City of Boulder 2012 Integrated Mosquito Management Program Report

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February 2013

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EXECUTIVE SUMMARY

For the 2012 mosquito season, the City of Boulder contracted OtterTail Environmental, Inc. (OtterTail) to operate a comprehensive Integrated Mosquito Management (IMM) program to protect public health from the effects of West Nile Virus (WNV) and to help suppress nuisance mosquito populations in a limited number of areas in the city.

Since the spring of 2003, the City of Boulder has conducted a vector mosquito control program designed to protect public health and biological resources from the effects of WNV. Through surveillance of potential mosquito breeding sites, areas identified as containing larvae of the Culex (vector) species were identified and treated with *Bacillus thuringiensis israelensis* (*Bti).* This method of targeting vector larvae prevents the mosquitoes from developing into adults and transmitting the virus, and is the most efficient and environmentally responsible way to reduce vector populations. The vector mosquito control program provided *Bti* treatments only on the areas where the target Culex species were found; areas with nuisance-only species were bypassed. This approach reduced the impact to many wetland environments from repeated applications of *Bti* because many of the mosquito breeding sites only bred Culex mosquitoes for a limited portion of the season.

Sites identified as breeding nuisance-only larvae were not treated in the vector mosquito control program which reduced control material costs as well as the time needed to apply them. More labor time was required to differentiate between vector and nuisance-only larvae as compared to nuisance-focused control. These costs were outweighed by the increase in early WNV detection that larval vector identification provides. A benefit of early identification of vector larvae can provide approximately two weeks advance notice before adult mosquitoes are identified. In addition, control of larvae reduces the possible future need for non-biological control of adult mosquitoes such as ultra-low volume (ULV) pesticide spraying.

The 2012 vector mosquito control program started in May with larval surveillance and the first Culex larval treatment occurred on May 30th. The project area included 511 sites totaling 3,094 acres consisting of City-owned lands within the city limits and City-owned lands outside of the city limits (**Appendix A, Map A-1**). OtterTail performed 243 treatments on 97 sites that were found to be breeding Culex mosquitoes. A total of 157 acres were treated for larvae during the 2012 season as a result of the vector mosquito control program.

Adult mosquito populations and WNV activity were monitored within the project area using 16 adult mosquito traps. These trap collections enabled OtterTail to monitor adult nuisance levels and provide adult mosquito samples to the Colorado Department of Public Health and Environment (CDPHE) which tested mosquitoes weekly for the presence of WNV.

Although areas within the central and southeastern regions of the U.S. had severe WNV outbreaks occur in 2012, Colorado was spared a large number of cases due to the regional climate patterns during the season. The overall lack of precipitation and high temperatures in 2012 caused mosquito populations to remain at lower than average levels throughout the season; consequently, there was significantly less WNV activity in Colorado. The City of Boulder's IMM program coupled with education and personal protection measures, also likely contributed to reduced mosquito populations and WNV activity in the city and county during 2012.

In addition to protecting public health with the vector mosquito control program, the City also wanted to help suppress the number of nuisance mosquitoes around several popular outdoor recreational areas and isolated neighborhoods. These were areas that had an unusually high number of visitor and residential complaints concerning nuisance mosquito bites in 2006. To address this issue, the City of Boulder started a nuisance mosquito control program during the 2007 season and continued it through the 2012 season. This program allows the City of Boulder to treat a limited number of habitat sites for nuisance mosquito larvae with *Bti*.

The habitat sites included were already a part of the City's vector mosquito control program, but since nuisance mosquitoes typically peak before the WNV season begins, OtterTail began monitoring the selected sites several weeks earlier in the season.

The 2012 nuisance mosquito control program started in April with larval surveillance and the first larval treatment for nuisance mosquitoes occurred on May 3rd. The project area included 120 sites totaling approximately 690 acres. OtterTail performed 16 treatments on 14 sites that were found to breeding nuisance-only mosquitoes. A total of 9 acres were treated for nuisance-only mosquito larvae during the 2012 season as a result of the nuisance mosquito control program.

Adult mosquito populations were monitored within the nuisance project area using 3 adult mosquito traps in addition to the 16 traps used in the vector mosquito control program. These trap collections enabled OtterTail to monitor adult nuisance levels around the nuisance mosquito control program areas to aid in determining the success of the nuisance mosquito control.

1.0 VECTOR MOSQUITO CONTROL PROGRAM

1.1 INTRODUCTION

For the 2012 mosquito season, the City of Boulder contracted OtterTail Environmental, Inc. to operate a vector mosquito control program (vector program) to protect public health and biological resources from the effects of West Nile Virus (WNV). For background information about WNV and mosquito control in Boulder, please refer to the *2006 City of Boulder West Nile Virus Mosquito Management Plan* (WNV MMP) and the *2011 West Nile Virus Season Report* (www.bouldercolorado.gov). This report explains the methods used in the Integrated Mosquito Management (IMM) program and provides a detailed summary of the results of this year's effort.

The City's primary goal was the same as in previous seasons; to protect public health from the effects of WNV. To accomplish this goal, specific objectives have been established for the vector program. First, the City of Boulder wanted to continue to prioritize mosquito habitats by determining which ones had the highest potential for mosquito breeding and then monitor and treat those sites when Culex larvae were present. Second, since Culex larvae were being identified, they wanted to use this as a tool to provide an early warning of any upcoming adult Culex populations. Third, they wanted to monitor adult mosquito populations. Monitoring is done by speciation, population counts, and testing for WNV in trapped vector specimens and provides an early warning system for the occurrence and severity of WNV activity in the program area. The City also wanted to limit the effect on the environment from control materials and to be as cost-effective as possible.

1.2 WEST NILE VIRUS UPDATE

West Nile Virus is a mosquito-transmitted virus that can cause a wide range of effects, from an asymptomatic infection to a neuroinvasive disease termed West Nile meningitis or encephalitis. West Nile Virus was first detected in the United States during the summer of 1999 in New York City while conducting routine St. Louis Encephalitis (SLE) and Eastern Equine Encephalitis (EEE) surveillance. The virus has since spread across the U.S. and has been confirmed in all continental states. Bird populations act as a reservoir for the virus until a mosquito bites an infected bird. Only then can an infected mosquito pass the virus on to humans, horses, and other animals through their bite. While many people who contract WNV experience mild or no symptoms, the more severe cases of West Nile meningitis or encephalitis can result in severe illness and even death.

There are over 50 mosquito species in Colorado, yet only species from the genus Culex are known to be effective transmitters of WNV. Mosquitoes and other insects that transmit disease are called vectors; mosquitoes that are not known to transmit a disease are often called nuisance mosquitoes. The most abundant mosquito in Boulder County, *Aedes vexans*, is an aggressive nuisance mosquito.

As of December 11th, 2012, there were 5,387 WNV human cases and 243 WNV related deaths in 48 states (**Table 1**). During the 2003 WNV epidemic, Colorado led the U.S. in WNV cases and then experienced a significant decrease in WNV cases in 2004 and 2005. During the 2006 and 2007 mosquito seasons, Colorado had a resurgence of cases and once again led the U.S. human case count in 2007. WNV activity decreased throughout the U.S. and Colorado during 2008 - 2011 seasons, with 2011 having the lowest totals in the state and nation since it was first detected in Colorado in 2002. The U.S. experienced a resurgence of WNV activity in 2012, which led to the second highest national case count since it was first detected in the country. Colorado, however, did not reach the epidemic levels that some areas of the country did due to its high temperatures and lack of precipitation throughout the 2012 mosquito season.

This year, Colorado ranked tenth in the national case count with 131 human WNV cases and 5 WNV related deaths reported as of December 11, 2012. Most WNV cases occurred in Colorado among the populous regions of the Front Range (Adams, Denver, and Larimer Counties) as well as in the western slope counties of Delta, Montrose and Mesa **(Table 2)**. No mosquito pools, horses, birds or humans tested positive for St. Louis Encephalitis or Western Equine Encephalitis in Colorado during the 2012 season**.**

As of December 31, 2012 there was 1 WNV related illness and no related deaths reported in Boulder County **(Table 2)**. With widespread and frequent testing of mosquito pools, 8 of the 94 submitted pools of mosquitoes tested WNV positive in the county. The relatively lower number of human infections and amounts of WNV activity in Colorado may be attributed to the temperature and precipitation patterns observed during the 2012 mosquito season and the affect they had on mosquito populations, as discussed further in **Section 1.3**.

Table 1 WNV Incidence, 2002-2012

Total WNV Human Cases	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Cases in the United States[1]	4,156	9,862	2,539	3,000	4,269	3,630	1,356	720	1,021	712	5,387
Deaths in the United States[1]	284	264	100	119	177	124	44	32	57	43	243
Highest State Count in United States[1]	884	2,947	779	880	996	578	445	115	167	158	1,739
Cases in Colorado[2]	14	2,947	291	106	345	578	71	103	81	7	131
Deaths in Colorado[2]	0	63	4	2	7	7	1	3	4	0	5
Cases in Boulder County[2]	0	421	14	5	74	95	18	12	6	2	1
Deaths in Boulder County[2]	0	7	0	0	1	2	0	0	0	0	0
Total WNV Positive Results	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Mosquito Pools in Boulder County[2]	0	118	8	0	107	55	3	4	1	9	8
Mosquito Pools in the City of Boulder[2]	0	43	0	0	12	7	0	0	0	3	2
Birds in Boulder County[2]	5	50	0	1	12	2	0	0	1	0	0
Horses in Boulder County[2]	3	18	0	0	1	0	0	0	0	0	0

1. Reported by the Center for Disease and Control (CDC); 2012 data reported as of December 11, 2012.
2. Reported by the Colorado Department of Public Health and Environment (CDPHE); 2012 data reported as of December 31, 2012.

There were no WNV related deaths in Boulder County and the number of Boulder County cases and WNV positive mosquito pools comprised approximately one percent and four percent of the state totals, respectively (**Table 2**). When populations of nearby Front Range Counties are taken into account, Boulder County had the second lowest crude attack rate (cases per 100,000 individuals) in the region **(Table 3).** The low number of human WNV cases, WNV positive mosquito pools and WNV crude attack rate suggests that the viral activity in Boulder County was lower than other nearby counties and significantly less in 2012 than during previous years with epidemic outbreaks. It is likely that the continued widespread larval control efforts to reduce mosquito populations combined with public education and personal protection measures helped reduce the exposure and consequently limited disease transmission within the City of Boulder and Boulder County.

Table 2 **Colorado WNV Cases and WNV Positive Mosquito Pools, 2012**

County	Human Cases[1]		Human Deaths[1]		Positive Mosquito Pools[1]	
	Number	% of State	Number	% of State	Number	% of State
Adams	16	12.2%	0	0.0%	9	4.3%
Alamosa	1	0.8%	0	0.0%	0	0.0%
Arapahoe	4	3.1%	1	20.0%	4	1.9%
Baca	1	0.8%	0	0.0%	0	0.0%
Boulder	1	0.8%	0	0.0%	8	3.8%
Broomfield	2	1.5%	0	0.0%	0	0.0%
Delta	22	16.8%	1	20.0%	53	25.4%
Denver	16	12.2%	0	0.0%	0	0.0%
Douglas	1	0.8%	0	0.0%	0	0.0%
El Paso	2	1.5%	0	0.0%	0	0.0%
Fremont	5	3.8%	0	0.0%	0	0.0%
Jefferson	3	2.3%	0	0.0%	0	0.0%
La Plata	4	3.1%	1	20.0%	0	0.0%
Larimer	8	6.1%	0	0.0%	84	40.2%
Las Animas	1	0.8%	0	0.0%	0	0.0%
Logan	0	0.0%	0	0.0%	1	0.5%
Mesa	14	10.7%	0	0.0%	32	15.3%
Montrose	20	15.3%	2	40.0%	2	1.0%
Morgan	2	1.5%	0	0.0%	0	0.0%
Otero	1	0.8%	0	0.0%	0	0.0%
Prowers	1	0.8%	0	0.0%	1	0.5%
Pueblo	1	0.8%	0	0.0%	0	0.0%
Weld	5	3.8%	0	0.0%	15	7.2%
Colorado Totals	**131**		**5**		**209**	

1. Reported by CDPHE as of December 31, 2012

Table 3 **Human WNV Crude Attack Rates[1] of Front Range Counties, 2012**

County	Population	# of WNV Cases	% of Front Range Cases by # of Cases	2012 Crude Attack Rates (per 100,000)	% of Front Range Cases by Population	Crude Attack Rank
Adams	441,603	16	27.1%	3.62	20.8%	1
Arapahoe	572,003	4	6.8%	0.70	4.0%	6
Boulder	294,567	1	1.7%	0.34	1.9%	10
Broomfield	55,889	2	3.4%	3.58	20.5%	2
Denver	600,158	16	27.1%	2.67	15.3%	4
Douglas	285,465	1	1.7%	0.35	2.0%	9
El Paso	622,263	2	3.4%	0.32	1.8%	11
Jefferson	534,543	3	5.1%	0.56	3.2%	8
Larimer	299,630	8	13.6%	2.67	15.3%	3
Pueblo	159,063	1	1.7%	0.63	3.6%	7
Weld	252,825	5	8.5%	1.98	11.4%	5

***** WNV human case information used for Crude Attack Rate calculations was obtained from CDPHE (CDPHE 2012); Population information for Crude Attack Rate calculations was obtained from U.S. Census Bureau 's 2010 Census of Population (USCB 2011); Crude Attack Rates are listed as cases per 100,000 people.

1.3 2012 CLIMATOLOGICAL DATA AND MOSQUITO ACTIVITY OVERVIEW

The weather patterns leading into and during the mosquito season are important factors that influence mosquito abundance and WNV activity. The following section describes the local climate in Boulder, the weather during the season, and how that may have affected the mosquito populations.

The City of Boulder is located in a semi-arid environment at an elevation of approximately 5,340 feet. The typical mosquito season for the City of Boulder is from April to September. Current and historical climate data from the National Oceanic Atmospheric Administration's (NOAA) Boulder, Colorado weather station were used for regional temperature and precipitation patterns.

Historical records for the mean monthly temperature at the station suggest that temperatures usually have a steady increase from April to July, making July, on average, the hottest month of the year. Typically there is then a steady temperature decrease into September. In 2012, every month of the mosquito season (April – September) had above normal temperatures, with the hottest month of 2012 being July. The month of June experienced the highest variation from normal with a monthly mean temperature seven and a half degrees above normal (**Figure 1**).

The historical averages for the monthly mean precipitation indicate that April, May and June are usually the wettest months of the year (**Figure 2**). During 2012, the accumulated precipitation from January through September was below the historical average of accumulated precipitation for the same period. During this time period in 2012, there was an accumulation of 13.4 inches. This is approximately 13 percent less than the normal accumulation for this time period when compared to the historical average, which is 15.4 inches. Six of the nine months received precipitation amounts lower than their normal averages. The most significant variations were the months of March and July. March received 94 percent less precipitation than average, making it the driest month of 2012. July received nearly three times more precipitation than average, making it the wettest month of the 2012 mosquito season (NOAA 2012).

Colorado experienced one of its hottest and driest summers on record in 2012. Every month of the mosquito season except July had lower than normal amounts of precipitation and higher temperatures. This led to many of the larval mosquito habitat sites significantly decreasing in size or becoming completely dry over the majority of the season, which consequently led to some of the lowest recorded mosquito populations on record during the 2012 season. Even though the City of Boulder received nearly three times the normal amount of precipitation during the month of July, the majority of this occurred during monsoon rainfalls in the second week of the month. Due to the extremely dry conditions at the time, the majority of the rainfall quickly soaked into the ground or was washed away into local streams during flashfloods. The larval habitat sites that did fill up with water were closely monitored by OtterTail for the next 1-2 weeks and were quickly treated if any Culex larval development occurred. Therefore, there was minimal amount of increased mosquito production and activity after the July rainfall events. The overall lack of precipitation in 2012 caused nuisance and Culex mosquito populations to remain at lower than average levels throughout the season; consequently, there was significantly less WNV activity in Colorado than in the other areas of the country that experienced epidemic outbreaks.

Figure 1 **2012 Monthly Mean Air Temperature and Historical Averages**

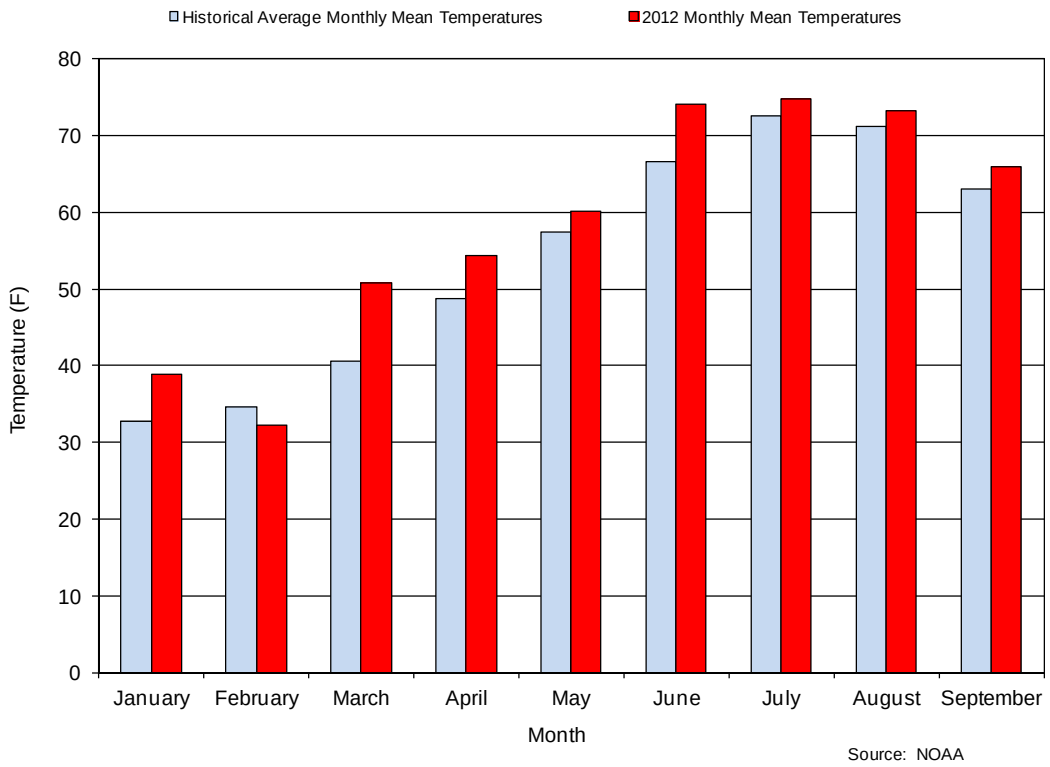
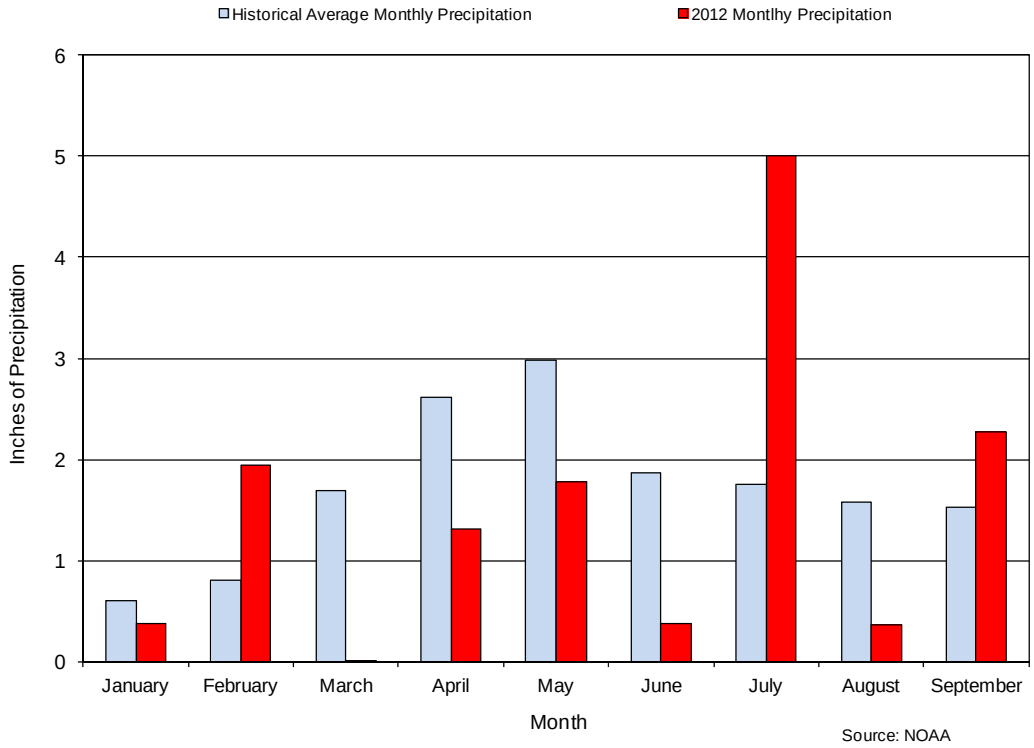


Figure 2 **2012 Monthly Total Precipitation and Historical Averages**



1.4 LARVAL MOSQUITO SURVEILLANCE AND CONTROL

The 2012 larval surveillance season began in May and continued through September. Monitoring for larvae throughout the project area and larval species identification determined if mosquito control was needed. During the season, a total of 6,769 individual larval site visits and 243 larval site treatments were performed within the program area. Of the potential breeding sites, 28% bred vector mosquito larvae during the 2012 season (**Table 4**).

As the season progressed, the sites were categorized and inspected according to larval abundance and occurrence per the City of Boulder WNV MMP. Low priority mosquito sites were not producing mosquitoes, had poor habitat, or had the presence of aquatic predators. High priority mosquito sites typically had larvae when sampled and often produced mosquitoes every seven to ten days during the peak season. Approximately 157 acres of active vector breeding habitat were identified and treated within the entire project area in 2012. For a detailed explanation of the larval surveillance methodology used during the 2012 season, please see the *2006 City of Boulder West Nile Virus Mosquito Management Plan* (www.bouldercolorado.gov).

Table 4 Larval Surveillance Summary, 2012 and Historical Data

Larval Site Surveillance Totals	2012	Historical Average[1]	Historical Range[1]
Site investigations	6,769	4,433	1,871 - 6,590
Percent of sites breeding (vector and/or nonvector)	28%	41%	28% - 50%
Percent of sites breeding vector	19%	24%	18% - 30%
Site treatments	243	326	196 - 558
Treated acreage	157	159	67 - 294

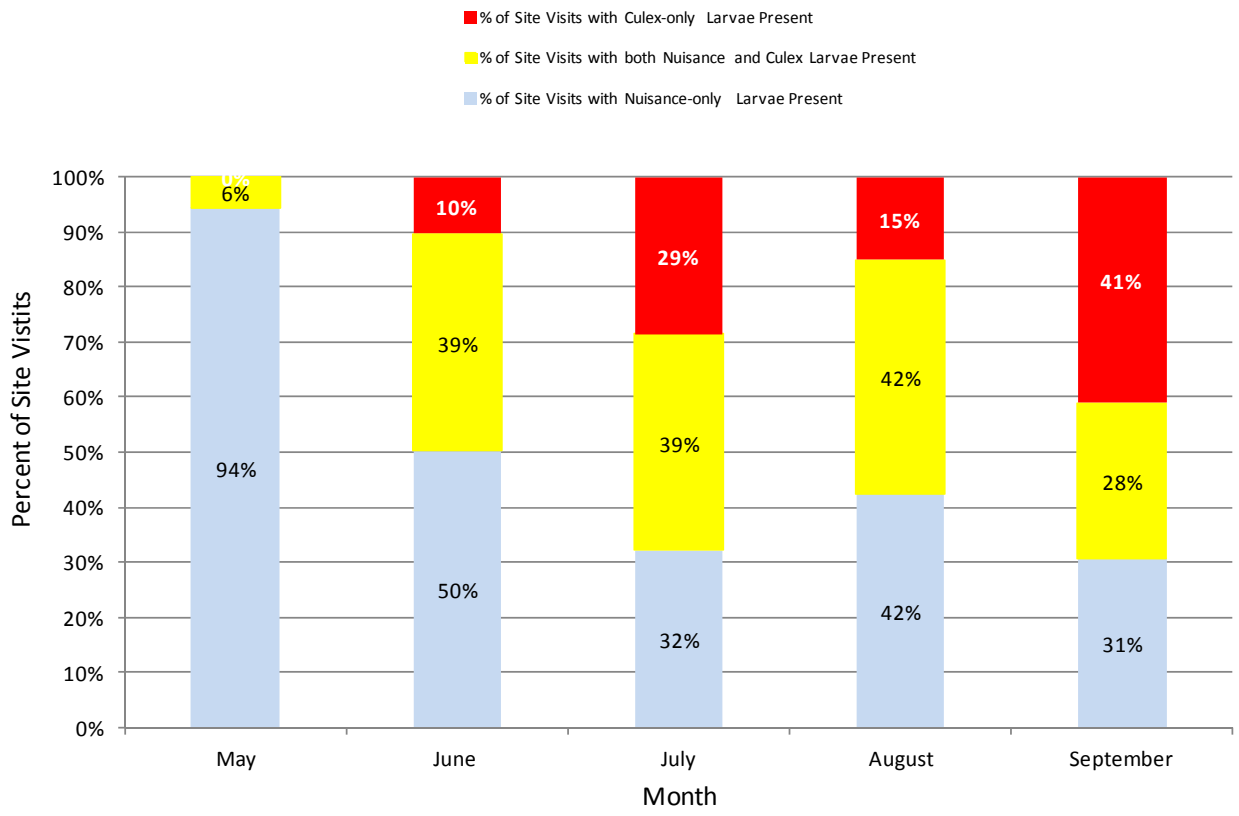
Notes: **1.** Historical average and range based on 2003 - 2011 seasons.

To help understand patterns of larval species presence throughout the season, the number of site visits was evaluated by the type of larvae present and used to represent relative larval abundance during the season (**Figure 3**). The methodology used in the larval surveillance and control program, as previously discussed, targeted Culex larval habitat. Therefore, these numbers are biased towards finding a higher prevalence of Culex mosquito larvae and should only be used to compare the abundances between the months of the season and should not be used in determining the overall larval abundance of the City of Boulder mosquito populations.

The season's overall average representative larval collection resulted in site visits with nuisance-only species present having the highest abundance at 47%, compared to site visits with both nuisance and Culex species present at 36%, and site visits with only Culex species making up 17% of the seasonal larval abundance. When site visits that had both Culex and nuisance are combined with the Culex-only visits, the resulting larval abundance for Culex mosquitoes is 53% compared to 47% nuisance-only for the season.

The number of sites breeding Culex larvae, or both Culex and nuisance larvae, along with treatments suggest that a substantial number of adult vector mosquitoes would have become airborne, which would have likely increased WNV activity, had the larval control program not been implemented.

Figure 3 Percentages of Site Visits with Nuisance and Culex Larvae per Month, 2012



1.5 ADULT MOSQUITO SURVEILLANCE

1.5.1 Adult Surveillance Methodology

Adult mosquito population surveillance is a crucial component of any successful IMM program. Adult surveillance provides information on which types of mosquito species are in an area as well as information on their abundance. Mosquitoes collected from mosquito traps can be tested for a variety of mosquito-borne diseases and are critical for monitoring and forecasting vector threats, particularly WNV.

Adult mosquito traps were placed and monitored at 16 sites around the city starting the first week in June through mid-September. Traps were set in areas of suitable harborage for adult mosquitoes, and were in the same locations used during previous years of the program. OtterTail uses two different types of mosquito traps to monitor adult mosquito populations, the gravid trap and the carbon dioxide (CO_2) baited light trap. The CO_2 baited light traps are based on the principle that most adult mosquitoes are attracted to light, CO_2 (via respiration), and heat. The CO_2 baited light trap collects adult female mosquitoes that are seeking a blood meal. The gravid trap mimics sources of mosquito breeding habitat and attracts gravid female mosquitoes that are seeking a spot to lay their eggs. Both types of traps are set overnight and on the following morning the nets are collected and returned to the lab to be identified and counted. Once identified, the mosquitoes were then sorted by species and samples of the vector mosquitoes were submitted to the Colorado Department of Public Health and Environment (CDPHE) for WNV testing. Refer to the *2006 City of Boulder West Nile Virus Mosquito Management Plan* (www.bouldercolorado.gov) for details about site selection and trap methods.

To maximize the efficiency of their WNV testing resources, CDPHE developed a statewide protocol for the sentinel surveillance program in 2007, which continued into the 2012 season. There were two main changes implemented in the 2007 surveillance guidelines. The first part of the 2007 protocol was to change each county's sentinel testing location from a single sentinel sampling site into a sentinel zone. The sentinel zone is a system of five light traps at five different locations within a five mile radius. Culex mosquitoes collected from all five traps within the zone are then pooled together each week for WNV testing. It is thought that the use of five traps within the sentinel zone will give more reliable data over time as well as cut down on weeks with lost data (e.g. trap malfunction when only a single trap site was being used). Based on the high WNV activity in the past, CDPHE allowed Boulder County to continue to operate and submit mosquitoes from three separate sentinel zones. The City of Boulder area was one sentinel zone, the second sentinel zone was located in the Longmont area, and the third sentinel zone was in a location of that county that is near the Erie and Lafayette area.

The second change to the CDPHE protocol was the monitoring schedule for the sentinel zones. After analyzing data from previous years, CDPHE found that the majority of all WNV activity occurred between June and August. In an effort to perform most of its WNV testing during this heightened transmission period, CDPHE requested that counties no longer perform early (May) or late (September) season monitoring for the sentinel program. Instead, they requested that counties run their sentinel zone traps once a week starting the second week of June, then run their sentinel zone traps for a second night each week from the first week of July until the first week of August, and run them once a week again until the end of August. This monitoring schedule would allow the vector mosquitoes collected from the traps within the sentinel zone to be submitted for WNV testing throughout the season, with extra samples being collected and tested during the height of the transmission period. Due to Federal funding cuts to the WNV testing budget, CDPHE changed the 2012 testing protocols by eliminating the second sentinel zone trap night. Therefore, samples were submitted once a week from the second week of June through the end of August during the 2012 season.

Beginning in June, 12 light traps and four gravid traps were set so that each would cover an approximately one-mile radius (**Appendix A, Map A-2**). The City cooperated with the University of Colorado (CU) and Boulder County Public Health Department (BCPH) in order to provide complete surveillance coverage of the

city. The 16 City traps, in combination with Boulder County and CU traps, provided comprehensive surveillance of the Boulder urban area. Five of the City's traps were also used in Boulder County's CDPHE WNV sentinel surveillance program. All 16 traps were set on a weekly basis until mid-September. The adult mosquito data were used to calculate potential WNV infection rates and to help City and County officials determine local areas of concern for public awareness and safety. These data could also be used to guide any potential adulticide efforts within the city, which was an important health and environmental issue to City officials and residents.

1.5.2 Adult Surveillance Results and Discussion

The City of Boulder's adult mosquito surveillance began on June 5th and ended on September 18th. The 12 light traps collected a variety of mosquito species and the 4 gravid traps collected mostly Culex species throughout the season. A total of 8,307 mosquitoes were trapped in these 16 traps during the 2012 season. The total adults collected during the season resulted in Aedes and Ochlerotatus species being the most abundant, followed by Culex (vector) species, Coquillettida species and finally Culiseta species as shown in **Table 5**. This resulted in approximately 61 percent nuisance vs. 39 percent Culex adults being collected over the entire season. As shown in **Table 6**, there was an average of 32 total adult mosquitoes per trap per night and an average of 13 adult Culex mosquitoes per trap per night in 2012.

Table 5 Total Number of Adult Mosquitoes per Trap for the 2012 Season[1] and Historical Data

Trap Name, (Type), and Location	*Culex spp.*		*Ae./Oc. Spp.*		*Coquillettidia spp.*		*Culiseta spp.*		Trap Total	Average per Trapnight	Trap %RA	Historical Avg. Per Trap Night[2]	Range of Historical Trap Nights[2]
	#	%RA	#	%RA	#	%RA	#	%RA					
H0 (Light) Rolling Rock Ranch	48	8%	467	73.9%	117	18.5%	0	0.0%	**632**	**40**	7.6%	108	31-213
H2 (Light) Sombrero Marsh	924	62%	532	35.7%	2	0.1%	34	2.3%	**1,492**	**93**	18.0%	159	61-399
H4 (Light) Papini	227	37%	382	62.6%	0	0.0%	1	0.2%	**610**	**38**	7.3%	38	11-79
H5 (Light) Tom Watson Park	262	19%	1,030	74.5%	91	6.6%	0	0.0%	**1,383**	**86**	16.6%	57	30-89
H6 (Light) Sawhill Ponds	363	40%	373	41.2%	165	18.2%	4	0.4%	**905**	**57**	10.9%	172	53-397
C1(Light) Locust/10th	26	46%	30	53.6%	0	0.0%	0	0.0%	**56**	**4**	0.7%	16	6-20
C2 (Light) 23rd/Meadow	19	53%	15	41.7%	1	2.8%	1	2.8%	**36**	**2**	0.4%	10	3-20
C3 (Light) Christensen Park	701	36%	1,228	63.4%	8	0.4%	0	0.0%	**1,937**	**121**	23.3%	127	22-246
C4 (Light) South Boulder Rec.Center	28	11%	215	84.6%	11	4.3%	0	0.0%	**254**	**16**	3.1%	38	7-76
C5 (Light) Broadway / Baseline	13	50%	13	50.0%	0	0.0%	0	0.0%	**26**	**2**	0.3%	7	1-13
C6 (Light) Broadway / Alpine	2	33%	3	50.0%	0	0.0%	1	16.7%	**6**	**0**	0.1%	6	0-19
C7 (Gravid) Table Mesa / Stevens	70	100%	0	0.0%	0	0.0%	0	0.0%	**70**	**4**	0.8%	10	1-28
C8 (Gravid) 7th / Pennsylvania	250	100%	0	0.0%	0	0.0%	0	0.0%	**250**	**16**	3.0%	6	0-18
C9 (Gravid) Columbine Park	62	100%	0	0.0%	0	0.0%	0	0.0%	**62**	**4**	0.7%	5	0-17
C10 (Gravid) Comanche / Mohawk Dr.	177	100%	0	0.0%	0	0.0%	0	0.0%	**177**	**11**	2.1%	14	2-35
C11(Light) Stazio Ballfields	99	24%	310	75.4%	2	0.5%	0	0.0%	**411**	**26**	4.9%	136	78-213
Total	**3,271**	**39.4%**	**4,598**	**55.4%**	**397**	**4.8%**	**41**	**0.5%**	**8,307**	**519**	**100.0%**	**910**	---
Average	204	---	287	---	25	---	3	---	**519**	**32**	---	57	---

1. Season includes June 5 through September 18, 2012 for surviellence traps for a total of 256 trap nights. 2. Historical avgerage per trapnight and range based on 2003-2011 data.
%RA=Percent Relative Abundance.

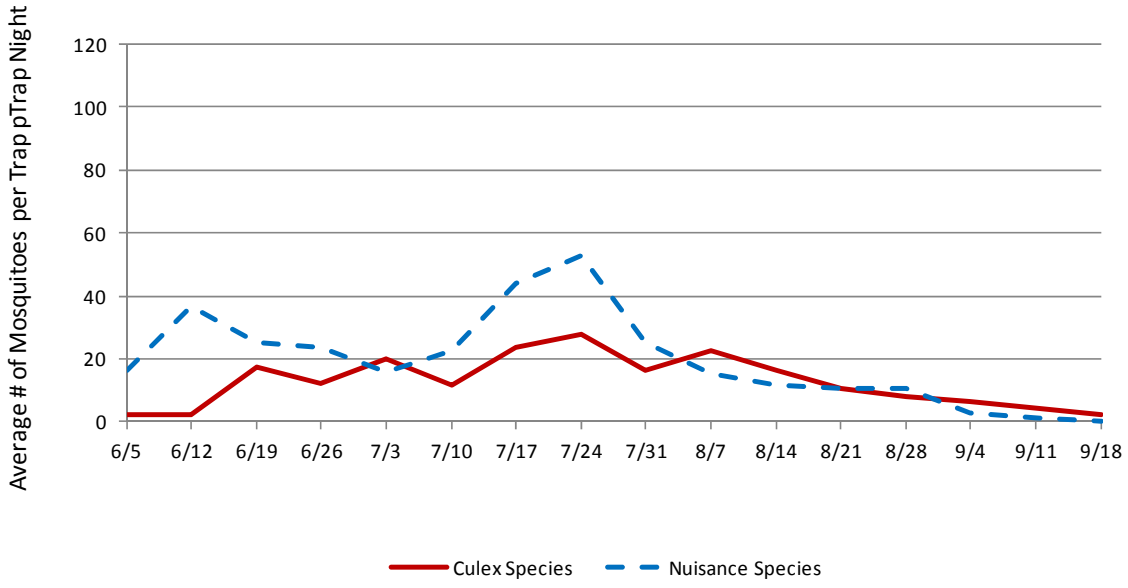
Table 6 Average Numbers of Mosquitoes, 2003 - 2012

Year	2003[1]	2004	2005	2006	2007	2008	2009	2010	2011	2012
Average # of Total Mosquitoes (per Trap per Trap Night)	200	32	41	86	50	62	68	42	55	32
Average # of Total Vector Mosquitoes (per Trap per Trap Night)	60	4	9	10	14	12	19	8	8	13

1. The 2003 season-wide averages are based upon traps H0-H6 only; traps H0-H6 historically capture significantly more mosquitoes than traps C1-C11 which likely cause the overall 2003 average to be much higher than following years.

As described in **Section 3**, Colorado experienced one of its hottest and driest summers on record in 2012. This led to many of the larval sites significantly decreasing in size or becoming completely dry over the majority of the season, which consequently led to some of the lowest recorded mosquito populations on record during the 2012 season. Even though the City of Boulder received nearly three times the normal amount of precipitation during the month of July, the majority of this occurred during monsoon rainfalls in the second week of July. Due to the extremely dry conditions at the time, the majority of the rainfall quickly soaked into the ground or was washed away into local streams during flashfloods. The larval habitat sites that did fill up with water were closely monitored by OtterTail for the next 1-2 weeks and were quickly treated if any Culex larval development occurred. Therefore, there was a minimal amount of increased adult Culex mosquito production and activity after the July rainfalls (**Figure 4**). The overall lack of precipitation in 2012 caused nuisance and Culex mosquito populations to remain at lower than average levels throughout the season.

Figure 4 Season-Wide Weekly Adult Trap Counts of All Trap Stations, 2012



1.6 OUTREACH AND EDUCATION

Public education is an important component to any successful mosquito control program and is vital in combating West Nile Virus. As in previous years, the *One Bite* campaign, produced by Boulder County Public Health, provided the City of Boulder with posters and flyers for distribution to the general public. The campaign materials contained information about personal protection using the "4 D's" (DEET, Dawn and Dusk, Dress, and Drain) and testimonials from local persons infected with WNV during previous outbreaks. Posters were displayed throughout the City of Boulder, at Open Space and Mountain Park trailheads, Parks and Recreation facilities, libraries, senior centers and the Municipal Building to raise awareness about WNV in the Boulder community.

The City of Boulder also provided an electronic notice to residents with their monthly online utility bill payments that provided information about WNV and their website contained sections for current WNV activity, the City's mosquito control plan, program maps and links to email City staff with WNV questions. The City also continued to provide a WNV hotline for residents. Callers were given information from a menu service and could leave a message for City staff to report any WNV or mosquito related concerns as well as request to be added to the City's no-spray list.

OtterTail also offered an extensive amount of information on its website, including sections on mosquito biology and control as well as actions residents and land users could take to help aid OtterTail and the City in our mosquito control efforts.

Educating residents on the need for property maintenance, source reduction, and the use of personal protection measures continued to be crucial in the fight against WNV in 2012. The resulting actions taken by the public likely helped reduce the mosquito populations in the area as well as decreasing the WNV activity levels and reported cases of infection is 2012.

2.0 NUISANCE MOSQUITO CONTROL PROGRAM

2.1 INTRODUCTION

Since the spring of 2003, the City of Boulder has conducted a vector management program designed to protect public health and biological resources from the effects of West Nile Virus (WNV). The design of the West Nile Virus Mosquito Management Plan (vector program) allows for mosquito control with the larvicide, *Bacillus thuringiensis israelensis* (*Bti*). This plan only targets species of mosquitoes that are known to most effectively transmit WNV to humans (Culex or vector species). Habitats that only contain species of mosquito larvae that are a nuisance to people (nuisance or non-vector species) are bypassed. While the results of the vector program suggest that it has been highly effective at protecting the public against the threat of WNV, there were certain issues that developed with the Culex-only approach to mosquito control.

In May and June of 2006, mosquito breeding conditions were ideal, and the City of Boulder received hundreds of complaints about nuisance mosquito activity from softball players and attendees at Stazio Ballfields and golfers at Flatirons Golf Course. These Parks and Recreation (P&R) facilities began realizing decreased revenues from declining attendance associated with these complaints. The City also received a large number of complaints about high numbers of nuisance mosquitoes from city and county residents living adjacent to several Open Space and Mountain Parks (OSMP) properties.

After the 2006 mosquito season, the City conducted several meetings to develop a strategy to address these issues. As a result, the Nuisance Mosquito Control Program (nuisance program) was developed. The nuisance program allows the City of Boulder to treat a limited number of habitat sites for nuisance mosquito larvae with *Bti* when nuisance mosquito larvae are present in high numbers. The habitat sites included were already a part of the City's vector control program, but since nuisance mosquitoes typically peak before the WNV season begins, OtterTail began monitoring the selected sites several weeks earlier in the season. The nuisance program was started in 2007 and was intended to be a two-year trial program to reduce the nuisance mosquito populations within the areas of concern. The City has since extended the program through the 2012 season.

Fifty-seven sites were initially approved to be included in the nuisance program project area for nuisance mosquito larval control. However, over the course of the 2007- 2008 seasons, two areas near the nuisance program continued to experience nuisance mosquito complaints. The two areas were the Greenbelt Meadows and San Lazaro neighborhoods. These neighborhoods are located near the nuisance program area, but dozens of habitat sites that are located within a mile radius of them were not included in the 2007 nuisance program, and therefore, could not be treated for nuisance-only species. As discussed in more detail in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009), uncontrolled nuisance mosquito populations from these nearby habitats likely increased the adult populations and consequently, the residential complaints of nuisance mosquitoes increased in each neighborhood. Due to the residents reporting a large number of complaints within the Greenbelt Meadows and San Lazaro neighborhoods, the City expanded the nuisance program during the 2009 season and again in the 2011 season to include 64 additional nuisance program sites, raising the total number of sites included in the nuisance program to 120 in 2011 (**Map A-3**).

For detailed background information including methods, results and discussion of the nuisance program, please reference the *2010 Nuisance Mosquito Control Pilot Program Report* (Ottertail 2010).

2.2 LARVAL SURVEILLANCE AND CONTROL

As shown in **Table 7**, a total of 2,809 individual larval site visits were performed on the 120 potential breeding sites during the 2012 season. Approximately 80 acres of active breeding habitat were identified and treated at 55 sites. There were a total of 26 site treatments performed for Culex-only species, 74 site treatments performed when both Culex and nuisance species were present, and 16 site treatments for

nuisance-only species over the course of the season (**Table 8**). Therefore the nuisance program increased the number of site treatments by 16 (14%), which increased the amount of acreage treated by 9 acres (11%), and the amount of *Bti* applied by 45 pounds (11%).

Table 7 Comparison of Larval Surveillance and Control During the Nuisance Program vs. What Would Have Been Performed With the Standard Vector Program, 2012 and Historical Averages

Year	Nuisance Program (Nuisance)[1]	Standard Vector Program (Culex)[2]	Increase Due to Nuisance Program[3]	
			Number	Percent
2012				
Potential Breeding Site Locations	120	120	0	0%
Number of Site Investigations	2,809	2,327	482	17%
Number of Site Treatments	116	100	16	14%
Number of Site Locations Treated	55	45	10	18%
Total Treated Acreage	80	71	9	11%
Pounds of *Bti* Used[4]	400	355	45	11%
Historical Average[5]				
Potential Breeding Site Locations	74	63	11	15%
Number of Site Investigations	1,485	929	557	37%
Number of Site Treatments	108	71	37	34%
Number of Site Locations Treated	30	21	10	33%
Total Treated Acreage	57	28	28	50%
Pounds of *Bti* Used[4]	284	142	142	50%

Notes:
1: The implemented program during 2007-2012 seasons.
2: Results if the standard vector program had been done instead of the nuisance program.
3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.
4: Amount of Bti used when applied at the typical 5 lbs. per acre application rate.
5: Historical average based on 2007-2011 data.

The number of site locations receiving *Bti* treatments and the amount of *Bti* being used for mosquito control was a concern of several City staff members and residents. The results of the nuisance program show that the amount of *Bti* that was used and the total amount of acreage treated increased by 11% in 2012. The additional site treatments for nuisance mosquitoes increased the number of site locations treated by 10 locations (or 18%) during the 2012 season. The increase in site investigations (17% increase) and treatments (14% increase) due to the nuisance program also increased the overall labor and material costs associated with those activities.

To help understand patterns of larval species presence and treatments throughout the season, the number of 2012 site treatments is shown by each month (**Figure 5**). The majority of the early season treatments were performed for sites that had both Culex and nuisance species. Of the 116 site treatments performed during the season, 64% were on sites when both Culex and nuisance species were present, 22% when Culex-only species were present and 14% for nuisance-only species (**Table 9**).

Figure 5 Percentages of Site Treatments for Nuisance and Culex Larvae per Month, 2012

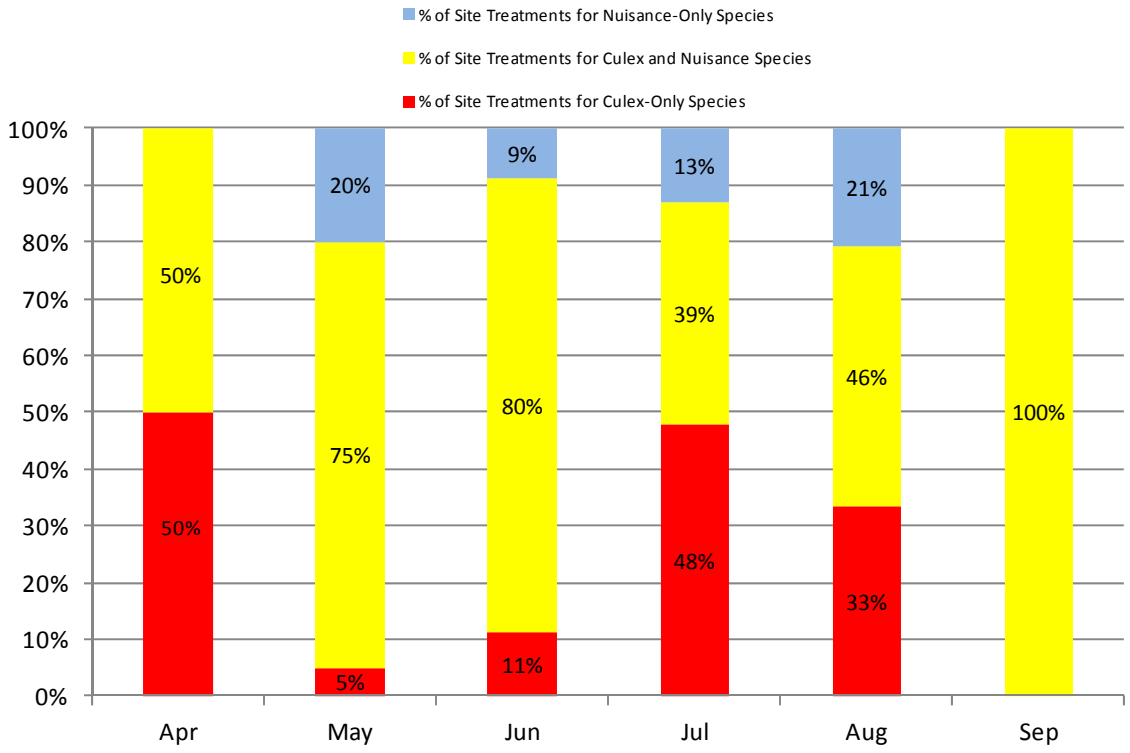


Table 8 Larval Treatment Summary by Month, 2012

Month	Apr	May	Jun	Jul	Aug	Sep	Total	Percent of Total
Number of Site Treatments for Culex-Only Species	1	1	5	11	8	0	26	22%
Number of Site Treatments for Culex and Nuisance Species	1	15	36	9	11	2	74	64%
Number of Site Treatments for Nuisance-Only Species Due to Nuisance Program	0	4	4	3	5	0	16	14%
Total Site Treatments	**2**	**20**	**45**	**23**	**24**	**2**	**116**	**100%**

The number of sites breeding mosquito larvae and their treatments suggest that more adult nuisance mosquitoes would have become airborne had the nuisance program not been implemented. The larval surveillance data were used to estimate larval populations controlled during the nuisance program vs. what would have been controlled with only the standard vector program. As shown in **Table 9**, the estimates suggest that a potential of over 61 million more mosquito larvae were controlled during the 2012 season due to the nuisance program. The properties where treatments for nuisance-only mosquitoes occurred over the course of the nuisance program can be found in **Table 10**.

Table 9 Comparison of Larval Populations Controlled During the Nuisance Program vs. What Would Have Been Controlled with the Standard Vector Program

Year	Nuisance Program[1]	Program (Culex)[2]	Increase Due to Nuisance Program	
			Number	Percent
2012 Estimated Larval Population Controlled[3]	209,378,032	148,142,516	61,235,516	29%
Historical Average[4]	126,707,829	79,189,901	47,517,928	38%

Notes:
1: The implemented program during 2007-2012 seasons.
2: The back-calculated population if the standard WNV program had been conducted instead of the nuisance program.
3: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding habitat; This is the theoretical maximum potential number of mosquitoes (including males and females) that would be produced with no mortality.
4: Historical average based on 2007-2011 data.

Table 10 Number of Treatments for Nuisance-Only Species Mosquitoes by Property, 2007-2012

Property Name (Managing Department)	# of Treated Sites on Property	Total # of Treatments in 2007[2]	Total # of Treatments in 2008[2]	Total # of Treatments in 2009[2]	Total # of Treatments in 2010[2]	Total # of Treatments in 2011[2]	Total # of Treatments in 2012[2]	Total
Boulder Reservoir (P&R)	11	9	12	9	5	3	1	39
Burke I	2	n/a	n/a	n/a	n/a	4	1	5
Colorado Open Lands II (OSMP)	2	n/a	n/a	1	6	0	0	7
Colorado Open Lands III (OSMP)	3	n/a	n/a	1	2	0	0	3
East Boulder Recreation Center (P&R)	3	0	3	0	11	6	0	20
Flatirons Golf Course (P&R)	4	0	0	5	1	0	0	6
Gebhard (OSMP)	2	n/a	n/a	3	1	2	0	6
Kentucky Property (P&R)	1	0	1	n/a	n/a	n/a	n/a	1
Mary Clyncke (OSMP)	1	n/a	n/a	1	0	0	1	2
Pleasantview Soccer Fields (P&R)	1	1	1	0	0	0	0	2
Hogan/Pancost Area (Private Ownership)	3	0	0	1	5	0	1	7
Sombrero Marsh (OSMP)	1	1	1	0	5	1	1	9
Stazio Ballfields (P&R)	2	2	2	3	4	1	0	12
Suitts (P&R)	1	n/a	n/a	n/a	n/a	0	1	1
Van Vleet (OSMP)	14	n/a	n/a	6	8	13	10	37
Total	51	13	20	30	48	30	16	141

Notes:
1: Total number of separate sites on property that were treated
2: Total number of treatments was obtained by combining the treatments from all of the separate breeding sites on the property during the season
n/a= sites that were not included in pilot program during corresponding year.

2.3 ADULT MOSQUITO SURVEILLANCE

The City of Boulder's 2012 adult mosquito nuisance surveillance program began on April 24th and ended on September 18th. The four nuisance program light traps collected a total of 3,719 mosquitoes during the 2012 season. The total adults collected during the nuisance program resulted in species within the genus Aedes and Ochlerotatus being the most abundant, followed by Culex (vector mosquitoes), Culiseta, and finally Coquillettida (**Table 11)**.

Table 11 Number of Adult Mosquitoes per Trap, 2012

Trap Location (Name)	*Culex spp.*		*Ae./Oc. spp.*		*Coquillettidia spp.*		*Culiseta spp.*		Total of All Trapnights	Average Total per Trapnight	Historical Average Total per Trapnight[3]	Range of Historical Average Total per Trapnight[3]
	#	% RA[2]	#	% RA	#	% RA	#	% RA				
Sombrero Marsh (H2)	942	61.5%	552	36.1%	2	0.1%	35	2.3%	1,531	70	96	53 - 145
Stazio Ballfields (C11)	103	21.3%	379	78.3%	2	0.4%	0	0.0%	484	22	123	69 - 175
Thorne Institute (C12)	68	10.9%	555	89.1%	0	0.0%	0	0.0%	623	28	109	32 - 240
East Community Center (C13)	72	6.7%	997	92.2%	9	0.8%	3	0.3%	1,081	49	141	57 - 350
Total of All Traps	**1,185**	**31.9%**	2,483	66.8%	13	0.35%	38	1.0%	3,719	169	468	---
Average	296		621		3		10		930	42	117	---

Notes: 1: Season was April 24 to September 18 for a total of 88 trapnights. **2: % RA** = Percent Relative Abundance

The season-long average numbers of mosquitoes for each of the nuisance program area traps are presented to help evaluate the success of the nuisance program's nuisance-larval control (**Table 12**). Each of the traps with 2006 data had lower total mosquito averages during the years of the nuisance program than their 2006 averages. Each trap also had counts that were considerably lower than their nuisance program average during the 2012 season. Overall, there was an average of 39 adult mosquitoes per trap per night in 2012, which is significantly lower than the 122 per trap per night average of the 2007-2011 seasons and 258 per trap per trap night average in 2006.

Table 12 Average Numbers of Mosquitoes of the Nuisance Program Area Traps, 2006-2012

Trap Location (Name)	Season-Long Avg. # of Mosquitoes per Trapnight			
	2006 (Pre-Nuisance)[1]	2007-2011 Nuisance Program Average[2]	2007-2011 Nuisance Program Range [2]	2012 Nuisance Program[2]
Sombrero Marsh (H2)	399	97	56 - 145	76
Sombrero Marsh (BC-32)[3]	360	142	82 - 204	18
Stazio Ballfields (C11)	143	124	76 - 175	24
Thorne Insitute (C12)	N/A	111	32 - 240	30
East Community Center (C13)	N/A	143	57 - 350	51
Old Tale/ Gapter Rd. (BC-01)[3]	131	118	46 - 314	32
Total	1,033	734	---	232
Average	258	122	---	39

Notes:
1: Pre-nuisance is without any larval nuisance-only control. 2: Nuisance program is with larval nuisance-only control in many of the breeding habitats near the adult traps. 3: Boulder County Mosquito Control District traps

To help show the possible effects of nuisance mosquito control within the nuisance program area throughout the season, season-wide weekly trap counts of the six associated traps are presented in **Figures 6** through **11**. All but the two new nuisance program traps (C12 and C13) have 2006 (pre-nuisance program) trap data included.

The traps in operation during 2006 (**Figures 6** through **9**) were examined to find any potential mosquito population trends that differed from before and after the implementation of the nuisance program's mosquito control. Each trap had high mosquito counts with significant population peaks during portions of the 2006 season when there was no nuisance control. Although each trap had varying counts compared to 2006, trap results suggest that the nuisance-controlled seasons of 2007-2012 had lower averages and weekly population peaks during the full seasons of each year of the nuisance program.

Figure 6 **Weekly Adult Trap Counts at Sombrero Marsh (Trap H2), 2012 and Historical Average**

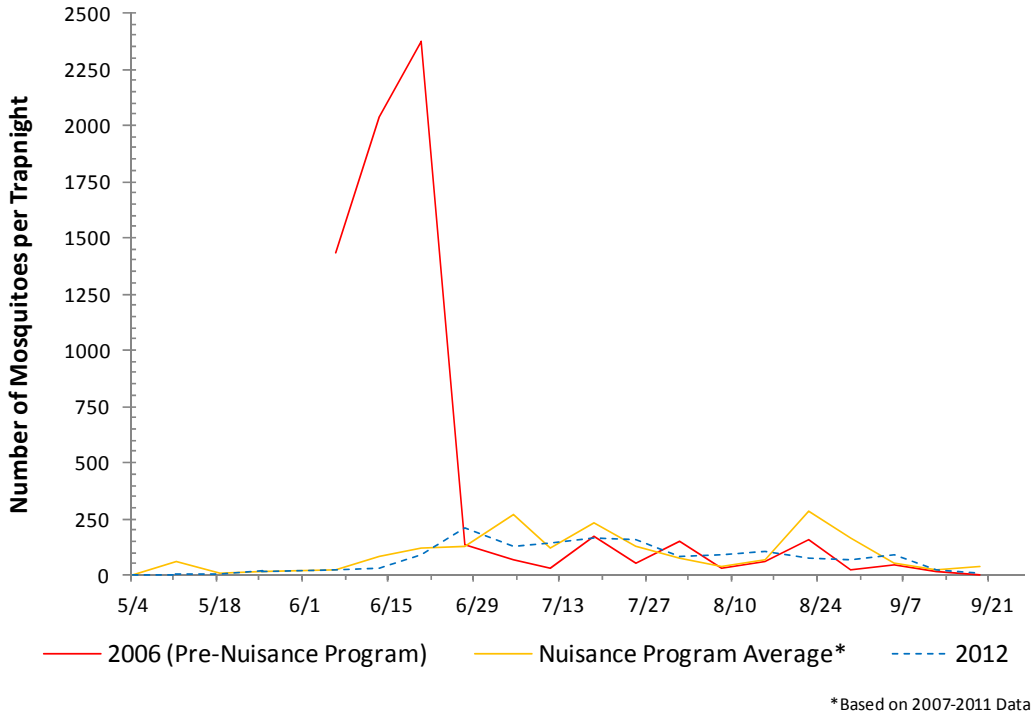


Figure 7 **Weekly Adult Trap Counts at Sombrero Marsh (Trap BC-32), 2012 and Historical Average**

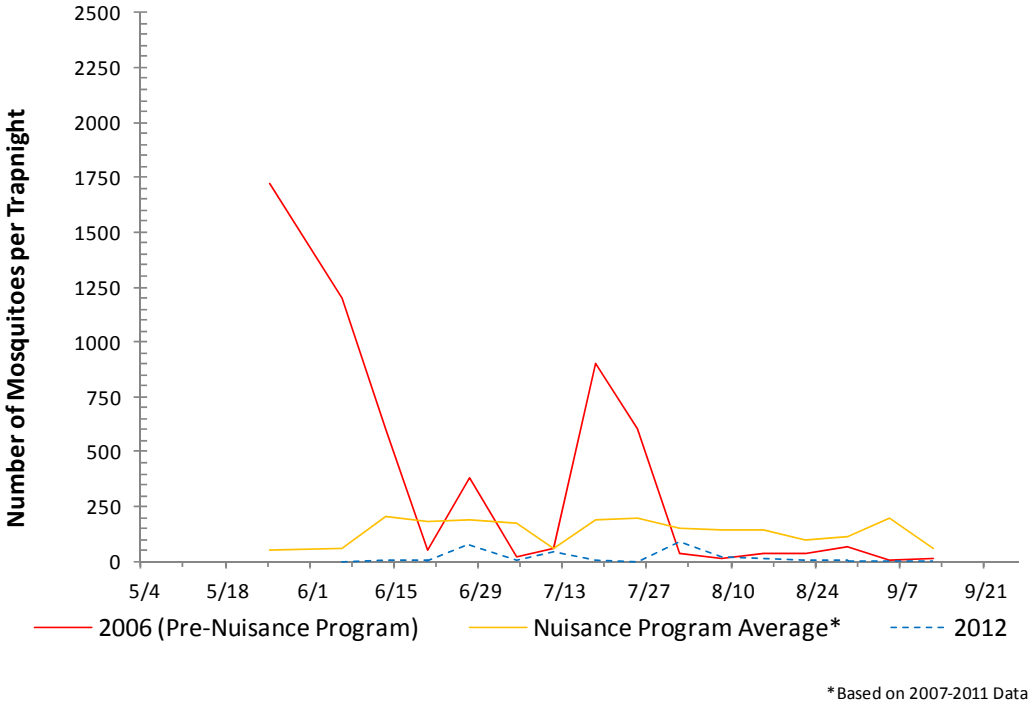


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Figure 8 **Weekly Adult Trap Counts at Gapter Rd/Old Tale (Trap BC-01), 2012 and Historical Average**

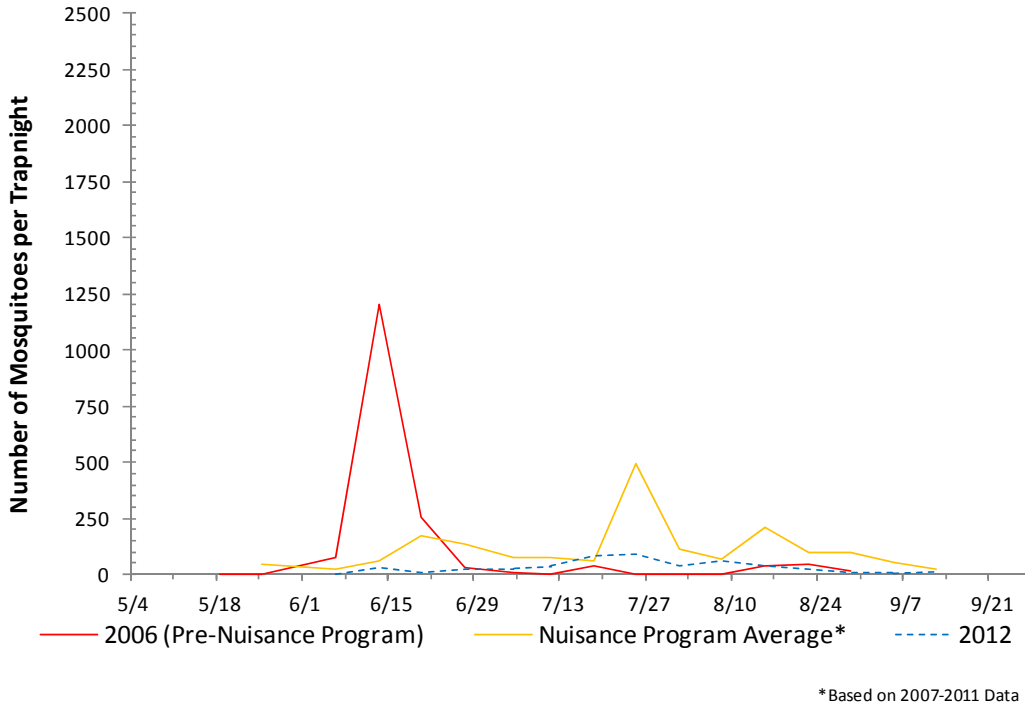


Figure 9 **Weekly Adult Trap Counts at Stazio Ballfields (Trap C11), 2012 and Historical Average**

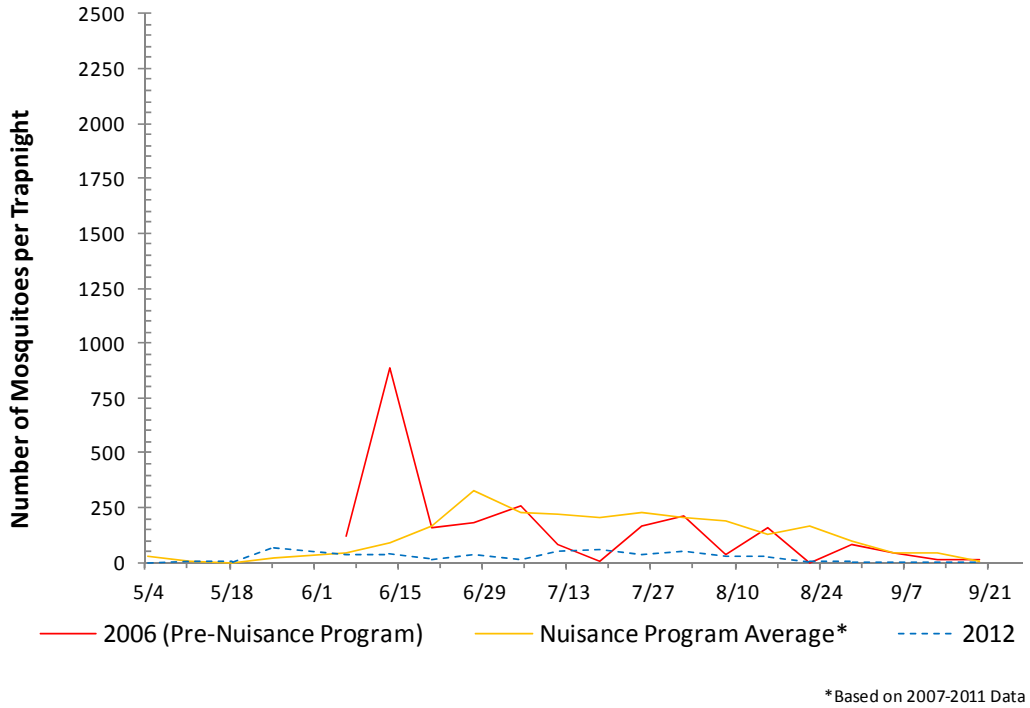


Figure 10 Weekly Adult Trap Counts at EBCC (Trap C12), 2012 and Historical Average

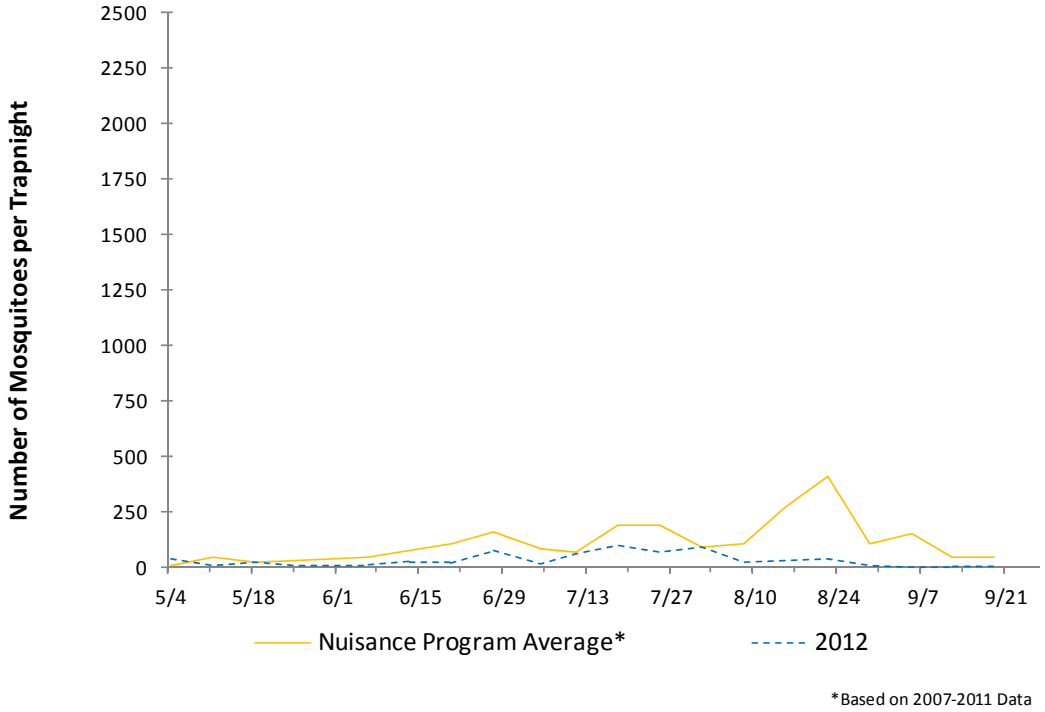
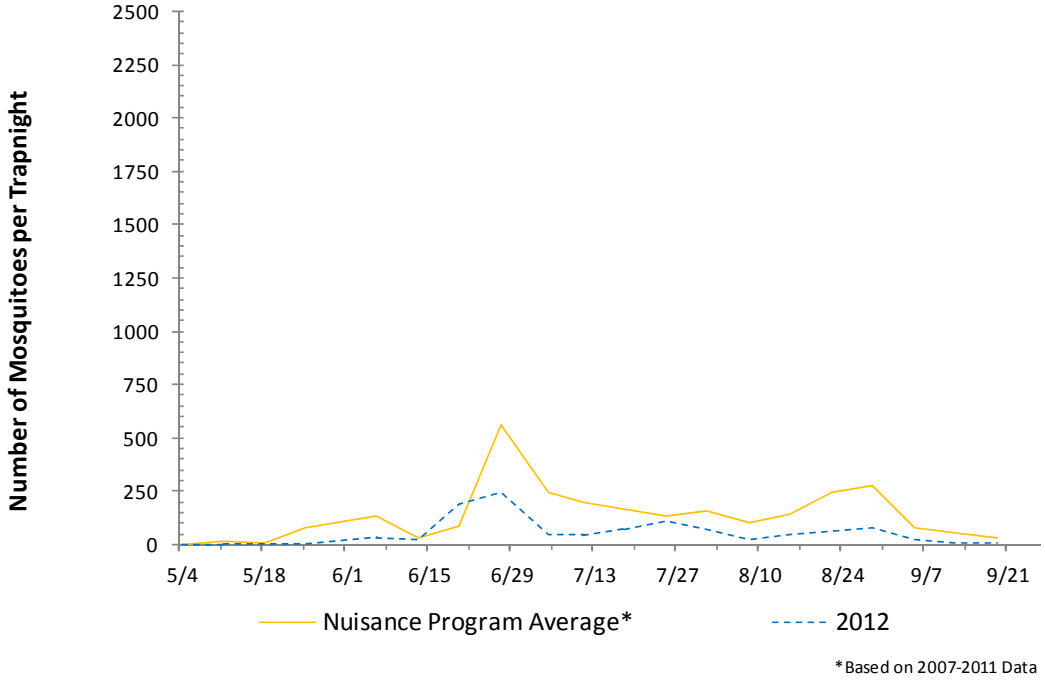


Figure 11 Weekly Adult Trap Counts at Thorne Institute (Trap C13), 2012 and Historical Average



2.4 EVALUATION OF THE EFFECTS OF THE NUISANCE PROGRAM ON COMPLAINT NUMBERS

The high number of complaints from the City-owned revenue generating areas was one of the primary reasons for the establishment of the nuisance program. These complaints substantially decreased since the 2007 implementation of the nuisance program. Although numbers weren't formally tracked before the 2007 season, City P&R staff reported that there was a substantial decrease in complaints. City staff estimated that the number of complaints went from an estimate of hundreds of complaints during the summer of 2006 to approximately one to two dozen during each of the 2007-2012 seasons. In 2006 (before the nuisance program), The Flatirons Golf Course received over 50 written complaints and staff reported receiving dozens of verbal complaints on a daily basis during May and June. Flatirons staff reported no written complaints and minimal verbal complaints during the 2007-2012 seasons. Parks staff reported a similar decrease in complaints reported at the Stazio ballfields.

2.5 EVALUATION OF THE EFFECTS OF THE EXPANDED NUISANCE PROGRAM SITES ON THE GREENBELT MEADOWS AND SAN LAZARO NEIGHBORHOODS

Over the course of the 2007 and 2008 seasons, two areas near the nuisance program reportedly experienced excessive nuisance mosquito related problems. The two areas were the Greenbelt Meadows and San Lazaro neighborhoods. These neighborhoods are located near the nuisance program area, but dozens of habitat sites that are located within a mile radius of them were not included in the first two years of the nuisance program, and therefore, could not be treated for nuisance-only species. As discussed in more detail in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009), uncontrolled nuisance mosquito populations from these nearby habitats likely increased the adult populations and consequently, the residential complaints of nuisance mosquitoes in each neighborhood.

Due to mosquito activity complaints from residents within the Greenbelt Meadows and San Lazaro neighborhoods, the City expanded the nuisance program during the 2009 season and again in the 2011 season to include 64 additional nuisance program sites located near these neighborhoods.

2.5.1 Greenbelt Meadows Neighborhood

OtterTail analyzed the site data from the 2007 and 2008 seasons of larval habitat sites within a mile radius of Greenbelt Meadows that were not included in the first two years of the nuisance program. The detailed results of the analysis can be found in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009). In summary, the analysis suggested that if these habitat sites were added to the nuisance program, mosquito populations affecting the Greenbelt Meadows neighborhood could potentially be lowered. In response to the number of residential complaints of high mosquito activity and based on the data from the nuisance mosquito control report, the City expanded the nuisance program in 2009 and again in 2011 to include a total of 59 additional habitat sites near Greenbelt Meadows.

As shown in **Table 13**, during the 2012 season, a total of 53 individual larval site treatments were performed on 30 of the 64 potential breeding sites, treating approximately 43 acres of active breeding habitat. Of these, 6 treatments were performed for nuisance-only mosquitoes. Therefore, the Greenbelt Meadows sites added to the nuisance program increased the number of site treatments by 26%, which increased the amount of acreage treated by approximately 8.9 acres (21%) and the amount of *Bti* applied by 45 pounds (21%).

Table 13 Comparison of Larval Surveillance and Control Activities at Greenbelt Meadows Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2012 and Historical Averages

Year	Expanded Nuisance Program[1]	Standard Vector Program (Culex)[2]	Increase due to the Expanded Nuisance Program Sites[3]	
			Number	Percent
2012				
Number of Site Treatments	53	39	14	26%
Number of Site Locations Treated	30	24	6	20%
Total Treated Acreage	43.0	34.1	8.9	21%
Pounds of *Bti* Used[4]	215	171	45	21%
Estimated Number of Larvae Controlled[5]	41,364,613	34,493,592	6,871,021	17%
Historical Average				
Number of Site Treatments	54	40	14	27%
Number of Site Locations Treated	21	20	2	5%
Total Treated Acreage	23	20	4	13%
Pounds of *Bti* Used[4]	117	90	18	23%
Estimated Number of Larvae Controlled[5]	68,524,340	50,320,641	15,683,740	27%

Notes:

1: Results from the 70 sites being added to the nuisance program during the 2009 and 2011 seasons, allowing larval control for nuisance-only mosquitoes at these 70 sites.

2: Results if the standard vector program had been done instead of the expanded nuisance program.

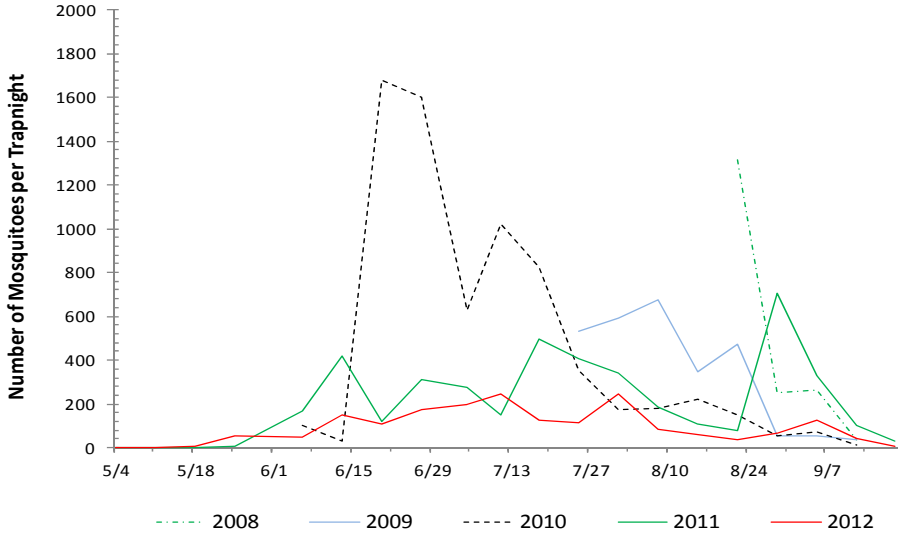
3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.

4: Amount of *Bti* used when applied at the typical 5 lbs. per acre application rate.

5: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding potential number of mosquitoes (including males and females) that would be produced with no mortality.

The City also had OtterTail continue to set an additional adult mosquito trap in the Greenbelt Meadows neighborhood during 2012 mosquito season in an attempt to evaluate the neighborhood mosquito populations. As shown in **Figure 12**, the additional trap captured varying numbers of nuisance mosquitoes throughout the 2012 season. Although the trap had several weeks with high counts, the population peaks remained considerably lower than those seen in the 2008 - 2010 seasons (pre-expansion seasons).

Figure 12 Weekly Adult Trap Counts at Greenbelt Meadows Temporary Trap, 2008-2012*



*Temporary trap was set for differing time periods during each season; results are shown for available data for each season.

2.5.2 San Lazaro Neighborhood

OtterTail analyzed the site data from the 2007 and 2008 seasons of larval habitat sites within a mile radius of San Lazaro which were not included in the nuisance program. The detailed results of the analysis can be found in the *Nuisance Mosquito Control Pilot Program Report* (OtterTail 2009). In summary, the analysis suggested that if these habitat sites were added to the nuisance program, mosquito populations affecting the San Lazaro neighborhood could potentially be lowered. In response to the number of residential complaints of high mosquito activity and based on the data from the nuisance mosquito control report, the City expanded the nuisance program to include 5 additional sites near San Lazaro in 2009 and then expanded the program again to provide more intense site monitoring on an additional 25 sites within the area in 2011.

As shown in **Table 14**, during the 2012 season, a total of 1 individual larval site treatment was performed on 1 of the potential breeding sites, treating approximately .002 acres of active breeding habitat for Culex mosquitoes. For the second consecutive season, no treatments were performed for nuisance-only mosquitoes on the San Lazaro sites that were added to the nuisance program.

Table 14 Comparison of Larval Surveillance and Control Activities at San Lazaro Nuisance Program Sites vs. What Would Have Been Performed With the Standard Vector Program, 2012 and Historical Averages

Year	Expanded Nuisance Program Sites (5 Sites)[1]	Standard Vector Program (Culex)[2]	Increase due to the Expanded Nuisance Program[3]	
			Number	Percent
2012				
Number of Site Treatments	1	1	0	0%
Number of Site Locations Treated	1	1	0	0%
Total Treated Acreage	0.002	0.002	0.0	0%
Pounds of *Bti* Used[4]	0.01	0.01	0.0	0%
Estimated Number of Larvae Controlled[5]	61,447	61,447	0	0%
Historical Average[6]				
Number of Site Treatments	17	14	3	20%
Number of Site Locations Treated	5	4	1	25%
Total Treated Acreage	6	4	2.2	34%
Pounds of *Bti* Used[4]	32	21	11.0	34%
Estimated Number of Larvae Controlled[5]	42,108,948	20,778,311	21,330,636	51%

Notes:
1: Results from the 5 sites added during the 2009 season, allowing larval control for nuisance-only mosquitoes at these 5 sites.
2: Results if the standard vector program had been done instead of the expanded nuisance program.
3: Difference between nuisance program and what would have occurred had the standard vector program been implemented instead.
4: Amount of *Bti* used when applied at the typical 5 lbs. per acre application rate.
5: Estimated larval populations were calculated by multiplying # per dip by 10 (each dip is approx. 1/10 of a sq. ft) by the sq. ft. of breeding potential number of mosquitoes (including males and females) that would be produced with no mortality.
6: Historical average based on nuisance program expansion (5 sites added).

2.6 EVALUATION OF THE EFFECT OF INCREASING THE SPRAY THRESHOLD ON ADULT SPRAYING FREQUENCY

One of the goals for doing larval nuisance control in the nuisance program area was to reduce the potential for pesticides to drift onto City property from the County's adult ULV adulticide applications. As part of the negotiations which enabled the approval of the nuisance program, the Boulder County commissioners and BCPH agreed to raise the thresholds that trigger an adult spray event surrounding the nuisance program from the historical threshold of 100 mosquitoes per trap night to 250.

Three County traps that were in or near the nuisance program were assigned a higher threshold (**Map A-4**). The data from traps BC-01 and BC-32 were used in combination by BCPH to aid in the weekly decision whether or not to spray the Gapter Road/Baseline Heights neighborhood of Boulder. If either trap were above the threshold during a given week, then areas of the neighborhood would be sprayed. The data from trap BC-34 were used by BCPH to aid in the weekly decision to spray the San Lazaro Mobile Home Park neighborhood of Boulder.

Table 15 Comparison of the Number of County ULV Spray Applications Using the Nuisance Program's 250 Threshold vs. the Previous Pre-Nuisance Threshold of 100, 2012 and Historical Data

Year	250 Threshold (Nuisance Program)[1]	100 Threshold (Previous)[2]	Decrease Due to Increase to 250 Threshold			
			Spray Events	Linear Miles Sprayed[3]	Pesticide Gallons[4]	Percentage
2012					0.0	
Baseline Heights Area Traps (BC-01 and BC-32)	0	0	0	0.0	0.0	0%
San Lazaro Area Trap (BC-34)	1	9	8	12.8	0.9	89%
Areas Combined	1	9	8	12.8	0.9	89%
Historical Average[5]					0.0	
Baseline Heights Area Traps (BC-01 and BC-32)	3	9	6	79.1	5.8	70%
San Lazaro Area Trap (BC-34)	6	12	6	9.6	0.7	51%
Areas Combined	8	21	12	52.7	3.9	59%

Notes:
1: The number of spray events occurring if spraying occurred each time the 250 mosquitoes per trap per trap night threshold was reached due to the nuisance program threshold
2: The number of spray events occurring if spraying occurred each time the 100 mosquitoes per trap per trap night threshold was reached without the nuisance program threshold
3: Calculated by multiplying the number of spray events not conducted by the average route distance; average route distance was calculated from 2007-2011 BCPH spray events data
4: Pesticide gallons were estimated using a typical application rate of 2.35 ounces per minute applied at 15 MPH for an undiluted adultcide
5: Historical average based on 2007 - 2011 data.

Based on the trap results, the County sprayed these areas 1 time during the 2012 season compared to the 9 times that they would have sprayed without the nuisance program threshold (see **Table 15**). This represents an average reduction of approximately 89% less adulticide spraying in these areas during the 2012 season. The average amount of linear miles sprayed and the amount of pesticides used also decreased by approximately 89%, with estimated amounts shown in **Table 15**. Although the majority of these spray events were likely avoided simply due to the increased threshold, it can be assumed that *Bti* treatments for nearby nuisance larvae potentially helped reduce the area adult populations and the corresponding trap counts (as discussed in **Section 2.3**).

2.7 EVALUATION OF POTENTIAL LONG-TERM IMPACTS OF BTI TREATMENTS ON BIOTA

As part of the nuisance program, the City wanted to perform studies to find the potential long term impacts of treating area wetlands with *Bti* for mosquito control. In 2007, the working group developed a plan to conduct a macroinvertebrate biodiversity study of all the wetland breeding habitats within the City's WNV program. This would consist of a taxa gathering effort at 3 different times of the year to determine the diversity value of each habitat to assess what the true impact is on habitats being treated with *Bti*. However, after receiving cost estimates, the studies were deemed to be cost prohibitive during the 2007 - 2008 seasons.

As part of the nuisance program extension, the City agreed to appropriate funds to perform studies on the populations of invertebrates, amphibians, and birds occurring in local wetlands during 2009 - 2010 seasons. The studies were designed to use paired habitat sites with similar habitat characteristics. Each pair of sites consisted of one site that was within the nuisance program area (nuisance-only *Bti* treatments allowed) and one site that was in the vector control program (nuisance-only *Bti* treatments not allowed). This would allow for a comparison of possible affects the extra *Bti* treatments for nuisance only mosquitoes had on the nuisance program sites. A total of 5 habitat site pairs, or 10 habitats sites, were used in the studies.

Detailed results of the studies can be found in the *Red-winged Blackbird Survey for the Nuisance Mosquito Control Pilot Program - 2010, (*Andrews, Bob 2010), *Report: 2010, City of Boulder, Colorado Invertebrate Survey of Bti- Treated Wetlands* (Durfee, R.S. and B.C. Kondratieff 2010), and *Amphibian Surveys on City of Boulder Bti-Treated Wetlands* (Herasimtschuk, David A. and Johnson, Pieter T. J. 2010).

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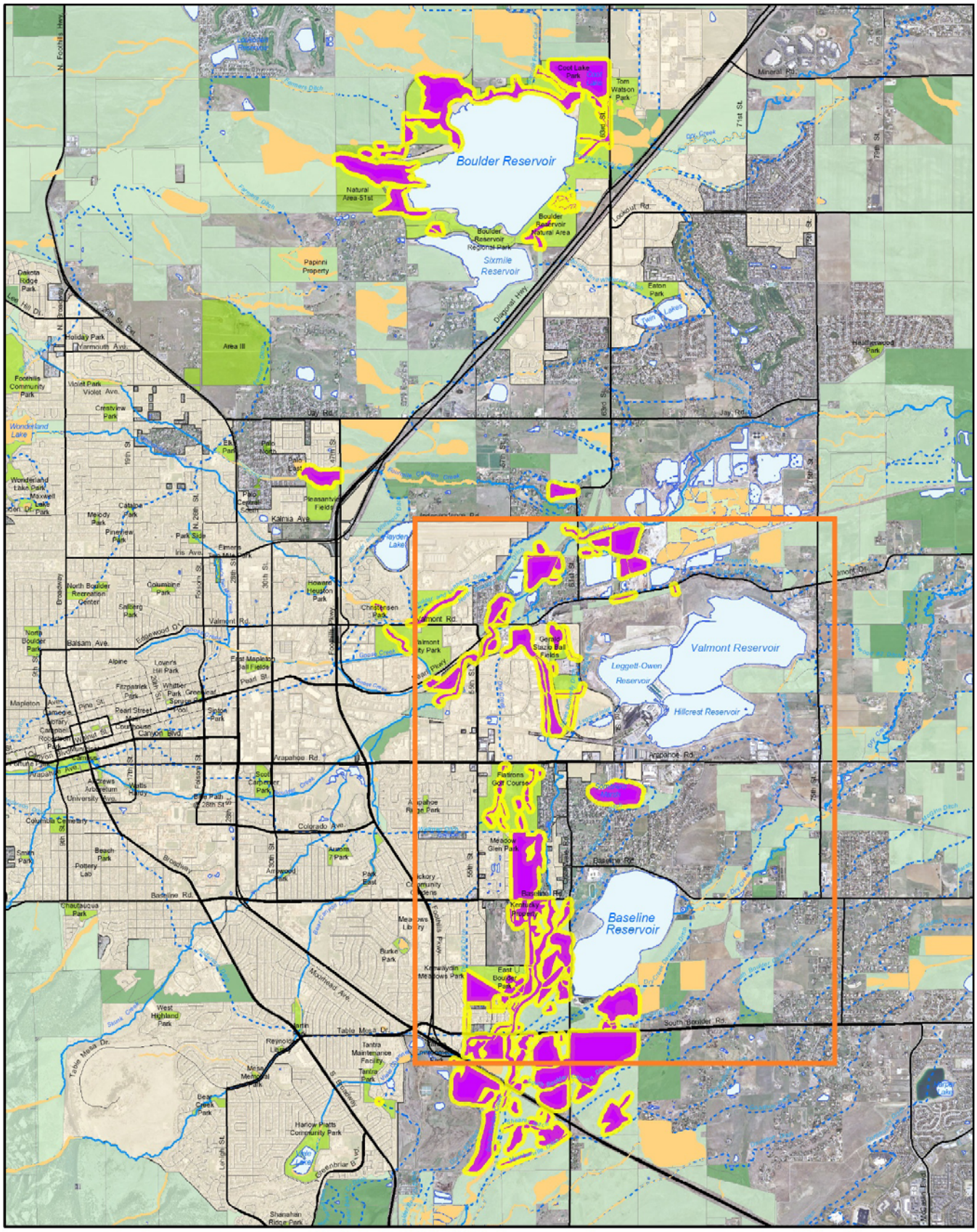
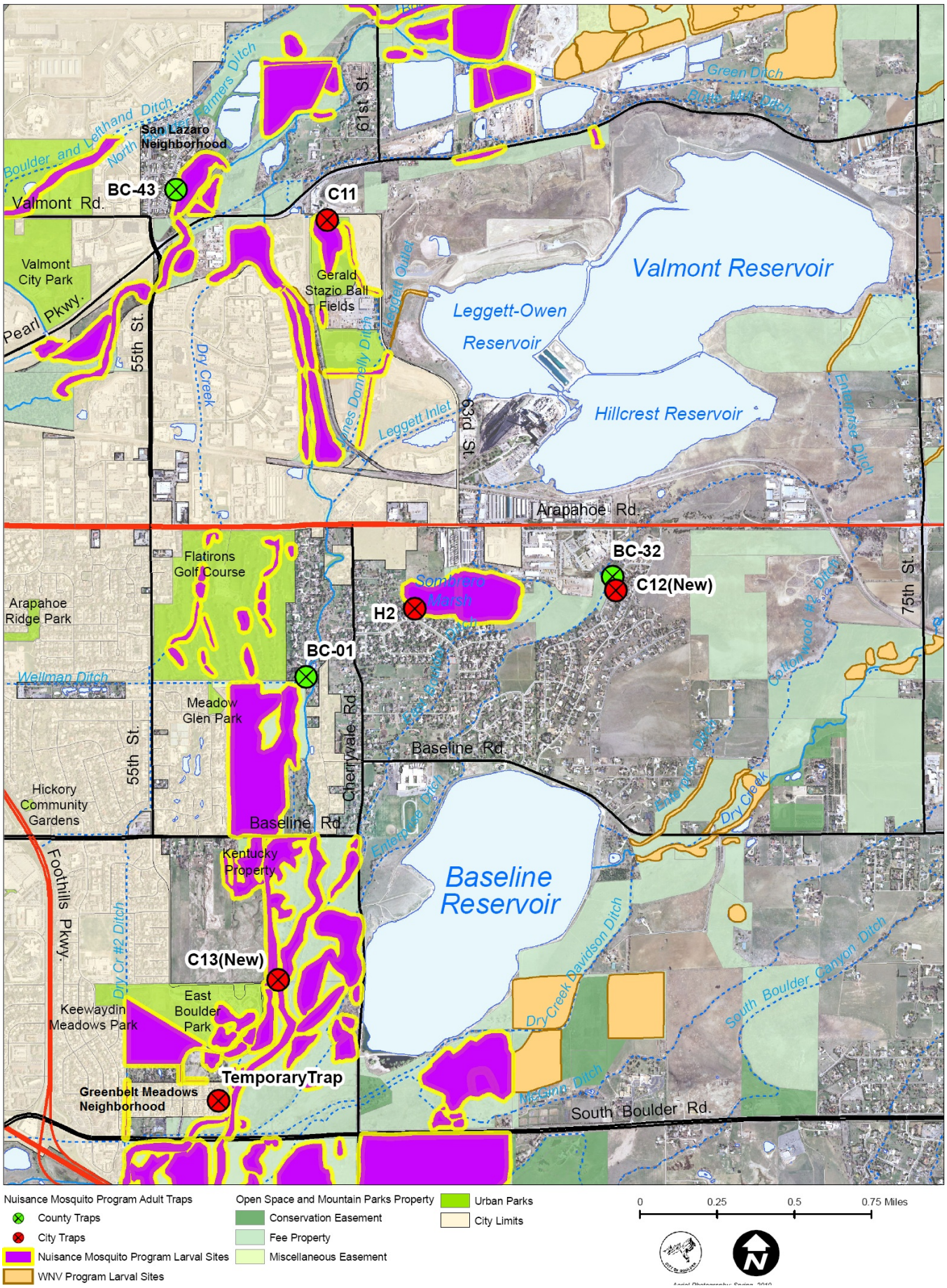
Appendix A: Maps

Map A-3: Nuisance Program Larval Site Locations



Map A-4: Nuisance Program Adult Trap Locations