarsalis* population appeared to peak during the first week of July. It fell through July and remained low for the rest of the season. Few *Cx. tarsalis* were collected by gravid trap, as is typical since the bait used is not ideally attractive to the species.

Culex restuans is another important vector of WNV in Minnesota. The species is largely responsible for the early season amplification of the virus and likely for season-long maintenance of the WNV cycle. Few *Cx. restuans* were collected in CO_2 traps in 2012 (Figure 1.21). The CO_2 trap capture peaked at 0.64 per trap on May 21. Gravid trap collections of *Cx. restuans* in 2012 peaked on June 4 and weekly mean collections were consistently between 2.5 and 4.0 most weeks between mid-May and mid-August.

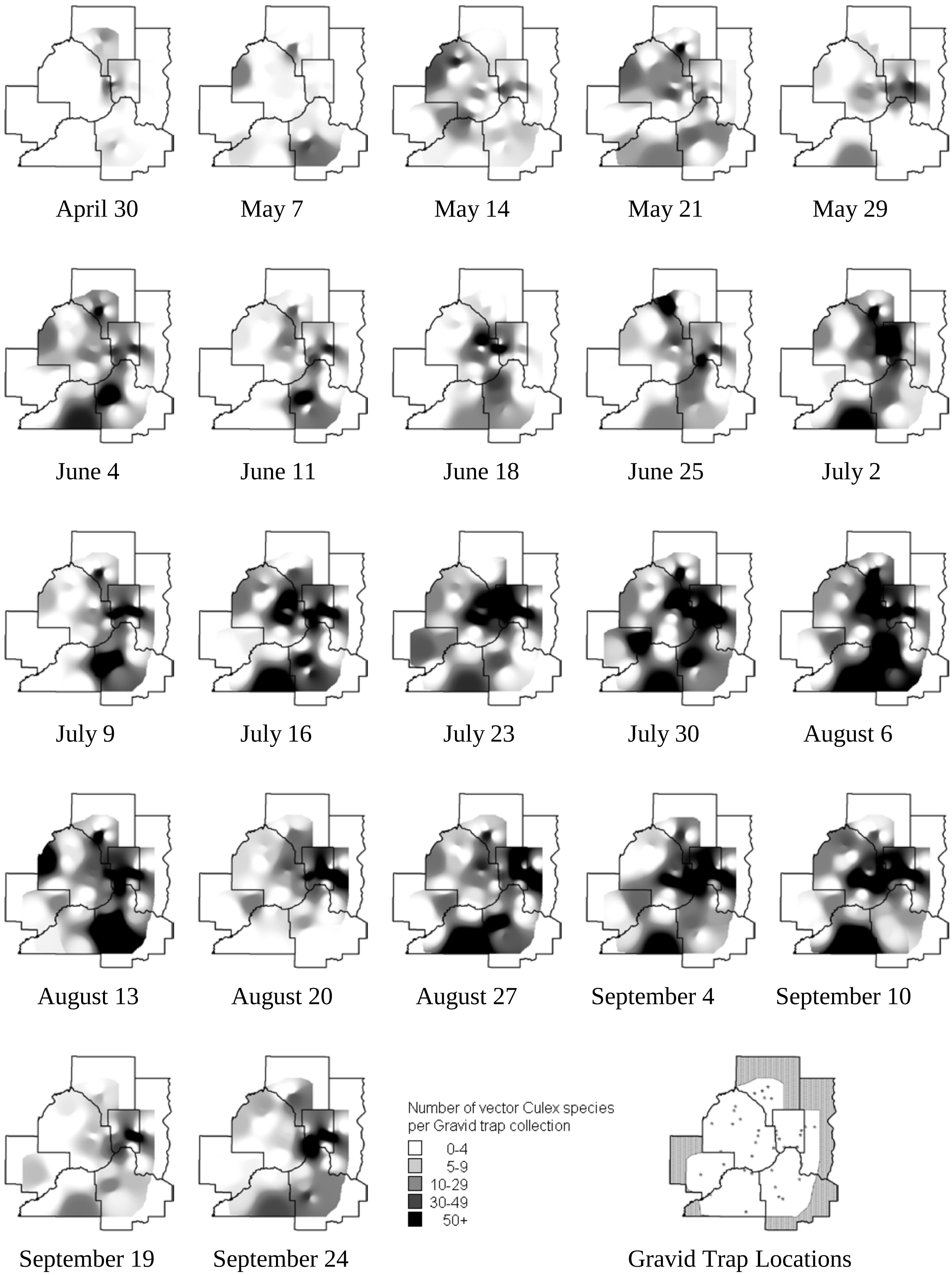


Figure 1.19 Number of vector *Culex* species in District gravid trap collections, 2012. The number of traps operated per week varied from 31-36. Inverse distance weighting was the algorithm used for shading of maps within an area of the District near the traps. A map of the gravid trap locations showing the area of District used to generate the weekly maps is also included.

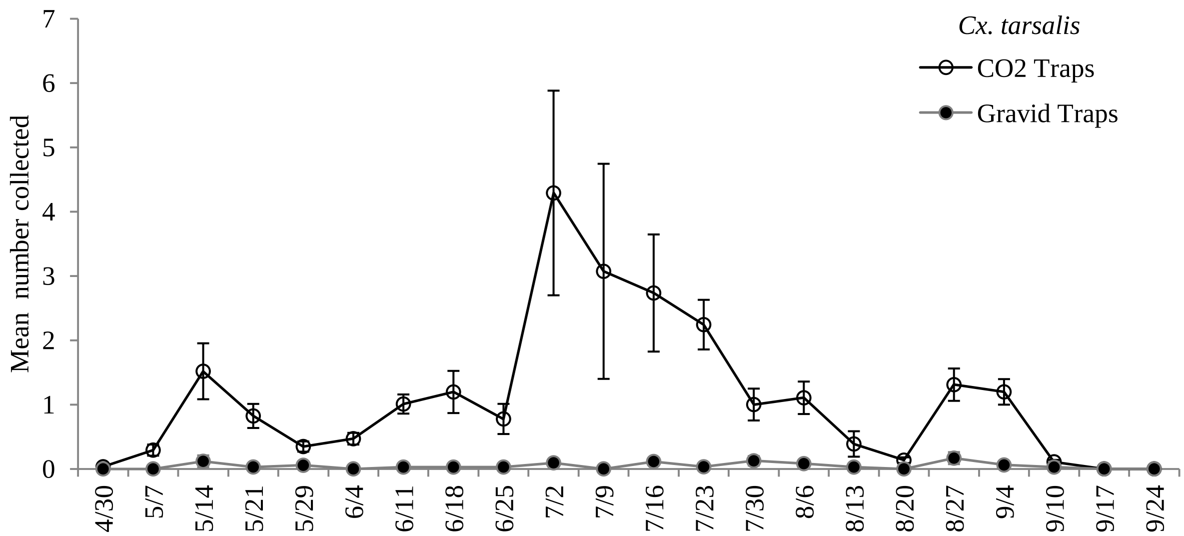


Figure 1.20 Average number of *Cx. tarsalis* in CO_2 traps and gravid traps, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

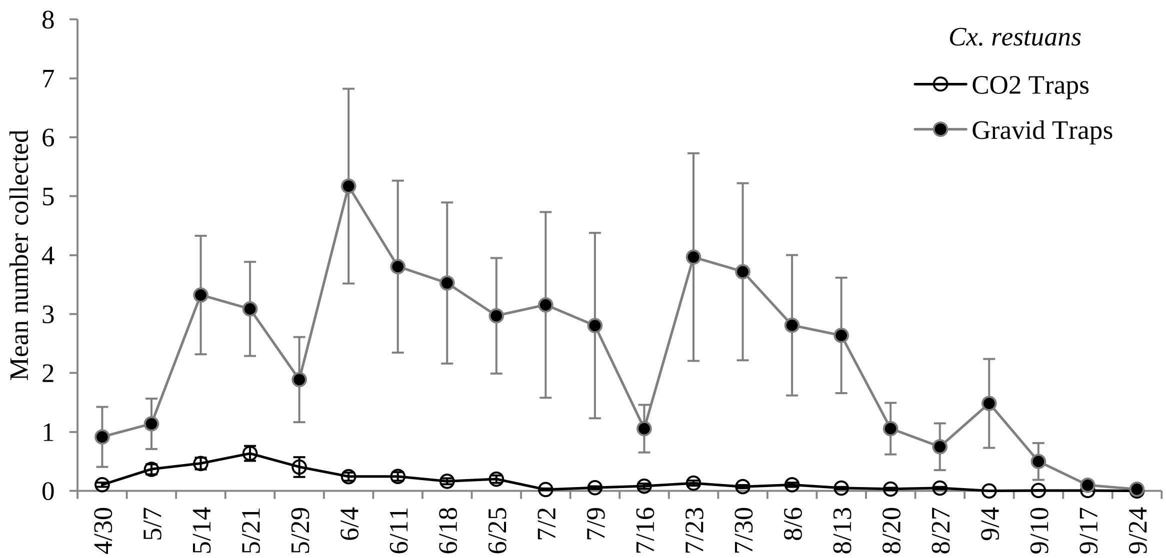


Figure 1.21 Average number of *Cx. restuans* in CO_2 traps and gravid traps, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

Culex pipiens has been an important vector of WNV in much of the United States. The species prefers warmer temperatures than *Cx. restuans*; therefore, populations of *Cx. pipiens* in the District tend to remain low and peak late in the summer when temperatures are typically warmer. Collections of *Cx. pipiens* were low in both CO_2 traps and gravid traps in 2012 (Figure 1.22). However, there was evidence in 2012 that the population was greater than we typically experience in the District (see Chapter 2 Larval *Culex* Surveillance). Many of the adult mosquitoes identified as *Culex* species or *Cx. pipiens/restuans* may have been *Cx. pipiens*.

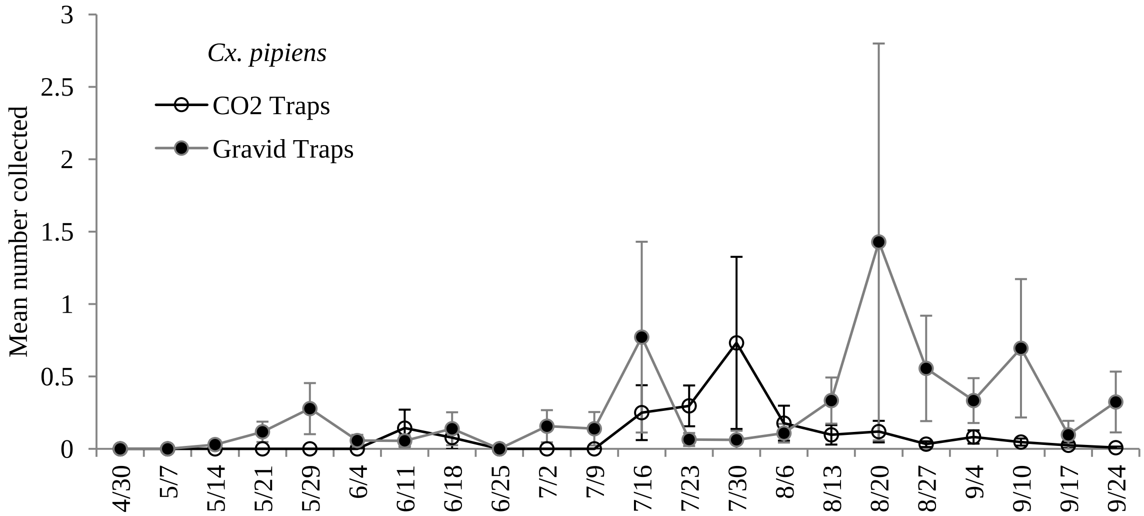


Figure 1.22 Average number of *Cx. pipiens* in CO_2 traps and gravid traps, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

When *Cx. pipiens* and *Cx. restuans* are difficult to distinguish from each other they are grouped together and identified as *Cx. pipiens/restuans*; when only a genus level identification can be made, they are classified as *Culex* species. Both groups usually consisted largely of *Cx. restuans* during the early and middle portions of the season with *Cx. pipiens* contributing more to the collections during the middle and later portions of the season. The numbers of *Cx. pipiens/restuans* (Figure 1.23) captured in gravid traps and CO_2 traps and *Culex* species (Figure 1.24) captured in gravid traps were greatest from the beginning of July until mid September when temperatures cooled. This is further evidence that the *Cx. pipiens* population was greater in 2012 than usual.

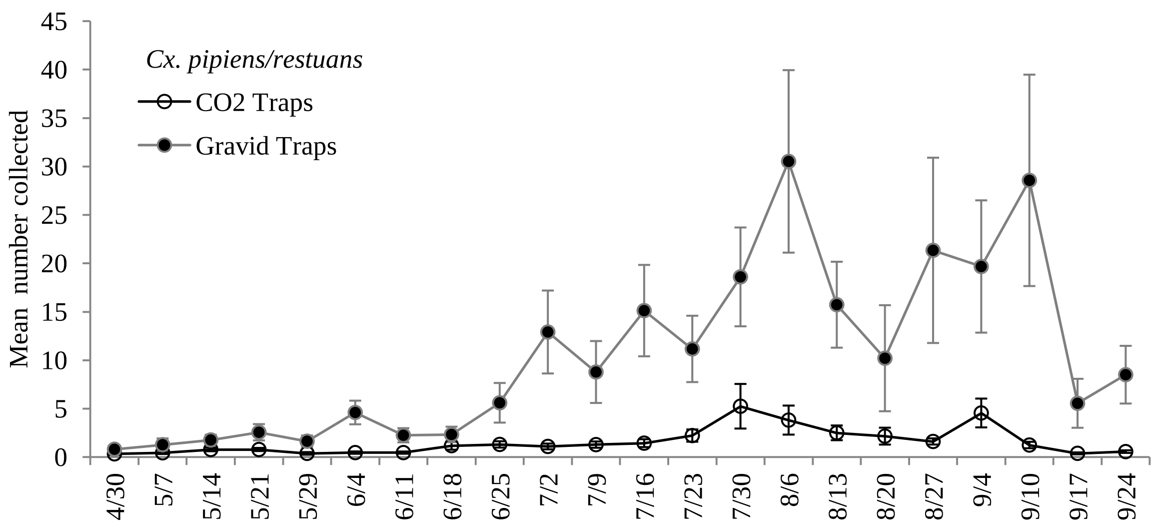


Figure 1.23 Average number of *Cx. pipiens/restuans* in CO_2 traps and gravid traps, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean.

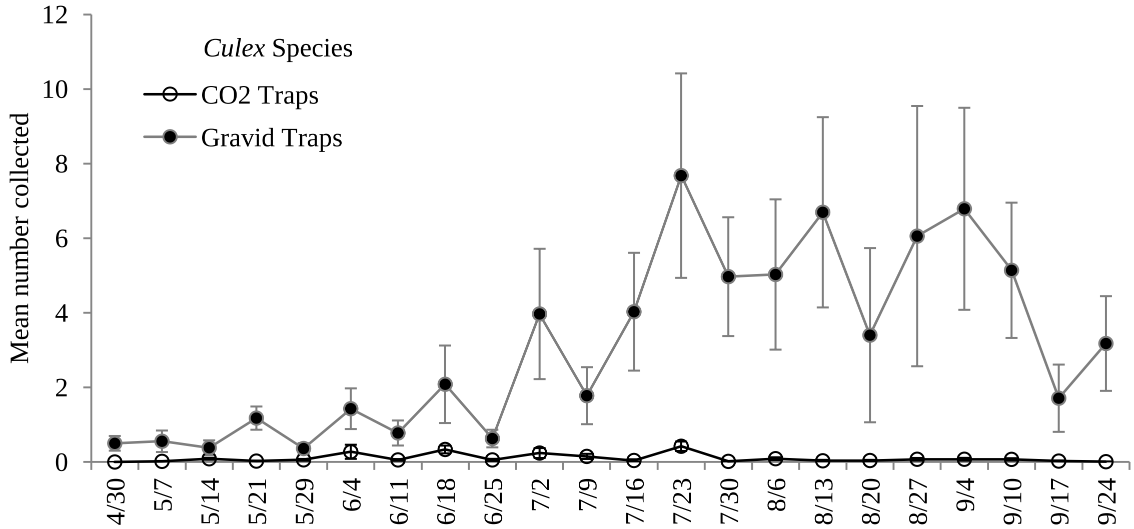


Figure 1.24 Average number of *Culex* species in CO_2 traps and gravid traps, 2012. Dates listed are the Monday of each sampling week. Error bars equal ± 1 standard error of the mean

Exotic Species Each season, MMCD conducts surveillance for exotic or introduced mosquito species. There are also opportunities to collect unexpected species through a variety of surveillance techniques used to monitor local mosquito species. MMCD laboratory technicians are trained to recognize exotic species in their adult and larval forms so that the mosquitoes can be spotted in any of the tens of thousands of samples processed each year.

The two exotic species most likely to be found here are *Ae. albopictus* and *Ae. japonicus*. Both are native to Asia and both have adapted to use tires and other artificial containers as oviposition sites and larval habitat. This allows them to be transported over great distances. *Aedes albopictus*, first introduced in the United States in 1985, are established in many states to the south and east of Minnesota and are frequently introduced to the District in shipments of used tires and by other means. *Aedes japonicus* recently became established in Minnesota. They were first found in the District in 2007 and have been collected in increasing numbers since then.

Aedes albopictus *Aedes albopictus* were found in two District communities in 2012, Watertown and Savage. A specimen collected by an independent research group was the first record of the species in Carver County. An MMCD gravid trap near a tire recycling facility in Savage captured *Ae. albopictus* on two occasions, September 4 and September 10. This was the seventh year since 1991 when *Ae. albopictus* were collected near the tire recycling facility and the ninth when MMCD collected the species. *Aedes albopictus* have been found in four Minnesota counties: Carver, Dakota, Scott and Wright. The species has not successfully established itself at any discovered introduction point.

Carroll-Loye Biological Research was in Watertown conducting a repellent efficacy study on June 23 when they collected a single *Ae. albopictus* adult that landed on one of their volunteers.

Carroll-Loye Biological Research notified MMCD of their discovery on July 6 and MMCD staff initiated a survey of Watertown on July 10. From July 10 through the remainder of the season staff eliminated 77 tires, 141 containers and 4 tree holes in Watertown. Seventy-one larval samples were collected from container and tire habitats. Twelve ovitrap samples were collected from the woodlot where the original specimen was captured; three each on August 6, August 13, August 23 and September 4. Twenty-seven aspirator samples were collected from 21 woodlots in Watertown. There were no *Ae. albopictus* found in any of the MMCD samples collected. Based upon surveillance results, it is unlikely that the species was established in Watertown at the time the *Ae. albopictus* adult was collected. It is plausible that a small number of *Ae. albopictus* were introduced to the area shortly before the specimen was collected, but that number was insufficient for establishment.

Aedes japonicus Since their arrival in the District in 2007, *Ae. japonicus* have spread throughout the District and have become increasingly more common. The species is routinely collected through a variety of sampling methods. In 2012, our preferred surveillance methods when targeting *Ae. japonicus* were container/tire/tree hole sampling for larvae and aspirator sampling of wooded areas for adults.

Aedes japonicus larvae were found in 886 samples. Most were from containers (603) and tires (212). Larvae were found in other habitats as well, including: artificial or ornamental ponds (32), stormwater structures (10), catch basins (10), tree holes (4), wetlands (6), and unspecified habitats (9). Each year since *Ae. japonicus* arrived in the District, we have observed an increase in the frequency of larval collections, especially from containers and tires (Table 1.5).

Table 1.5 Percentage of samples from containers, tires, and tree holes that contained *Ae. japonicus* larvae, 2009 – 2012

Habitat type	2009	2010	2011	2012
Containers	4.2%	23.5%	36.2%	39.4%
Tires	2.9%	15.5%	21.3%	26.7%
Tree holes	0	8.8%	9.3%	4.7%

Aedes japonicus adults were identified in 335 samples. They were found in 199 aspirator samples, 53 CO_2 trap samples, 47 NJ trap samples, 20 gravid trap samples, and 16 two-minute sweep samples. Most of the samples contained only one *Ae. japonicus* adult; however, 72 samples contained more than one (Table 1.16).

Aedes japonicus were collected from 421 District sections in 2012 (Figure 1.25). The growth and spread of the *Ae. japonicus* population is highlighted when this is compared to the number of sections where they were found in previous seasons (Fig. 1.26). *Aedes japonicus* were also found in two Minnesota counties for the first time in 2012, Stearns and St. Louis.

Table 1.6 *Aedes japonicus* adult collections by each surveillance method used in the District in 2012

Surveillance method	Total samples	No. with *Ae. japonicus*	No. with >1 *Ae. japonicus*	Maximum capture
Aspirator	3,535	199	53	15
CO_2 trap	2,614	53	8	10
NJ trap	963	47	7	5
Gravid trap	762	20	4	4
Two-minute sweep	3,253	16	0	1

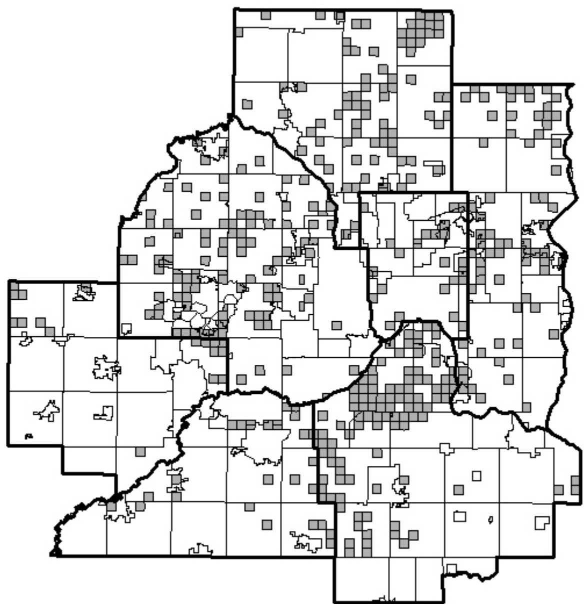


Figure 1.25 *Aedes japonicus* distribution in MMCD. Areas shaded in gray represent sections where *Ae. japonicus* were collected in 2012.

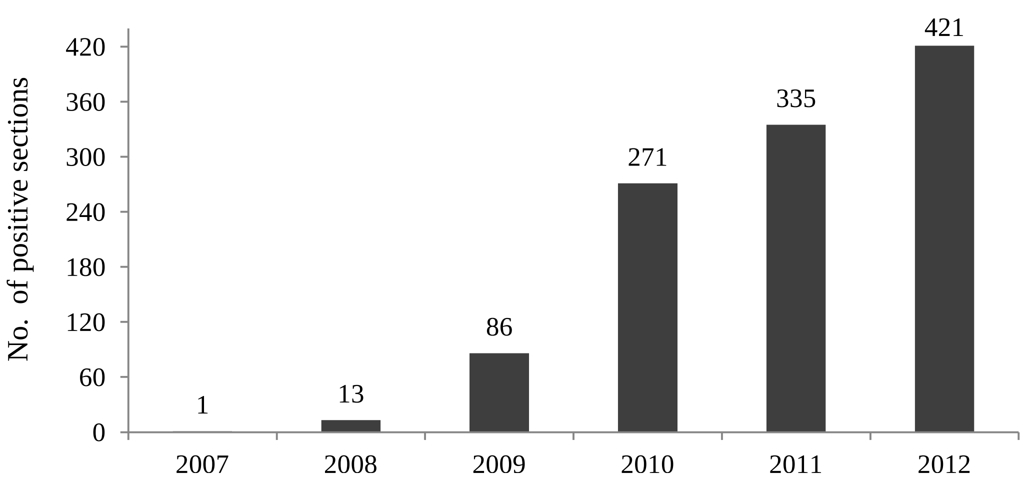


Figure 1.26 Number of MMCD sections with *Aedes japonicus* by year.

2013 Plans

Surveillance will continue as in past years with possible adjustments to monitor disease vector presence in the District, including refining *Cs. melanura* surveillance. The placement of CO_2, gravid, and New Jersey traps will be evaluated.

Chapter 2 Vector-borne Disease

2012 Highlights

- There were four La Crosse encephalitis cases in Minnesota, two in District residents
- WNV illness confirmed in 70 Minnesotans, 15 cases occurred in District residents
- WNV detected in 105 District mosquito samples and 20 birds
- First Minnesota EEE illness since 2001 in Chisago Co. horse
- Collected and recycled 21,493 waste tires
- Average *I. scapularis* per mammal was 0.950 in 2012, 2^{nd} highest since 1990
- MMCD did not receive reports of *Amblyomma americanum*; however, MDH had reports from Eden Prairie or Burnsville, Bloomington, and Rice County
- Signs posted in dog parks to educate & facilitate tick collections from the public
- 2012 tick-borne illness totals not yet available, but MDH reported 1,201 Lyme and 782 HGA (new record) cases in 2011
- Tick Risk Meter estimates posted weekly at mmcd.org & on Facebook

Background

District staff provides a variety of disease surveillance and control services, as well as public education, to reduce the risk of mosquito-borne illnesses such as La Crosse encephalitis (LAC), western equine encephalitis (WEE), eastern equine encephalitis (EEE), and West Nile (WNV) encephalitis, as well as tick-borne illnesses such as Lyme disease and human granulocytic anaplasmosis (HGA). Past District efforts have also included determining metro-area risk for infections of Jamestown Canyon virus, babesiosis, Rocky Mountain spotted fever, and Sin Nombre virus (a hantavirus).

La Crosse encephalitis prevention services were initiated in 1987 to identify areas within the District where significant risk of acquiring this disease exists. High-risk areas are defined as having high populations of the primary vector *Aedes triseriatus* (eastern tree-hole mosquito) or a history of LAC cases. MMCD targets these areas for intensive control efforts including public education, larval habitat removal (e.g., tires, tree holes, and artificial containers), and limited adult mosquito treatments. Additionally, routine surveillance and control activities are conducted at past LAC case sites. Surveillance for the invasive species *Aedes albopictus* (Asian tiger mosquito) and *Aedes japonicus* (Japanese rock pool mosquito) routinely occurs to detect infestations of these potential disease vectors.

The District collects and tests *Culex tarsalis* to monitor WEE activity. Western equine encephalitis can cause severe illness in horses and humans. The last WEE outbreak in Minnesota occurred in 1983.

Culex tarsalis and other *Culex* species are vectors of WNV, which arrived in Minnesota in 2002. Since then MMCD has investigated a variety of mosquito control procedures to enhance our comprehensive integrated mosquito management strategy to prevent West Nile illness. We do limited in-house testing of birds and mosquitoes for WNV, and use that information along with other mosquito sampling data to make mosquito control decisions.

2013 Plans

- Continue to provide surveillance and control for La Crosse encephalitis prevention
- Continue to improve surveillance and control of *Ae. japonicus*
- Continue catch basin larvicide treatments to manage WNV vectors
- Communicate disease prevention strategies to other local governments
- Continue surveillance for WNV and other mosquito-borne viruses
- Continue to monitor for *Ae. albopictus* and other exotic species
- Continue C*s. melanura* surveillance and evaluate control options for EEE prevention
- Continue *I. scapularis* surveillance at 100 sampling locations
- Continue with tick-borne disease education, tick identifications, and homeowner consultations
- Continue to post signs at dog parks and expand to additional locations
- Continue to update the Tick Risk Meter and provide updates on Facebook
- Continue to post signs at dog parks and expand to additional locations
- Continue to track collections of *A. americanum* or other new or unusual tick species

The first occurrence of EEE in Minnesota was in 2001. Since then, MMCD has conducted surveillance for *Culiseta melanura*, which maintains the virus in birds. A "bridge vector" such as *Cq. perturbans* can acquire the virus from a bird and pass it to a human in a subsequent feeding.

On the tick front, in 1989 the state legislature mandated the District "*to consult and cooperate with the MDH in developing management techniques to control disease vectoring ticks*." The District responded by beginning tick surveillance and forming the Lyme Disease Tick Advisory Board (LDTAB) in 1990. The LDTAB includes MMCD and Minnesota Department of Health (MDH) staff, local scientists, and agency representatives who offer their expertise to the tick-borne effort.

MMCD initiated tick surveillance to determine the range and abundance of the black-legged tick (*Ixodes scapularis*, also known as the deer tick) and the Lyme disease spirochete, *Borrelia burgdorferi*, within the District. To date, MMCD has mapped the current distribution of black-legged ticks (545 total sites sampled) and continues to monitor their populations in the metropolitan area. Additionally, District employees have assisted the University of Minnesota with spirochete and anaplasmosis studies. All collected data are summarized and presented to the MDH for their risk analysis.

Because wide-scale tick control is neither ecologically nor economically feasible, tick-borne disease prevention is limited to public education activities which emphasize tick-borne disease awareness and personal precautions. District employees continue to provide tick identifications upon request and are used as a tick referral resource by agencies such as the MDH and the Minnesota Department of Natural Resources (MnDNR).

As described in this and prior operational reports, the MMCD uses sophisticated surveillance techniques to determine the geographic distribution and estimated population levels of both mosquito and tick vectors in the metropolitan area. We continue to modify our surveillance efforts as new or different diseases and disease vectors are detected. This information is used to direct vector control and public education where needed. However, knowing the location and population levels of the vectors is only one part of the vector-borne disease cycle; understanding where vector-borne disease pathogens may be circulating is also important. Because MMCD lacks the equipment to test vectors or reservoir hosts for tick-borne and most mosquito-borne pathogens, samples are sent to MDH for testing.

In 2009, MMCD began examining ways to expand its programs to be more proactive in the area of vector-borne diseases. We contacted various agencies and held a Lyme Disease Tick Advisory Board meeting to solicit technical expertise. We would ultimately like to increase our ability to serve metro citizens given that in recent years we have more frequently received reports of rarely detected vector-borne illnesses (EEE, Powassan, Rocky Mountain spotted fever). Additionally, we are detecting invasive vector species (*Ae. albopictus*, *Ae. japonicus*, *Amblyomma americanum*) more often and our surveillance continues to show increases in population levels and geographic distribution of disease vectors (*Ae. japonicus*, *I. scapularis*).

2012 Mosquito-borne Disease Services

Breeding Source Reduction

Water-holding containers such as tires, buckets, tarps, and even plastic toys provide developmental habitat for many mosquito species including the LAC vector *Ae. triseriatus*, the invasive species *Ae. albopictus,* and *Ae. japonicus*, and the WNV vectors *Cx. restuans* and *Cx. pipiens*. Eliminating these container habitats is an effective strategy for preventing mosquito-borne illnesses. In 2012, District staff recycled 21,493 tires that were collected from the field (Table 2.1). Since 1988, the District has recycled 573,291 tires. In addition, MMCD eliminated 3,908 containers and filled 577 tree holes in 2012. This reduction of breeding sources occurred while conducting a variety of mosquito, tick, and black fly surveillance and control activities, including the 2,679 property inspections by MMCD staff.

Table 2.1 Number of tire, container, and tree hole habitats eliminated during each of the past ten seasons

Year	Tires	Containers	Tree holes	Total
2003	14,654	1,542	518	16,714
2004	15,751	1,415	1,128	18,294
2005	10,614	2,656	1,008	14,278
2006	10,513	2,059	228	12,800
2007	14,449	1,267	107	15,823
2008	16,229	1,615	93	17,937
2009	39,934	8,088	529	48,551
2010	23,445	5,880	275	29,600
2011	17,326	3,250	219	20,795
2012	21,493	3,908	577	25,978

La Crosse Encephalitis

La Crosse encephalitis is a viral illness that is transmitted in Minnesota by *Ae. triseriatus*. *Aedes albopictus* and *Ae. japonicus* are also capable of transmitting the La Crosse virus. Small mammals such as chipmunks and squirrels are the vertebrate hosts of the La Crosse virus, they amplify the virus through the summer months. The virus can also pass transovarially from one generation of mosquitoes to the next. Most cases of La Crosse encephalitis are diagnosed in children under the age of 16. In 2012 there were 72 La Crosse illnesses documented in the United States, 50 fewer than in 2011. Several La Crosse endemic states were impacted by severe drought in 2012. Populations of the mosquitoes that transmit the La Crosse virus tend to remain low during dry periods.

***Aedes triseriatus* Surveillance and Control** *Aedes triseriatus* is a container inhabiting, floodwater mosquito whose preferred natural habitat is tree holes. MMCD staff sample wooded mosquito habitats by aspirator to monitor adult *Ae. triseriatus* populations and to direct adult and larval control efforts. Weather conditions in 2012, especially frequent rainfall through July, allowed for nearly continuous *Ae. triseriatus* larval development from late April to mid August. Collections of *Aedes triseriatus* adults were in the normal range throughout the season (see Chapter 1, page 19, Fig. 1.16).

In 2012, MMCD staff collected 3,175 aspirator samples to monitor *Ae. triseriatus* populations. The District's treatment threshold ($\geq$ 2 adult *Ae. triseriatus*/aspirator collection) was met in 554 samples. Inspections of wooded areas and surrounding residential properties to eliminate larval habitat were provided as follow-up service when *Ae. triseriatus* adults were collected. Additionally, 395 adulticide applications to wooded areas were prompted by collections of *Ae. triseriatus* in aspirator samples.

Adult *Ae. triseriatus* were captured in 911 of 2,381 individual wooded areas sampled. This ratio, as well as the mean number of *Ae. triseriatus* captured per sample, approached those of the early 2000s, prior to the four drought summers of 2006 – 2009 (Table 2.2). Prior to 2012, the last season when a La Crosse encephalitis case occurred in the District was 2005.

Table 2.2 *Aedes triseriatus* aspirator surveillance data, 2000 – 2012

Year	Total areas surveyed	No. with *Ae. triseriatus*	Percent with *Ae. triseriatus*	Total samples collected	Annual Mean
2000	1,037	575	55.4	1,912	1.94
2001	1,222	567	46.4	2,155	1.32
2002	1,343	573	42.7	2,058	1.70
2003	1,558	470	30.2	2,676	1.20
2004	1,850	786	42.5	3,101	1.34
2005	1,993	700	35.1	2,617	0.84
2006	1,849	518	28.0	2,680	0.78
2007	1,767	402	22.8	2,345	0.42
2008	1,685	495	29.4	2,429	0.64
2009	2,258	532	24.0	3,125	0.56
2010	1,698	570	33.6	2,213	0.89
2011	1,769	566	32.0	2,563	0.83
2012	2,381	911	38.3	3,175	1.10

La Crosse Encephalitis in Minnesota There were four LAC cases reported in Minnesota in 2012. The four children affected are residents of Carver, Scott, Stearns, and Wright counties. Since 1970, the District has had an average of 2.2 LAC encephalitis cases per year (range 0 – 10, median 2). Since 1990, the mean is 1.4 cases per year (range 0 – 8, median 0).

While *Ae. triseriatus* is known as the primary vector of the La Crosse virus, less is understood of the role *Ae. japonicus* might play in the La Crosse cycle. *Aedes japonicus* is a competent vector of LAC in laboratory settings, but has not been implicated as vector in nature. The species was collected near two of three likely LAC exposure areas investigated by MMCD and at one LAC exposure area investigated by MDH. In 2012, MMCD submitted 220 pools of *Ae. japonicus* to MDH to be tested for the La Crosse virus as well as West Nile virus. Neither virus was detected from the *Ae. japonicus* samples.

MMCD La Crosse Case Responses MMCD was notified of the Carver County LAC case on August 13. The District's field response was initiated the next day. The suspected exposure location is the child's residence which is a farmstead surrounded by agricultural use open space. The residence and outbuildings sit on wooded property of approximately 12 acres. The nearest wooded area to the farmstead is over ¼ mile away. Two aspirator samples and one two-minute sweep sample were collected from the home property on August 14. The sweep contained 12 *Ae. triseriatus* and the aspirator samples contained two and 15 *Ae. triseriatus*. Backpack applications of permethrin were made to part of the woodlot immediately surrounding the home and outbuildings on August 14 and to the entire woodlot on August 17. An aspirator sample collected on August 23 contained zero *Ae. triseriatus*.

On August 14, MMCD staff located and eliminated 14 tires and 62 containers from the farmstead. Mosquito larvae were found in 64 of the 76 habitats, nearly all were *Ae. triseriatus*. Larvae from the many habitats were combined into 11 samples that were reared to adults in the MMCD lab. Fifteen pools containing 455 *Ae. triseriatus* were submitted to MDH for viral analysis. All of the samples were negative for LAC.

In the two weeks following the initial response MMCD staff eliminated an additional 116 tires and 96 container habitats from the area surrounding the Carver County La Crosse case site. Mosquito larvae were found in 21 of the tires and containers that were inspected. Seven of the samples collected contained *Ae. triseriatus* and two contained *Ae. japonicus*.

On August 23 MMCD was informed of the Wright County LAC case because MDH determined that, in addition to the child's home, a Hennepin County property in an area with a history of LAC cases was a possible exposure location.

The District's field response began on August 27. Few larval habitats were found in the neighborhood immediately surrounding the suspect exposure site; however, the search of an expanded area extending over ½ mile from the site resulted in the elimination of 136 tires, 57 containers and 28 tree holes. The nearest wooded habitat where *Ae. triseriatus* were found is approximately 250 yards from the residence where the infected child spent time, although the owner of the suspected exposure site eliminated two tires prior to our inspection of the area. Twenty larval samples were collected from the area, 12 contained *Ae. triseriatus* and three contained *Ae. japonicus*. Eight pools containing 49 *Ae. triseriatus* and two pools containing four *Ae. japonicus* were submitted to MDH for viral analysis. The samples were all negative for LAC.

MMCD staff collected 22 aspirator samples in response to the Wright/Hennepin LAC case. Eight of the samples contained *Ae. triseriatus* and five woodlots were treated with backpack applications of permethrin.

On October 1, MMCD was informed of the Scott County La Crosse encephalitis case. Our field response was initiated on October 3. MMCD staff inspected 130 properties yet eliminated only three tires and 18 containers. Due to little rainfall during the previous several weeks, only one of the containers discovered held any water. The mosquito larvae present in that container were all *Culex* species. Still, it is likely that the child's home area was the location of exposure to the LAC virus. Two properties in the neighborhood held several hundred tire and container habitats that were certainly available for *Ae. triseriatus* and other container inhabiting mosquito species during most of the 2012 mosquito season. Clean-up efforts initiated by other parties were underway on both properties prior to the diagnosis of the LAC case.

Eastern Equine Encephalitis

Eastern equine encephalitis (EEE) is a viral illness of humans, horses and some other domestic animals such as llamas, alpacas and emus. The EEE virus circulates among mosquitoes and birds and is most common in areas near the habitat of its primary vector, *Cs. melanura*. These habitats include many coastal wetlands, and in the interior of North America, tamarack bogs and other bog sites. The first record of EEE in Minnesota was in 2001 when three horses were diagnosed with the illness, including one from Anoka County. Wildlife monitoring by the Minnesota Department of Natural Resources has detected antibodies to the EEE virus in wolves and moose in northern Minnesota each year since 2007.

In 2012, the EEE virus was detected in 23 states. There were 12 human illnesses diagnosed: seven in Massachusetts, two in Vermont, and one each in Florida, North Carolina and Virginia. There were 213 veterinary reports of EEE illnesses in domestic animals, primarily horses, from 20 states. For the first time since 2001, a Minnesota horse was diagnosed with an EEE illness. The horse, stabled in Chisago County, became ill on October 13. EEE illnesses were also diagnosed in four Wisconsin horses.

***Culiseta melanura* Surveillance** *Culiseta melanura* are relatively rare in the District and are restricted to a few bog-type larval habitats. The greatest concentration of this type of habitat is in the northeast part of MMCD in Anoka and Washington counties. Still, *Cs. melanura* specimens are occasionally collected in other areas of the District.

Following the unusually high observations of *Cs. melanura* in 2011, the population in 2012 returned to a level to which we are more accustomed in the District (see Chapter 1, page 20). Twenty-six pools containing 175 *Cs. melanura* were submitted to MDH for viral analysis. All samples were negative for eastern equine encephalitis and West Nile virus.

In June we began a pilot project to evaluate adult control methods for *Cs. melanura*. With the assistance of an intern from the University of Kentucky, we monitored *Cs. melanura* at four locations each week using CO_2 traps and aspirator sampling. We set a threshold of five *Cs. melanura* (male or female) in a CO_2 trap or an aspirator collection to initiate an adulticide application.

The sites monitored are all near bog habitats where either *Cs. melanura* larvae or large numbers of adults have been collected in the past. The strategy we investigated was to reduce the *Cs. melanura* population through adult control by detecting when the adults emerged from the bog habitats and timing the application as soon as possible to prevent dispersal.

Thirteen of 116 samples exceeded the threshold, unfortunately only one was collected while the intern was available for pre and post-treatment surveillance. That collection was an aspirator sample containing four female and ten male *Cs. melanura* from June 5. On June 8 we applied 30 oz of permethrin by backpack and 24 oz of Anvil 2+2 to the site. Pre and post treatment sampling occurred at the treated site with aspirator collections immediately before the treatment, ½ hour after the treatment, and 24 hours after the treatment and with a CO_2 trap placed overnight following the treatment. Those collections were compared to samples from two untreated sites where *Cs. melanura* were collected in the past. For evaluation of our ability to control *Cs. melanura*, the results from this single trial were inconclusive. We did, however, identify bottlenecks where improvements can occur; specifically in how we prioritize sample delivery and processing and communication of results.

Western Equine Encephalitis

Western equine encephalitis (WEE) circulates among mosquitoes and birds in Minnesota. Occasionally, the virus causes illness in horses and less frequently in people. *Culex tarsalis* is the species most likely to transmit the virus to people and horses. In both 2004 and 2005, the virus was detected in *Cx. tarsalis* specimens collected in southern Minnesota. The virus has not been detected in Minnesota since then. MMCD's *Cx. tarsalis* collections were low during most of the 2012 season and while 169 samples were tested for West Nile virus, there were no samples tested for WEE.

West Nile Virus

West Nile virus (WNV) circulates among many mosquito and bird species. It was first detected in New York in 1998 and has since spread through the continental U.S., much of Canada, Mexico, Central America and South America. The virus causes many illnesses in humans and horses each year. West Nile virus was first detected in Minnesota in 2002. It is transmitted locally by several mosquito species, but most frequently by *Cx. tarsalis*, *Cx. pipiens* and *Cx. restuans*.

WNV in the United States West Nile virus transmission was documented in 48 states in 2012. There were no WNV findings in Alaska or Hawaii. The U.S. Centers for Disease Control and Prevention received reports of 5,387 West Nile illnesses from 48 states and the District of Columbia in 2012, the most cases reported since 2003. There were 243 fatalities attributed to

WNV infections. Texas had the greatest number of cases with 1,739. Nationwide screening of blood donors detected WNV in 597 individuals from 35 states. Ninety-four of the 597 presumptively viremic blood donors eventually developed clinical illnesses and are also included in the confirmed cases reported to CDC. Additionally, West Nile illness was diagnosed in 654 domestic animals, mainly horses, from 42 states.

WNV in Minnesota MDH reported 70 WNV illnesses from 34 Minnesota counties. One case in Stevens County was fatal. The earliest onset of a WNV illness in the state was May 29. That person had a history of travel both inside and outside the state of Minnesota. There were 33 presumptively viremic blood donors reported from 20 Minnesota counties. Additionally, there were 11 reports of WNV illness in horses from 10 Minnesota counties. Twenty-six birds from seven counties and 105 mosquito samples from six counties also returned positive results for WNV.

West Nile in the District There were 15 WNV illnesses reported in residents of the District. Eight of the individuals are residents of Hennepin County and two are residents of Ramsey County. Anoka, Carver, Dakota, Scott and Washington counties each had one case in 2012. At least two of the cases (Dakota Co., Scott Co.) were likely exposed outside of the District. Since WNV arrived in the Minnesota, the District has experienced an average of 9.6 WNV illnesses each year (range 0 – 25, median 6). When cases with known exposure locations outside of the District are excluded, the mean is 7.1 cases per year (range 0 – 17, median 4).

Surveillance for WNV Even though WNV reached detectable levels later than in some years, MMCD saw one of the most active WNV seasons on record in 2012. The earliest detection of WNV in the District was from an American crow collected on July 5. The first WNV positive mosquito samples were collected on July 11. In total, 20 bird specimens and 105 mosquito samples were positive for WNV.

MMCD conducted surveillance for WNV in wild birds with help from the public. Citizens reported dead birds to MMCD and some of those birds were selected for WNV analysis. Two hundred eighty-five reports of dead birds were received by telephone, internet, or from employees in the field. Response Biomedical Corporation's RAMP® tests were done on 26 birds. Twenty birds were positive for WNV (Table 2.3).

Several mosquito species from 39 CO_2 traps (13 elevated into the tree canopy) and 37 gravid traps were processed for viral analysis each week. In addition, we processed *Cx. tarsalis* collected by any of the CO_2 traps in our Monday night network for viral analysis. MMCD tested 740 mosquito pools using the RAMP® method. We also submitted 269 mosquito pools to MDH for WNV analysis by PCR. The samples sent to MDH were tested for LAC or EEE as well and consisted of *Ae. japonicus*, *Ae. triseriatus*, and *Cs. melanura*. Some results were pending as of the printing of this draft. One hundred-five mosquito samples were positive for WNV, all by the RAMP® method. Table 2.4 is a complete list of mosquitoes MMCD processed for viral analysis.

Table 2.3 Dates and locations of collection for WNV positive birds tested by MMCD

County	City	Date Found	Species
Hennepin	Minneapolis	7/5/2012	American Crow
Ramsey	St. Paul	7/12/2012	American Crow
Hennepin	Medina	7/13/2012	American Crow
Ramsey	St. Paul	7/20/2012	American Crow
Ramsey	St. Paul	7/24/2012	American Crow
Hennepin	Richfield	7/31/2012	American Crow
Hennepin	Hopkins	8/1/2012	American Crow
Hennepin	Brooklyn Center	8/5/2012	American Crow
Hennepin	New Hope	8/6/2012	American Crow
Hennepin	Minneapolis	8/7/2012	American Crow
Dakota	Mendota Heights	8/7/2012	American Crow
Hennepin	Hopkins	8/8/2012	American Crow
Hennepin	Brooklyn Park	8/9/2012	Blue Jay
Hennepin	Champlin	8/10/2012	American Crow
Anoka	Spring Lake Park	8/13/2012	American Crow
Hennepin	Robbinsdale	8/13/2012	American Crow
Dakota	Mendota Heights	8/18/2012	American Crow
Hennepin	Brooklyn Park	8/21/2012	Blue Jay
Ramsey	Moundsview	8/22/2012	American Crow
Ramsey	Little Canada	8/22/2012	American Crow

Table 2.4 Number of MMCD mosquito pools processed for viral analysis and minimum infection rate (MIR) by species, 2012

Species	Number of mosquitoes	Number of pools	WNV+ pools	MIR per 1000
Aedes albopictus	2	2	0	0
Aedes japonicus	307	222	0	0
Aedes triseriatus	555	33	0	0
Culex erraticus	311	40	0	0
Culex pipiens	195	8	3	15.38
Culex restuans	578	29	3	5.19
Culex salinarius	96	16	0	0
Culex tarsalis	2,010	169	2	1.00
Culex species	5,131	238	41	7.99
Culex pipiens/restuans	6,261	226	56	8.94
Culiseta melanura	175	26	0	0
Total	15,621	1009	105	6.72

The 105 WNV positive mosquito samples in 2012 was a new high for MMCD collections; the previous record was 89 in 2006. The first two WNV positive samples, both collected on July 11 were mixed pools of *Culex pipiens/restuans* from Ramsey County gravid traps. The majority of

WNV positive mosquito samples were collected in Ramsey County (75). Hennepin County mosquito collections produced 19 WNV positive samples, Anoka had six, Dakota had three, Carver and Scott counties had one each. The virus was amplified rapidly following the initial detections in early July. By the last week of July, *Culex* infection rates surpassed 13 per 1,000 and remained between 8 per 1,000 and 14 per 1,000 until late September (Figure 2.1).

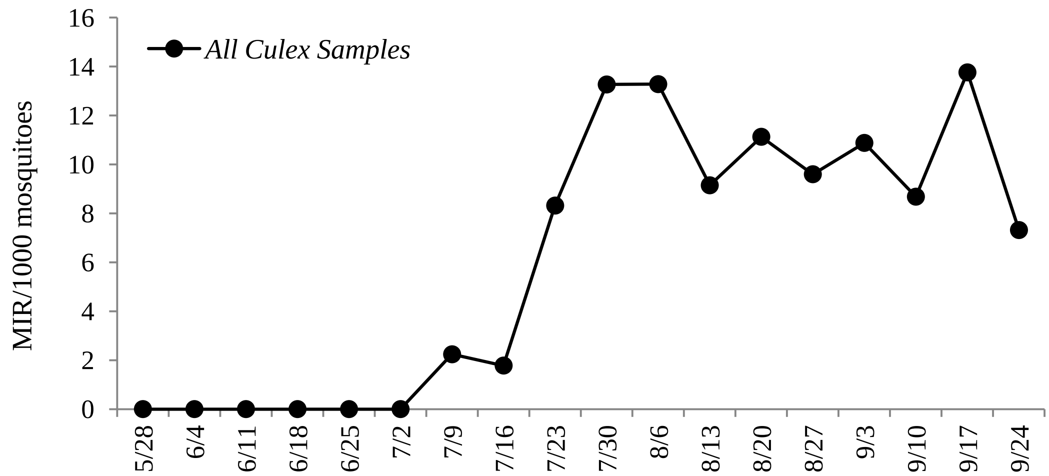


Figure 2.1 Weekly minimum WNV infection rates (MIR) for *Culex* samples, 2012. Dates listed are the Monday of each sampling week.

Larval *Culex* Surveillance

Culex mosquitoes lay rafts of eggs on the surface of standing water in both natural and man-made habitats. Detecting *Culex* mosquitoes can be challenging since larvae will not be present in a wet habitat unless adult, egg-laying females have been recently active, the area was wet and attractive for oviposition, and the characteristics of the site allow for survival of newly hatched mosquitoes. *Culex* are also less abundant than other types of mosquitoes in our area. Furthermore, in large wetlands larvae can disperse over a wide area or they may clump together in small, isolated pockets. They are generally easier to locate in small habitats (i.e., catch basins, stormwater management structures, etc.) where greater concentrations of larvae tend to be more evenly dispersed.

Stormwater Management Structures and Other Man Made Habitats Since 2006, MMCD field staff have been working to locate stormwater structures, evaluate habitat, and provide larval control. A classification system was devised to categorize potential habitats. Types of structures include culverts, washouts, riprap, risers (pond level regulators), underground structures, swimming pools, ornamental ponds and intermittent streams. In 2012, crews concentrated on surveying and applying larvicides to confirmed *Culex* habitats and mapping newly discovered structures.

Staff made 14,664 inspections of 9,596 structures in 2012. Mosquito larvae were found in 1,988 of the 6,702 habitats that were wet on the date of inspection. Inspectors collected 1,080 larval samples from stormwater structures and other man-made habitats. West Nile virus vector *Culex* species were found in 74.5 percent of the samples which is similar to the past two seasons (Table 2.5). In 2012, *Cx. restuans* and *Cx. tarsalis* were found less frequently than in 2010 and 2011 while *Cx. pipiens* and *Cx. salinarius* were found more frequently than during the past two years.

Table 2.5 Frequency of *Culex* vector species collected from stormwater management structures and other man made habitats in 2010, 2011 & 2012

	Yearly percent occurrence		
Species	2010 (N=2,020)	2011 (N=1,567)	2012 (N=1,080)
Cx. pipiens	31.8	13.7	39.8
Cx. restuans	64.2	65.3	53.1
Cx. salinarius	0.0	0.1	0.6
Cx. tarsalis	4.5	3.8	3.4
Any *Culex* vector species	77.4	76.6	74.5

Mosquito Control in Underground Stormwater Structures Many stormwater management systems include large underground chambers to trap sediments and other pollutants. There are several designs in use that vary in dimension and name, but collectively, they are often referred to as BMPs from *Best Management Practices for Stormwater* under the U.S. Environmental Protection Agency's National Pollution Discharge Elimination System (NPDES). MMCD has worked with city crews to survey and treat underground BMPs since 2005.
In 2012, we continued the cooperative mosquito control plan for underground habitats. Twenty-four municipalities volunteered their staff to assist with material applications (Table 2.6). Altosid® XR briquets were used at the label rate of one briquet per 1,500 gal of water retained. Briquets were placed in 888 underground habitats.

Table 2.6 Cities that assisted in treating underground stormwater habitats in 2012; 888 structures were treated and a total of 1,223 briquets were applied

City	Structures treated	Briquets used	City	Structures treated	Briquets used
Arden Hills	6	6	Lauderdale	13	13
Blaine	6	21	Lino Lakes	10	10
Bloomington	74	94	Maplewood	170	170
Brooklyn Park	4	15	Mendota Heights	33	43
Columbia Heights	7	10	Minneapolis	166	166
Crystal	5	14	New Brighton	5	8
Eagan	20	20	New Hope	6	12
Eden Prairie	12	20	Plymouth	150	335
Edina	17	17	Prior Lake	28	56
Fridley	10	35	Roseville	11	14
Golden Valley	125	125	Savage	6	15
Hastings	2	2	Spring Lake Park	2	2

Prolific mosquito development has been documented in local underground BMPs. The majority of mosquitoes found in BMPs are *Culex* species and successfully controlling their emergence from underground habitats will remain an objective in MMCD's comprehensive strategy to manage WNV vectors. We plan to continue working with municipalities to limit mosquito development in stormwater systems.

Larval Surveillance in Catch Basins Frequent spring and early summer rainfall in 2012 inhibited mosquito development in catch basins. Even though mosquitoes may often be found in catch basins during wet periods, many larvae are swept away by flushing rainfall before emerging as adults. After July, the weather was consistently warm and dry — ideal conditions for mosquito development in catch basins.

Larval surveillance was conducted primarily in St. Paul catch basins beginning the week of May 21 and ending during the first week of October (Figure 2.2). There were five weeks during that period with no catch basin larval surveillance. Larvae were found during 429 of 626 catch basin inspections (68.5%) in 2012.

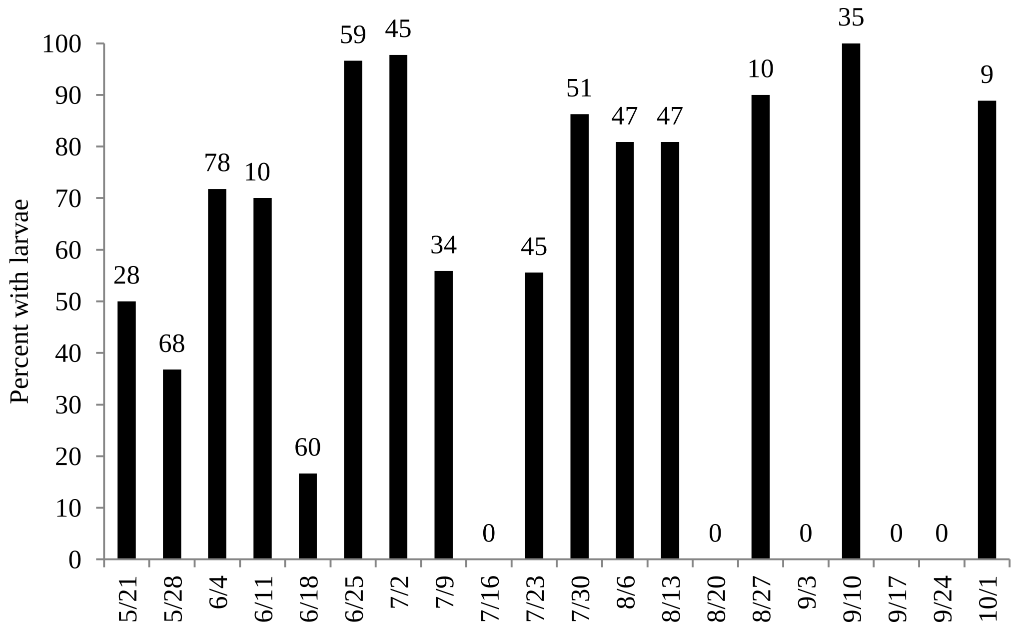


Figure 2.2 Percent of catch basins inspected with mosquitoes present in 2012. Bars are labeled with the number of inspections occurring during the week.

Mosquito larvae were identified from 420 catch basin samples. *Culex pipiens* were found in 73.1% of catch basin larval samples (Figure 2.3). *Culex restuans* were found in 67.4% of samples. At least one *Culex* vector species was found in 99.3% of samples. This was only the second year on record when more catch basin larval samples contained *Cx. pipiens* than *Cx. restuans*. *Culex restuans* were found as frequently in 2012 as they were in 2011, but *Cx. pipiens* were nearly three times more common than in 2011. From July 30 on, 162 of 168 catch basin larval samples contained *Cx. pipiens*.

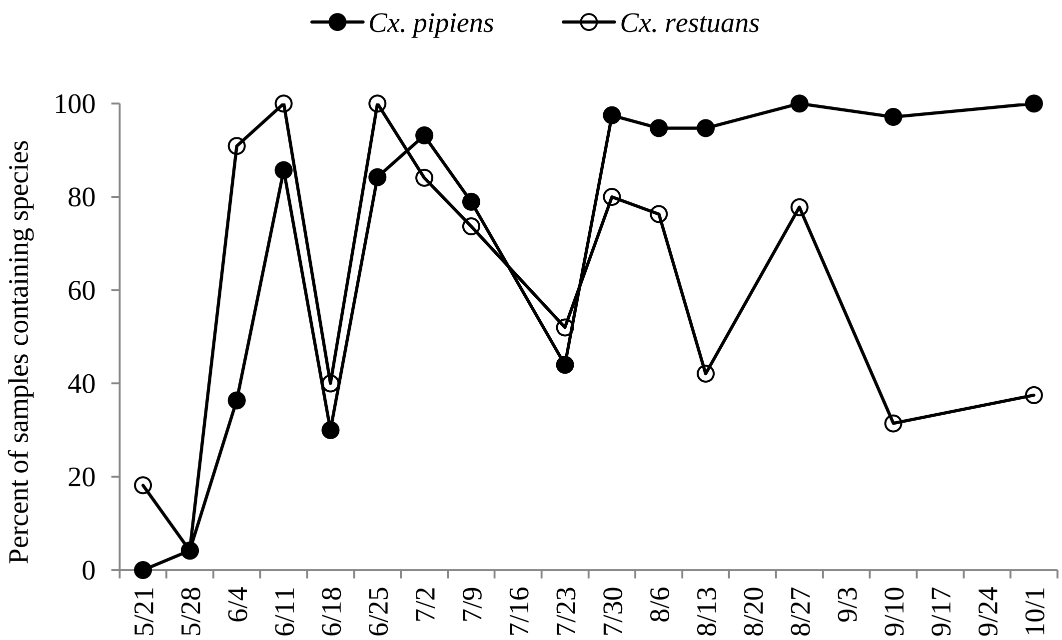


Figure 2.3 Occurrence of *Cx. pipiens* and *Cx. restuans* in catch basin larval samples by week.

2013 Plans Mosquito-borne Disease

Results from the surveillance efforts of several entities suggest that the eastern equine virus has been active in Minnesota and Wisconsin for much of the past decade. While rare, the severity of EEE cases in both humans and horses dictates the importance of improving our understanding of this virus and its vectors in our region. MMCD will continue to improve *Cs. melanura* surveillance and we will continue to investigate options for control. We will also work in collaboration with others to evaluate EEE risk in Minnesota.

District staff will continue to provide mosquito surveillance and control services for the prevention of La Crosse encephalitis. Preventive measures include *Ae. triseriatus* adult sampling, adult control and, especially, tree hole and container habitat reduction. Eliminating small aquatic habitats will also serve to control populations of *Ae. japonicus*.

The District will continue to survey aquatic habitats for *Culex* larvae for use in design and improvement of larval control strategies. The WNV and WEE vector *Cx. tarsalis* will remain a species of particular interest. Cooperative work with municipalities within the District to treat underground stormwater structures that produce mosquitoes will continue. District staff will continue to target *Culex* larvae in catch basins in our efforts to reduce WNV amplification.

MMCD will continue to conduct surveillance for WNV and other mosquito-borne viruses in coordination with MDH and others involved in surveillance for WNV in Minnesota. We plan to work with other agencies, academia and individuals to improve vector-borne disease prevention in the District, as well as to serve as a resource for others in the state.

2012 Tick-borne Disease Services

Ixodes scapularis Distribution

The District continued to sample the network of 100 sites set up in 1991-1992 to monitor potential changes in tick distribution over time. As in previous years, the primary sampling method involved capturing small mammals from each site and removing any attached ticks from them. Collections from the northeastern metropolitan area (primarily Anoka and Washington counties) have consistently detected *I. scapularis*, and in 1998 *I. scapularis* was detected in Hennepin and Scott counties for the first time. We collected at least one *I. scapularis* from all seven counties that comprise our service area for the first time in 2007. Since then we have continued to detect *I. scapularis* with greater frequency in sites located south of the Mississippi River and they appear to be prevalent now in many wooded areas. The 2012 report will be available on our website (www.mmcd.org) in June. Following are some 2012 highlights.

The average number of *I. scapularis* collected per mammal of 0.950 in 2012 is the second highest average since this study began in 1990. 2012 is comparable to the averages we have come to expect in recent years; the years 2000 – 2002, 2004, 2005, 2007, 2009 and 2010 were all ≥ 0.806 and all averages since 2000 are higher than those compiled from 1990-1999 (range 0.089 - 0.406). In addition, *I. scapularis* comprised 66% of our total tick collections in 2012, an occurrence for only the sixth time (all since 2002) that *I. scapularis* has comprised ≥ 50% of overall collections (Table 2.7).

In 2012, the overall positive site total was 71, a new all-time high, compared with a yearly positive site total typically in the 50s since 2000 (Table 2.8). Aside from 2011, in all years since 2007 we have collected at least one *I. scapularis* from all of the counties that comprise our service area, and in 2012, we again tabulated a new record positive site total from our counties located south of the Mississippi River. The total of 27 surpasses the previous record high of 26 from 2011. As has been typical in recent years, the majority of the Dakota County (13 of 15) sites were positive in 2012 (a new record high for Dakota County). We also found *I. scapularis* in half of the Scott (4 of 8) and Hennepin (7 of 14) county sites and in 3 of 7 (a record high) of Carver County sites.

While the average *I. scapularis* and positive site totals provide a picture of what occurred in 2012, the number and percentage of infested mammals in 2012 versus any other year is another way to evaluate *I. scapularis* (Table 2.8) populations. The average number of *I.* scapularis per infested mammal (i.e., tick load) alone does not tell the whole story. In fact, 2005 had the highest tick loads per infested mammal, while tick loads in 2012 were similar to past years. The percent of infested mammals has increased over the years, however, and 2012 had the highest percentage of infested mammals.

Table 2.7 Numbers and percentages of tick species collected by stage and year

Year	No. sites	Total ticks collected	*Dermacentor variabilis* Percent larvae (n)		*Dermacentor variabilis* Percent nymphs (n)		*Ixodes scapularis* Percent larvae (n)		*Ixodes scapularis* Percent nymphs (n)		Other species[b] percent (n)	
1990[a]	3651	9957	83	(8289)	10	(994)	6	(573)	1	(74)	0	(27)
1991	5566	8452	81	(6807)	13	(1094)	5	(441)	1	(73)	0	(37)
1992	2544	4130	79	(3259)	17	(703)	3	(114)	1	(34)	0	(20)
1993	1543	1785	64	(1136)	12	(221)	22	(388)	1	(21)	1	(19)
1994	1672	1514	53	(797)	11	(163)	31	(476)	4	(67)	1	(11)
1995	1406	1196	54	(650)	19	(232)	22	(258)	4	(48)	1	(8)
1996	791	724	64	(466)	20	(146)	11	(82)	3	(20)	1	(10)
1997	728	693	73	(506)	10	(66)	14	(96)	3	(22)	0	(3)
1998	1246	1389	56	(779)	7	(100)	32	(439)	5	(67)	0	(4)
1999	1627	1594	51	(820)	8	(128)	36	(570)	4	(64)	1	(12)
2000	1173	2207	47	(1030)	10	(228)	31	(688)	12	(257)	0	(4)
2001	897	1957	54	(1054)	8	(159)	36	(697)	2	(44)	0	(3)
2002	1236	2185	36	(797)	13	(280)	42	(922)	8	(177)	0	(9)
2003	1226	1293	52	(676)	11	(139)	26	(337)	11	(140)	0	(1)
2004	1152	1773	37	(653)	8	(136)	51	(901)	4	(75)	0	(8)
2005	965	1974	36	(708)	6	(120)	53	(1054)	4	(85)	0	(7)
2006	1241	1353	30	(411)	10	(140)	54	(733)	4	(58)	1	(11)
2007	849	1700	47	(807)	8	(136)	33	(566)	10	(178)	1	(13)
2008	702	1005	48	(485)	6	(61)	34	(340)	11	(112)	1	(7)
2009	941	1897	48	(916)	9	(170)	39	(747)	3	(61)	0	(3)
2010	1320	1553	21	(330)	7	(101)	65	(1009)	7	(107)	0	(6)
2011	756	938	40	(373)	10	(97)	28	(261)	22	(205)	0	(2)
2012	100	2223	25	(547)	10	(211)	59	(1321)	6	(139)	0	(5)

[a] 1990 data excludes one *Tamias striatus* with 102 *I. scapularis* larvae and 31 nymphs
[b] other species mostly *Ixodes muris.* 1999—second adult *I. muris* collected

Table. 2.8 Number of positive sites, total mammals collected; number and percent of infested mammals; and average *I. scapularis* per infested mammal by year: 1990-2012[a]

Year	Number positive sites	Total mammals	Number infested	Percent (%) infestation	Average *I. scap.* per infested mammal
1990	32	1,302	106	8.14	2.91
1991	39	2,354	145	6.16	2.83
1992	24	1,268	58	4.57	0.91
1993	37	1,543	141	9.14	2.90
1994	35	1,672	159	9.50	3.42
1995	35	1,406	124	8.82	2.47
1996	30	791	61	7.71	1.67
1997	24	728	52	7.14	2.27
1998	39	1,246	128	10.27	3.95
1999	46	1,627	221	13.58	2.87
2000	55	1,173	232	19.78	4.07
2001	49	897	188	20.96	3.94
2002	56	1,236	223	18.04	4.93
2003	39	1,226	144	11.77	3.31
2004	46	1,152	200	17.36	4.88
2005	53	965	206	21.35	5.43
2006	52	1,241	241	19.42	3.28
2007	53	849	181	21.32	4.11
2008	52	702	133	18.95	3.40
2009	57	941	198	21.04	4.08
2010	70	1,320	271	20.53	4.12
2011	55	756	158	20.90	2.95
2012	71	1,537	422	27.46	3.46

[a]Mammals or sites with at least one *I. scapularis*

Tick-borne Disease – Lyme Disease and Human Granulocytic Anaplasmosis The Minnesota Department of Health (MDH) has been documenting record-setting human tick-borne disease case totals since 2000. Pre-2000, the highest Lyme case total was 302 but since 2000 the Lyme totals have ranged from 463 to 1,293 cases and typically average >1,000 per year. Human granulocytic anaplasmosis (HGA) cases have also been on the rise. After averaging roughly 15 cases per year through 1999, the total HGA case numbers ranged from 78 to 186 from 2000 – 2006, then increased into the range of the 300s. The all-time high, statewide Lyme disease case record (1,293) was set in 2010 with the all time high HGA record of 782 set in 2011. Case data for 2012 is not yet available.

Additional Updates and New Strategies 2012

Posting Signs, Dog Parks Since the initial suggestion of the Technical Advisory Board (TAB) in 2010, we have visited dog parks and vet offices as part of our outreach. Since 2010, signs have been posted in approximately 21 parks, with additional signs posted in active dog walking areas, including at Stubbs Bay Park, Luce Line Trail Entrance. We have also worked on expanding our sign placements into additional metro locations.

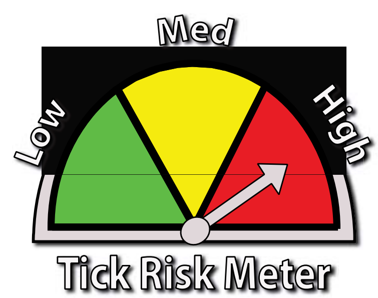
Targeted Education Material Distribution Brochures, tick cards, and/or posters were distributed to roughly 100 locations (city halls, libraries, schools, child-care centers, retail establishments, vet clinics, parks) across the metro as well as at fair booths and city events, with many more mailed upon request.

Occurrence of *Amblyomma americanum* (Lone Star Tick) *Amblyomma americanum* is an aggressive human biter and can transmit human monocytic ehrlichiosis (HME), among other potential pathogens. Both the tick and HME are more common to the southern US, but *A. americanum*'s range is known to be moving northward. *Amblyomma* ticks have been submitted to MMCD from the public on a rare, sporadic basis and this species was first collected by MMCD in 1991 via a road kill examination of a white-tailed deer (*Odocoileus virginianus*). However, for the first time in a number of years, *Amblyomma* was submitted to MDH and MMCD by the public in 2009 (Minneapolis and Circle Pines). In 2010, MMCD received *Amblyomma* specimens from Eagan, Mound, and the Orono/Lake Minnetonka areas of the metro. In 2011, the MDH had submissions of adults from Shakopee, Lindstrom, and Hennepin County (unconfirmed location), and in 2012 the MDH had three more *Amblyomma* submitted from Eden Prairie or Burnsville, Bloomington, and Rice County. MMCD did not receive any *Amblyomma* in 2011 or 2012.

Tick Identification Services/Outreach

The overall scope of tick-borne disease education activities and services were maintained in 2012 using previously described methods and tools although we did expand our outreach efforts by implementing new strategies for tick-borne disease risk reduction.

Tick Risk Meter Tick activity estimate was available on our website beginning April 20 until ticks became inactive in late fall (they were still active until December 9 in 2012!). Deer tick activity levels (low, medium, high) were estimated throughout the entire 2012 season and were based on the dynamics of peaks in the general deer tick life cycle bell curve for Minnesota in combination with actual numbers of deer ticks found on MMCD field staff. "Tick Thursday" was the District-wide collection day and the website was updated Fridays by noon. We also posted updates on Facebook.



2013 Plans for Tick-borne Disease Services

Metro Surveillance

We plan to continue the metro-based *I. scapularis* distribution study that began in 1990 unchanged.

Tick Identification Services/Outreach

We plan to maintain our tick-borne disease education activities and services (including tick identifications and homeowner consultations) using previously described methods and tools, including weekly website updates of our Tick Risk Meter, and via social media. Since our *I. scapularis* collections as well as the MDH's tabulated human tick-borne disease case totals remain elevated, we will continue to stock local parks and other appropriate locations with tick cards, brochures and/or posters and signs along with targeting specific metro townships based on higher human case totals and/or numbers of *I. scapularis* collected. We will also distribute materials at local fairs and the Minnesota State Fair, set up information booths at events as opportunities arise, and continue to offer an encompassing slide presentation.

Outreach Expansion

Posting Signs We will continue to post at dog parks and plan to continue our expansion to additional areas. As in past years, signs will be posted in the spring and removed in late fall after *I. scapularis* activity ceases for the year.

***Amblyomma americanum* / New or Unusual Tick Species** MMCD and MDH continue to discuss possible strategies that would enable both agencies to detect possible establishment of *A. americanum* in Minnesota. MMCD will continue to monitor for this tick in our surveillance and to track collections turned in by the public as part of our tick identification service. Both MMCD and MDH plan to maintain our current notification process to the other agency upon identifying an *A. americanum* or other new or unusual tick species.

U of MN Collaboration – Rearing Bot Flies

Each facility will collect roughly 20 pupal bot flies (*Cuterebra fontinella fontinella* Clark) from *Peromyscus leucopus* and rear to adulthood. We will give the adult flies to Dr. Roger Moon (UM-St. Paul) for identification. Previous efforts of this collaborative work were presented in a poster, listed in 2012 Presentations & Posters in Chapter 6.

Chapter 3 Mosquito Control

2012 Highlights

- 10,628 more acres worth of larvicides were applied to wetlands in 2012 than in 2011
- Aerial *Aedes vexans* prehatch treatments increased significantly in 2012 (12,412 acres) compared to 2011 (4,576 acres) and approached 2010 (14,410 acres)
- A cumulative total of 226,934 catch basin treatments were made in three rounds to control vectors of WNV
- 17,215 fewer acres worth of adulticides were applied in 2012 than in 2011

2013 Plans

- Integrate Natular™ G30 and MetaLarv™ S-PT into our *Aedes vexans* prehatch treatment program
- Begin to incorporate September Vectolex® CG treatments in our cattail mosquito control program
- Work closely with MnPCA to fulfill the requirements of a NPDES permit
- Continue to increase vector surveillance and control in response to the observed geographic expansion of *Ae. japonicus* within the District

Background

The mosquito control program targets the principal summer pest mosquito *Aedes vexans*, several species of spring *Aedes*, the cattail mosquito *Cq. perturbans*, and several disease vectors (*Ae. triseriatus, Cx. tarsalis, Cx. pipiens, Cx. restuans, Cx. salinarius*). *Aedes japonicus*, another potential vector species, arrived on the scene in 2007 and has also increased control needs.

Due to the large size of the metropolitan region (2,975 square miles), larval control was considered the most cost-effective control strategy in 1958 and remains so today. Consequently, larval control is the focus of the control program and the most prolific mosquito habitats (over 77,000 potential sites) are scrutinized for all human-biting and vector mosquitoes.

Larval habitats are diverse. They vary from very small, temporary pools that fill after a rainfall to large acres of wetlands. Small sites (ground sites) are three acres or less and field crews treat them by hand. Large sites (air sites) are treated by helicopter only after certain criteria are met: larvae occur in sufficient numbers (threshold), larvae are of a certain age (instar), and larvae are the target species (human biting or disease vector).

The insect growth regulator methoprene (Altosid®, MetaLarv™) and the soil bacterium *Bacillus thuringiensis* var *israelensis* or *Bti*, (VectoBac®) are the primary larval control materials. Other materials including *B. sphaericus* (VectoLex® CG) and *Saccharopolysora spinosa* or spinosad (Natular™ G30) are being integrated into larval control programs. Adult control augments the larval control program when necessary.

The District uses priority zones to focus service in areas where it will benefit the highest number of citizens (Figure 3.1). Priority Zone 1 (P1) contains the majority of the population of the Twin Cities metropolitan area and has boundaries similar to the Metropolitan Urban Service Area (MUSA, Metropolitan Council). Priority Zone 2 (P2) includes sparsely populated and rural parts of the District. We consider small towns or population centers in rural areas as satellite communities and they receive services similar to P1. Citizens in P1 receive full larval and adult vector and nuisance mosquito control. In P2, the District focuses on vector control and provides additional larval and adult control services as resources allow.

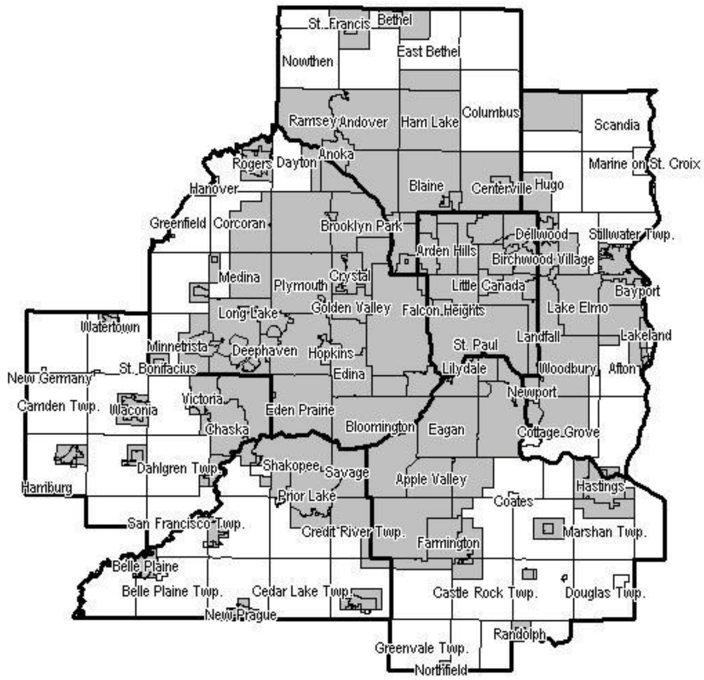


Figure 3.1 Priority Zones 1 (shaded) and 2 (white), with District county and city/township boundaries, 2012.

To supplement the larval control program, adulticide applications are performed after sampling detects mosquito populations meeting threshold levels (especially disease vectors), primarily in high use park and recreation areas, for public events, or in response to citizen mosquito annoyance reports.

Three synthetic pyrethroids are used: resmethrin, permethrin, and sumithrin. Sumithrin (Anvil®) and two formulations of natural pyrethrins, Pyrenone® and Pyrocide®, can be used in agricultural areas. A description of the control materials is found in Appendix C. Appendix D indicates the dosages of control materials used by MMCD, both in terms of amount of formulated (and in some cases diluted) product applied per acre and the amount of active ingredient (AI) applied per acre. Appendix E contains a historical summary of the number of acres treated with each control material (2004-2012). Pesticide labels are located in Appendix F.

2012 Mosquito Control

Larval Mosquito Control

Thresholds *Bti* treatments in small ground sites are only done where larvae are present, as measured by taking 10 dips with a standard 4-inch diameter dipper. Treatments with materials formulated for application prior to flooding and egg hatch (prehatch materials) are applied to sites with a history of larvae present. For helicopter *Bti* treatments, the average number of larvae per 10 dips must be over a threshold value to warrant treatment. P1 and P2 areas have different thresholds to help focus limited time and materials on productive sites near human population centers (Table 3.1). Spring *Aedes*, which tend to be long-lived, aggressive biters, have lower thresholds. In 2011 we increased the spring *Aedes* threshold to conserve larvicides. After mid-May, when most larvae found are floodwater summer species, thresholds are increased. If *Aedes* and *Culex* are both present in a site and neither meet threshold, the site can be treated if the combined count meets the threshold. We increased the *Culex* 4 threshold in 2012, primarily because many of these larvae are *Culex restuans* (an amplifying vector) rather than bridge vectors (*Culex tarsalis, Culex salinarius*).

Table 3.1 Larval thresholds (average number of larvae in ten dips) in P1 and P2.

	Spring *Aedes*		Summer*		*Culex* 4**	
Year	P1	P2	P1	P2	P1	P2
2010	0.1	0.5	2.0	5.0	1.0	1.0
2011	0.5	1.0	2.0	5.0	1.0	1.0
2012	0.5	1.0	2.0	5.0	2.0	2.0

* Summer = Summer *Aedes* or *Aedes* + *Culex* 4
** *Culex* 4 = *Cx. restuans, Cx. pipiens, Cx. salinarius, Cx. tarsalis*

Season Overview The 2012 season was notable for its early, warm spring that began very dry. Spring *Aedes* larvae began hatching in the early snowmelt in March. The first larvicide treatments were completed on April 4, three weeks earlier than in 2011. Precipitation was above average with frequent rain from April through mid-June. (Chapter 1, Figure 1.1). Large parts of the District received 9-10 inches of rain in May. Precipitation decreased significantly by late June. As a result, we treated one large brood of spring *Aedes* and four large and seven small-medium broods of *Aedes vexans* (a typical season has four large broods) (Figure 3.2). September was one of the driest on record.

Total larval control material use in 2012 was higher than 2011 (Table 3.2), but still less than the record larvicide total 297,000 acres in 2010. By late June, the budget for helicopters and materials was almost 90% expended which prompted us to ask the Commission for access to reserve funds (previously requested in 2002, 2010 and 2011). The cessation of rainfall after mid-June minimized additional large *Ae. vexans* broods; consequently, we did not use any reserve funds.

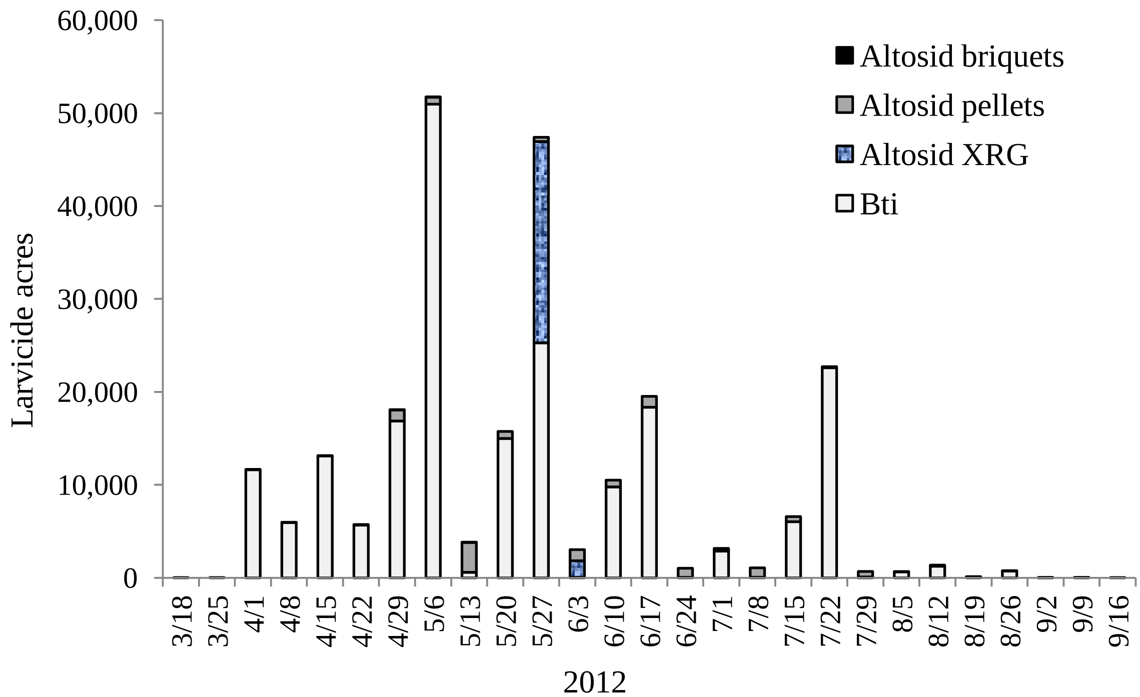


Figure 3.2 Acres treated with larvicide each week (March-September 2012). Date represents start date of week.

Table 3.2 Comparison of larval control material usage in wetlands (including stormwater structures other than catch basins) and in stormwater catch basins for 2011 and 2012 (research tests not included)

	2011		2012	
Material	Amount used	Area treated	Amount used	Area treated
Wetlands				
Altosid briquets	286.64 cases	205 acres	228.71 cases	165 acres
Altosid pellets	99,947.02 lb	30,749 acres	34,646.62 lb	13,172 acres
Altosid XR-G	133,360.00 lb	13,336 acres	234,360.00 lb	23,436 acres
VectoLex CG	0.00 lb	0 acres	0.00 lb	0 acres
Natular G30	0.00 lb	0 acres	47,629.65 lb	9,524 acres
MetaLarv S-PT	0.00 lb	0 acres	10,865.65 lb	2,750 acres
VectoBac G	1,615,714.75 lb	201,957 acres	1,362,095.11 lb	207,827 acres
Larvicide subtotals		246,246 acres		256,874 acres
Catch basins				
Altosid briquets	0.00 cases	0 CB[1]	2.08 cases	458 CB[1]
Altosid pellets	1,841.33 lb	234,033 CB	1,751.30 lb	226,398 CB
Natular XRT	4.90 cases	1,078 CB	0.00 cases	0 CB
VectoLex CG	0.00 lb	0 CB	0.61 lb	78 CB
CB subtotals		235,111 CB		226,934 CB

[1]CB=catch basin treatments

A primary limiting factor for treatments continues to be budgetary. The District is actively looking at ways to reduce cost while maintaining treatment capacity, for example, by testing new materials or formulations. We continued to study how to reduce the amount of time and personnel required for effective season-long control of mosquitoes in many kinds of sites. In 2012, we switched to the most cost-effective larvicides and dosages.

In addition to the rainfall pattern, several operational changes enabled us to maintain the service levels provided by the District in 2012 by switching to lower cost materials or lower dose rates:

- The 2012 control materials budget remained the same as 2011;
- We retained the higher larval treatment thresholds for spring *Aedes* in P1 and P2 that were increased in 2011 (Table 3.1);
- To conserve control materials, we reduced the *Bti* dosage from 8 lb/acre to 5 lb/acre in late May;
- Aerial and ground cattail treatment totals (24,375 acres) in 2012 were comparable to 2011 (25,629 acres);
- We converted all aerial cattail treatments to Altosid XR-G because per acre material cost of XR-G sand is lower than Altosid pellets;
- Altosid pellets were mostly restricted to 11,944 acres of ground *Ae. vexans* prehatch treatments (2.5 lb/acre instead of the 4 lb/acre aerial dosage) and ground cattail treatments (873 acres);
- We used Natular G30 and MetaLarv S-PT for most aerial *Ae. vexans* prehatch treatments (12,148 acres) and some ground treatments (126 acres);
- We were able to complete 12,412 acres of aerial *Ae. vexans* prehatch treatments in 2012 which is close to our 2010 total (14,410 acres).

In 2012, adult *Ae. vexans* in CO_2 trap counts peaked above threshold beginning in early June through late July (Figure 3.3). Customer calls in 2012 (3,207) were lower than in 2011 (4,232) and more similar to 2010 (3,092).

Stormwater catch basin treatments to control *Culex* mosquitoes began in early June and ended in early September. Most catch basins were treated three times with Altosid pellets (3.5 grams per catch basin) from June through mid-September (Table 3.2).

Surveillance detected *Ae. japonicus* in 417 sections within all District counties in 2012 (Chapter 1, Figure 1.25); *Ae. japonicus* was found in 334 sections in 2011, 271 sections in 2010 and 86 sections in 2009 (Chapter 1, Figure 1.26). Although most larvae have been found in containers, they have also been found in a wide variety of habitats, including stormwater structures and catch basins. Control efforts for this species continued to focus on removal of artificial container larval habitat, plus treatment of other habitat as needed.

We continued to work with Minnesota Pollution Control Agency (MnPCA) to satisfy the requirements of our National Pollution Discharge Elimination System (NPDES) permit. We submitted our Notice of Intent (NOI) and paid permit fees in April 2012. We plan to submit our 2012 treatment report to MnPCA after the beginning of 2013. Our report will contain site-specific larval surveillance and larvicide treatment records and GIS-encoded locations of sites (more details included in Chapter 6).

Adult Mosquito Control

Thresholds Adult mosquito control operations are considered when mosquito levels rise above established thresholds of two mosquitoes in a two-minute sweep or two-minute slap count or 130 mosquitoes in an overnight CO_2 trap. In 2004, we established treatment thresholds specific to the *Culex* 4 species: *Cx. restuans*, *Cx. pipiens*, *Cx. salinarius*, and *Cx. tarsalis*. The thresholds are one of any of these *Culex* species in a two-minute sweep, five in an overnight CO_2 trap, five in a two-day gravid trap, and one *Cx. tarsalis* in an aspirator sample. Adulticide treatments were also considered when two or more *Ae. triseriatus* were captured in an aspirator sample. One *Ae. japonicus* captured using any adult surveillance method was the threshold established in 2009. We may modify this threshold as we learn more about the impacts of *Ae. japonicus*' expansion in the District. In response to elevated *Culiseta melanura* abundance in 2011, early in 2012 we established a threshold of five *Cs. melanura* captured in an overnight CO_2 trap or aspirator sample for consideration of an adulticide treatment. This threshold was based upon surveillance data collected between 2002 and 2011.

Season Overview In 2012, adult mosquito levels rose in mid-June before peaking in late June through mid-July; at those times counts over threshold were fairly widespread (Figure 3.3). In 2012, MMCD applied 17,215 fewer acres worth of adulticides than in 2011 (Table 3.3, Appendix E). Figure 3.3 shows weekly adulticide acres treated (line). The peaks in late June and early July reflect a response to both widespread *Ae. vexans* and *Cq. perturbans* emergence and increasing numbers of *Culex* (WNV vectors). The number of traps over the vector threshold remained high for much of the summer. Most adulticide treatments later in the summer were barrier treatments targeting vectors. Resmethrin use was reduced as we used our stocks in response to the manufacturer (Bayer) withdrawing its Scourge® re-registration effort.

Table 3.3 Comparison of adult control material usage in 2011 and 2012

	2011		2012	
Material	Gallons used	Acres treated	Gallons used	Acres treated
Permethrin	1,467.89	7,544	1,675.27	8,578
Resmethrin	301.69	24,605	94.67	8,078
Sumithrin*	643.86	29,208	645.14	27,486
Total		61,357		44,142

* Products labeled for use in agricultural areas

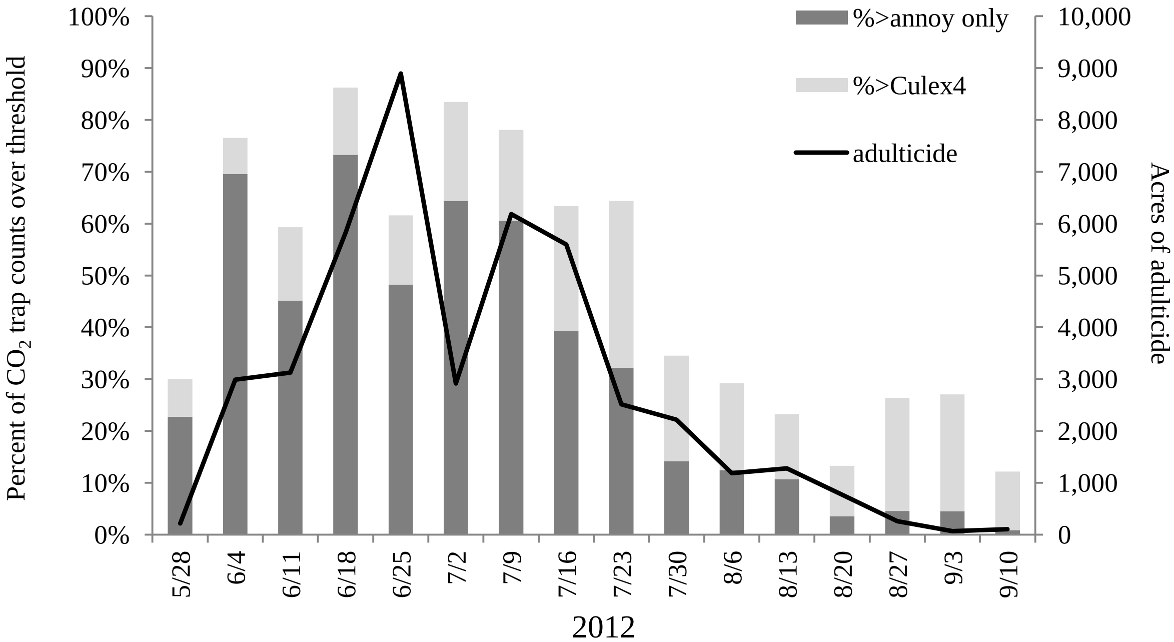


Figure 3.3 Percent of Monday CO_2 trap locations with counts over threshold (date is day of CO_2 trap placement), showing subtotals by annoyance or *Culex* vector thresholds, with acres of adulticides applied, 2012.

2013 Plans for Mosquito Control Services

Integrated Mosquito Management Program

In 2013, MMCD will review all aspects of its integrated mosquito management program to ensure that budgetary resources are being used as effectively as possible with the goal of maximizing mosquito control services per budget dollar and complying with all NPDES-related permit requirements. Further discussion regarding the Clean Water Act's NPDES permit requirements is in Chapter 6. Our Control Materials budget in 2013 will be increased slightly compared to 2012. Most of the increase will be used to support larval control.

Larval Control

Cattail Mosquitoes In 2013, control of *Cq. perturbans* will use a strategy similar to that employed in 2012. MMCD will focus control activities on the most productive cattail marshes near human population centers. Altosid briquet applications will start in early March to frozen sites (e.g., floating bogs, deep water cattail sites, remotely located sites). Because of new control material prices, more acres will be treated with Altosid pellets and MetaLarv S-PT and fewer with Altosid XR-G sand to decrease per-acre treatment costs. Beginning in late May, staff will apply MetaLarv S-PT (3 lb/acre), Altosid pellets (4 lb/acre) and Altosid XR-G sand (10 lb/acre) aerially. Ground sites will be treated with Altosid pellets (4 lb/acre) and MetaLarv S-PT (3 lb/acre). Staff will begin to integrate late summer VectoLex CG applications (15 lb/acre) into the cattail mosquito control program based upon site inspections completed between mid-August and mid-September.

Floodwater Mosquitoes The primary control material will again be *Bti* corn cob granules. Budgeted larvicide needs in 2013, mainly *Bti* - VectoBac G, Altosid pellets, Altosid XRG sand, Natular G30, and MetaLarv S-PT (tested in 2010 and 2011 as VBC-60215), are expected to be similar to the five-year average larvicide usage (232,542 acres). As in previous years, to minimize shortfalls, control material use may be more strictly rationed during the second half of the season, depending upon the amount of the season remaining and control material supplies. Regardless of annoyance levels, MMCD will maintain sufficient resources to protect the public from potential disease risk.

Staff will treat ground sites with methoprene products (Altosid pellets, Altosid briquets, MetaLarv S-PT), Natular G30 or *Bti* corncob granules. During a wide-scale mosquito brood, sites in highly populated areas will receive treatments first. The District will then expand treatments into less populated areas where treatment thresholds are higher. We will continue with the larval treatment thresholds used in 2012 (Table 3.1).

Each year staff review ground site histories to identify those sites that produce mosquitoes most often which helps us to better prioritize which sites to inspect before treatment, which sites to pre-treat with Natular G30 or methoprene products before flooding and egg hatch, and which sites to not visit at all. The ultimate aim is to provide larval control services to a larger part of the District by focusing on the most prolific sites.

Vector Mosquitoes Employees will routinely monitor and control *Ae. triseriatus*, *Ae. japonicus*, *Ae. albopictus*, *Cs. melanura*, *Cx. tarsalis*, *Cx. pipiens*, *Cx. restuans*, and *Cx. salinarius* populations (See Chapter 2).

MMCD has expanded control to four *Culex* species since the arrival of WNV in 2002. Ground and aerial larvicide treatments of wetlands have been increased to control *Culex*. Catch basin treatments control *Cx. restuans* and *Cx. pipiens* in urban areas. Most catch basins will be treated with Altosid pellets. Catch basins selected for treatment include those found holding water, those that potentially could hold water based on their design, and those for which we have insufficient information to determine whether they will hold water. Treatments could begin as early as the end of May and no later than the third week of June. We have tentatively planned to complete a first round of pellet treatments by June 25 with subsequent Altosid pellet treatments every 30 days.

We intend to continue working cooperatively with cities to treat underground stormwater management structures (see Chapter 2) and slowly expand the kinds of structures we treat with larvicides beyond pond level regulators as we determine which larvicides effectively control vector larvae in these structures (see Chapter 5).

Intensive surveillance for *Ae. japonicus* and *Cs. melanura* will continue in 2013 to determine abundance and common larval habitats and refine potential larval control methods.

Adult Mosquito Control

Staff will continue to review MMCD's adulticide program to ensure effective resource use and minimize possible non-target effects. Budgeted adulticide needs in 2013 are similar to 2012 requirements. We will continue to focus efforts where there is potential disease risk, as well as provide service in high-use park and recreation areas and for public functions, and respond to areas where high mosquito numbers are affecting citizens.

We plan to use Anvil (sumithrin) as needed to control WNV vectors in agricultural areas because the updated label now allows applications in these areas. We will also be evaluating possible adulticide use in response to *Ae. japonicus* and *Cs. melanura*. We plan to continue testing additional ULV adulticides (see Chapter 5) to prepare for the loss of Scourge® (resmethrin); Bayer, the manufacturer, has withdrawn its re-registration. We are making sure that all employees that may apply adulticides have passed applicator certification testing, in preparation for a shift in label status of permethrin to Restricted Use (certified applicators only).

Chapter 4 Black Fly Control

2012 Highlights

- Treated 29 small streams sites with 6.94 gallons of *Bti* when the *Simulium venustum* population met the treatment threshold
- Treated 70 large rivers sites with 3,089.5 gallons of *Bti* when the target species population met the treatment threshold
- Monitored adult populations using overhead net sweeps and CO_2 traps
- Processed 2011 Mississippi River non-target monitoring samples

2013 Plans

- Threshold for treatment will be the same as previous years
- Monitor adult populations by the overhead net sweep and CO_2 trap methods
- Prepare report for Mississippi River non-target monitoring samples collected in 2011
- Collect Mississippi River non-target monitoring samples

Background

The goal of the black fly control program is to reduce pest populations of adult black flies within the MMCD to tolerable levels. Black flies develop in clean flowing water of rivers and streams. Larval populations are monitored at more than 150 small stream and at 28 large river sites using standardized sampling techniques during the spring and summer. Liquid *Bti* is applied to sites when the target species reach the treatment threshold.

The small stream program began in 1984. The large river program began with experimental treatments and non-target impact studies in 1987. A full-scale large river treatment program did not go into effect until 1996. The large river treatment program was expanded in 2005 to include the South Fork Crow River in Carver County. Large river and small stream monitoring/treatment locations are shown in Figure 4.1.

2012 Program

Small Stream Program
Simulium venustum Control

Simulium venustum is the one human-biting black fly species that develops in small streams in our area that is targeted for control. It has one early spring generation.

In April and early May, 168 potential *S. venustum* breeding sites on 24 streams were sampled to determine larval abundance using the standard grab sampling technique developed by the MMCD. The treatment threshold was 100 *S. venustum* per sample. A total of 29 sites on 11 streams met the threshold and were treated once with VectoBac® 12AS *Bti*. A total of 6.94 gallons of VectoBac® was used for the treatments (Table 4.1). The total amount of *Bti* used in 2012 was well below the yearly average of 29 gallons used in the small streams from 1996-2011. This was due in part to very dry conditions resulting from lack of snow available for melting and runoff to streams.

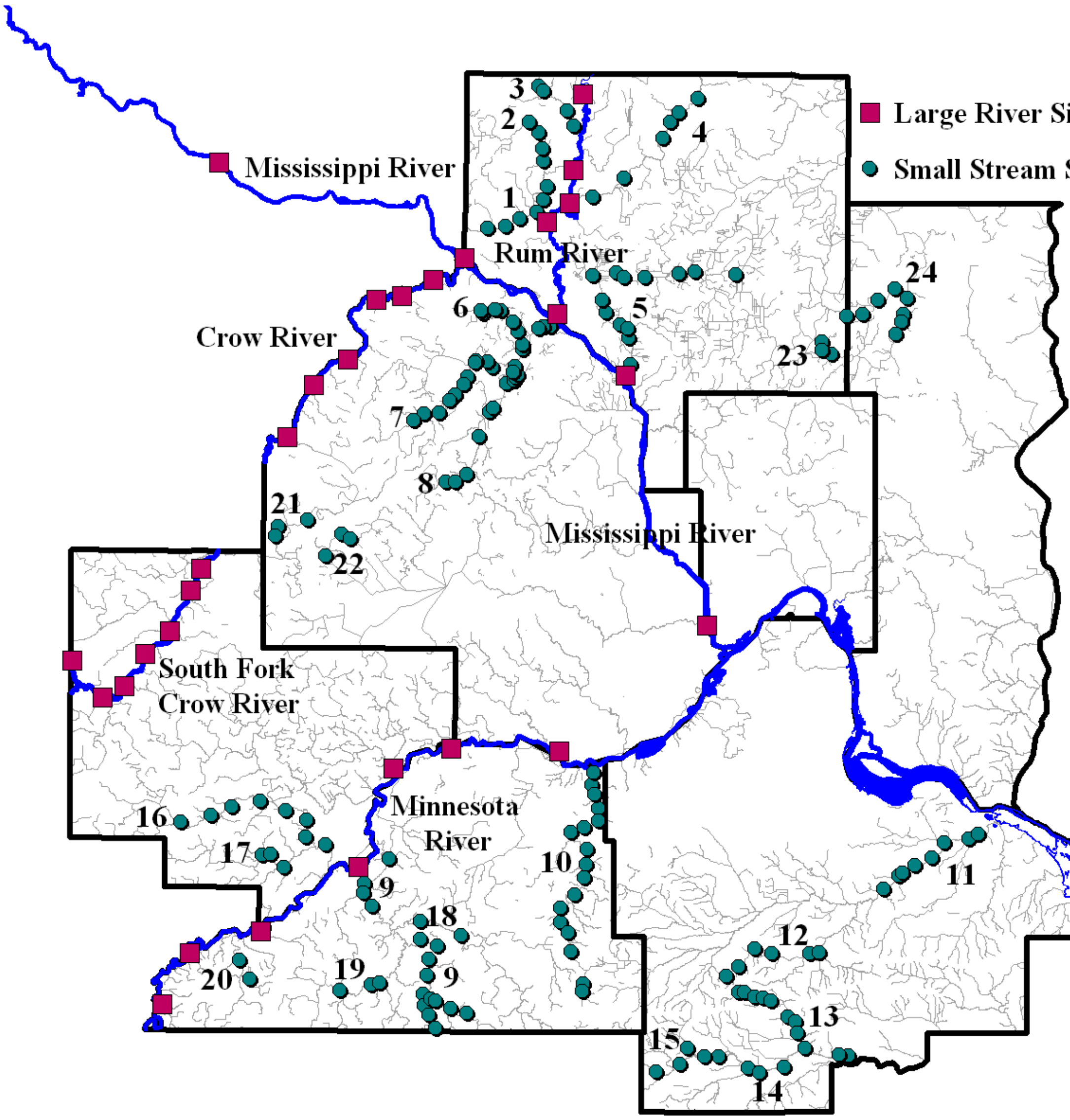


Figure 4.1 Large river and small stream black fly larval monitoring/treatment locations, 2012. Note: the large river site located outside the District on the Mississippi River is for monitoring only. Since 1991 more than 450 of the more than 600 original small stream treatment sites have been eliminated from the annual small stream sampling program. This is both due to the increased treatment threshold as well as our findings from years of sampling that some sites do not produce any, or very few, S. *venustum*. The numbers on the map refer to the small stream names listed below:

1=Trott	6=Diamond	11=Vermillion	16=Bevens	21=Pioneer
2=Ford	7=Rush	12=Vermillion So. Branch	17=Silver	22=Painter
3=Seelye	8=Elm	13=Chub No. Branch	18=Porter	23=Clearwater
4=Cedar	9=Sand	14=Chub	19=Raven W. Br.	24=Hardwood
5=Coon	10=Credit	15=Dutch	20=Robert	

Table 4.1 Summary of *Bti* treatments for black fly control by the MMCD in 2011 and 2012

	2011			2012		
Water body	No. sites treated	Total no. treatments	Gallons of *Bti* used	No. sites treated	Total no. treatments	Gallons of *Bti* used
Small Stream Totals	54	54	38.9	29	29	6.9
Large River						
Mississippi	2	8	1,273.0	2	10	1,334.5
Crow	2	3	140.0	1	1	19.9
South Fork Crow	5	6	136.6	3	9	47.2
Minnesota	6	11	2,067.6	7	22	1,407.9
Rum	3	11	161.0	5	28	280.1
Large River Totals	18	39	3,778.2	18	70	3,089.5
Grand Total	72	93	3,817.1	47	99	3,096.5

Large River Program

MMCD targets three large river black fly species for control: *Simulium luggeri*, *Simulium meridionale*, and *Simulium johannseni*. *Simulium luggeri* develops mainly in the Rum and Mississippi rivers, although it also occurs in smaller numbers in the Minnesota and Crow rivers. Depending on river flow, *S. luggeri* is abundant from mid-May through September. *Simulium meridionale* and *S. johannseni* occur primarily in the Crow, South Fork Crow, and Minnesota rivers. These species are most abundant in May and June, although *S. meridionale* populations will remain high throughout the summer if river flow is also high.

The black fly larval population was monitored weekly between May and early September using artificial samplers at the 28 sites permitted by the Minnesota Department of Natural Resources (MnDNR) on the Rum, Mississippi, Crow, South Fork Crow, and Minnesota rivers. A total of 408 monitoring samples were collected and analyzed to determine if the treatment threshold was met. The treatment thresholds were the same as those used since 1990. The treatment threshold for *Simulium luggeri* was an average of 100 larvae/sampler at each treatment site location. The treatment threshold for *Simulium meridionale* and *Simulium johannseni* was an average of 40 larvae/per sampler at each treatment site location.

Seventy samples from 18 different monitoring sites met the treatment thresholds and were treated with a total of 3,089.5 gallons of VectoBac® 12AS *Bti* (Table 4.1). The total amount of *Bti* used in the large river treatments in 2012 was 142 gallons above the yearly average of 2,947 gallons used on the large rivers between 1997 and 2011.

The average post-*Bti* treatment larval mortality (measured at least 250 m downstream of the point of the *Bti* application) was 100% on the Mississippi River, 93% on the Minnesota River, 92% on the Rum River, and 85% on the South Fork Crow River. Only one treatment was done on the Crow River and larval mortality was not determined.

Adult Population Sampling

Daytime Sweep Net Collections The adult black fly population was monitored at 53 standard stations throughout the MMCD using the District's standard black fly over-head net sweep technique that was established in 1984. Samples were taken once weekly from early May to mid-September, generally between 8:00 A.M. and 10:00 A.M. The average number of all species of adult black flies captured in 2012 was 1.55 (Table 4.2). The average number of adult black flies captured per net sweep sample from 1984 to 1986, when no large river *Bti* treatments were done, was 14.8. Between 1987 and 1995, when limited experimental *Bti* treatments were conducted on the large rivers, the average number of adult black flies captured per sample was 3.6. The average number of adult black flies captured per sample since the start of the District's full-scale large river larval black fly control program in 1996 is 1.5 (1996-2012).

The most abundant black fly collected in the overhead net-sweep samples in 2012 was *S. luggeri*, comprising 86% of the total captured. The overall average number of *S. luggeri* captured per net-sweep sample in 2012 was 1.33 (Table 4.2). *Simulium luggeri* was most abundant in Anoka County in 2012, as it has been since the program began. The average number of *S. luggeri* captured in Anoka County was 7.93 in 2012. The average number of *S. luggeri* captured in Hennepin County was 1.02. In the other MMCD counties (Carver, Dakota, Ramsey, Scott and Washington) it was between 0 and 0.22 per sample. The higher number of *S. luggeri* captured in Anoka County compared to other counties in the MMCD is likely due to the close proximity of prime *S. luggeri* larval habitat in the nearby Rum and Mississippi rivers.

The second most abundant black fly adult species captured in 2012 was *S. meridionale*, comprising 7% of the overall number of black flies captured in net-sweep monitoring samples. The overall average number of *S. meridionale* captured per sample was 0.11 (Table 4.2).

Black Fly Specific CO_2 Trap Collections Adult black fly populations were monitored in 2012 between mid-May and mid-June with CO_2 traps at four stations each in Scott and Anoka counties, and five stations in Carver County. The stations in Anoka and Scott counties have been monitored with CO_2 traps since 1998; monitoring in the Carver County expansion area began in 2004. Black flies captured in the CO_2 traps are preserved in alcohol so they can be identified to species.

Results of CO_2 trap collections from Anoka, Scott, and Carver counties are in Table 4.3. As in previous years of CO_2 sampling, the most abundant black fly species captured in the traps were *S. venustum, S. johannseni*, and *S. meridionale*.

The average number of *S. venustum* captured per trap in 2012 was 2.9 in Anoka County, 5.5 in Scott County, and 0.4 in Carver County. The average number of *S. venustum* captured per trap between 1998 and 2011 was 12.7 in Anoka County, 45.5 in Scott County, and 99.8 in Carver County.

Table 4.2 Annual mean number of black fly adults captured in over-head net sweeps in samples taken at standard sampling locations throughout the MMCD between mid-May and mid-September; samples were taken once weekly beginning in 2004 and twice weekly in previous years

Year	All species[4]	*Simulium luggeri*	*Simulium johannseni*	*Simulium meridionale*
1984	17.95	16.12	0.01	1.43
1985	14.56	13.88	0.02	0.63
1986	11.88	9.35	0.69	1.69
1987	6.53	6.33	0.02	0.13
1988[1]	1.60	1.54	0.05	0.00
1989	6.16	5.52	0.29	0.18
1990[2]	6.02	5.70	0.01	0.24
1991	2.59	1.85	0.09	0.60
1992	2.63	2.19	0.12	0.21
1993	3.00	1.63	0.04	1.24
1994	2.41	2.31	0.00	0.03
1995	1.77	1.34	0.32	0.01
1996[3]	0.64	0.51	0.01	0.07
1997	2.91	2.49	0.00	0.25
1998	2.85	2.64	0.04	0.04
1999	1.63	1.34	0.04	0.06
2000	2.38	2.11	0.01	0.02
2001	1.30	0.98	0.04	0.18
2002	0.61	0.43	0.01	0.14
2003	1.96	1.65	0.01	0.20
2004	0.97	0.35	0.02	0.39
2005	0.74	0.58	0.01	0.08
2006	0.55	0.45	0.00	0.04
2007	0.82	0.60	0.00	0.12
2008	1.07	0.88	0.01	0.08
2009	1.80	1.60	0.01	0.07
2010	2.16	1.92	0.03	0.11
2011	1.96	1.31	0.04	0.45
2012	1.55	1.33	0.00	0.11

[1]1988 was a severe drought year and limited black fly production occurred.
[2]The first operational treatments of the Mississippi River began in 1990 at the Coon Rapids Dam.
[3]First year of full operational treatments on large rivers.
[4]All species includes *S. luggeri*, *S. meridionale*, *S. johannseni*, and all other species collected.

The average number of *S. johannseni* captured per trap in 2012 was 1.0 in Anoka County, 81.7 in Scott County, and 154.1 in Carver County. The average number of *S. johannseni* captured per trap between 1998 and 2011 was 1.0 in Anoka County, 30.7 in Scott County, and 659.9 in Carver County.

The average number of *S. meridionale* captured per CO_2 trap in 2012 was 0.4 in Anoka County, 242.6 in Scott County, and 100.5 in Carver County. The average number of *S. meridionale* captured per trap between 1998 and 2011 was 1.6 in Anoka County, 126.6 in Scott County, and 341.3 in Carver County.

Table 4.3 Mean number of adult *S. venustum*, *S. johannseni*, and *S. meridionale* captured in CO_2 traps set twice weekly between May and mid-June

County	Year	*Simulium venustum*	*Simulium johannseni*	*Simulium meridionale*
Anoka	1998	15.34	2.42	0.08
	1999	1.53	0.26	0.30
	2000	4.83	0.08	0.35
	2001	6.22	0.37	0.29
	2002	4.77	0.26	1.09
	2003	18.29	1.35	2.61
	2004	0.89	5.11	14.09
	2005	2.31	0.03	1.23
	2006	22.80	0.75	0.75
	2007	37.62	0.20	0.51
	2008	13.84	0.13	0.68
	2009	18.32	0.34	0.70
	2010	21.75	0.03	0.05
	2011	8.90	2.61	0.93
	2012	2.89	0.95	0.41
Scott	1998	3.16	1.08	2.56
	1999	6.58	5.50	35.35
	2000	0.51	1.71	11.17
	2001	8.30	4.70	611.27
	2002	0.62	0.41	53.82
	2003	1.76	12.93	109.57
	2004	2.25	0.17	0.65
	2005	3.40	3.50	23.25
	2006	3.38	38.07	10.50
	2007	35.59	32.50	172.48
	2008	228.93	20.18	75.03
	2009	238.16	22.80	98.77
	2010	44.60	6.18	256.90
	2011	60.64	280.64	311.55
	2012	5.45	81.73	242.55
Carver	2004	0.25	32.93	327.29
	2005	0.84	99.04	188.02
	2006	1.82	98.75	107.53
	2007	75.67	112.77	388.64
	2008	169.63	95.63	359.02
	2009	425.00	35.92	820.25
	2010	77.00	219.38	271.08
	2011	48.30	4,584.72	268.28
	2012	0.40	154.13	100.53

Monday Night CO_2 Trap Home Collections Black flies captured in District-wide CO_2 traps operated weekly for mosquito surveillance (see Chapter 1) were counted and identified to family level in 2012. Because these traps are operated for mosquito surveillance, samples are not placed in ethyl alcohol making black fly species-level identification difficult. Results are represented geographically in Figure 4.2.

The areas in dark gray and black represent the highest numbers collected, ranging from 250 to more than 500 per trap. The highest number of black flies was observed in late April, June, and early July in Carver, and parts of Scott, Dakota, and Hennepin counties (Figure 4.2). The results in Scott and Carver counties are similar to those obtained from the standard black fly CO_2 trap sampling. Higher adult black fly numbers were also observed in parts of northern Hennepin and Anoka counties in September.

Non-target Monitoring

The District conducts biennial monitoring of the non-target invertebrate population in the Mississippi River as part of the permit requirements set by the MnDNR. This monitoring began in 1995. The study was designed to provide a long-term assessment of the invertebrate community in *Bti*-treated reaches of the Mississippi River. Results from monitoring data collected and analyzed through 2009 indicate that there have been no large-scale changes in macroinvertebrate community in the *Bti*-treated reaches of the Mississippi River. Monitoring sampling was repeated as scheduled on the Mississippi River in 2011. Sample processing and enumeration is on schedule for completion in March 2013. Monitoring samples will be collected again in 2013.

2013 Plans

2013 will be the 29^{th} year of black fly control in the District. Our primary goal in 2013 will be to continue to effectively monitor and control black flies in the large rivers and small streams. The larval population monitoring program and thresholds for treatment with *Bti* will continue as in previous years. The 2013 black fly control permit application request will be submitted to the MnDNR in January. Sorting, identification, and enumeration of the non-target monitoring samples collected in 2011 are on-going and scheduled for completion in March. Data will be analyzed and a report submitted to the MnDNR in late spring. Non-target monitoring sampling will be repeated on the Mississippi River in 2013. Increased larval surveillance will continue in those areas of Carver and Scott counties with elevated adult black fly populations. Program development will continue to emphasize improving program effectiveness, surveillance, and efficiency.

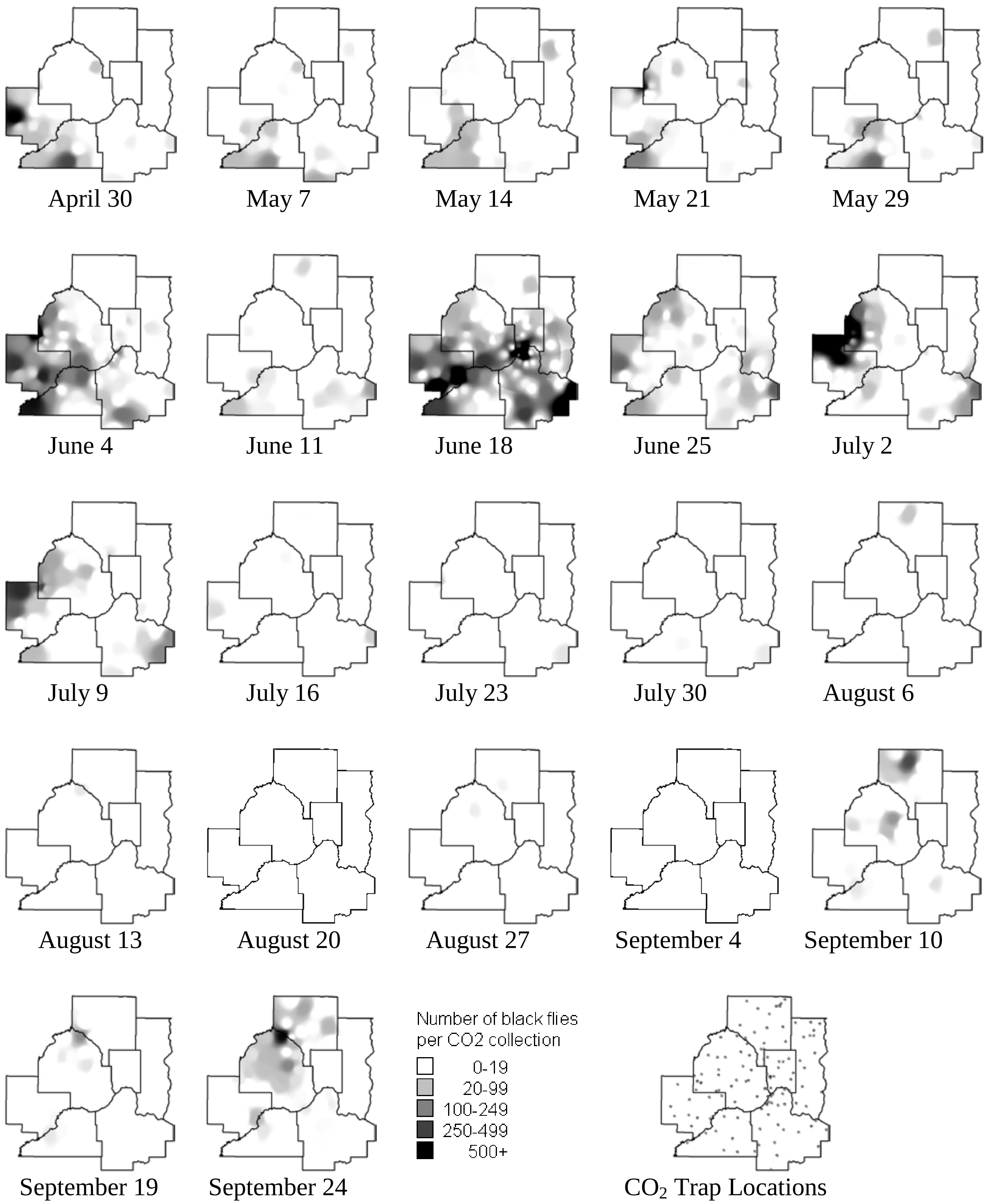


Figure 4.2 Number of black flies collected in mosquito surveillance District low (5 ft) and elevated (25 ft) CO_2 traps, 2012. The number of traps operated per night varied from 110-123. Inverse distance weighting was the algorithm used for shading of maps.

Chapter 5 Product & Equipment Tests

2012 Highlights

- A reduced dosage of VectoBac® G *Bti* achieved good control of *Ae. vexans* in air sites
- Natular™ G30 controlled *Ae. vexans* in air sites for four weeks
- MetaLarv™ S-PT controlled multiple *Ae. vexans* brood in air sites
- MetaLarv S-PT controlled *Culex* mosquitoes in catch basins
- Permethrin (barrier) controlled mosquitoes including *Ae. triseriatus* and WNV vectors for up to one week in woodlots

2013 Plans

- Repeat emergence cage evaluations of MetaLarv S-PT to verify effective control of the cattail mosquito
- Integrate late summer cattail treatments of VectoLex® CG into our cattail control program
- Test MetaLarv S-PT against spring *Aedes* to evaluate its effectiveness as a spring pre-hatch larvicide
- Continue tests of Natular G30 against the cattail mosquito to explore control potential
- Continue tests of adulticides in different situations emphasizing control of vectors and effectiveness of barrier treatments

Background

Evaluation of current and potential control materials and equipment is essential for MMCD to provide cost-effective service. MMCD regularly evaluates the effectiveness of ongoing operations to verify efficacy. Tests of new materials, methods, and equipment enable MMCD to continuously improve its operations.

2012 Projects

Quality assurance processes focused on product evaluations, equipment, and waste reduction. Before being used operationally, all products must complete a certification process that consists of tests to demonstrate how to use the product to effectively control mosquitoes. The District continued certification testing of two larvicides and two new adulticides. The larvicides and adulticides have been tested in different control situations in the past. Our goal is to determine that different larvicides can control two or more target mosquitoes in multiple control situations. One adulticide was tested as an alternative ULV material and the other as an alternative barrier material. These additional control materials will provide MMCD with more tools to use in our operations.

Control Material Acceptance Testing

Larval Mosquito Control Products Warehouse staff collected random product samples from shipments received from manufacturers for active ingredient content analysis. MMCD contracts an independent testing laboratory, Legend Technical Services, to complete the active ingredient (AI) analysis. Manufacturers provide the testing methodologies. The laboratory protocols used were CAP No. 311, “Procedures for the Analysis of S-Methoprene in Briquets and Premix”, CAP No. 313, “Procedure for the Analysis of S-Methoprene in Sand Formulations”, VBC Analytical Method: VBC-M07-001.1 Analytical Method for the Determination of (S)-Methoprene by High Performance Liquid

Chromatography and Clarke Analytical Test Method SP-003 Revision #2 "HPLC Determination of Spinosad Content in Natular G30 Granules".

All 2012 samples were within acceptable values of the label claim of percent active ingredient (Table 5.1). XRG sand samples were slightly low, but manufacturer's certificates of analysis at the time of production was acceptable at 1.58% (n=37, SE=0.0157). Technical Services staff will continue to work with manufacturers to monitor AI content discrepancies of future purchases.

Table 5.1 AI content of Altosid® (methoprene) briquets, pellets, and sand; MetaLarv S- PT Granules (methoprene); and Natular G30 Granule (spinosad)

Methoprene Product	No. Samples	AI Content: Label Claim	AI Content: Analysis Average	SE
Altosid XR-Briquet	12	2.10%	2.10%	0.0083
Altosid Pellets	10	4.25%	4.21%	0.0233
Altosid XR-G Sand	10	1.50%	1.31%	0.0100
MetaLarv S-PT Granules	10	4.25%	4.45%	0.0703
Natular G30 Granules	12	2.50%	2.62%	0.0365

Adult Mosquito Control Products MMCD requests certificates of AI analysis from the manufacturers to verify product AI levels at the time of manufacture. MMCD incorporated AI analysis as part of a product evaluation procedure and will submit randomly selected samples of adulticide control materials to an independent laboratory for AI level verification. This process will assure that all adulticides (purchased, formulated, and/or stored) meet the necessary quality standards. Technical Services is building a database on warehoused adult control materials to assist in inventory management and purchasing decisions. In 2012, MMCD did not purchase a large volume of adulticides and used products remaining in inventory. Our product storage data shows there is negligible breakdown of active ingredients after one season. Therefore, MMCD did not re-analyze products in inventory and saved expenses of analysis.

Efficacy of Control Materials

VectoBac® G VectoBac G brand *Bti* (5/8 inch mesh size corncob granules) from Valent BioSciences was the primary *Bti* product applied by helicopter in 2012. To conserve resources in 2012, we reduced the aerial *Bti* dosage from 8 lb/acre to 5 lb/acre in May when mosquito breeding switched from spring *Aedes* to *Ae. vexans*. Mean efficacy calculated using pre- and post-treatment larval counts from randomly selected sites was slightly lower in 2012 than in 2011 (Table 5.2).

We based our decision to decrease the *Bti* dosage on data from a 1993 in-house study that suggested very little efficacy decrease in the summer (water temperature >50°F). In the 1993 study efficacy of small-scale aerial 5- and 8 lb/acre treatments in the summer achieved 85-95% efficacy. In 2010, 2011 and 2012 we asked the Commission for authorization to use emergency funds to continue larval mosquito control. After two wet years in succession, we felt conservation was necessary for us to maintain larval control services with our budgetary resources especially if we experienced another wet season. We compared efficacy of treatments in May 2012 to treatments completed later in the season to determine if factors such as higher vegetation in June and thereafter might impact efficacy. We observed no difference.

Table 5.2 Efficacy of aerial VectoBac G applications in 2011 (8 lb/acre) and 2012 (5 lb/acre) (SE=standard error)

Year	n	Mean % mortality	Median % mortality	SE
2011	531	93.3	100.0	0.9%
2012 (May)	166	84.2	100.0	2.4%
2012 (June-Aug)	116	84.7	100.0	3.0%

New Control Material Evaluations

The District, as part of its Continuous Quality Improvement philosophy, strives to continually improve its control methods. Testing in 2012 was designed to evaluate how different segments of mosquito control programs can be modified to deliver more mosquito control services to a greater part of the District area using existing resources. Much testing has focused upon controlling multiple mosquito species including potential vectors of WNV.

Larval Control

Clarke Natular™ G30 in Air Sites Tests completed in 2008 and 2009 demonstrated that Natular G30 can control the first brood of floodwater mosquitoes (i.e., egg hatch induced by rainfall) in ground sites treated either before the rain or after larvae were present. In 2008 and 2009, Natular G30-treated sites did not re-flood after they dried up, thereby preventing us from evaluating effectiveness against subsequent mosquito broods. Tests in 2010 demonstrated that a single application of Natular G30 (10 lb/acre) could effectively control two broods of *Ae. vexans* separated by complete drying of the sites. Tests in 2011 demonstrated that a lower dosage (5 lb/acre) of Natular G30 could control multiple *Ae. vexans* broods for at least three weeks during periods of heavy rainfall; the higher dosage (10 lb/acre) still was effective five weeks after treatment. These results suggested that Natular G30 (5 lb/acre) could be an effective pre-hatch larvicide for controlling *Ae. vexans* up to four weeks.

In 2012, we treated over 4,500 acres – mostly air sites—twice with Natular G30 (5 lb/acre) to control *Ae. vexans* (368 sites). Natular treatments occurred on May 16 and June 15. To evaluate effectiveness, we compared larval dip counts in Natular-treated sites with pre-treatment dip counts in sites treated with *Bti* (Figure 5.1).

Before the May 16 treatment, larval abundance as measured by dip counts was highest in sites treated with Natular G30 (Figure 5.1). Dip counts in Natular-treated sites after May 16 were much lower than *Bti* pre-treatment dip counts collected on similar dates strongly suggesting that Natular G30 was effective for at least four weeks. Weekly cumulative rainfall was highest during May with three inches falling each of two weeks and five inches falling another week. All sites remained wet during the entire month.

The same sites were treated a second time with Natular G30 on June 15. Larval abundance in Natular-treated sites remained well below larval abundance in sites inspected for *Bti* treatment until August 24 (70 days after treatment) (Figure 5.1). Less rain fell after the June 15 treatment which seemed to be associated with a longer period of control. Natular-treated sites dried completely and were re-flooded more than once in June and July. We conclude that both Natular G30 treatments were effective for four weeks after treatment. The June 15 treatment seemed to be effective longer than four weeks because of drier conditions.

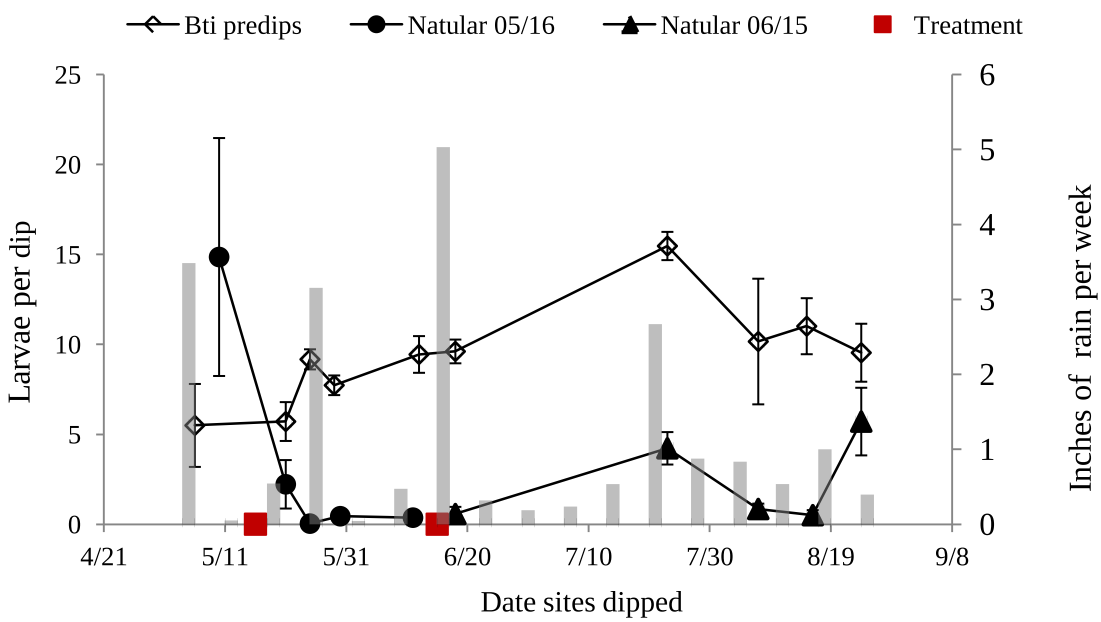


Figure 5.1 Control of *Aedes vexans* in air sites treated with Natular G30 (5 lb/acre) on May 16, 2012 and June 15, 2012 (dip counts in treated sites compared to *Bti* pre-treatment dips). Error bars equal ±1 SE; gray bars equal weekly cumulative rainfall. Natular 5/16 n=131 sites, Natular 6/15 n=214 sites, *Bti* predips n=4,406 sites

Valent MetaLarv™ S-PT in Air Sites In 2010 MMCD tested MetaLarv S-PT (at that time an experimental larvicide designated as VBC-60215) in small ground sites. Results were promising enough to conduct larger scale aerial tests in 2011. MetaLarv S-PT received its EPA registration and label in late 2011. The active ingredient is S-methoprene, the same active ingredient as in Altosid® products.

In 2012, we applied MetaLarv S-PT to 2,750 acres (159 sites) to control *Ae. vexans*. Aerial treatments were completed on three dates: May 16, June 15, and July 17 (Figure 5.2, Table 5.3). The desired dosage was 4 lb/acre. Problems with application equipment on May 16 resulted in an overall treatment dosage of about 3 lb/acre with potentially less uniformity than a treatment without problems. Treatments on June 15 and July 17 were completed without problems.

Efficacy was evaluated by comparing pupal bioassays collected from MetaLarv-treated and untreated sites. Emergence inhibition in untreated sites was low. Overall efficacy was expressed as the mean emergence inhibition for treated sites and the proportion of bioassays from treated sites that were greater than the 95% confident limit calculated for untreated. All three treatments achieved significant levels of control. Control due to the two later treatments was higher and more uniform (Figure 5.2, Table 5.3). Efficacy was similar to aerial Altosid pellet treatments (4 lb/acre) (Mean EI = 73.7% ± 4.1%, n = 84; see 2005 Operational Review for details).

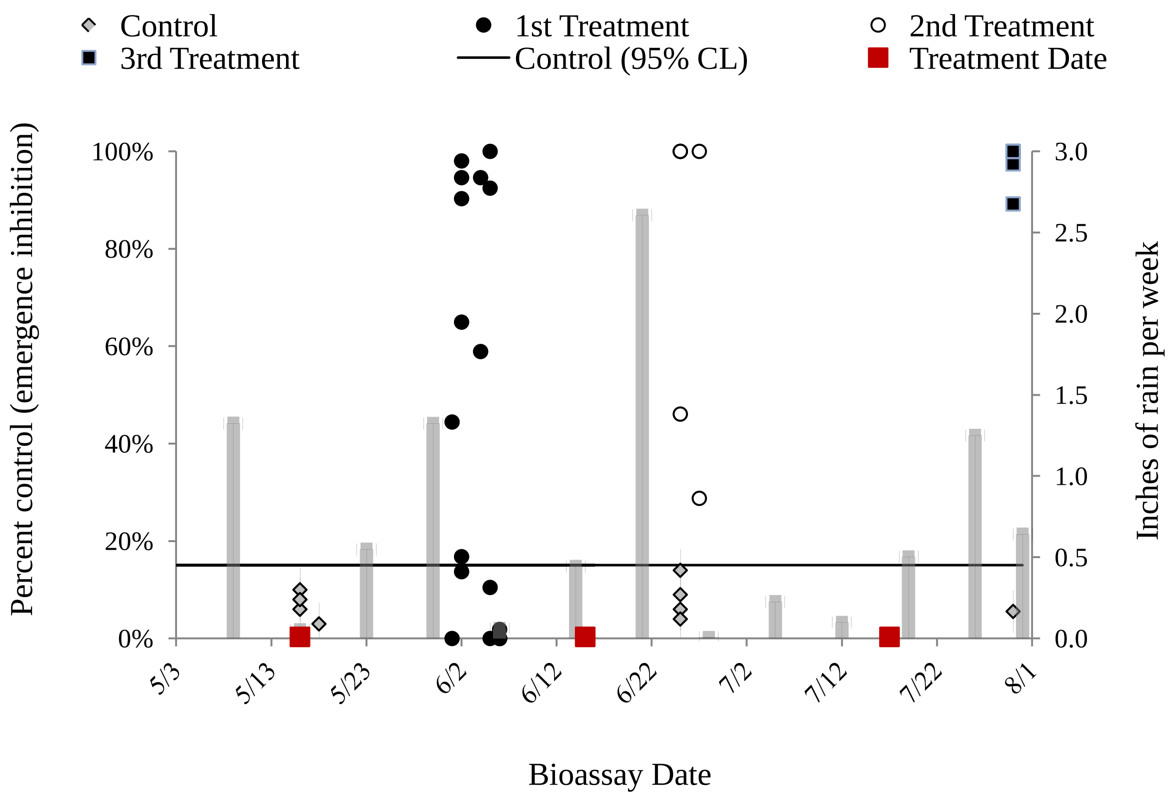


Figure 5.2 Bioassay results (emergence inhibition) of samples collected in untreated and MetaLarv S-PT treated sites (May 16, June 15, July 17, 2012). Emergence inhibition values from MetaLarv S-PT treated sites were corrected for untreated control mortality. Gray bars equal weekly cumulative rainfall.

Table 5.3 Bioassay results (emergence inhibition=EI) of samples collected in MetaLarv S-PT treated sites compared to the upper 95% CL for untreated control bioassays*

Treatment dosage and date	Bioassays (n)	Corrected EI mean (±SE)	Bioassays >95% CL (%)	Days after treatment mean (±SE)(min-max)
3 lb/acre§ (May 16)	18	43.40% (±9.99%)	10 (56%)	18.9 (±0.49) (16-22)
4 lb/acre (June 15)	6	79.14% (±13.38%)	6 (100%)	10.7 (±0.42) (10-12)
4 lb/acre (July 17)	5	97.33% (±2.09%)	5 (100%)	13.0 (±0.00) (13)

*Untreated Control: mean EI=7.28% (SE=1.13%)(n=9); upper 95% CL=15.08%

§ Light treatment due to application problems; intended dosage was 4 lb/acre

***Coquillettidia perturbans* Control** *Coquillettidia perturbans* is an abundant pest that lays its eggs in mid- to late summer and overwinters as larvae attached to aquatic vegetation, primarily cattail roots. Our current operations treat for this single brood mosquito in late May, just prior to its emergence. We compared late May treatments (ground and aerial) of MetaLarv S-PT with concurrent Altosid® XRG treatments to determine if we could increase the number of larvicides we can incorporate into late spring cattail mosquito control operations.

Because cattail control applications often coincide with treatments of other floodwater species, a late summer application period may lessen the demand of limited resources during this extremely active floodwater treatment period. To that end, we continued evaluating if later summer applications of VectoLex® CG (*B. sphaericus* 30-day granules) can provide good control of the subsequent season's cattail mosquitoes. We also treated a small number of ground cattail sites with Natular G30 to evaluate its potential.

Valent MetaLarv S-PT—Late May Treatments We treated three cattail sites aerially and three by ground with MetaLarv S-PT (3 lb/acre) on May 30, 2012. In early June 2012, emergence cages (five per site) were placed in all six sites treated with MetaLarv S-PT. Emergence cages (five per site) were placed in three untreated sites and in three sites receiving concurrent operational aerial Altosid XRG treatments (10 lb/acre). Adult mosquitoes were collected from all emergence cages twice each week beginning in mid-June through the end of July. Efficacy was evaluated by comparing cumulative emergence in each treatment with that of the untreated control.

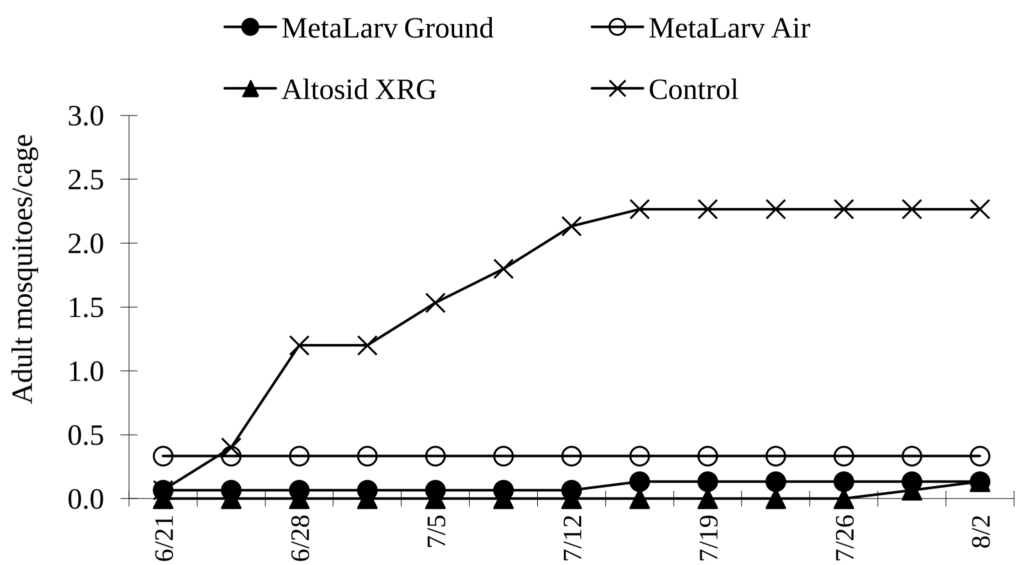


Figure 5.3 Mean cumulative emergence of *Cq. perturbans* in cages in sites treated with MetaLarv S-PT, Altosid XRG, and untreated sites, June – July 2012.

Emergence of adult *Cq. perturbans* from untreated sites was quite low compared to previous years. However, emergence in sites treated with MetaLarv S-PT or Altosid XRG was much lower than from untreated sites (Figure 5.3, Table 5.4). The percentage of cages in which *Cq. perturbans* emerged was significantly lower in MetaLarv S-PT treated and Altosid XRG treated sites than in untreated sites (Table 5.4). Both MetaLarv S-PT and Altosid XRG appeared to be equally effective, which further justifies including MetaLarv S-PT in operational cattail mosquito control in the future. Additional tests to verify these results are required.

Table 5.4 Emergence of *Cq. perturbans* (mean per cage, percent of cages with emergence) in MetaLarv S-PT treated, Altosid XRG treated and untreated sites, June – July 2012

Treatment	Total cages	Cages with *Cq. perturbans*	Percent with *Cq. perturbans*	Fisher Exact p-value*	*Cq. perturbans*[§] per cage (% control)
Control	15	8	53.3%	N/A	2.27 (N/A)
MetaLarv (gd)	15	2	13.3%	0.022489	0.13 (94.1%)
MetaLarv (air)	15	3	20%	0.053598	0.33 (85.3%)
Altosid	15	2	13.3%	0.022489	0.13 (94.1%)

* Untreated control compared to MetaLarv S-PT or Altosid XRG.
§ Mean cumulative emergence per cage (June-July 2012)

Valent VectoLex® CG in Mid-September VectoLex CG (20 lb/acre) applied in September 2008 to seven cattail marshes in Anoka and Washington counties while water temperatures were approximately 50° F achieved 95.7% control of *Cq. perturbans* throughout the June-August emergence period. In September 2010, we treated 15 sites with VectoLex CG granules, eight sites with 10 lb/acre and seven with 20 lb/acre. Control (determined with emergence cages in June-July 2011) was consistently high in sites treated with 20 lb/acre (99.1%). Control also was very good in sites treated with 10 lb/acre (86.9%). Most emergence in the 10 lb/acre treatment occurred in three cages. These results suggested that 10 lb/acre is near the minimum effective dosage.

In September 2011, we treated 440 acres with VectoLex CG (10 lb/acre, 15 lb/acre) to more accurately determine the minimum effective dosage. We placed emergence cages in three sites treated with each dosage and collected adult *Cq. perturbans* in June through July 2012.

The higher dosage (15 lb/acre) achieved good control in terms of adult *Cq. perturbans* emergence compared to the untreated control. Control achieved by the lower dosage was less consistent with low emergence compared to the untreated control in June; more *Cq. perturbans* emerged in July which increased the per cage average emergence to that observed in the untreated control (Table 5.5, Figure 5.4). Two of the fifteen cages in the 10 lb/acre treatment gave rise to 41 of the 43 adult *Cq. perturbans* that emerged in that treatment, a pattern very similar to that seen in the 2010-11 test (Table 5.6). These results suggest that 15 lb/acre is the lowest VectoLex CG dosage that can provide uniform control of *Cq. perturbans*.

Table 5.5 Emergence of *Cq. perturbans* (mean per cage, percent of cages with emergence) in VectoLex® CG treated and untreated sites, June – July 2012

Treatment	Total cages	Cages with *Cq. perturbans*	Percent with *Cq. perturbans*	Fisher Exact p-value*	*Cq. perturbans*§ per cage (% control)
Control	15	8	53.3%	N/A	2.27 (N/A)
VectoLex (10lb)	15	4	26.7%	0.101554	2.87 (0%)
VectoLex (15lb)	15	4	26.7%	0.101554	0.27 (88.2%)

* Untreated control compared to VectoLex CG.
§ Mean cumulative emergence per cage (June-July 2012)

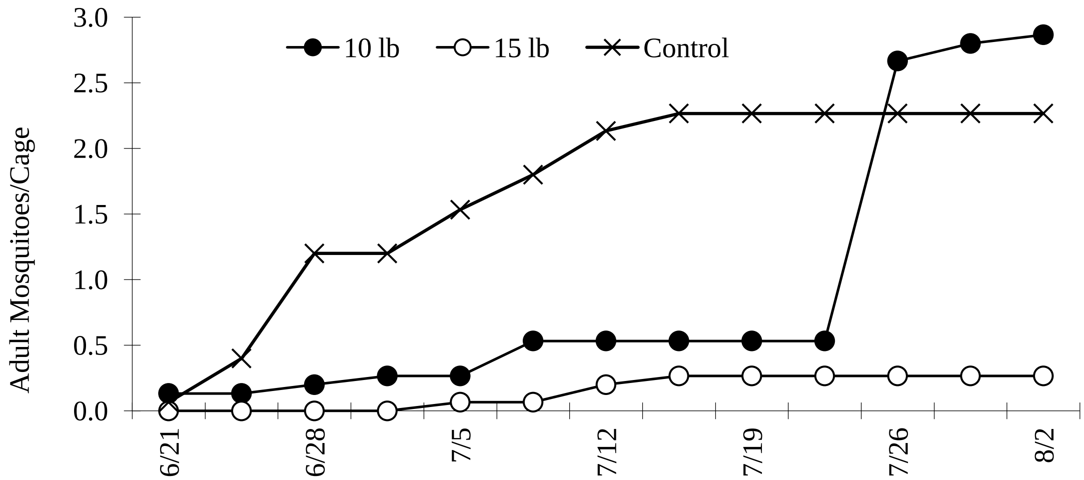


Figure 5.4 Mean cumulative emergence of *Cq. perturbans* in cages in VectoLex CG treated (10 lb/acre, 20 lb/acre) and untreated sites, June – July 2012.

Table 5.6 Number of cages in VectoLex CG treated and untreated sites from which "n" *Cq. perturbans* emerged, June – July 2012

Treatment	Number of cages with "n" *Cq. perturbans* 0	1	2	3	4	5	6-10	11-20	21-30	>30	Total *Cq. perturbans*
VectoLex 10 lb	11	2	0	0	0	0	1	0	0	1	43
VectoLex 15 lb	11	4	0	0	0	0	0	0	0	0	4
Control	7	3	0	1	1	1	2	0	0	0	34

Clarke Natular G30 in Ground Sites in Mid-September In mid-September 2011 we treated a small number of ground cattail sites with Natular G30 (10 lb/acre) to evaluate its potential. We placed emergence cages in three sites treated with Natular G30 and collected adult *Cq. perturbans* in June through July 2012.

Natular G30 demonstrated potential to control *Cq. perturbans* (Figure 5.5, Table 5.7). The dosage used in this test (10 lb/acre) is higher than the dosage used to effectively control multiple *Ae. vexans* broods. Future research needs to be designed to determine how spinosad (the active ingredient in Natular G30) moves through and persists in cattail sites so we can determine if lower dosage treatments can effectively control *Cq. perturbans* larvae.

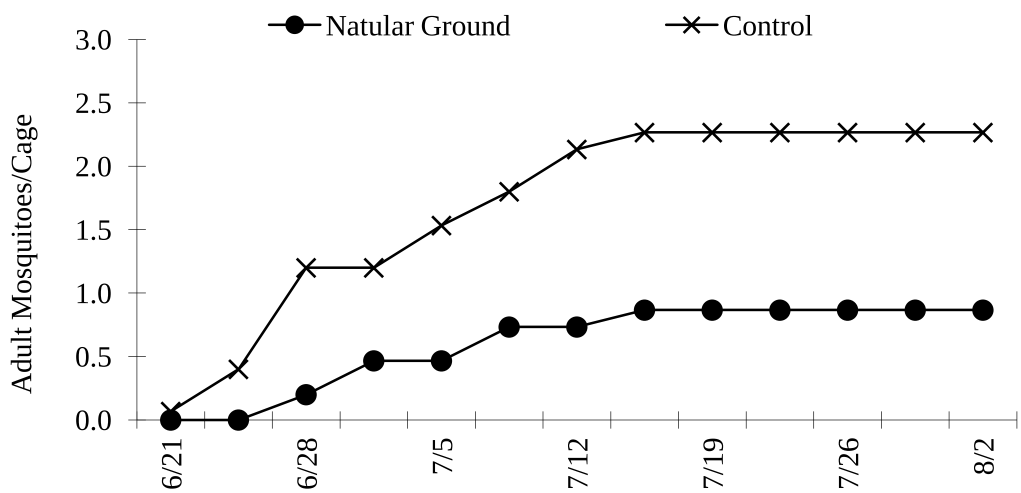


Figure 5.5 Mean cumulative emergence of *Cq. perturbans* in cages in Natular™ G30 treated (10 lb/acre) and untreated ground sites, June – July 2012.

Table 5.7 Emergence of *Cq. perturbans* (mean per cage, percent of cages with emergence) in Natular™ G30 treated and untreated ground sites, June – July 2012

Treatment	Total cages	Cages with *Cq. perturbans*	Percent with *Cq. perturbans*	Fisher Exact p-value*	*Cq. perturbans*§ per cage (% control)
Control	15	8	53.3%	N/A	2.27 (N/A)
Natular (10 lb)	15	7	46.7%	0.267	0.87 (61.8%)

* Untreated control compared to Natular G30.
§ Mean cumulative emergence per cage (June-July 2012)

Valent MetaLarv S-PT in Catch Basins We treated catch basins with MetaLarv S-PT (3.5 g/catch basin) three times (June 22, July 27, Sept 4, 2012) and collected pupal bioassays from treated and untreated catch basins to evaluate effectiveness. Mortality of pupae from untreated catch basins was relatively high. The fact that 70% of bioassays from MetaLarv S-PT-treated catch basins were higher than the upper 95% confident limit (76.7%) strongly supports the conclusion that

MetaLarv S-PT effectively control mosquitoes in catch basins (Figure 5.6, Table 5.8). More rain fell in June and July than in August and September, but effectiveness of MetaLarv S-PT was consistent throughout the test period (Figure 5.6). No rain events greater than 1 inch in 24 hours occurred during this test. More tests are necessary to determine how resistant MetaLarv S-PT treatments are to heavy rain events. MetaLarv S-PT appears to be a viable choice for controlling mosquitoes (including WNV vectors) in catch basins.

Efficacy of MetaLarv S-PT in catch basins was very similar to efficacy of Altosid pellets (3.5 g/catch basin) evaluated in 2003 (Mean EI = 84.3% ± 4.2%, n = 56; see 2003 Operational Review for details).

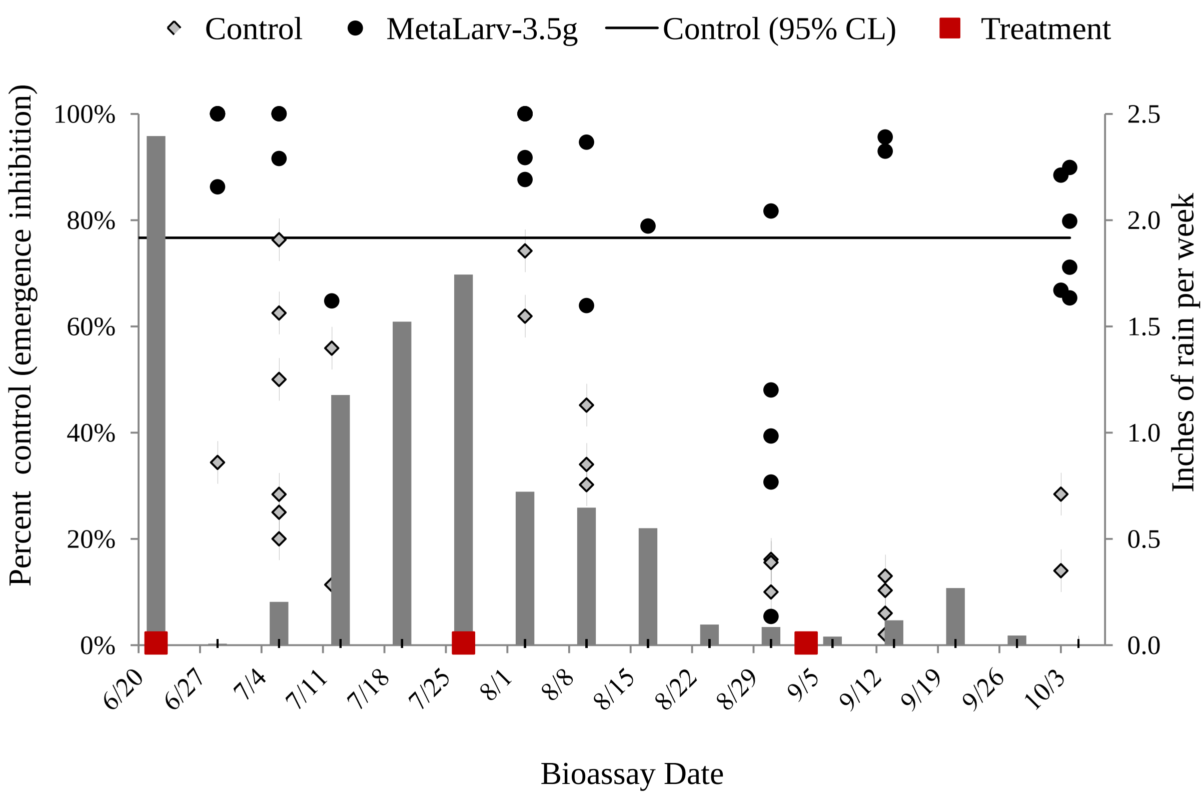


Figure 5.6 Bioassay results (emergence inhibition) of samples collected in untreated and MetaLarv S-PT treated catch basins (June 22, July 27, Sept 4, 2012). Emergence inhibition values from MetaLarv S-PT treated catch basins were corrected for untreated control mortality. Gray bars equal weekly cumulative rainfall.

Table 5.8 Bioassay results (emergence inhibition=EI) of samples collected in MetaLarv S-PT treated catch basins compared to the upper 95% CL for untreated control bioassays.

Treatment	bioassays (n)	Corrected EI Mean (±SE)	Bioassays* >95% CL (%)	Days After Treatment Mean (±SE)(min-max)
Control	24	30.75% (±4.53%)	0 (0%)	16.7 (±1.87) (7-35)
MetaLarv S-PT	29	79.81% (±4.44%)	20 (70%)	18.8 (±2.10) (7-35)

* Untreated Control: upper 95% CL=76.68% (Catch basin Control EI similar to 2004, mean=27.2%; see 2004 Operational review for details)

Adulticide Tests

Beginning in 2008, research focused upon evaluating how effectively barrier and ULV (cold fogging) treatments controlled mosquitoes, especially West Nile virus vectors. This research is partially in response to recommendations by the Technical Advisory Board that MMCD demonstrate vector-specific efficacy, especially for barrier permethrin treatments that pose the greatest potential risk to non-target organisms in treated areas.

Permethrin and Onslaught® Barrier We continued barrier tests in 2012, focusing on evaluating effectiveness on vector species. Tests were done in woodlot locations where operational permethrin treatments could potentially be made. Mosquito populations in each woodlot were estimated using overnight CO_2 trap and aspirator samples, placed (trap) or collected (aspirator) 24 hours before treatment, 30 minutes after treatment, 24 hours after treatment and one week after treatment. Efficacy was evaluated using Mulla's equation (a correction that accounts for natural changes in the untreated control site, as well as the treatment site). The goal of all tests was to better evaluate the duration and consistency of control achieved by barrier treatments and to include vector-specific efficacy evaluations.

The first study was a series of tests done in late June in woodlots that had a history of *Ae. triseriatus* or *Ae. japonicus* captures in an attempt to collect vector-specific efficacy data. The study locations included nine woodlots, grouped in sets of three, with one site in each group assigned to permethrin, Onslaught, or untreated. Two CO_2 trap and two aspirator collections were taken at each woodlot on each evaluation date. Permethrin effectively controlled all mosquitoes within 24 hours of treatment in all three tests. Efficacy lasted one week in only one test (Table 5.9). Onslaught also was effective, although slightly less than permethrin, for one week in this test. Onslaught was not effective in the other two tests (Table 5.9). Sufficient vectors were captured in one test to evaluate effectiveness. Permethrin very effectively suppressed vectors for 24 hours. Onslaught also impacted vectors within 24 hour after treatments but less than permethrin (Table 5.9).

The second study was done in mid-July and used two woodlot locations, assigned to permethrin or untreated, with two CO_2 trap and two aspirator collections taken at each woodlot on each evaluation date. Permethrin very effectively controlled adult mosquitoes for one week. Too few vector mosquitoes were captured to evaluate efficacy (Table 5.10).

The third test set was done in September in an isolated location with two small woodlots near a prolific *Culex* production site. The two woodlots were assigned to permethrin or untreated, with one CO_2 trap taken at each woodlot on each evaluation date (the woodlots were too small for more than one CO_2 trap per woodlot). Permethrin effectively controlled all adult mosquitoes and *Culex* vectors for at least one week. Control persisted at slightly lower levels two weeks after treatment (Table 5.11).

Table 5.9 Barrier treatment efficacy in 2012 (6/26 – 7/6 tests): Efficacy percent calculated using Mulla's formula*

		All mosquito species		*Ae. triseriatus***	
Test 1	Collection	CO_2 trap catch§	Efficacy	Aspirator catch§	Efficacy
Permethrin	Pre-treat	250 (±102)	---	0.0 (±2.0)	---
	Post-treat	64 (±34)	93%	0.0 (±0.0)	---
	Post-24 h	98 (±7)	94%	0.0 (±0.0)	---
	Post-7 day	161 (±25)	74%	0.0 (±0.0)	---
Onslaught	Pre-treat	185 (±82)	---	3.0 (±3.0)	---
	Post-treat	93 (±75)	87%	2.5 (±2.5)	---
	Post-24 h	374 (±153)	70%	2.5 (±2.5)	---
	Post-7 day	254 (±12)	46%	3.0 (±0.5)	---
Untreated control	Pre-treat	222 (±52)	---	0.0 (±0.0)	---
	Post-treat	825 (±492)	---	0.0 (±0.0)	---
	Post-24 h	1,469 (±309)	---	0.0 (±0.0)	---
	Post-7 day	559 (±263)	---	2.0 (±1.0)	---
Test 2					
Permethrin	Pre-treat	100 (±53)	---	12.5 (±2.5)	---
	Post-treat	39 (±27)	73%	0.0 (±0.0)	100%
	Post-24 h	108 (±15)	13%	1.5 (±1.5)	94%
	Post-7 day	283 (±104)	0%	31.0 (±15.0)	0%
Onslaught	Pre-treat	48 (±43)	---	1.5 (±1.5)	---
	Post-treat	172 (±47)	0%	3.5 (±0.5)	32%
	Post-24 h	106 (±37)	0%	5.0 (±1.0)	0%
	Post-7 day	167 (±38)	0%	6.5 (±2.5)	0%
Untreated control	Pre-treat	124 (±33)	---	6.0 (±5.0)	---
	Post-treat	177 (±145)	---	20.5 (±17.5)	---
	Post-24 h	153 (±98)	---	11.5 (±11.5)	---
	Post-7 day	231 (±124)	---	13.5 (±5.5)	---
Test 3					
Permethrin	Pre-treat	557 (±42)	---	0.0 (±0.0)	---
	Post-treat	199 (±197)	59%	0.0 (±0.0)	---
	Post-24 h	251 (±24)	0%	0.0 (±0.0)	---
	Post-7 day	204 (±203)	40%	0.0 (±0.0)	---
Onslaught	Pre-treat	431 (±112)	---	0.0 (±0.0)	---
	Post-treat	603 (±35)	0%	0.0 (±0.0)	---
	Post-24 h	473 (±122)	0%	0.0 (±0.0)	---
	Post-7 day	791 (±3)	0%	0.0 (±0.0)	---
Untreated control	Pre-treat	1,275 (±682)	---	0.0 (±0.0)	---
	Post-treat	1,101 (±517)	---	1.0 (±1.0)	---
	Post-24 h	369 (±53)	---	0.0 (±0.0)	---
	Post-7 day	773 (±743)	---	4.0 (±4.0)	---

* Mulla's formula incorporates untreated control trap counts to correct for changes in the treated traps that are not due to the treatment

** Abundance evaluated using aspirator samples.

§ Mean (±SE), n=2 (CO_2 traps or aspirator samples)

Table 5.10 Barrier treatment efficacy in 2012 (7/11-19): Efficacy percent calculated using Mulla's formula*

	Collection	All mosquito species		*Ae. triseriatus***	
		CO_2 trap catch§	Efficacy	Aspirator catch§	Efficacy
Permethrin	Pre-treat	633 (±102)	---	0.0 (±0.0)	---
	Post-treat	51 (±23)	97%	0.0 (±0.0)	---
	Post-24 h	19 (±4)	97%	0.0 (±0.0)	---
	Post-7 day	23 (±1)	98%	0.0 (±0.0)	---
Untreated control	Pre-treat	144 (±40)	---	0.0 (±0.0)	---
	Post-treat	388 (±7)	---	0.5 (±0.5)	---
	Post-24 h	152 (±34)	---	0.0 (±0.0)	---
	Post-7 day	287 (±76)	---	0.0 (±0.0)	---

* Mulla's formula incorporates untreated control trap counts to correct for changes in the treated traps that are not due to the treatment

** Abundance evaluated using aspirator samples.

§ Mean (±SE), n=2 (CO_2 traps or aspirator samples)

Table 5.11 Barrier treatment efficacy in 2012 (9/5-12): Efficacy percent calculated using Mulla's formula*

	Collection	All mosquito species		*Culex 4***	
		CO_2 trap catch§	Efficacy	CO_2 trap catch§	Efficacy
Permethrin	Pre-treat	271	---	89	---
	Post-treat	14	87%	6	87%
	Post-24 h	36	94%	12	84%
	Post-7 day	1	99%	0	100%
	Post-14 day	6	69%	4	74%
Untreated control	Pre-treat	281	---	35	---
	Post-treat	239	---	18	---
	Post-24 h	1,201	---	30	---
	Post-7 day	395	---	15	---
	Post-7 day	42	---	6	---

* Mulla's formula incorporates untreated control trap counts to correct for changes in the treated traps that are not due to the treatment

** *Culex*4=*Cx. tarsalis*, *Cx. restuans*, *Cx. pipiens*, and *Cx. salinarius*

§ CO_2 trap catch, n=1 CO_2 trap per woodlot (woodlots too small for two CO_2 traps)

Between 2006 and 2012, we completed 15 barrier tests that included permethrin. Permethrin effectively controlled adult mosquitoes within 24 hours after treatment in virtually all tests (Table 5.12). Permethrin also effectively controlled vector mosquitoes within 24 hours after treatment in all tests where enough vectors were captured to evaluate efficacy. One week after treatment permethrin effectively controlled adult mosquitoes in only about half of those tests (Table 5.12). (see 2006, 2007, 2008, 2010 and 2011 Operational Reviews for details).

We completed five barrier tests that included Onslaught between 2007 and 2012. Onslaught was able to effectively control adult mosquitoes. Overall, control was less consistently achieved by Onslaught than by permethrin although the low number of Onslaught tests makes comparisons with permethrin difficult. Onslaught is able to control *Culex* vectors within 24 hours after treatment; insufficient data are available to evaluate effectiveness against *Ae. triseriatus* (Table 5.12) (see 2006, 2007, 2008, 2010 and 2011 Operational Reviews for details).

Table 5.12 Barrier tests with high efficacy (>80% control using Mulla's equation).

Material used and number of tests*	Target mosquitoes	24-48 hours after treatment	7 days after treatment
Permethrin (2006-2012)			
15	All species	14 (93%)	6 (46%)
6	*Culex* (WNV)	6 (100%)	3 (50%)
2	*Ae. triseriatus* (LAC)	2 (100%)	1 (50%)
Onslaught (2007-2012)			
5	All species	3 (60%)	1 (20%)
1	*Culex* (WNV)	1 (100%)	0 (0%)
1	*Ae. triseriatus* (LAC)	0 (0%)	0 (0%)

* Number of tests in which sufficient mosquitoes of a particular species group were captured to evaluate efficacy.

In the future we plan to continue barrier adulticide tests. Our goal is to collect as much vector-specific data (includes *Culex*, *Ae. triseriatus*, *Ae. japonicus*) as possible. We plan to explore causes of inconsistent efficacy, especially more than 24 hours after treatment, perhaps by comparing efficacy in smaller and larger scale treatments (different sized treatment areas).

Zenivex® (ULV) compared to Anvil® Zenivex is a new formulation of the pyrethroid etofenprox. Like Anvil (sumithrin), Zenivex is a softer adulticide, both because of its pyrethroid active ingredient and the lack of PBO in the formulation. We are testing Zenivex to increase the number of ULV adulticides we have available. Tests in 2010 and 2011 showed good control immediately following treatment (see 2010 and 2011 Operational Reviews for details). In 2012, we attempted to test Zenivex in campgrounds in Anoka County. Weather (thunderstorms) and trap failures precluded the completion of any tests.

Equipment Evaluations

Helicopter Swath Analysis and Calibration Procedures for Larvicides Technical Services and field staff conducted four aerial calibration sessions for dry, granular materials during the 2012 season. These computerized calibrations directly calculate application rates and swath patterns for each pass so each helicopter's dispersal characteristics are optimized. Sessions were held at the municipal airport in LeSueur, MN. Staff completed calibrations for ten different operational and experimental control materials. In total, seven helicopters were calibrated and each helicopter was configured to apply an average of three different control materials.

Droplet Analysis of Ground-based Spray Equipment During March 2012, Technical Services and the East Region staff used our 20 ft x 40 ft indoor spray booth to evaluate our adulticide application equipment. This self-contained booth collects the adulticide spray particles, which minimizes their release into the air following the calibration process, thus limiting any environmental effects. Technical Service staff optimized 48 ultra low-volume (ULV) insecticide generators (truck-mounted, ATV-mounted, or handheld) using the KLD Model DC-III portable droplet analyzer. Staff uses this analyzer to fine-tune equipment to produce an ideal droplet spectrum of 8-20 microns. Adjusting the ULV sprayers to produce a more uniform droplet range maximizes efficacy by creating droplets of the correct size to impinge upon flying mosquitoes. In addition, more uniform swaths allow staff to better predict ULV application patterns and swath coverage throughout the District.

In October 2012, Technical Services and the East Region staff conducted droplet testing of ULV equipment for the 2013 Season. Technical Services implemented a new process during the fall to reduce the workload of staff during the busy spring season. This timing change allows staff to focus on control efforts in March and better utilizes staff resources in the slower fall season.

Optimizing Efficiencies and Waste Reduction

Improvement of Warehouse Functions In 2012, the warehouse implemented an improved tracking system for the various products it manages. A warehouse spreadsheet program was developed to track each product handled in our three-warehouse system. The spreadsheet monitors on-hand quantities, products received, deliveries, and transfers on a weekly basis. This warehouse process assists the District in the overall tracking of control materials and provides additional checks and balances and accounting of control material use in our seven facilities.

Recycling of Pesticide Containers MMCD continued to use the Minnesota Department of Agriculture’s (MDA) pesticide container recycling program. This project focuses on properly disposing of agricultural pesticide waste containers, thereby protecting the environment from the related pesticide contamination of ground and water.

MMCD implemented a new procedure for recycling pesticide containers. Field offices collected their empty, triple-rinsed plastic containers at their facility and packaged them in large plastic bags for recycling. Each facility delivered their empty jugs to our Rosemount warehouse for pickup by the MDA contractor, Consolidated Container. MMCD prearranged two semi-trailer pickups during the treatment season and staff assisted contractor with loading of the recycled packaging materials.

MMCD staff collected 3,156 jugs for this recycling program. The control materials that use plastic 2.5 gal containers are sumithrin (260 jugs), *Bti* liquid (1,239 jugs), Altosid pellets (1,647 jugs), and other materials (10 jugs).

MMCD also purchases adulticides in 55-gal drums and refills the 5-gal steel cans of the same labeled material. Thereby, the District reduces the need for new packaging and lowers the amount of packaging waste generated by the District. In addition, the warehouse triple-rinsed and recycled numerous plastic drums and steel containers this past season. These 30 or 55-gal drums were brought to a local company to be refurbished and reused.

Recycling of Pesticide Pallets In 2012, MMCD operations produced 852 empty hardwood pallets used in the transportation of VectoBac® G brand *Bti* granules. Technical Services worked with the vendor, Valent BioSciences, to re-use these heavy-duty pallets. After new product deliveries, MMCD periodically returns truckloads of empty pallets to Valent. In doing so, MMCD reduces the need for new pallets, reduces the overall cost of production, and maintains lower control material cost for the District.

MMCD is working with other manufacturers to reuse their pallets to reduce waste streams and costs for both organizations. The warehouse is working with manufacturers to color code pallets and make arrangements for the return of each company's individual pallets for reuse. Each company has specialized pallets to meet the specifications of each product. Therefore, MMCD is implementing new warehouse processes to separate these pallets and store them for pick up by each individual company.

Bulk Packaging of Control Materials In 2012, MMCD met with several vendors to explore the possible options of reusable packaging containers. The focus is to reduce the packaging waste of the various high use materials. MMCD can produce over 40,000 empty bags in an average year. MMCD would like to eliminate a significant portion of these bags by using a large pallet-sized tote that could be adaptable to our field operations. In 2013, MMCD will conduct a pilot project to test the feasibility of using these larger containers in helicopter and ground operations.

2013 Plans

Quality assurance processes will continue to be incorporated into the everyday operations of the regional process teams. Technical Services will continue to support field operations to improve their ability to complete their responsibilities most effectively. A primary goal will be to continue to assure the collection of quality information for all evaluations so decisions are based upon good data. We will continue to improve our calibration techniques to optimize all of our mosquito control equipment.

In 2013, we plan to continue tests of Natular G30 against the cattail mosquito to explore control potential. We will repeat emergence cage evaluations of MetaLarv S-PT to verify effective control of the cattail mosquito. We also plan to test MetaLarv S-PT against spring *Aedes* to evaluate its effectiveness as a spring pre-hatch larvicide. We also will repeat tests of adulticides, emphasizing vector (*Culex*, *Ae. triseriatus*, *Ae. japonicus,* and others) control and effectiveness of barrier treatments.

References

Mulla's Formula:

$$\text{Percent Efficacy} = 100 - \left(100 \times \left(\frac{\text{CntlPre}}{\text{TrtPre}}\right) \times \left(\frac{\text{TrtPost}}{\text{CntlPost}}\right)\right)$$

CntlPre = Mean pretreatment count of untreated control
TrtPre = Mean pretreatment count of treated group
CntlPost = Mean post treatment count of untreated control
TrtPost = Mean post treatment count of treated group

Mir S. Mulla, R. Lee Norland, Dean M. Fanara, Husam A. Darwazeh and Donald W. McKean. 1971. Control of Chironomid Midges in Recreational Lakes. J. Econ. Ent. 64(1): 300-307.

Chapter 6 Supporting Work

2012 Highlights

- First all-staff use of parts of the new web-based system for field data entry
- Started working with new National Wetlands Inventory data for the metro area
- Worked with TAB subgroup to examine nontarget concerns for spinosad products
- Downloads of previous nontarget research reached all-time high
- Customer requests for tire removal reached a 10-year high
- Started providing more frequent updates to citizens using Facebook and Twitter

2013 Plans

- Continue upgrade of data systems by completing larval control section
- Contribute to Minnesota Stormwater Best Practices manual update
- Continue to work with manufacturer on Natular nontarget research
- Continue to expand use of social media to communicate with citizens

2012 Projects

Data System Transition

Field data at MMCD includes records of all larval and adult site inspections, samples, and treatments, container inspection and removal, and treatment check-backs and bioassays, as well as control material physical inventory and truck mileage. This is the data on which most of the rest of this report is based.

In 2012, we continued development of a new web-based field data system to replace our aging PDA and local database system. The new system allows centralized data management, real-time reporting, and can be accessed from any web-enabled device, including both smart phones and PCs, using one software base.

The new system is composed of (1) a central database (using PostgreSQL), hosted on a remote server; (2) web-based data entry forms that reside on the remote server, but can be cached and used on devices even when no web connection is present; and (3) a web "Dashboard" that provides MMCD users easy access to entry screens, data review and edit tools, and reports and summaries which update continuously from the underlying data. Access to the system can be done from any device with a web browser, but requires a user name and password. The system has been built by Houston Engineering, Inc. (HEI), entirely with open source software, so there are no licensing issues for distribution to our 229 users.

By using smart phones as field input devices, we hope to reduce total field hardware expenses after the PDAs are retired. The web-based design also means that the software can be used on tablets or other devices as appropriate, and that eventually there will be only one unified code base to maintain. In the meantime, however, we expect to need both the PDAs and older PC software until the full system can be built, expected in 2014.

An example of the new dashboard is shown in Figure 6.1. The dashboard incorporates MMCD's other web-based data management tools already developed, including the Call System, Public Web Map, Internal Web Map, and Helicopter Track viewer. These systems all use a common database, which can store both spatial data for map viewing and non-spatial data. The dashboard includes views from other websites, such as the National Weather Service daily precipitation summary, that are important for MMCD operations.

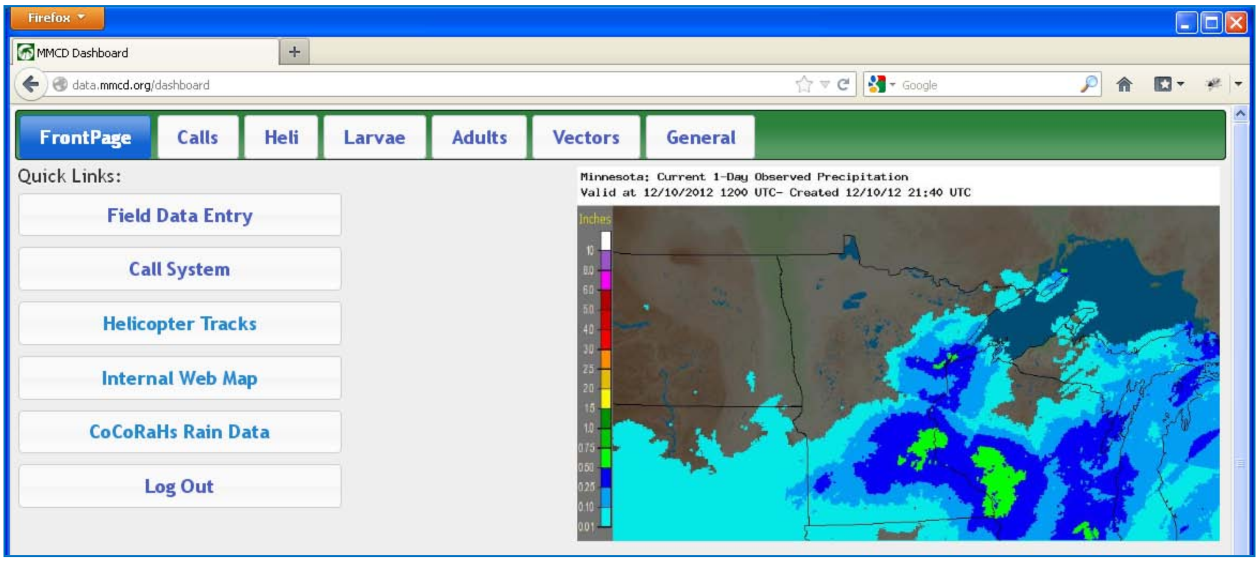


Figure 6.1 MMCD's new "data.mmcd.org" internal data system dashboard.

In 2012, we worked on the following components of the data system:

- Authentication (user name and password) – including tools for password reset
- User interface, "First" and "Home" screen, "Outbox" – clarified work flow, how a user's "Facility" applies to other records, and how to store records when off line and send when connected
- Reference tables (employees, vehicles, materials) – these were set up and Computer Support team members learned how to do remote updates on table contents
- Dashboard (Fig. 6.1) – central access to entry, review, reporting, and other resources
- Vehicle use (daily mileage) and fuel (except when using fuel card, see below) – all staff switched to the new system, starting at the beginning of the field season.
- Larval inspections for cattail sites (fall) – data entry and data review were done entirely through the new system, and on-line reports were developed
- Physical inventory (control materials) – all week-end official inventory entry and review switched to the new system as of Jan. 1, 2013

We have also been working with HEI to improve the robustness and security of the underlying web server and related architecture and backup systems. We were able to learn from several hardware, backup, and security incidents during the summer and have taken steps to prevent recurrences. We are in the process of moving the main system to a cloud-based virtual server.

Our target for 2013 is to have the system set up so that even major disruptions result in no more than 2 hours of down time.
In 2013, we plan to complete the following:

- larval inspection and treatment sections of the data entry system (beyond cattail)
- lab entry of sample identifications
- aerial treatment recording by automatic transfer from helicopter GPS tracks (after review)
- improve control material use recording and daily material balance calculations

We hope to start development of new entry and reporting systems for adult sampling and treatment, and records of container inspections, as time and resources allow. Current estimates are that these will be completed in 2014. This means that in 2013 we will need to continue to run part of the data recording in the old PDA and local database system.

We chose to go with an entirely web-based approach, rather than developing native applications for mobile devices, because we needed software that would run in both desktop and mobile environments while minimizing development and maintenance costs, and we wanted to keep flexibility for future mobile devices. By using a combination of HTML5, CSS and JavaScript, with the jQuery Mobile library, we have been able to achieve near-native functionality without having to customize and install software on each mobile device. The web-based data entry framework developed by HEI for use in this and other field data collection applications has been released as an open source project called "wq" (see "wq: A modular framework for collecting, storing, and utilizing experiential VGI", by S. Andrew Sheppard, ACM Sigspatial geocrowd '12, Nov. 6, 2012, Redondo Beach, CA) (VGI is volunteer geographic information). MMCD and HEI staff gave a presentation on this approach at the Minnesota Government IT Symposium in December, 2012 (see presentations, below).

Mapping

Restricted Access The new Customer Call System add-on for mapping requests for limited treatments or access (see 2011 report) worked well in 2012. About 54 calls requesting restricted access were taken directly through the call system in 2012 (similar to previous years). Parcel boundaries were added along with call information. Mapped boundaries for organizational restricted areas (USF&W, MnDNR, Minneapolis Parks, etc.) were also transferred to the new system. MMCD also receives locations of nesting sites for birds of concern (endangered, threatened, or special concern species) under a license agreement from the MnDNR Natural Heritage Information System "Rare Features Data", which are used to avoid disturbance by helicopter or ground operations.

Public Web Map MMCD continues to make wetland locations and multi-year larval treatment history available through a public web map available at www.mmcd.org. Larval treatment records are automatically updated daily. The site was developed by HEI and uses the MetroGIS Geocoder, basemap information from MetroGIS (Metropolitan Council) and aerial photos from MnGeo (Minnesota Geospatial Information Office). In 2012, the public web map access page on MMCD’s site received 2,973 visits (similar to previous years).

Helicopter GPS Guidance and Tracking MMCD's helicopter contractor continues to provide AgNav GPS guidance and tracking systems for aerial treatments. MMCD staff members prepare "shape" files delineating areas to be treated that are loaded into the AgNav units before flight, and the pilots return track files that show hopper "on" and "off" status. MMCD staff load the track files into a web-based mapping system, where the tracks can be reviewed by both pilots and staff. MMCD staff continues to work with the helicopter contractor as needed to keep this system working smoothly.

Wetland Mapping MMCD staff members updated maps of the approximately 70,000 wet areas that serve as potential larval mosquito habitat. This map data was again made available for download through the MetroGIS “DataFinder” web service. Spring 2012 aerial photography covering much of the metro area, made available by USGS at the end of 2012 and served through the web by MnGeo, is being used where available to update maps for 2013.

In addition to wetlands, MMCD staff members map locations of many stormwater structures, such as street catchbasins, large culverts or separators, and pond water level regulators, which provide larval habitat for species such as *Culex* vectors of West Nile virus and for *Aedes japonicus.* Over 24,000 structures are now mapped, in addition to 280,000 catchbasins.

A District staff member serves on the Technical Advisory Committee of the National Wetlands Inventory (NWI) update project, funded by Legislative-Citizen Commission on Minnesota Resources (LCCMR). This project recently updated the NWI for an area including the metro, using the 2010 aerial photography. MMCD wetland areas were provided as ancillary data for this effort, and MMCD staff members are reviewing the NWI results, comparing them with our maps and field experience, and providing feedback to the NWI effort. We are also finding that the automated photo analysis approach used as a basis for NWI, which incorporates many data sets including elevation and soils data, occasionally indicates new areas not currently on MMCD maps that we will field check in 2013.

GIS Community MMCD staff continue to participate in MetroGIS, and in 2012 assisted with various projects providing benefit to metro governments, including work on a new website with better access to resources and collaboration tools, continued support for the Metro Geocoder used by other agencies as well as by our Customer Call system and web maps (averages ~600 hits per week), and continued progress on a metro-wide Address Points dataset. Staff also gave a GIS project management presentation in the University of Minnesota GIS Masters program class, and participated in planning the Free and Open Source For Geospatial – North America (FOSS4G-NA) conference to be hosted in Minneapolis in May 2013.

Climate Trends – Spring Degree Day Study

The unusual spring of 2012 (see Chapter 1) prompted MMCD staff to take a closer look at trends in spring weather conditions, particularly temperature, and their effect on the need for control activities. As a starting point, we examined degree-day accumulations (air temperature), and compared it with aerial treatments for spring *Aedes*.

Insect development rate changes with the temperature of the environment. Larval mosquito development from hatch to adult emergence can vary from 5 days at midsummer temperatures to over 14 days in cool spring conditions. This speed of development is most accurately described using a 'rate curve' to relate growth per day to temperature (for example, for *Ae. vexans* see Read, N. R. and R. D. Moon, 1996, Environ. Entomol. 25(5): 1113-1121). More growth occurs on warmer days, up to some max temperature at which growth is inhibited by excessive heat. At cooler temperatures, growth accumulates very slowly, and can be estimated as zero below a 'base' temperature (Figure 6.2).

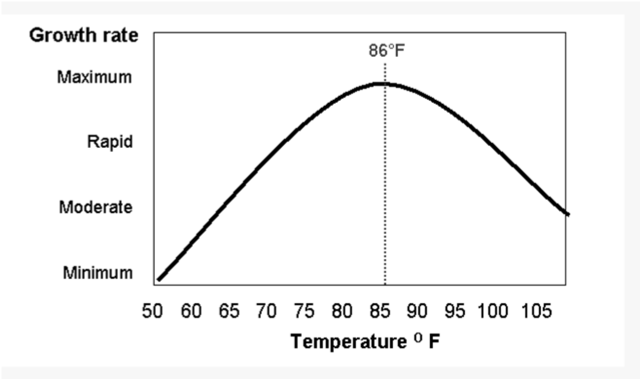


Figure 6.2 Hypothetical growth rate curve (from www.agron.iastate.edu/courses/agron212/Calculations/GDD.htm)

A simple model called Degree-Days (DD) or 'heat units' is often used in place of the more complex rate curve to estimate temperature-dependent growth, and can give very useful results with relatively little computation. The DD model uses the daily maximum and minimum temperature to compute a daily average, and then compares that with the base temperature at which no growth is assumed to occur, to estimate the 'heat units' accumulated each day for that base (DD_{base}). These are then summed from a date chosen for start.

Cumulative sum of daily: $DD_{base} = T_{avg} - baseT$ where $T_{avg} = [(T_{max}+T_{min})/2]$

For the study described here, the base temperature chosen was 40F (4.4C) based on where rate curves for mosquitoes typically intersect 0 growth per day. Air temperature from MSP Airport (from MN State Climatology Office) provided a readily-available multi-year temperature dataset. Figure 6.3 shows the cumulative sum of DD_{40F} from Jan 1 by week of the year (value at end of week), for each year from 1993-2012. Week numbers were based on standard CDC weeks (week starts on Sunday, week 1 = first week with 4 or more days, modified so that all dates after Jan. 1 were in week 1 or higher, not in previous year's week 52). The week totals with an outlined box mark the first week with ≥ 200 DD.

- First week with CumDD40 > 200   - Aerial Treatments for Spring spp. (many or few)   - Treatment on CumDD40 > 200 week

Week #	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Last date in week (2012)
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
2	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	
3	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	
4	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	3	
5	0	0	0	0	0	0	0	0	0	2	3	0	6	0	0	0	0	0	0	3	
6	0	0	0	0	0	0	0	0	0	2	3	0	6	0	0	0	1	0	0	3	
7	0	0	0	0	0	1	0	0	0	2	3	0	6	0	0	0	1	0	0	3	
8	0	0	0	0	0	17	0	20	0	8	3	0	6	0	0	0	1	0	0	3	
9	0	4	0	0	0	17	0	39	0	8	3	2	6	0	0	0	1	0	0	3	
10	0	4	5	0	0	17	0	104	0	8	3	2	13	4	0	0	1	4	0	18	
11	0	9	61	12	0	17	2	104	0	8	19	3	13	4	20	2	30	49	6	135	
12	3	22	69	12	0	72	8	150	0	8	55	56	13	4	54	2	54	70	7	306	Mar 24
13	17	32	72	12	20	95	83	184	0	16	85	81	68	27	148	2	54	174	12	358	Mar 31
14	26	41	79	12	80	158	143	209	23	16	104	132	187	58	156	30	64	236	70	450	Apr 7
15	44	100	100	37	80	234	181	233	66	75	146	209	300	209	162	34	166	356	134	497	Apr 14
16	106	199	129	81	100	335	231	268	115	220	233	292	405	318	281	82	249	461	144	554	Apr 21
17	185	245	184	109	162	436	350	388	213	243	327	385	424	416	415	173	328	576	200	640	Apr 28
18	331	310	273	158	225	571	486	586	367	295	439	492	508	521	566	213	460	646	271	786	May 5
19	474	448	385	220	312	753	601	710	494	356	537	611	607	629	740	321	567	719	411	913	May 12
20	564	627	515	347	372	939	754	809	699	440	664	746	725	762	914	437	765	896	554	1112	May 19
21	689	796	637	492	490	1114	899	973	778	539	775	848	869	951	1075	545	923	1146	692	1280	May 26
22	791	977	810	627	616	1210	1069	1111	910	755	939	1005	1059	1205	1274	690	1071	1341	905	1442	
23	993	1152	970	753	811	1345	1290	1305	1060	913	1093	1204	1292	1417	1457	873	1202	1512	1121	1681	
24	1153	1392	1192	967	1017	1558	1424	1462	1276	1117	1273	1388	1500	1633	1732	1059	1432	1721	1316	1881	

Figure 6.3 Cumulative Degree Days (base 40F, 4.4C) from January 1, MSP Airport.

MMCD field staff members begin checking wetland sites for presence of larval mosquitoes as soon in the spring as weather allows. Site checks may be delayed if conditions are particularly cold or dry, to try to minimize the need to re-check sites later in the spring if conditions improve. Sites with larval populations that met the established control threshold (Chapter 3) are treated (in recent years, primarily with *Bti*), either by hand or from helicopters.

Gray boxes in Fig. 6.3 indicate in which weeks helicopter treatments for spring *Aedes* were done each year. In addition to being timed to match mosquito abundance, aerial treatments are not started until a sufficient number of sites are over threshold, seasonal inspectors are hired, and helicopters are calibrated. In 2012, we considered hiring staff early, but determined we had enough time to complete control before the spring *Aedes* larvae developed completely. In 2010, we also had to mobilize control efforts 1-2 wks earlier than usual.

In addition to temperature, amount and timing of snow melt has a large influence on populations and timing of spring *Aedes*. Warm, dry springs are very different than cold, wet springs. For example, 2000 had two weeks in February with temperatures 25° F above average, a new record, and snow melted very early, followed by a dry period. Spring *Aedes* counts were very low. While 2008, however, had below-normal temperatures and additional snowfall in April, and spring *Aedes* hatched slowly, but resulted in record numbers of adults, possibly because additional larvae hatched after our initial site inspections.

Larval development is more accurately estimated if water temperature is known. MMCD has water temperature monitoring data collected during studies in the late 1980s and we may try to apply correction equations developed for that work to improve these estimates. Other possible sources of data include studies on the Urban Heat Island effect**,** which showed runoff from warm, paved surfaces can increase water temperature in lakes by 10-20° F (Peter Snyder, U of M, see website at islands.environment.umn.edu).

For this study we used aerial treatment dates both because it represents MMCD's needs for control activity, and it acts as a convenient indicator of larval development timing and frequency of occurrence over a large area. We also have extensive larval mosquito sampling data which has been used to determine if sites meet a threshold for treatment. In looking at the larval data we found that first occurrence data alone was not a very valuable indicator of larval timing, since it is strongly influenced by when sampling begins. However, we continue to try to find ways to analyze other biological information from this data, such as larval instar distribution and relative species abundance, that could be usefully compared with degree day accumulations.

The spring of 2012 challenged MMCD to examine how early we need to be prepared to conduct control (hire seasonal staff, prepare helicopters). The early start can also have implications for other species later in the year, particularly those that have multiple generations. We are continuing to examine multi-year trends in biology and their implications for control techniques and budget.

Stormwater Management, Wetland Design, and Mosquitoes

MMCD staff works to maintain awareness of mosquito issues within the stormwater design and regulatory community. For example:

- Staff participated in the MN Water Resources Conference (civil engineers, city & watershed district staff, U of M researchers) and presented a poster titled “Early Spring Effect on Mosquitoes and Wetlands” (see Degree Day study, above).
- The “Stormwater and Mosquitoes” page on the MMCD web site received 759 visits in 2012, compared with 690 visits in 2011 and 1,031 in 2010 (see Resources – Stormwater Management, http://www.mmcd.org/storm.html).
  - The fact sheet on rain barrels recorded 489 downloads in 2012, compared to 592 downloads in 2011.
  - The Rain Gardens poster (produced for the 2009 Water Resources Conference) recorded 800 downloads, a significant increase compared with 145 in 2011 and 121 in 2010 (after 280 downloads in Nov-Dec 2009).
  - The “Mosquitoes and Wetlands” slide show had 63 visits in 2012, compared with 30 in 2011 and 47 in 2010.
  - The site includes a link to the section on mosquitoes in the MPCA Stormwater Manual (http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/stormwater-management.html). This Manual is undergoing an update in 2013 to a web-based format and MMCD staff are working with MPCA staff to update the mosquito information as well.

MMCD continued active participation in the Minnesota Climate Change Adaptation Working Group, comprised of the State Climatologist, staff from the U of MN, federal, state, and local governments, private and nonprofit sector, and other interested individuals. The group focuses on sharing information on climate predictions and temperature and water-related changes, and shares insights and potential challenges member's agencies face. In 2012, the group sponsored a series of lectures including one on "Urban Heat Islands" and a "Mini Climate School", kept up an active list of information and opportunities for local climate adaptation information, and continued work toward expanding web resources for sharing information. Basic information on the group is available at climate.umn.edu/adapt/ and a social network site is available at mnclimateadaptation.ning.com.

Nontarget Studies

Nontarget research on spinosad (Natular) At the February 2012 TAB meeting, the TAB created a subgroup to review information about non-target impacts of spinosad (Natular G30) on aquatic invertebrates, and report back to the full TAB by e-mail within two months. This was in response to some members' concern about chronic toxicity levels and exposure of aquatic invertebrates (including other insects), particularly in woodland pools and cattail marshes, and MMCD staff requests for more input from TAB members on organisms of concern. The subgroup consisted of Gary Montz (MnDNR), Steve Hennes (MnPCA), Karen Oberhauser (UMn) and Bob Koch (Mn Dept. of Ag.), with MMCD staff support provided by Stephen Manweiler. Stephen set up a web-based location where all subgroup members could post and access non-target and other information.

In April 2012, Gary Montz summarized the subgroup's concerns, which primarily involved spring *Aedes* or cattail sites where exposure would occur for longer periods of time (more than five to seven days). The subgroup felt that published non-target information about aquatic invertebrates mostly contained acute (short term) rather than chronic toxicity results, and the few chronic studies showed NOEC (no observed effect concentration) levels for some invertebrates that were close to estimated exposure due to operational dose rates. Therefore they recommended "toxicity testing should focus on longer exposures to determine what impacts may occur." Organisms suggested for study included fairy shrimp, clam shrimp, fingernail or pea clams (Sphaeriidae), some snail species, midges (Chironomidae), and some amphipods. For temporary (spring *Aedes*) habitats, the subgroup recommended testing *Eubranchipus bundyi* (fairy shrimp), Sphaeriidae, two of the gastropod genera, and possibly some common Chironomidae taxa.

Stephen Manweiler relayed these concerns to Clarke, the manufacturer of Natular G30, and requested information about how the EPA had evaluated the potential non-target risk of Natular G30 in various aquatic environments. EPA has approved Natular G30 for use in all the kinds of sites where MMCD conducts larval mosquito control. The EPA compares expected environmental concentrations of spinosad (both directly-measured and modeled data) with acute and chronic toxicity data for a suite of indicator species and calculates a risk ratio (acute or chronic toxicity divided by expected environmental concentration for each indicator species) to estimate risk. EPA typically includes a 10-100X safety buffer (expected exposure 10-100X lower than toxicity result) when determining acceptable material uses (including target insects, characteristics of appropriate treatment areas/conditions, treatment dosages, treatment frequency, etc.) to design the product Label instructions.

MMCD has asked Clarke to share information submitted to EPA as part of the registration process including determinations of expected environmental exposure to spinosad caused by

Natular G30 treatments. Clarke also is working with other agencies (including the Florida Department of Environmental Protection [FLDEP]) to allow use of Natular for larval mosquito control in lands they oversee. Clarke has shared toxicity data and compared the results for two other commonly-used larvicides (*Bti* and methoprene). After reviewing this information, the FLDEP approved Natular for controlling larval mosquitoes in places where *Bti* or methoprene can be used.

Research ongoing at Clarke involves more detailed determinations of the expected environmental exposures in places with characteristics of sites within which spring *Aedes* larvae develop in the Metro area. Stephen Manweiler passed to Clarke the description of spring *Aedes* site characteristics determined by the subgroup for inclusion in the ongoing modeling work. Clarke expects the initial modeling results to be available in mid-2013 with more refined results available before the end of 2013.

Previous Larvicide Nontarget Studies Earlier publications and reports on Wright County Long-term Study and other studies on *Bti* and methoprene done under the direction of the Scientific Peer Review Panel (SPRP) assembled by MMCD, are available on the MMCD web site, mostly as PDF files. Download totals for 2006-2012 are given in Table 6.1. A large number of downloads (1,529) took place on August 30, 2012. The frog malformation study done by C. M. Johnson et al. (NRRI Technical Report # NRRI/TR-2001/01) showed 44 downloads in 2012, compared with 88 in 2011, 72 in 2010, and 12 in 2009.

Table 6.1 Larvicide nontarget impact study report downloads from www.mmcd.org

Report content		2006	2007	2008	2009	2010	2011	2012
SPRP Final Report, 1996		89	289	313	499	703	3,445	5,689
Long-term study brief overview		72	125	58	58	116	258	164
Results summary (1991-1998) with graphs		119	213	223	190	269	408	279
Balcer et al. 1999 Report	text	104	190	73	47	116	180	131
	figures	66	122	23	25	58	36	19
	tables	61	119	37	48	77	58	43
	appx. – cores	48	130	26	31	59	68	38
	appx. – substrates	41	107	27	26	71	56	38
Dose Report		62	131	92	116	120	165	73

Permits and Treatment Plans

National Pollutant Discharge Elimination System Permit A Clean Water Act - National Pollutant Discharge Elimination System (NPDES) permit is currently required for most applications of mosquito control pesticides to water. The MPCA procedures for Pesticide NPDES Permits, in effect since April 30, 2012, is described at http://www.pca.state.mn.us/index.php/water/water-permits-and-rules/water-permits-and-forms/pesticide-npdes-permit/pesticide-npdes-permit-program.html. As required, MMCD prepared a Pesticide Discharge Management Plan (PDMP) that describes contact people, target pests and data sources, thresholds and management, and steps to be taken to respond to various types of incidents included in the NPDES permit. Staff submitted a Notice of Intent (NOI) to the Minnesota Pollution Control Agency (MPCA) and paid permit fees ($1,240 plus $345 per year) in April 2012. The 2012 treatment report, including site-specific treatment history and site locations, is being assembled and will be submitted to MnPCA after the beginning of 2013.

US Fish & Wildlife Service – Mosquitoes and Refuges MMCD continues to work with US Fish & Wildlife Service (FWS) to conduct mosquito surveillance on and near local FWS lands. Activities on the Minnesota Valley National Wildlife Refuge are done according to the stipulations of a Special Use Permit issued by the Refuge Manager. "Emergency Response Procedures" and "Pesticide Use Proposals" forms for the larvicide *Bacillus sphaericus* (VectoLex®) and the adulticide sumithrin (Anvil®) prepared in 2009 by FWS staff allow treatment of disease vectors if "a mosquito-borne disease human health emergency exists in vicinity of the Refuge" (agreed on by MDH, FWS, and MMCD) and such treatment "is found to be appropriate".

FWS regional leadership met in January 2012 with MMCD and MDH staff and other mosquito-borne disease experts to discuss the biology of these diseases and implications for prevention and control. In 2012, MMCD continued to conduct larval surveillance within and near lands managed by FWS in accordance with our sampling permit.

Public Communication

Notification of Control The District continues to post daily adulticide information on its web site (www.mmcd.org) and on its "Bite Line" (651-643-8383), a pre-recorded telephone message interested citizens can call to hear the latest information on scheduled treatments. Aerial larvicide treatment schedules are also posted on the web site as they become available. Information on how to access daily treatment information is regularly posted on Facebook and Twitter.

Calls Requesting Service Calls requesting treatment began in mid-May when mosquito populations were low (Figure 6.4) and peaked around the 4th of July. By late July, treatment requests dropped dramatically and stayed low for the remainder of the season. As in 2011, calls requesting treatment closely tracked a late season drop in precipitation and subsequent drop in mosquito numbers. People planning outdoor activities, such as picnics, outdoor weddings, and graduation open houses continue to be responsible for many early season calls, as they anticipate the number of mosquitoes with which they may have to contend (Table 6.2). Total requests for adult mosquito treatment were the highest seen since 2004; however, calls requesting larval site checks were down from 2011 levels. Calls requesting treatment for public and private events also decreased slightly in 2012. Calls requesting tire removal, however, were up significantly in 2012 to their highest level in at least a decade, reflecting a late-season emphasis on mosquito-borne disease prevention as public awareness of West Nile virus and La Crosse encephalitis risk increased.

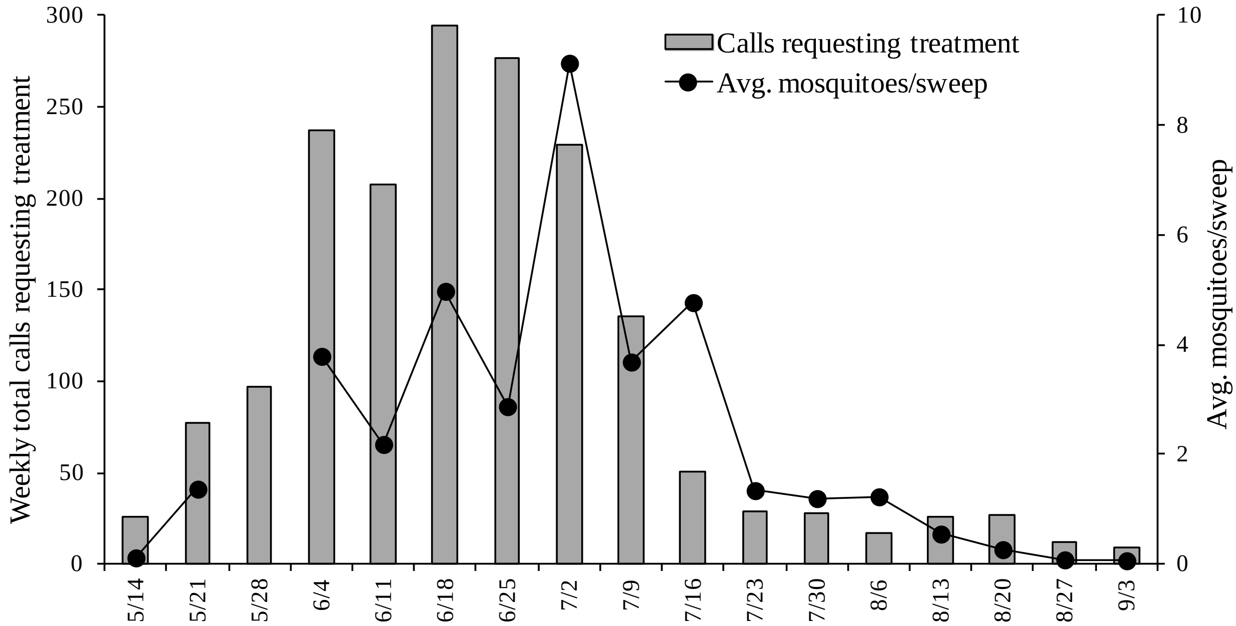


Figure 6.4 Calls requesting treatment of adults, and sweep net counts, by week, 2012. Data for the week of 5/28 is missing due to weather-related cancellation of sweep activity.

Table 6.2 Yearly comparisons of citizen calls tallied by service request from 2002 to 2012*

	Number of Calls/Year										
Caller Concern	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Check a breeding site	1,307	1,516	984	633	610	393	220	197	164	626	539
Request adult treatment	3,062	2,714	2,506	1,094	854	867	1,375	594	1,384	1,291	1,413
Public event, request treatment	171	132	135	100	72	60	109	250	78	68	61
Request tire removal	321	236	255	242	170	208	257	253	335	316	419
Request or confirm limited or no treatment	**190	60	38	36	**171	49	66	61	55	56	54

* Includes email requests for service
** Years where confirmation postcards sent to confirm restricted access property status

Curriculum in Schools MMCD continued to deliver “Mosquito Mania,” a 3-day curriculum for upper elementary and middle school students. This curriculum was introduced to metro-area schools during the 2005-2006 school year. “Mosquito Mania” builds on MMCD’s relationship with schools by offering a standards-based approach to the subject of mosquitoes and their relationship to the environment. Main Office and regional facility staff made presentations to 5,959 students in 47 schools during 2012. We continue to monitor changes in middle-school learning standards and make the adjustments necessary to keep the curriculum relevant and useful.

Social Media As part of an ongoing effort to notify residents when and where treatment is to take place, MMCD continues to build a presence on Facebook and Twitter. Sign up to receive MMCD Tweets (@metromosquito). People can also "friend" Metropolitan Mosquito Control District on Facebook. MMCD currently has 149 Twitter followers and 84 "Likes" on Facebook.

MMCD currently uses the service "GovDelivery" to give advance notification to District residents of adult mosquito treatments. In 2013, GovDelivery will continue to manage MMCD's direct treatment notification email lists. MMCD will work with GovDelivery to make efficient use of social media to reach people who are interested in finding out more about District treatment activities.

Professional Association Support

American Mosquito Control Association MMCD staff members continue to provide support for the national association in a variety of ways.

- Jim Stark is continuing in the elected position of Regional Director for the North Central AMCA region, and serves on the AMCA Board of Directors.
- Diann Crane continues to provide editorial assistance with the AMCA Annual Meeting Program.

North American Black Fly Association John Walz served as President and Program Chair for this group again in 2012 and developed and maintains the association's web site, http://www.nabfa-blackfly.org.

North Central Mosquito Control Association Mark Smith and Sandy Brogren serve on the Board of Directors of this regional association focused on education, communication, and promoting interaction between various regional organizations and individuals in Minnesota, North Dakota, South Dakota, Wisconsin, Iowa, and the Central Provinces of Canada. Mark and other MMCD staff members are involved in planning the 2013 annual meeting, to be hosted at our North facility in Andover, MN, April 11 and 12. The 2012 annual meeting took place in Aberdeen, SD.

Scientific Presentations, Posters, and Publications

MMCD staff attends a variety of scientific meetings throughout the year. Following is a list of papers and posters presented during 2012 and talks that are planned in 2013. Also included are publications that have MMCD staff as authors or co-authors.

2012 Publications

No published papers.

2012 Presentations & Posters

Johnson, K. 2012. Stormwater management contributions to the West Nile virus cycle. Presentation: Minnesota Structural Pest Management Conference. Minneapolis, MN.

Johnson, K. 2012. Control methods for container inhabiting mosquitoes. Presentation: Minnesota Pesticide Applicator Recertification Workshop. St. Paul, MN.

Manweiler, S. 2012. Evaluating effectiveness of barrier adulticide treatments in Minnesota. Presentation: Michigan Mosquito Control Association Annual Meeting, Troy, MI.

Manweiler, S. 2012. Evaluating effectiveness of barrier adulticide treatments in Minnesota. Presentation: Minnesota Structural Pest Management Conference. Minneapolis, MN.

McLean, M. 2012. Mosquito control crisis communication: expecting the best, planning for the worst. Presentation: Minnesota Pesticide Applicator Recertification Workshops. Andover, MN, August 22, 2012; Brainerd, MN, October 23, 2012.

Moon, R.D. and J. Jarnefeld 2012. Seasonal prevalence of *Cuterebra fontinella fontinella* Clark among white-footed mice and other rodents in east-central Minnesota. Poster: ESA 60th Annual Meeting in Knoxville, TN.

Read, N., S. Brogren, D. Crane, and C. LaMere 2012. Early spring effect on wetlands and mosquitoes. Poster: Minnesota Water Resources Conference, St. Paul, MN.

Read, N. and S. A. Sheppard 2012. One data entry web app for many devices? Yes! Presentation: Minnesota Government IT Symposium, St. Paul, MN.

Smith, M. 2012. Helicopter crash: emergency response and crisis management. Presentation: American Mosquito Control Association Annual Meeting in Austin, TX.

Walz, J. 2012. Metropolitan Mosquito Control District (MMCD) black fly program update with National Pollutant Discharge Elimination System (NPDES) permit update. Presentation: North American Black Fly Association Annual Meeting, Venus, FL.

2013 Presentations & Posters

Brogren, S., D. Crane, and C. LaMere 2013. What's causing the population explosion of *Culex erraticus* and *Anopheles quadrimaculatus* in Minnesota? Poster: American Mosquito Control Association Annual Meeting, Atlantic City, NJ.

Crane, D. M., S. Brogren, and C. LaMere 2013. Minnesota mosquito fauna: intriguing changes in a half century of sampling. Presentation: Michigan Mosquito Control Association Annual Meeting, Bay City, MI.

Grant, S. 2013. Framework for excellence: Mission, vision, values. Presentation: Michigan Mosquito Control Association Annual Meeting, Bay City, MI.

Herrmann, M. 2013. Framework for excellence: Mission, vision, values. Presentation: American Mosquito Control Association Annual Meeting in Atlantic City, NJ.

LaMere, C. and J. Walz. 2013. Long-term nontarget monitoring for larval black fly control operations in the Mississippi River. Poster: North American Black Fly Association Annual Meeting, Athens, GA.

Smith, M. 2013. A reduction in your budget can improve your program’s operational effectiveness and efficiency. Presentation: American Mosquito Control Association Annual Meeting in Atlantic City, NJ.

Smith, M. 2013. Focus on leadership to improve your mosquito control operations. Presentation: North Central Mosquito Control Association Annual Meeting in Andover, MN.

Stark, J. 2013. Sustainability: MMCD’s efforts to reduce waste and save energy. Presentation: American Mosquito Control Association Annual Meeting in Atlantic City, NJ.

APPENDICES

Appendix A Mosquito and Black Fly Biology and Species List

Appendix B Average Number of Common Mosquito Species Collected per Night in 4 New Jersey Light Traps 1965-2012

Appendix C Description of Control Materials

Appendix D 2012 Control Materials: Percent Active Ingredient (AI), AI Identity, Per Acre Dosage, AI Applied Per Acre and Field Life

Appendix E Acres Treated with Control Materials Used by MMCD for Mosquito and Black Fly Control for 2004-2012

Appendix F Graphs of Larvicide, Adulticide, and ULV Fog Treatment Acres, 1984-2012

Appendix G Control Material Labels

Appendix H Technical Advisory Board Meeting Minutes and Bird Surveillance Subgroup Meeting Minutes

APPENDIX A Mosquito and Black Fly Biology and Species List

Mosquito Biology

There are 50 species of mosquitoes in Minnesota. Thirty-nine species are found within the MMCD. Species can be grouped according to their habits and habitat preferences. For example, the District uses the following categories when describing the various species: disease vectors, spring snow melt species, summer flood water species, permanent water species, and the cattail mosquito.

Disease Vectors

Aedes triseriatus Also known as the eastern treehole mosquito, *Ae. triseriatus,* is the vector of La Crosse encephalitis. It breeds in tree holes and artificial containers, especially discarded tires. The adults are found in wooded or shaded areas and stay within ¼ to ½ miles from where they emerged. They are not aggressive biters and are not attracted to light. Vacuum aspirators are best for collecting this species.

Culex tarsalis *Culex tarsalis* is the vector of western equine encephalitis (WEE) and a vector of West Nile virus (WNV). In late summer, egg laying spreads to temporary pools and artificial containers, and feeding shifts from birds to horses or humans. MMCD monitors this species using New Jersey light traps and CO_2 traps.

Other *Culex* Three additional species of *Culex* (*Cx. pipiens, Cx. restuans,* and *Cx. salinarius*) are vectors of WNV. All three breed in permanent and semipermanent sites and *Cx. pipiens* and *Cx. restuans* breed in storm sewers and catch basins as well. *Culex erraticus*, normally a southern mosquito, has been increasing in our area over the past decade. In 2012, larvae were found for the first time since 1961 in permanent water sites with no emergent vegetation and edges with willow. *Culex erraticus* is a potential vector of eastern equine encephalitis.

Culiseta melanura *Culiseta melanura* is the enzootic vector of eastern equine encephalitis (EEE). Its preferred breeding sites are spruce tamarack bogs. Adults do not fly far from their breeding sources. A sampling strategy including both larvae and adults is currently being developed.

Floodwater Mosquitoes

Spring Snow Melt *Aedes* Spring snowmelt mosquitoes are the earliest mosquitoes to hatch in the spring. They breed in woodland pools, bogs, and marshes that are flooded with snow melt water. There is only one generation per year and overwintering is in the egg stage. Adult females live throughout the summer and can take up to four blood meals. These mosquitoes do not fly very far from their breeding sites, so localized hot spots of biting can occur both day and night. Our most common spring species are *Ae. abserratus*, *Ae. punctor*, *Ae. excrucians* and *Ae. stimulans*. Adults are not attracted to light, so human (sweep nets) or CO_2-baited trapping is recommended.

Summer Flood Water *Aedes* Eggs of summer floodwater species hatch in late April and early May. Floodwater mosquitoes lay their eggs at the margins of grassy depressions, marshes, and along river flood plains. There are multiple generations per year resulting from rainfalls greater than one inch. Overwintering is in the egg stage. Adult females live about three weeks. Most species can fly great distances and are highly attracted to light. Peak biting activity is as at dusk. The floodwater mosquito, *Ae. vexans* is our most numerous pest. Other summer species are *Ae. canadensis, Ae. cinereus, Ae. sticticus* and *Ae. trivittatus*. New Jersey light traps, CO_2-baited traps, and human-baited sweep net collections are effective methods for adult surveillance of these species.

Cattail Mosquito

Coquillettidia perturbans This summer species breeds in cattail marshes and is called the cattail mosquito. A unique characteristic of this mosquito is that the larvae can obtain oxygen by attaching its specialized siphon to the roots of cattails and other aquatic plants. They overwinter in this manner. This species has one generation per year with adults beginning to emerge in late June and their peak emergence around the first week of July. They are very aggressive biters, even indoors, and can disperse up to five miles from their larval habitat. Peak biting activity is at dusk and dawn. Eggs are laid in rafts on the surface of the water. Surveillance of adults is best achieved with CO_2 traps.

Permanent Water Species

Larvae of other mosquito species not previously mentioned develop in permanent and semipermanent sites. These mosquitoes comprise the remaining *Anopheles*, *Culex*, and *Culiseta* species. These mosquitoes are multi-brooded and lay their eggs in rafts on the surface of the water. The adults prefer to feed on birds or livestock but will bite humans. The adults overwinter in places like caves, hollow logs, stumps or buildings. The District targets four *Culex* species and one *Culiseta* species for surveillance and/or control.

Exotic or Rare Species

Aedes albopictus This exotic species is called the Asian tiger mosquito. It breeds in tree holes and containers. This mosquito is a very efficient vector of several diseases, including La Crosse encephalitis. *Aedes albopictus* has been found in Minnesota, but it is not known to overwinter here. It was brought into the country in recycled tires from Asia and has established itself in areas as far north as Chicago. An individual female will lay her eggs a few at a time in several containers, which may contribute to rapid local spread of the species. This mosquito has transmitted dengue fever in southern areas of the United States. Females feed predominantly on mammals but will also feed on birds.

Aedes japonicus This is an exotic species that was first detected in Minnesota in 2007. In 2008, we determined they are established in the District and southeast Minnesota. Larvae are found in a wide variety of natural and artificial containers, including rock holes and used tires. Preferred sites usually are shaded and contain water rich in organic matter. The transport of eggs, larvae, and pupae in used tires may be an important mechanism for introducing the species into previously uninfested areas. Eggs are resistant to desiccation and can survive several weeks or months under dry conditions. Overwintering is in the egg stage.

***Psorophora* species** Species of this genus breed in floodwater areas, are human-biting, and not known as a vector for any disease. The larvae are predacious, especially on mosquito larvae and are also cannibalistic. They are considered rare in the District, but have recently been collected more often than in the past. The adult *Psorophora ciliata* is the largest mosquito found in the District.

Black Fly Biology

Life Cycle Females lay eggs directly onto the water or on leaves of aquatic plants and objects in rivers, streams, and other running water. Once they hatch, the larvae attach themselves to stones, grass, branches, leaves and other objects submerged under the water. In Minnesota, black flies develop in large rivers (e.g. Mississippi, Minnesota, Crow, and Rum) as well as small streams. Most larval black flies develop under water for 10 days to several weeks depending on water temperature. Larvae eat by filtering food from the running water with specially adapted mouthparts that resemble grass rakes. They grow to about 1/4 inch when fully developed; after about a week as pupae, they emerge as adults riding a bubble of air to the surface.

Female black flies generally ambush their victims from tree-top perches near the edge of an open area. They are active during the day with peak activity in the morning and early evening. Females live from one to three weeks, depending on the species and weather conditions. They survive best in cool, wet weather. Studies done by MMCD show that the majority of black flies in the region lay only one egg batch.

Simulium venustum develops in smaller streams. It has one generation in the spring (April through early June). Species is univoltine. Eggs overwinter and larvae begin hatching in April. Females can travel an average of 9-13 km (maximum=35km) from their natal waterways. *S. venustum* is one of the most common black flies and probably one of the major biting pests of humans in North America.

Simulium johannseni develops primarily in the Crow and South Fork Crow rivers. It has one generation in the spring (April through May). It breeds in large, turbid, meandering streams and rivers with beds of sand and silt. Female adults feed on both birds and mammals

Simulium meridionale develops in the Minnesota, Crow, and South Fork Crow rivers and has three to six generations (May- July). Female adults feed on both birds and mammals. Females will travel at least 30 km from their natal sites and have been collected at heights up to 1500 m above ground.

Simulium luggeri develops primarily in the Mississippi and Rum rivers and has five to six generations a year. Eggs overwinter with larvae and pupae present from May to October. Three to five overlapping generations are produced annually. Host-seeking females can travel at least 42 km from their natal waters and perhaps more than 300 km with the aid of favorable winds. Hosts include humans, dogs, horses, pigs, elk, cattle, sheet and probably moose.

Simulium vittatum develops in smaller streams and to a lesser degree in the Mississippi and Rum rivers. It occurs throughout spring and summer.

References

Adler, Peter H., Douglas C. Currie, and D. Monty Wood. 2004. The Black Flies (Simuliidae) of North America. Cornell University Press.

Species Code and Significance/Occurrence of the Mosquitoes and Black Flies in Minnesota

Code	Genus	species	Significance/ Occurrence	Code	Genus	species	Significance/ Occurrence
Mosquitoes							
1.	*Aedes*	*abserratus*	common, spring	27.	*Anopheles*	*barberi*	rare, tree hole
2.		*atropalpus*	rare, summer	28.		*earlei*	common
3.		*aurifer*	rare, spring	29.		*punctipennis*	common
4.		*euedes*	rare, spring	30.		*quadrimaculatus*	common
5.		*campestris*	rare, spring	31.		*walkeri*	common
6.		*canadensis*	common, spring	311.	*An*. unidentifiable		
7.		*cinereus*	common, spring-summer				
8.		*communis*	rare, spring	32.	*Culex*	*erraticus*	rare
9.		*diantaeus*	rare, spring	33.		*pipiens*	common
10.		*dorsalis*	common, spring-summer	34.		*restuans*	common
11.		*excrucians*	common, spring	35.		*salinarius*	uncommon
12.		*fitchii*	common, spring	36.		*tarsalis*	common
13.		*flavescens*	uncommon, spring	37.		*territans*	common
14.		*implicatus*	uncommon, spring	371.	*Cx*. unidentifiable		
15.		*intrudens*	rare, spring	372.	*Cx.*	*pipiens/restuans*	common
16.		*nigromaculis*	uncommon, summer				
17.		*pionips*	rare, spring	38.	*Culiseta*	*inornata*	common
18.		*punctor*	common, spring	39.		*melanura*	uncommon
19.		*riparius*	common, spring	40.		*minnesotae*	common
20.		*spencerii*	uncommon, spring	41.		*morsitans*	uncommon
21.		*sticticus*	common, spring-summer	411.	*Cs*. unidentifiable		
22.		*stimulans*	common, spring	42.	*Coquillettidia*	*perturbans*	common
23.		*provocans*	common, early spring	43.	*Orthopodomyia*	*signifera*	rare
24.		*triseriatus*	common, summer, LAC vector	44.	*Psorophora*	*ciliata*	rare
25.		*trivittatus*	common, summer	45.		*columbiae*	rare
26.		*vexans*	common, #1 summer species	46.		*ferox*	uncommon
50.		*hendersoni*	uncommon, summer	47.		*horrida*	uncommon
51.		*albopictus*	rare, exotic, Asian tiger mosquito	471.	*Ps*. unidentifiable		
52.		*japonicus*	summer, Asian rock pool mosq.				
53.		*cataphylla**		48.	*Uranotaenia*	*sapphirina*	common, summer
118.		*abserratus/punctor*	inseparable when rubbed	49.	*Wyeomyia*	*smithii*	rare
261.	*Ae.* unidentifiable			491.	Males		
262.	Spring *Aedes*			501.	Unidentifiable		
264.	Summer *Aedes*			601.	Not a mosquito or broken bottle		
Black Flies							
91.	*Simulium*	*luggeri*	summer, treated	96.	Other Simuliidae		
92.		*meridionale*	summer, treated	97.	Unidentifiable Simuliidae		
93.		*johansenni*	spring, treated				
94.		*vittatum*	summer, non-treated				
95.		*venustum*	spring, treated				

* Two *Aedes cataphylla* larvae were collected in April, 2008 in Minnetonka

Genus Abbreviations for mosquitoes

Aedes=Ae.	*Orthopodomyia=Or.*
Anopheles=An.	*Psorophora=Ps.*
Culex=Cx.	*Uranotaenia=Ur.*
Culiseta=Cs.	*Wyeomyia=Wy.*
Coquillettidia=Cq.	

APPENDIX B Average Number of Common Mosquitoes Collected/Night in Four NJ Light Traps and Average Yearly Rainfall, 1965-2012

Year	Spring *Aedes*	*Aedes cinereus*	*Aedes sticticus*	*Aedes trivittatus*	*Aedes vexans*	*Culex tarsalis*	*Cq. perturbans*	All species	Avg. Rainfall
1965	0.10	0.22	0.06	0.01	107.54	8.76	1.28	135.69	27.97
1966	0.16	0.06	0.00	0.01	17.26	0.45	1.99	22.72	14.41
1967	0.31	0.27	0.25	0.03	85.44	0.96	4.93	95.5	15.60
1968	0.21	0.71	0.04	0.19	250.29	2.62	3.52	273.20	22.62
1969	0.15	0.23	0.01	0.03	20.39	0.57	3.57	30.12	9.75
1970	0.20	0.57	0.03	0.33	156.45	0.97	3.07	179.71	17.55
1971	0.87	0.42	0.12	0.11	90.45	0.50	2.25	104.65	17.82
1972	1.05	1.79	0.19	0.07	343.99	0.47	14.45	371.16	18.06
1973	0.97	0.68	0.03	0.04	150.19	0.57	22.69	189.19	17.95
1974	0.37	0.36	0.10	0.03	29.88	0.26	5.62	38.75	14.32
1975	0.28	0.63	0.44	0.17	40.10	6.94	4.93	60.64	21.47
1976	0.24	0.04	0.01	0.00	1.69	0.25	4.24	9.34	9.48
1977	0.14	0.07	0.00	0.02	21.75	5.98	7.42	34.07	20.90
1978	0.84	0.77	0.17	0.11	72.41	4.12	0.75	97.20	24.93
1979	0.29	0.21	0.03	0.48	27.60	0.29	2.12	35.44	19.98
1980	0.03	0.19	0.05	0.79	74.94	0.93	16.88	96.78	19.92
1981	0.05	0.14	0.13	0.69	76.93	1.50	4.45	87.60	19.08
1982	0.10	0.08	0.02	0.03	19.95	0.23	3.16	25.91	15.59
1983	0.15	0.08	0.02	0.04	45.01	0.67	3.44	53.39	20.31
1984	0.08	0.09	0.15	0.36	74.68	2.97	22.60	110.26	21.45
1985	0.07	0.00	0.02	0.01	21.02	0.33	4.96	28.72	20.73
1986	0.35	0.22	0.11	0.04	30.80	1.55	2.42	40.76	23.39
1987	0.00	0.09	0.01	0.17	29.91	1.18	1.52	37.43	19.48
1988	0.01	0.09	0.00	0.00	12.02	0.84	0.18	15.31	12.31
1989	0.05	0.35	0.01	0.26	13.13	1.60	0.17	21.99	16.64
1990	0.30	3.39	0.22	0.08	119.52	4.97	0.08	147.69	23.95
1991	0.11	0.56	0.15	0.26	82.99	1.17	0.45	101.33	26.88
1992	0.04	0.04	0.03	0.13	50.30	0.62	16.31	74.56	19.10
1993	0.03	0.24	0.10	1.15	50.09	0.96	10.90	72.19	27.84
1994	0.02	0.14	0.03	0.08	23.01	0.05	15.19	40.92	17.72
1995	0.04	0.28	0.02	0.29	63.16	0.42	6.79	77.71	21.00
1996	0.12	0.10	0.01	0.04	14.28	0.05	12.06	28.81	13.27
1997	0.09	0.64	0.14	0.63	39.06	0.14	2.03	45.35	21.33
1998	0.03	0.14	0.16	1.23	78.42	0.10	6.13	91.29	19.43
1999	0.01	0.28	0.09	0.11	28.24	0.06	1.74	33.03	22.41
2000	0.01	0.07	0.00	0.22	24.09	0.15	1.36	29.50	17.79
2001	0.05	0.41	0.32	0.10	20.97	0.27	1.01	26.26	17.73
2002	0.05	0.22	0.07	2.53	57.87	0.35	0.75	65.82	29.13
2003	0.04	0.15	0.43	2.00	33.80	0.13	1.59	40.51	16.79
2004	0.02	0.33	0.22	0.63	24.94	0.16	0.99	28.91	21.65
2005	0.05	0.11	0.17	0.42	22.27	0.17	0.57	25.82	23.60
2006	0.05	0.08	0.14	0.01	6.73	0.08	1.85	10.04	18.65
2007	0.22	0.27	0.01	0.01	8.64	0.26	0.94	13.20	17.83
2008	0.38	0.32	0.17	0.01	8.17	0.10	2.01	12.93	14.15
2009	0.10	0.07	0.00	0.02	3.48	0.04	0.23	4.85	13.89
2010	0.07	0.08	0.06	0.17	16.18	0.23	0.36	26.13	24.66
2011	0.10	0.07	0.11	0.78	33.40	0.07	5.76	47.36	20.61
2012	0.04	0.03	0.15	0.21	21.10	0.04	4.01	30.39	16.98

APPENDIX C Description of Control Materials

The following is an explanation of the control materials currently in use by MMCD. The specific names of products used in 2012 are given. The generic products will not change in 2013, although the specific formulator may change.

Altosid® (methoprene) 150-day briquets Central Life Sciences
Altosid® XR Extended Residual Briquet

Altosid briquets are typically applied to mosquito breeding sites which are three acres or less. Briquets are applied to the lowest part of the site on a grid pattern of 14-16 ft apart at 220 briquets per acre. Sites that may flood and then dry up (Types 1 & 2) are treated completely. Sites that are somewhat permanent (Types 3, 4, 5) are treated with briquets to the perimeter of the site in the grassy areas. Pockety ground sites (i.e., sites without a dish type bottom) may not be treated with briquets due to spotty control achieved in the uneven drawdown of the site.

Cattail mosquito (*Coquillettidia perturbans*) sites are treated at 330 briquets per acre in rooted sites or 440 briquets per acre in floating cattail stands. Applications are made in the winter and early spring.

Altosid® (methoprene) pellets Central Life Sciences
Altosid® Pellets

Altosid pellets consist of methoprene formulated in a pellet shape. Altosid pellets are designed to provide up to 30 days control but trials have indicated control up to 40 days. Applications will be made to ground sites (less than three acres in size) at a rate of 2.5 lb per acre for *Aedes* control and 4-5 lb per acre for *Cq. perturbans* control. Applications will also be done by helicopter in sites that are greater than three acres in size at the same rate as ground sites, primarily for *Cq. perturbans* control.

Altosid® (methoprene) sand Central Life Sciences
Altosid® XR-G

Altosid XR-G sand consists of methoprene formulated in a sand-sized granule designed to provide up to 20 days control. Applications for control of *Cq. perturbans* are being evaluated at 10 lb per acre.

MetaLarv® S-PT (methoprene) granules Valent Biosciences
MetaLarv® S-PT

MetaLarv S-PT consists of methoprene formulated in a sand-sized granule designed to provide up to 28 days control. Applications for control of *Cq. perturbans* and *Aedes* mosquitoes are being evaluated at three and four lb per acre.

***Bacillus thuringiensis israelensis* (*Bti*) corn cob** Valent Biosciences
VectoBac® G

Bti corncob may be applied in all types of larval habitat. *Bti* can be effectively applied during the first three instars of the mosquito breeding cycle. Typical applications are by helicopter in sites that are greater than three acres in size at a rate of 5-10 lb per acre. In sites less than three acres, *Bti* is applied to pockety sites with cyclone seeders or power backpacks.

***Bacillus thuringiensis israelensis* (*Bti*) liquid** Valent Biosciences
VectoBac® 12AS

Bti liquid is applied directly to small streams and large rivers to control black fly larvae. Treatments are applied when standard Mylar sampling devices collect threshold levels of black fly larvae. Maximum dosage rates are not to exceed 25 ppm of product as stipulated by the MnDNR. *Bti* is applied at pre-determined sites, usually at bridge crossings applied from the bridge, or by boat.

Bacillus sphaericus (Bs) Valent Biosciences
VectoLex® CG

Bs corn cob may be experimentally applied in all types of *Culex* mosquito breeding. *Bs* can be effectively applied during the first three instars of the mosquito breeding cycle. Typical experimental applications are by helicopter in sites that are greater than three acres in size at a rate of 5-10 lb per acre. In sites less than three acres, *Bs* is applied to pockety sites with cyclone seeders or power back packs at rates of 8 lb per acre. This product is also being evaluated as a control material for catch basin applications.

Natular® (spinosad) Clarke
Natular® G30, XRT

Natular is a new formulation of spinosad, a biological toxin extracted from the soil bacterium *Saccharopolyspora spinosad,* being developed for larval mosquito control. Spinosad has been used by organic growers for over 10 years. Natular is formulated as long release tablets (XRT) and granules (G30) and can be applied to dry and wet sites. This product is also being evaluated as a control material for catch basins, other small storm water management structures, and small ground sites.

Permethrin Clarke
Permethrin 57% OS

Permethrin is used by the District to treat adult mosquitoes in known daytime resting or harborage areas. Harborage areas are defined as wooded areas with good ground cover to provide a shaded, moist area for mosquitoes to rest during the daylight hours.

Adult control is initiated when MMCD surveillance (sweep net and light trap collections) indicates nuisance populations of mosquitoes, when employee conducted landing rate collections document high numbers of mosquitoes, or when a large number of citizen complaints of mosquito annoyance are received from an area. In the case of citizen complaints, MMCD staff evaluates mosquito levels to determine if treatment is warranted. MMCD also treats functions open to the public and public owned park and recreation areas upon request and at no charge if the event is not-for-profit.

The District mixes permethrin with soybean and food grade mineral oil and applies it to wooded areas with a power backpack mister at a rate of 25 oz of mixed material per acre (0.0977 lb active ingredient (AI) per acre).

Esfenvalerate MGK, McLaughlin Gormley King
Onslaught® Microencapsulated Insecticide

Esfenvalerate (Onslaught) is used by the District to treat adult mosquitoes in known daytime resting or harborage areas. Harborage areas are defined as wooded areas with good ground cover to provide a shaded, moist area for mosquitoes to rest during the daylight hours. Esfenvalerate is a non-restricted use compound. The District mixes Onslaught with water and applies it to wooded areas with a power backpack mister at a rate of 25 oz of mixed material per acre (0.0919 lb AI per acre).

Resmethrin Bayer
Scourge® 4+12

Resmethrin is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Resmethrin is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand-held cold fog machines that enable the applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Resmethrin is applied at a rate of 1.5 oz of mixed material per acre (0.0035 lb AI per acre). Resmethrin is a restricted used compound and is applied only by Minnesota Department of Agriculture licensed applicators.

Sumithrin Clarke
Anvil® 2+2

Sumithrin is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Sumithrin is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enable applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Sumithrin is applied at a rates 1.5 and 3.0 oz of mixed material per acre (0.00175 and 0.0035 lb AI per acre). Sumithrin is a non-restricted use compound.

Natural Pyrethrin Bayer
Pyrenone® 25-5

Pyrenone is used by the District to treat adult mosquitoes in known areas of concentration or nuisance where crop restrictions prevent treatments with resmethrin or sumithrin. Pyrenone is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enables the applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Pyrenone is applied at a rate of 1.5 oz of mixed material per acre (0.00172 lb AI per acre). Pyrenone is a non-restricted used compound.

Natural Pyrethrin MGK, McLaughlin Gormley King
Pyrocide® 7396 (5+25)

Pyrocide is used by the District to treat adult mosquitoes in known areas of concentration or nuisance where crop restrictions prevent treatments with resmethrin or sumithrin. Pyrocide is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enables the applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Pyrocide is applied at a rate of 1.5 oz of mixed material per acre (0.00217 lb AI per acre). Pyrocide is a non-restricted used compound.

Etofenprox Central Life Sciences
Zenivex® E20

Etofenprox is used by the District to treat adult mosquitoes in known areas of concentration or nuisance. Etofenprox is applied from truck or all-terrain-vehicle mounted ULV machines that produce a fog that contacts mosquitoes when they are flying. Fogging may also be done with hand held cold fog machines that enable applications in smaller areas than can be reached by truck. Cold fogging is done either in the early morning or at dusk when mosquitoes become more active. Etofenprox is applied at a rate of 1.0 oz of mixed material per acre (0.00175 lb AI per acre). Etofenprox is a non-restricted use compound.

APPENDIX D 2012 Control Materials: Active Ingredient (AI) Identity, Percent AI, Per Acre Dosage, AI Applied Per Acre and Field Life

Material	AI	Percent AI	Per acre dosage	AI per acre (lbs)	Field life (days)
Altosid® briquets [a]	Methoprene	2.10	220	0.4481	150
			330	0.6722	150
			440	0.8963	150
			1*	0.0020*	150
Altosid® pellets	Methoprene	4.25	2.5 lb	0.1063	30
			4 lb	0.1700	30
			0.0077 lb* (3.5 g)	0.0003*	30
Altosid® SR-20 [b]	Methoprene	20.00	20 ml	0.0091	10
Altosid® XR-G	Methoprene	1.50	10 lb	0.1500	20
MetaLarv™ S-PT	Methoprene	4.25	2.5 lb	0.1063	30
			3 lb	0.1275	30
			4 lb	0.1700	30
Natular™ G30	Spinosad	2.50	5 lb	0.1250	30
VectoBac® G	*Bti*	0.20	5 lb	0.0100	1
			8 lb	0.0160	1
VectoLex® CG	*Bs*	7.50	8 lb	0.6000	7-28
			0.0077 lb* (3.5 g)	0.0006*	7-28
Permethrin 57%OS [c]	Permethrin	5.70	25 fl oz	0.0977	5
Scourge® [d]	Resmethrin	4.14	1.5 fl oz	0.0035	<1
Anvil® [e]	Sumithrin	2.00	3.0 fl oz	0.0035	<1

[a] 44 g per briquet total weight (220 briquets=21.34 lb total weight)
[b] 1.72 lb AI per 128 fl oz (1 gal); 0.45 lb AI per 1000 ml (1 liter)
[c] 0.50 lb AI per 128 fl oz (1 gal) (product diluted 1:10 before application, undiluted product contains 5.0 lb AI per 128 fl oz)
[d] 0.30 lb AI per 128 fl oz (1 gal)
[e] 0.15 lb AI per 128 fl oz (1 gal)
* Catch basin treatments—dosage is the amount of product per catch basin.

APPENDIX E Acres Treated with Control Materials Used by MMCD for Mosquito and Black Fly Control, 2004-2012. The actual geographic area treated is smaller because some sites are treated more than once

Control Material	2004	2005	2006	2007	2008	2009	2010	2011	2012
Altosid® XR Briquet 150-day	398	635	352	290	294	225	174	205	165
Altosid® Sand-Products	0	0	0	1,776	6,579	8,320	9,924	13,336	23,436
Altosid® Pellets 30-day	19,139	29,965	31,827	36,818	35,780	35,161	36,516	30,749	13,172
Altosid® Pellets Catch Basins	148,023	145,386	167,797	161,876	195,973	219,045	227,611	234,033	226,934
MetaLarv™ S-PT	0	0	0	0	0	0	0	0	2,750
Natular™ G30	0	0	0	0	0	0	0	0	9,524
Natular™ XRT Catch Basins	0	0	0	0	0	0	0	1,078	0
Altosid® XR Briquet Catch Basins	0	0	5,210	6,438	40	0	0	0	458
VectoLex® CG granules	0	810	540	27	6	0	0	0	0
VectoMax® CG granules	0	0	0	0	182	5	0	0	0
Bti Corn Cob granules	166,299	176,947	160,780	118,128	122,251	151,801	250,478	201,957	207,827
Bti Liquid Black Fly (gallons used)	2,813	3,230	1,035	1,348	2,063	2,181	2,595	3,817	3,097
Permethrin Adulticide	8,292	7,982	5,114	3,897	8,272	4,754	8,826	7,544	8,578
Resmethrin Adulticide	71,847	40,343	29,876	24,102	64,142	12,179	27,794	24,605	8,078
Sumithrin Adulticide	15,508	25,067	5,350	5,608	35,734	7,796	26,429	29,208	27,486
Pyrenone® Adulticide	0	0	0	0	2,214	943	2,560	0	0
Pyrocide® Adulticide	0	0	0	0	299	0	0	0	0

APPENDIX F Graphs of larvicide, adulticide, and ULV fog treatment acres, 1984-2012

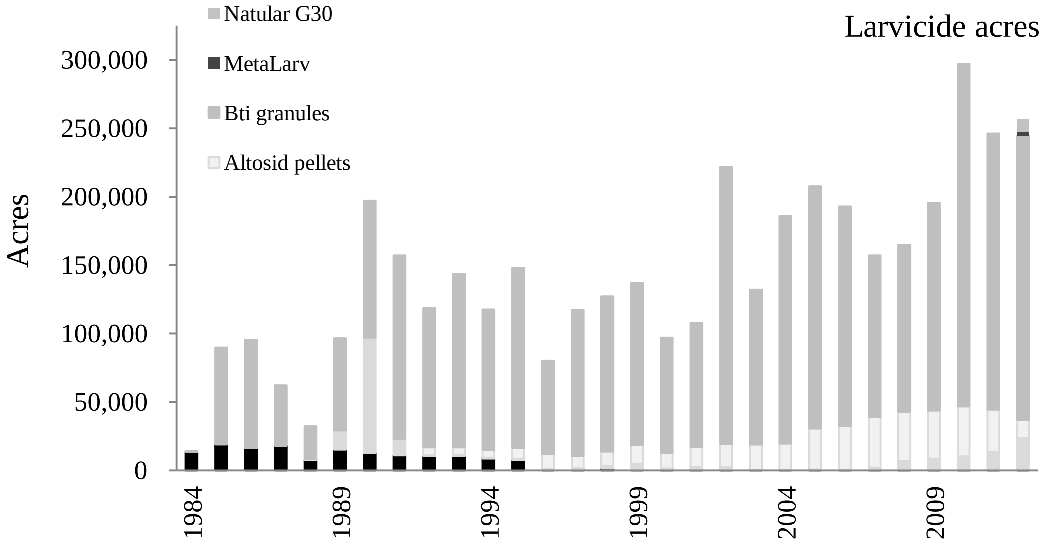


Figure F.1 Summary of total acres of larvicide treatments applied per year since 1984. For materials that are applied to the same site more than once per year, actual geographic acreage treated is less than that shown.

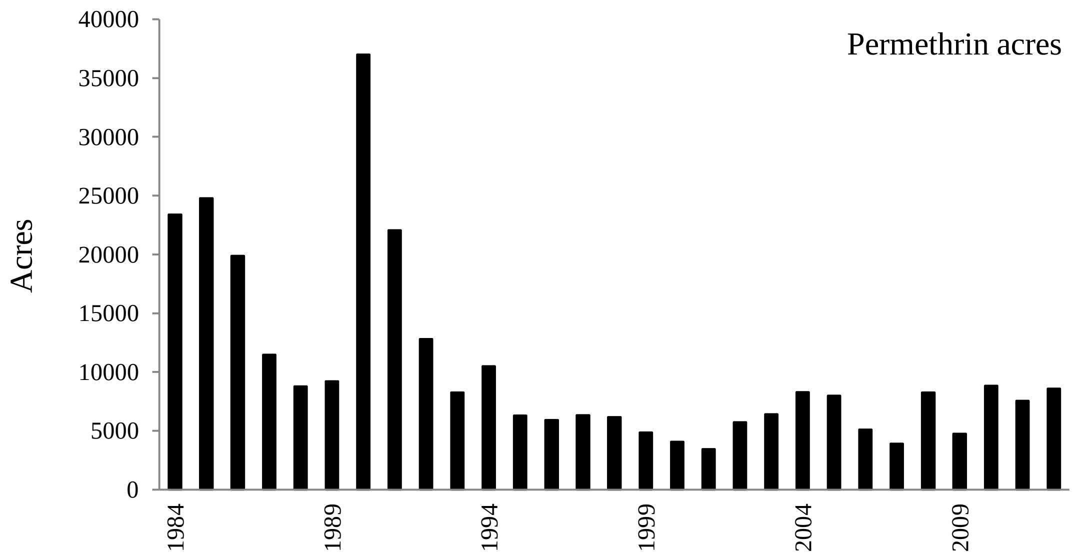


Figure F.2 Summary of total acres of permethrin treatments applied per year since 1984. This material may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

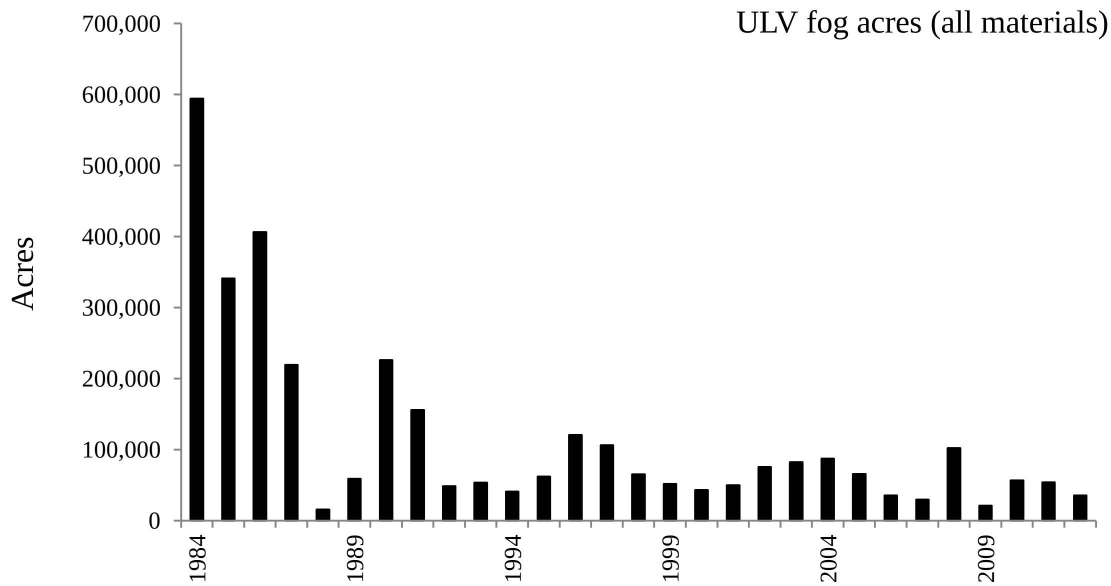


Figure F.3 Summary of total acres of ULV fog treatments applied per year since 1984. These materials may be applied to the same site more than once per year, so actual geographic acreage treated is less than that shown.

APPENDIX H Meeting Minutes – Technical Advisory Board Meeting and Bird Surveillance Subgroup

MMCD Technical Advisory Board
Meeting Minutes
February 14, 2013

TAB members Present:
Gary Montz, MN Dept. of Natural Resources
David Neitzel, MN Department of Health
Mark Abrahamson, MN Dept. of Agriculture
Robert Sherman, Independent Statistician
Vicky Sherry, US Fish and Wildlife Service
Susan Palchick, Hennepin County Public Health
Roger Moon, University of Minnesota
Sarma Straumanis, MN Department of Transportation
John Moriarty, Three Rivers Park District
Larry Gillette, Three Rivers Park District (retired)

MMCD staff in Attendance: Jim Stark, Nancy Read, Diann Crane, Kirk Johnson, Mike McLean, Janet Jarnefeld, Carey LaMere, Stephen Manweiler, John Walz

Guests:
Hannah Friedlander, (MDH - Council of State and Territorial Epidemiologists Fellow working on vector-borne disease issues), Elizabeth Schiffman (MDH)

(Initials in the notes below designate discussion participants)

Welcome and Call to Order
Chair Roger Moon called the meeting to order at 12:30 p.m. All present introduced themselves. Roger then introduced MMCD Director, Jim Stark.

2012 Budget Review, Sustainability
MMCD Executive Director Jim Stark welcomed TAB members and discussed MMCD's history, taxing authority, and its current budget situation. MMCD's levy has remained constant since 2010 and our budget has fluctuated little since 2011. The budget for 2013 is roughly the same as it was in 2012. Jim also presented information on a sustainability initiative that the District is undertaking. This initiative is being demonstrated by one of our major suppliers, Clarke Mosquito Control (see www.clarke.com).

NPDES Permit Requirement (National Pollutant Discharge Elimination System)
Jim Stark also gave an update on the situation with the Clean Water Act and its extension to pesticide applications including mosquito control, as a result of 2009 court actions. MN PCA has developed permitting procedures and MMCD has complied by developing an Integrated Pest Management plan and paying appropriate permit fees. Treatment reports for 2012 are being prepared for submission to MN PCA.

Mosquito Surveillance
Diann Crane presented a report on the relationship between weather conditions and mosquito populations for 2012. Populations of *Anopheles quadrimaculatus* have been increasing and numbers were notably high this year. The usually rare *Culex erraticus* was also found in higher numbers. Staff found this species' larvae for the first time in the District since the 1960s.
LG: For *An. quadrimaculatus*, can you compare CO_2 trap with New Jersey light trap results? His light trap count was high this year. Diann responded that we do not typically compare the two methods, as they use different attractants and run for different time periods. The NJ traps are used for our long-term multi-year trap comparisons; LG's trap is a more recent trapping location.

LG – Referring to the draft TAB report: p.52, Fig 3.3 shows some of counts used for vector or annoyance threshold and asked if we could find out how many treatments are initiated based on each. Stephen Manweiler responded that this information will be included in next year's report.

Degree Day Analysis
Nancy Read presented an analysis of degree day accumulation as a way to put spring 2012 conditions and treatment decisions in context relative to conditions for the last 20 years.

RS – Asked if water temperature is ever so hot it reduces larval development? NR responded that there is a point at which development decreases.
RM – Noted that for spring *Aedes*, which overwinter as eggs, this degree day approach and starting accumulation from Jan. 1 makes sense.

Black Fly Surveillance and Control
John Walz described the history of MMCD's black fly control program, and gave an overview of treatments, efficacy, adult numbers, and nontarget monitoring.

GM – Asked why MMCD is getting less control in the South Fork Crow River yet good control in other areas. JW – responded that that watershed was very flooded early and it was difficult to put out the samplers. Later, water levels dropped to very low levels.
GM – Questioned the low percentage of mortality when doing a treatment. JW – said that when water flow was low the material may not carry to the downstream monitoring point.
RM – Asked if population numbers were related to previous discharge patterns (and will anticipated climate change effects on discharge patterns affect black fly populations and our ability to treat them?)
RM – Noted that some potential treatment sites were dropped because of low productivity and asked if MMCD does any long-term check-backs to see if those sites are still unproductive? JW – responded that we do some, but do not have a specific protocol for streams.

Tick Surveillance
Janet Jarnefeld reported on our tick surveillance work. Overall numbers of *Ixodes scapularis* were comparable to recent years, but a higher number of mammals had ticks, and more sites were positive. She reminded us that Minnesota and Wisconsin are hot spots for anaplasmosis.

RS – Asked if none of the indicators of tick activity were going down?!
DN – Noted that you would expect a difference with dry summers, perhaps with tick larvae more sensitive to drought. JJ – responded that numbers don't always bear that out.

JM – Asked about symptoms of anaplasmosis. DN – high fever, usually clears, but can result in fatality. The Health Department reports several deaths every year.

Mosquito-Borne Disease
Kirk Johnson discussed La Crosse encephalitis, which made a comeback in the District in 2012. For eastern equine encephalitis in 2012 there was increasing activity in northern parts of New England, and cases in WI and one in horse case in MN. WNV was also in the news this year with significant outbreaks in TX, SD and western MN. High case rates were seen in MN up to only 65 miles from the western edge of the District.

Bird Surveillance
Kirk then led a discussion on possible changes to MMCD's practice regarding bird surveillance for WNV. MMCD is getting fewer reports of dead birds from the public, possibly due to loss of public interest or change in bird susceptibility. We are also looking at cost in staff time and processing for picking up dead birds. It is difficult retaining enough staff (especially students) in late summer, when dead bird reports typically peak. Right now, the public can report birds via phone or through MMCD’s web site. These reports are mapped and we can look for clusters. If the reported birds are in good shape, we quickly collect them and test for WNV. Where clusters of positive birds are found, we respond with neighborhood inspections for larval habitat, and we sample adult mosquitoes and take control action if adults or larvae are over threshold. Kirk handed out a table of results of various types of surveillance for the last 10 years (**attached to these notes), and discussed some of the factors that affect timing of virus detection. We have also adjusted our criteria for determining which birds to test. He then discussed benefits of doing bird surveillance.

JM – Noted that in 2006, some percentage of birds tested positive, and asked if that percentage has been similar most years? KJ – Responded that it varies, ranging from 40% to 75%; typically over 65% in more severe epidemic years.
GM – Noted you talk about using clusters, but are 20 tested birds enough to show a cluster? What level of testing do you need to find it useful? KJ – Responded that the numbers of positive birds is a limiting factor, but number of calls can be more useful.
RS – Asked if we could consider sequential sampling. We could stop testing after some number is reached. He also asked about test reliability. KJ – Responded that the RAMP test is about 82% versus PCR. All positives by RAMP were confirmed, and some negative RAMP findings turned out to be positive by PCR analysis.
LG – Asked, are you in touch with Roseville Rehabilitation Center, they are testing birds? KJ – Responded, yes, the Wildlife Rehabilitation Center is a good resource, and MMCD has helped them with testing.
LG – Noted that MMCD data shows a rise in infected birds prior to human cases showing up. Crows are in territories early in year while on their nests; later in the year (after July 1) they have a much larger flight range, does that affect bird infection rates?
MA – Noted a huge variation in numbers of bird reports from the public year-to-year, and asked if there has there been a difference in interaction with public. KJ – Responded that media coverage will vary from year to year which accounts for much of the variation in reports. MA – Asked about ways to seed stories early in year. KJ – Responded that we are interested in exploring this further so we can increase public awareness.

JM – Noted that the spatial distribution of dead bird reports follows the distribution of the human population (that makes those reports), and asked if dead bird reports really help show where WNV cases will occur. KJ – Responded that the reports are a good predictor of virus activity, but don't always translate into an indicator of human risk.
SP – Noted that sometimes media coverage is very general, and people may have seen that MDH is not collecting dead birds. The public may not differentiate with MMCD's efforts; is MDH forwarding dead bird reports to MMCD? DN – Said that MDH sees positive bird reports as having a low predictive value for human disease risk, but might be useful for directing further surveillance.
RM – Asked about cost of surveillance vs. the opportunity to gain information. KJ – Said that, especially later in the year, we can be pretty sure that a dead crow is an infected crow, and that there are clear advantages if we wait to stop testing until later in the year.
GM – Asked if general reports of dead crows correlate well with the verified WNV positive birds. Does that help you save money if you just use dead bird reports, not testing? KJ – Responded that there are some advantages to knowing locations of dead crows in directing operations, including larval and adult control of vector species.
SP – Noted that reports only show where dead crows are found, and it doesn't necessarily follow that they aren't dying in other places.
RM – Asked if the information is really useful for directing operations. KJ – Responded that dead bird calls are still the timeliest indicator of virus activity. RM – Asked, what do you do in response? KJ – Said that extra mosquito surveillance (adult and larval) is initiated, possibly followed up by larviciding and adulticiding when appropriate to reduce risk.
RS – Asked, if you have dead crows, what is lowest rate of virus? How often do you test 50 crows and get no positive birds? KJ – Noted that were was an abrupt seasonal change. It starts at 0, but at some point we "hit the switch".
RS – Asked, if you test 5-10 birds could you set aside the rest of the collecting process? KJ – Responded that this year the "switch" was the 6th bird collected.
SP – Suggested that crow testing doesn't show much in the way of spatial distribution, but timing of WNV activity could be useful indicator.
RM – Asked is this real-time info necessary or is it counting fire trucks on the way to the fire? RM then surveyed the TAB about forming a subcommittee to address dead bird reporting. . There was general assent from TAB members to form a subgroup to give direction and feedback on this issue and to report back to MMCD. The following agreed to be on the subcommittee: DN, SP, RM, RS, JM.

Break 2:15-2:30 p.m.

Material Re-registration and Restricted Use

Mark Smith presented information on the re-registration of pyrethroids by EPA, and its implications on restricted use. We are expanding training and licensing of staff so that all staff that apply these materials will be licensed, not just working under the direction of a licensed applicator. We also have implemented guidelines for treatment that exceed label requirements for things such as buffers. Mark also noted the upcoming meeting of the North Central Mosquito Control Association, which is designed to meet recertification needs as well (see www.north-central-mosquito.org).

SP – Asked if sumithrin was becoming a restricted use pesticide. MS – Responded that it was labeled after 1984, so it is not coming up for reregistration and will probably not become restricted use. SP – Asked if, in that case, MMCD plans increasing use of sumithrin. SM – Responded yes, plus sumithrin has the advantage of being labeled for use in agricultural areas.

Control Materials

MMCD Director of Operations/Technical Services Stephen Manweiler described our integrated mosquito control program, and how we address the various kinds of mosquitoes and conditions faced, given budgetary limits. Different kinds of larvicides help us address different treatment needs. He reported on threshold and dose changes that have been implemented to provide more cost-effective control. He described our current use and testing of new materials, including MetaLarv, another formulation of methoprene, and Natular, a formulation of spinosad.

LG – Asked, when you elevated treatment thresholds, what public response did you get? SM – Responded that we can't directly relate call volume to threshold changes.

Natular Nontarget Studies

Stephen presented information on Natular nontarget studies, including a summary of the meetings of a TAB subgroup from earlier in 2012. He summarized published information and other available data. The latest model being used for evaluation by EPA is based on a spring wetland treatment scenario, and estimates ppm in the water over time. This can be used to compare chronic exposure tolerances for different species. The Florida Dept. of Environmental Protection has evaluated data on Natular and decided it was at least as tolerable as methoprene, and has approved it for use. There is continued work evaluating Natular products for long-term release. Right now the District is using Natular at the lowest label rate, only in summer treatment sites.

GM – Noted that neither MMCD nor Clarke seem to have any intention of doing nontarget testing on particular organisms, or in cattail habitats. SM – Responded that we don't see a need to do testing in cattail habitats unless there's better product efficacy for cattail mosquito control. Right now it doesn't appear to be cost effective for control in those site types since the material has a very short half-life in highly organic environment (days). Clarke is not interested in doing tests of specific organisms, but is more interested in testing suites of organisms, like the EPA proposes.

RS – Asked which organisms they think there would be a case for doing testing on. SM – (see TAB subgroup response) some similar organisms have been proposed. GM – Noted that mysid shrimp aren't closely related to what you would find in woodland pools.

RM – Asked about concern over use of this product in stormwater structures and its effects on mollusks. SM – Natular products are no longer being used in stormwater structures by MMCD.

GM – Said our main concern now is spring pools, which have a rich assemblage of invertebrates, and are important for waterfowl. We have less concern about summer *Aedes* habitats.

RM – Said that he was not sure he bought the argument (from Florida DEP) that if methoprene is ok, spinosad should be ok, because the mode of action is very different. SM – Noted that spinosad is a neurotoxin.

RM – Asked if there were any plans to do toxicity studies on woodland pool organisms. SM – Responded no, Clarke will only test on those required by EPA.

JM – Asked about the cost of these tests. SM – Said that the cost could be up to $30,000.

RS – Asked if MMCD could do any of the testing here. SM – Responded that MMCD is not set up for that. RM – Suggested it was better to have a 3rd party do testing.
RM – Asked what was the recommendation for a path of action made by the TAB subgroup? GM – Noted that the group, of which he was a member, was charged to identify sites and organisms of most concern, and we did that (see our write-up). Snails, for example, would not be as important in the woodland pools as in cattail sites, however, there are a small number of organisms we recommended to do chronic testing on.
RM – Noted the motion last year regarding staying at small-scale testing, and asked if there was progress on that score. SM – Said that MMCD took the recommendation as direction to hold back on treating spring *Aedes* sites and did not get Clarke to agree to do testing.
RM – Asked if MMCD wanted to go ahead with operational use. SM – Responded that, for summer sites, yes. For spring sites, we may want to use Natular in some conditions, but we have alternatives.
SM – Asked the TAB if it trusted the work that EPA has done. We could have someone from EPA come in and review this. GM – Responded that the toxicity data that's been shown does not address the concerns about chronic exposure to specific kinds of local organisms. If they don't have that data, more or other information wouldn't help. SM – Noted that Clarke has the chronic exposure data which was required for registration, they could present the information here. GM – Asked if they could send that information to the TAB. SM – Noted that the data were expensive to collect, and that Clarke may require nondisclosure agreement to share.
RM – Asked if we could we do field testing. Treat some sites; survey the biology afterward. JM – Said that Ron Lawrenz (Director, Lee and Rose Warner Nature Center - Science Museum of Minnesota) in Washington Co. could do this. SM – Responded that the cost would need to be reasonable.
RS – Said that testing would be a good investment in order to have this material available.
SM – Summarized: I've heard two things proposed – more data from EPA and the manufacturer, and some local testing (if inexpensive).
JM – Asked, what would you spend on testing vs. the total amount of the contract [with Clarke]? Wouldn't it be worth it to them? JS – Noted that they have worldwide distribution, and it would seem impractical to do specific testing for everyone.
RM – Said that we're proposing something more in-house; something on the scale of the divided pond study [see Scientific Peer Review Panel summary, http://www.mmcd.org/sprp/SprpIndex.htm]. SP – Said that there is also more trust now than for the last SPRP studies; there's a lot of EPA data which we probably could look at in-house as a first pass. SM – Asked, would you believe the results if we bring those back? Involve some TAB members? The general response was yes to both questions.
The Social Media presentation prepared by Mike McLean was tabled due to lack of time.

Discussion and Resolutions

Chair Roger Moon opened the floor for discussion and suggestions for resolutions to be brought before the MMCD Commission (3:32 p.m.)

There was general discussion on the possibility of doing a field study on possible nontarget impact of Natular G30 in vernal pools. The TAB would like to ask Clarke for some support, and ask last year's subcommittee to draft a plan for tests. JM knows some nice sites in northern Ramsey County. RM could do statistical analysis. GM can't commit much time for this spring but could be persuaded to participate. JM – Noted that researcher would need to know if the wetlands have those organisms before they start. GM – Noted that's one reason to do lab studies instead of field studies. SM – Asked GM to point out which organisms from last year's subcommittee list are found in vernal pools.

Motion – That the chair of the TAB send a letter to Clarke regarding nontarget studies on Natular, asking for support and additional data to address the TAB's concerns about chronic toxicity. Motion passed.

Motion – That MMCD work with a subgroup of TAB members to draft plans for nontarget impact studies of Natular G30 in vernal pools, including choice of organisms for study. Motion passed.
Group to consist of JM, RM, GM, and Karen Oberhauser (absent)

Motion – That MMCD work with a subgroup of TAB members to discuss issues related to changes in dead bird surveillance, and that group present a summary to MMCD for consideration. Motion passed. Group to consist of DN, RM, JM, SP, BS. (Notes attached)

Motion – That the TAB commends Larry Gillette for his many years of service, his advocacy for the environment and social responsibility, and for his active participation on the TAB. Motion passed.

LG – in my area the worst mosquito problems from annoyance are cattail and spring mosquitoes, but the summer mosquitoes aren't as bad, don't last as long. He asked that when considering budget priorities, the District consider more zone 2 spring and cattail control rather than attempting huge control efforts for very large summer broods, which may get worse as we get more big events with climate change. This past year the Spring *Aedes* and Cattail mosquito levels were great (low!). SP – Suggested that the question is whether the mosquito numbers are going to be just as bad whether you treat or not.

Meeting adjourned 3:58 p.m.

Next chair will be representative from Mn Dept. of Agriculture (Mark Abrahamson)

Handout for Bird Surveillance Discussion

MMCD bird and mosquito surveillance for West Nile virus 2003 - 2012

Year	1st WNV+ Bird	1st WNV+ Mosquito	No. WNV+ Birds	No. Birds Tested	No. WNV+ Mosq. Pools	No. Pools Tested	MIR/1000 Mosquitoes	Notes
2003	June 12	July 15	194	366	15	3369	2.57	MIR excluding *Aedes* & *Coquillettidia* species tested
2004	June 16	Sept. 1	116	275	2	3859	0.19	MIR excluding *Aedes* & *Coquillettidia* species tested
2005	June 24	July 13	48	114	13	3309	1.08	MIR excluding *Aedes* & *Coquillettidia* species tested
2006	June 6	June 6	484	745	89	2867	3.37	
2007	June 5	July 5	60	88	85	2474	3.09	
2008	July 12	July 8	7	25	23	913	1.13	
2009	June 25	June 24	1	7	4	762	0.24	
2010	July 30	Aug. 11	3	9	11	1245	0.41	
2011	June 24	Aug 16	4	10	5	924	0.37	
2012	July 5	July 11	20	26	105	1009	6.72	231 of 285 dead birds reported were corvids

MMCD Technical Advisory Board – 2013 Bird Surveillance Subgroup
Meeting Minutes
March 7, 2013

Participants: Roger Moon, John Moriarty, David Neitzel, Robert Sherman, Stephen Manweiler, Kirk Johnson. Susan Palchick was unable to participate. The meeting was held via teleconference.

Review of background information
Kirk Johnson reviewed information that had been presented in the February 14th TAB meeting. He outlined the reasoning for re-evaluating MMCD bird surveillance for WNV monitoring including:

- Diminished citizen participation
- Options for use of dollars and staff time for other services
- Possibility that WN mortality rate in corvids is in decline
- Some overlap of information from WNV tests of birds and mosquitoes

This is not the first time that changes have been considered to bird surveillance as a method for monitoring WNV. From 2001 through 2006 MMCD partnered with the Minnesota Department of Health to collect and test birds for the virus. MDH decided to divert funds from testing birds to other WNV monitoring efforts in 2007. During the first few years of WNV circulation in Minnesota, many bird species were collected and tested. In 2006, we limited WNV testing to corvids and raptors. In 2008, we decided to collect corvids only. In 2006, MMCD started using the RAMP test for birds to supplement PCR analyses by MDH and RAMP has been the exclusive test method for birds collected by MMCD since 2007. In addition, MMCD has developed a method for screening reports so that only the best candidate birds are collected for testing resulting in a biased sample set.

We also reviewed the benefits of collecting dead bird reports and of testing dead birds. Corvids, especially crows, have been a particularly sensitive sentinel for WNV activity. As such, they have offered an early warning mechanism, of sorts, indicating when enzootic WNV transmission is increasing. Clusters of dead corvids in space and time might indicate an increase in risk to human health. Information obtained through bird surveillance can help fill geospatial gaps between mosquito monitoring locations. MMCD staff also appreciate the positive interactions with citizens when collecting specimens.
Kirk Johnson reiterated the options under consideration for 2013 bird surveillance:

- Continue with the current level of surveillance with steps to improve public participation
- Continue to take reports of dead birds, but reduce tests for WNV
- Continue to take reports of birds, but stop testing for WNV
- Discontinue bird surveillance altogether

Dave Neitzel asked for a review of how MMCD uses bird surveillance data operationally. Kirk Johnson indicated that both test results and reports of corvids that are not tested are used to evaluate WNV circulation. The reports that come in later in the season, after WNV activity is well documented, are used to identify clusters. If multiple corvids are reported from one area within a short time span, MMCD will respond by inspecting the area for larval mosquito habitats that were not previously treated and often by conducting adult mosquito surveillance. Of particular concern is a situation where WNV has been detected in an area, several dead corvids have been reported and the *Culex tarsalis* population is elevated. The adult mosquito surveillance is used to determine if and where adult mosquito control will occur. As noted by Susan Palchick during the February 14th TAB meeting, most reports of dead birds come from the areas of greatest human density.

Roger Moon asked about the intrinsic incubation period of WNV in crows. Kirk Johnson and David Neitzel agreed that it is about two days and that most crows die within three to five days post infection.

Roger Moon stated that he would like to see a formal analysis of the data to determine the predictive value of a WNV positive or negative bird with respect to human infections. How does the first WNV positive bird compare to the first human WNV illness? David Neitzel indicated that statewide bird testing was discontinued due to limited data leading to limited predictability but that MMCD data is more complete and should be more predictive. Robert Sherman noted that there are few human cases compared to the number of dead birds. The bird deaths are indicative of an epizootic but not necessarily of elevated human risk. Dave Neitzel agreed that an epizootic is not always predictive of human cases. We need bridge vector involvement to raise the risk of human infections. Kirk Johnson stated that 2012 was an example of year with an active epizootic but lacking a severe human epidemic. In 2012 the population of the main bridge vector, *Culex tarsalis*, peaked about a month earlier than the populations of the enzootic vectors, *Culex pipiens* and *Culex restuans*. The infection rate in mosquitoes peaked at the same time of year as the *Cx. pipiens/restuans* population peak. There were only two WNV positive *Cx. tarsalis* pools among the 105 positive pools in 2012.

Roger Moon reminded the group that many states have abandoned bird surveillance due to its poor predictive value for human health risk. He proposed MMCD work to increase public awareness of WNV and the role that birds play in the virus' cycle, and encourage the public to report dead birds. MMCD should look for birds to test early in the season as a method to confirm early enzootic WNV transmission. Once there is a WNV positive bird, inform the public that the virus has been detected and stop testing birds. He proposed that MMCD also stop taking reports of dead birds at that time. John Moriarty suspected that people will continue to call about dead birds even after MMCD stops taking reports. He wondered if it would be of any value to continue collecting that information. Kirk Johnson indicated that the MMCD call system is set up to record that information and that staff will log the call anyway so it would be easy to continue maintaining reports of birds through the season.

Robert Sherman asked what infection rate in birds raises concerns. Is a 10 percent infection rate significant? He suggested MMCD could test a small number of birds early, perhaps 10. If there are no positives, stop testing for a while then repeat the process. Roger Moon suggested we look at previous years' bird test data by week and calculate weekly proportion positive. From that you can determine what sample size is needed each week to achieve a level of confidence in predictability of virus activity dates. You can analyze data from all years combined and also compare annual patterns. Robert Sherman asked if there are correlations between weather conditions and temporal patterns of virus activity that are indicated by bird test results. The group briefly discussed the many factors involved in WNV amplification including several species of mosquitoes and birds and how different weather conditions favor various mosquito species. But that in general terms, a wet winter and/or wet spring can improve habitat availability for vector species and that hot, dry conditions in the summer lead to rapid amplification of WNV.

David Neitzel supported the idea of concentrating surveillance efforts for WNV in birds early in the season including testing birds to detect when WNV is active. However, to get meaningful data from such an effort it will be critical to increase public awareness. Robert Sherman agreed and added that there is much PR value in explaining how the District is using bird data to detect WNV activity. There was some discussion of the multiple outlets available for communicating information: MMCD website, social media, and traditional media. Roger Moon suggested the first step is to get people interested enough to look at the information on the District's web site or to connect through social media sites. He wondered if MMCD can make use of staff in the field to distribute information.

Robert Sherman asked if dead birds are reported from the same areas every year or during most years. Can reports of dead birds be used to identify areas where more mosquitoes are developing or where there are higher concentrations of adult mosquitoes? Roger Moon asked David Neitzel if MDH has a student worker looking for a thesis project who could help evaluate the ten plus years of bird data that has been collected. David will poll student workers at MDH. Robert Sherman suggested employing mathematical models of epidemiology. He also pointed out that anyone analyzing MMCD data should be aware of changes in public interest over time and that the data are not random since reports of birds seem to increase when there are WNV stories on TV news or in newspapers.

Kirk Johnson suggested another project for a student might be to research WNV immunity in the local crow population. It could be useful for identifying whether using birds for WNV surveillance will be obsolete over time.

The group agreed to recommend Roger Moon's proposal to MMCD:
Increase public awareness of WNV and the role that birds play in the virus' cycle and encourage the public to report dead birds. MMCD should look for birds to test early in the season as a method to confirm early enzootic WNV transmission. Once there is a WNV positive bird, inform the public that the virus has been detected and stop testing birds. The District should develop a general model for what to do with bird report data that is received after WNV is detected.

Action Items

Kirk Johnson will compile a set of data for all birds tested in past years. He'll work with David Neitzel to recover any information that resides at MDH. That data will be sent to all subgroup members.

Roger Moon and David Neitzel will both look for students who are interested in epidemiological projects.

Robert Sherman will review epidemiological models and work with the bird test result data.

Editorial Staff & Contributors

Diann Crane, M.S., Assistant Entomologist
Carey LaMere, Laboratory Technician

The following people wrote or reviewed major portions of this document:
*Sandra Brogren, Janet Jarnefeld, Kirk Johnson, Carey LaMere,
Stephen Manweiler, Mike McLean, Nancy Read, Ken Simmons,
Mark Smith,* and *John Walz*

First Draft February 1, 2013
Second Draft March 31, 2013
Final April 22, 2013