



## Introduction

The Zika outbreak from 2015 to 2017 in the United States shined an urgent spotlight on the needs of mosquito and vector control programs from federal, state, and local organizations. The National Association of County and City Health Officials (NACCHO) partnered with the Centers for Disease Control and Prevention (CDC) to identify and gain a better understanding of the capabilities, or lack thereof, of these programs to address future outbreaks.

In 2017, NACCHO conducted a survey of all vector control organizations to assess mosquito surveillance and control capacity. They found that most programs lacked the tools needed to deliver the five core competencies of vector control as recognized by the CDC.

1. Routine mosquito surveillance, standardized trapping, and species identification;
2. Larviciding and adulticiding capabilities;
3. Routine vector control (e.g., chemical, biological, source reduction, or environmental management);
4. Species-specific abatement activities; and
5. Pesticide resistance testing.<sup>1</sup>

After analyzing the data, they were able to identify specific gaps, challenges, and needs for mosquito surveillance and control programs. NACCHO then worked to create the Vector Control Workgroup, develop a Vector Control Toolkit, and provide training and guidance to interested programs through Vector Control Summits. In addition to meeting these objectives of the assessment, NACCHO also wished to provide these programs with a focused, practical guide to build new programs and provide guidance to existing programs to enhance their capabilities in the core competencies.

The purpose of this resource is to provide guidance to local mosquito control programs, whether they are establishing a mosquito surveillance and control program for the first time or considering building on their current capacity. This resource will provide information on establishing baseline activities and further enhancing the building blocks of a comprehensive mosquito control program: surveillance; control and abatement; resistance testing; communication and outreach; partnerships; and workforce development. The guide is provided as a means to educate, support, and encourage programs to be better prepared for future outbreaks of vector-borne disease. It is also a tool that programs can use to foster and strengthen relationships with key stakeholders and the public to inform them of the risks of vector-borne disease, and help them better protect themselves.

## Abbreviations

- **IMM:** Integrated Mosquito Management
- **FTE:** Full Time Employee
- **CDC:** The Centers for Disease Control and Prevention
- **NACCHO:** The National Association of County and City Health Officials
- **NEHA:** National Environmental Health Association
- **GIS:** Geographic Information System
- **HIPAA:** The Health Insurance Portability and Accountability Act

<p><b>SURVEILLANCE</b></p> <p>Mosquito surveillance is the foundation for any vector control program and consists of routine monitoring of both larval and adult mosquito populations over the course of an entire mosquito season. It allows a vector control program to monitor changes in mosquito populations, identify which mosquito species are present, detect mosquito-borne pathogens, and ultimately determine what control measures need to be conducted.</p>	<p><b>BASELINE ACTIVITIES</b></p>
	<p><i>Know vector species in your area and their basic biology.</i></p>
	<ul style="list-style-type: none"> <li>» Vector species and associated pathogens: Vectors of the United States Map and Informational Hub from the National Environmental Health Association (NEHA): <a href="http://www.neha.org/vector-map">www.neha.org/vector-map</a>.</li> <li>» Mosquito Identification Keys: The Walter Reed Biosystematics Unit (WRBU) offers a variety of mosquito identification keys: <a href="http://www.wrbu.si.edu/vectorspecies/keys">www.wrbu.si.edu/vectorspecies/keys</a>.</li> <li>» Mosquito Life Cycle (<i>Aedes aegypti</i>): Refer to this document from CDC: <a href="https://www.cdc.gov/mosquitoes/about/life-cycles/aedes.htm">https://www.cdc.gov/mosquitoes/about/life-cycles/aedes.htm</a>.</li> <li>» Mosquito Life Cycle (Culex): Refer to this document from CDC: <a href="http://www.cdc.gov/mosquitoes/about/life-cycles/culex.html">www.cdc.gov/mosquitoes/about/life-cycles/culex.html</a>.</li> </ul>
	<p><i>Have the appropriate types and number of traps.</i></p>
	<p>The number and types of traps depends upon vector species present in the area. They can also vary depending on how you are using them - for example, broad surveillance over a large area like a county vs. targeted surveillance for case investigation or monitoring control efficacy.</p> <ul style="list-style-type: none"> <li>» Vector species determine the trap types: This information can usually be found through several avenues (e.g., local universities, Departments of Agriculture, state entomologists, scientific journals/literature reviews).</li> <li>» Trap selection: Collaborate with peers in your area, if available. Industry representatives can be very helpful, and may have subject matter experts on staff.</li> <li>» Number of traps: Sorting, testing, and reporting on collected mosquitoes can be time-intensive and expensive. The number of full time employees (FTEs) in your vector program may limit the number of traps that can be reasonably used and managed.</li> </ul>

<p><b>SURVEILLANCE</b></p>	<p><b>BASELINE ACTIVITIES</b></p>
	<p><i>Examples of possible locations</i></p>
	<p><b>Fire Stations</b></p> <ul style="list-style-type: none"> <li>» Not always exposed to the public so there is a low risk of tampering.</li> <li>» Easy to access.</li> <li>» Located in population centers.</li> </ul> <p><b>Public Parks</b></p> <ul style="list-style-type: none"> <li>» Prone to tampering.</li> <li>» Publicly available areas so they are easy to access.</li> <li>» Can be important recreational areas to monitor due to increased activity in warmer months.</li> </ul> <p><b>Employee/Residential Homes</b></p> <ul style="list-style-type: none"> <li>» Not prone to damage or tampering by the public.</li> <li>» Property must be easy to access or the employee, if properly trained, can perform maintenance and collection.</li> <li>» Can be in residential areas and population centers.</li> </ul>
	<p><i>Routine versus temporary trap locations</i></p>
	<ul style="list-style-type: none"> <li>» <b>Routine:</b> To collect comparable data each season, it is important to keep trap locations the same. By doing this, you can track fluctuations in mosquito populations and positive pools over time. Also, if a habitat remediation effort or adulticide spraying is required in an area near a trap, you will be familiar with normal mosquito counts for a trap site.</li> <li>» <b>Temporary:</b> In certain situations, it may be necessary to add more traps during the season. These traps would not serve routine surveillance tasks, but instead would be used when an area in your jurisdiction needs additional monitoring. For example, after a human case of a mosquito-borne disease, such as Zika, it may be necessary to place temporary traps around the case's property to determine whether the vector species is present in that area.</li> </ul>

ENHANCED ACTIVITIES	
SURVEILLANCE	<i>Perform routine trap maintenance and repairs.</i>
	<ul style="list-style-type: none"> <li>» Check the manufacturer’s website or trap manual for maintenance suggestions and guidance.</li> <li>» Traps should be routinely maintained, cleaned, and repaired to prevent trap failure during deployment.</li> <li>» Trap cleaning should be performed periodically during the season and at the end of the season.</li> <li>» Trap maintenance and repair can be performed during the season if needed, or preferably during the off-season.</li> <li>» Trap repair can typically be performed using purchased replacement parts or by reusing parts from traps that are no longer in service. <ul style="list-style-type: none"> <li>• Some parts and equipment used for repairs can usually be purchased at a local hardware store or from online retailers. Hardware store employees may be able to answer some of your basic questions about equipment, supplies, and repairs/maintenance. Take the trap with you so they can see what you are trying to repair.</li> </ul> </li> <li>» Trap repair can be performed by your staff, possibly by the company that sells the traps (e.g., BioQuip, John Hock), or a local company with that expertise.</li> <li>» Traps should be identified (e.g., numbered) to allow for tracking maintenance or operational issues.</li> <li>» To reduce the likelihood of disruption of surveillance during the season, some extra traps should be available to use if traps fail.</li> <li>» For in-house repairs, techniques (e.g., soldering) and the correct tools are necessary. <ul style="list-style-type: none"> <li>• YouTube is a helpful resource to learn about necessary techniques (e.g., soldering, wiring). However, videos specific to trap repair are required.</li> </ul> </li> <li>» Contractual trap maintenance may be possible with local companies who have this type of expertise.</li> <li>» If using rechargeable batteries, they should be identified (e.g., numbered) to allow for tracking purchase date, deployment date, maintenance or operational issues; they should be tested regularly; and they should be maintained during the off-season. Consult the manufacturer, a battery distributor, or manuals for year-round charging suggestions and guidance to maintaining “healthy” batteries.</li> </ul>

ADVANCED ACTIVITIES	
SURVEILLANCE	<i>Utilize Geographic Information System (GIS) software.</i>
	<ul style="list-style-type: none"> <li>» After considering all the factors involved in trap placement, you can utilize GIS software to find potential sites. With GIS software, you can map high population areas, past human cases, known mosquito problem areas, public parks, and other items that guide your decision.</li> </ul>
CONTROL/ABATEMENT	<i>Test vectors for disease.</i>
	<ul style="list-style-type: none"> <li>» Determine vector species and associated pathogens for your geographic area. <ul style="list-style-type: none"> <li>• Determine the appropriate collection technique (light traps, resting boxes).</li> </ul> </li> <li>» Utilize local health department staff, students, or other stakeholders for collection/identification.</li> <li>» Develop in-house testing capabilities or contract with academic, commercial, or state labs (if available). <ul style="list-style-type: none"> <li>• If using in-house testing capabilities, determine protocols and confirmations for pathogen analyses.</li> </ul> </li> <li>» Detect Pathogens: determine prevalence, track changes in prevalence over time, document geographic distribution, and track changes in geographic distribution over time.</li> <li>» Estimate the public health risk of vector-borne pathogen exposure.</li> <li>» Share results with stakeholders to guide education and intervention strategies (local health department, DEC, medical, vets, parks department, general public).</li> </ul>
CONTROL/ABATEMENT	<i>Know vector species in your area and their basic biology.</i>
	<ul style="list-style-type: none"> <li>» Vector species and associated pathogens: Vectors of the United States Map and Informational Hub from the National Environmental Health Association (NEHA): <a href="http://www.neha.org/vector-map">www.neha.org/vector-map</a>.</li> <li>» Mosquito Identification Keys: The Walter Reed Biosystematics Unit (WRBU) offers a variety of mosquito identification keys: <a href="http://www.wrbu.si.edu/vectorspecies/keys">www.wrbu.si.edu/vectorspecies/keys</a>.</li> <li>» Mosquito Life Cycle (<i>Aedes aegypti</i>): Refer to this document from CDC: <a href="https://www.cdc.gov/mosquitoes/about/life-cycles/aedes.htm">https://www.cdc.gov/mosquitoes/about/life-cycles/aedes.htm</a>.</li> <li>» Mosquito Life Cycle (<i>Culex</i>): Refer to this document from CDC: <a href="http://www.cdc.gov/mosquitoes/about/life-cycles/culex.html">www.cdc.gov/mosquitoes/about/life-cycles/culex.html</a>.</li> </ul>
	<i>Mapping</i>
CONTROL/ABATEMENT	<i>Mapping</i>
	<ul style="list-style-type: none"> <li>» Use the appropriate map scale to resolve mosquito larval habitats, adult populations, and other control efforts.</li> <li>» Use aerial photography and GIS modeling.</li> <li>» Utilize the GIS map to show the geographical visualization of high larval and adult mosquito abundance/distribution.</li> <li>» Mark known troublesome mosquito larval habitats.</li> <li>» Link all of the data to spatial information for use in GIS.</li> </ul>



<b>CONTROL/ABATEMENT</b>	<b>ENHANCED ACTIVITIES (contd.)</b>
	<b>Larval source reduction and sanitation</b>
	<ul style="list-style-type: none"> <li>» Removing or reducing mosquito larval habitats is the most effective method of mosquito control.</li> <li>» Removal of water-holding containers should be a continual process. This will successfully eliminate man-made mosquito-breeding sources.</li> <li>» Consider both natural and artificial containers as sources for mosquito breeding.</li> </ul>
	<b>Chemical control of larvae</b>
	<ul style="list-style-type: none"> <li>» Use larvicides when necessary. Refer to <a href="http://www.cdc.gov/mosquitoes/pdfs/larvicides-508.pdf">www.cdc.gov/mosquitoes/pdfs/larvicides-508.pdf</a>.</li> <li>» Should also be considered as part of comprehensive program to control container-inhabiting mosquitoes.</li> </ul>
	<b>Adulticiding</b>
<ul style="list-style-type: none"> <li>» Use of adulticides when necessary.</li> <li>» Use Ultra Low Volume (ULV) space sprays.</li> <li>» Use barrier and residual sprays.</li> </ul>	
<b>Biological control of mosquito larvae</b>	
<ul style="list-style-type: none"> <li>» Use of aquatic predators such as <i>Gambusia</i> mosquito fish, <i>Toxorhynchites</i> predatory mosquitoes, copepods, and others such as sunfish, minnows, etc.</li> </ul>	
<b>Education</b>	
<ul style="list-style-type: none"> <li>» Implementation of environmentally-sound source reduction techniques.</li> <li>» Continuing education of mosquito technicians.</li> <li>» Educate the public on mosquito-transmitted pathogens and control methods.</li> </ul>	

<b>RESISTANCE TESTING</b>	<b>BASELINE ACTIVITIES</b>
	<b>Find or identify an agency or other mosquito control district to provide resistance testing for your district.</b>
	<ul style="list-style-type: none"> <li>» Colleges and universities such as the Florida Medical Entomology Laboratory with the University of Florida or the U.S. Department of Agriculture have researchers performing bottle bioassays and/or genetic testing for resistance in mosquito adults or egg rafts that you collect.</li> </ul>
	<b>ENHANCED ACTIVITIES</b>
	<ul style="list-style-type: none"> <li>» Attend or participate in online training for bottle bioassays to familiarize yourself with the process and to learn how to interpret results. Refer to <a href="#">CDC's Bottle Bioassay webpage</a>. <ul style="list-style-type: none"> <li>• Programs in the continental United States and its territories can order free Insecticide Resistance Kits by sending an email to <a href="mailto:USBottleAssayKit@cdc.gov">USBottleAssayKit@cdc.gov</a> and requesting an order form. Kits include bottles, insecticide, and manual.</li> </ul> </li> <li>» Obtain necessary equipment to perform the bioassays to include active ingredients from the manufacturer.</li> <li>» Perform bottle bioassays using the active ingredients that are contained in the formulated products being used by your district annually or biannually.</li> <li>» Field test adulticides in conjunction with bottle bioassays.</li> </ul>
<b>ADVANCED ACTIVITIES</b>	
<ul style="list-style-type: none"> <li>» Consult with other districts or check the literature to learn to perform larvicide resistance testing. <ul style="list-style-type: none"> <li>• The Pacific Southwest Center of Excellence in Vector-Borne Diseases (PacVec CoE) has training videos on this: <a href="https://pacvec.us/larval-mosquito-resistance-testing-video/">https://pacvec.us/larval-mosquito-resistance-testing-video/</a>.</li> </ul> </li> <li>» Conduct larvicide resistance testing to ensure that your larvicides are still controlling larvae in various environments.</li> </ul>	



<p><b>COMMUNICATION/OUTREACH</b></p> <p>Education and community outreach are an important part of an integrated vector management approach to mosquito control. Educating the public to be aware of potential mosquito habitats in their area and showing them how to reduce or eliminate such resources can help reduce mosquitoes. Additionally, communicating with the public on how to avoid, prevent, and protect from mosquito bites can help prevent the spread of mosquito-borne diseases.</p>	<p><b>BASELINE ACTIVITIES</b></p>
	<p><i>Have communication strategies in place for awareness, outreach, and education including having:</i></p> <ul style="list-style-type: none"> <li>» CDC/SHD/LHD contact information readily available.</li> <li>» Information on your (LHD, Public Works, Mosquito Control District) website.</li> <li>» Information ready to disseminate via social media (e.g., posts, tweets, Facebook Live).</li> <li>» Information ready to disseminate via traditional media (e.g., local TV news shows, interviews).</li> <li>» Press releases ready to push through website and/or media.</li> <li>» Annual reporting in place (e.g., number of samples collected, number of positive pools, number of species identified).</li> <li>» Messaging ready for your agency leadership, as well as for leaders in your jurisdiction (e.g., the mayor, town council, county supervisors).</li> </ul>
	<p><b>ENHANCED ACTIVITIES</b></p>
	<p><i>Interact with the public using regular, direct outreach using:</i></p> <ul style="list-style-type: none"> <li>» Literature and/or graphic art distribution (e.g., brochures, fact sheets, cards, trailhead signage). Make these available at your agency, libraries, and with other stakeholders and community partners.</li> <li>» Information booths/tables at Farmers’ markets, health fairs, and other community events.</li> <li>» Public service announcements online or at movie theaters.</li> <li>» Public transportation advertising on buses, trains, cabs, and benches at stops using billboards.</li> <li>» Community presentations (e.g., civic groups, homeowners associations, scouts).</li> <li>» School presentations/activities.</li> <li>» Contacts at your local or state extension office, or any other local agency that regularly has contact with the public for additional events.</li> </ul>
	<p><b>ADVANCED ACTIVITIES</b></p>
	<p><i>Create and maintain a position in your district for an Outreach Coordinator (or) similar titles.</i></p> <ul style="list-style-type: none"> <li>» The position would be responsible for the base capacity building and Enhanced activities, regularly scheduling and attending events, teaching inside classrooms, managing social media and participating in training opportunities to expand their skills.</li> </ul>
<p><b>PARTNERSHIPS</b></p> <p>Establishing partnerships can help integrate your vector control program into the broader public health infrastructure at the local, state, and federal levels. Epidemiology departments can help you determine the types of vector-borne pathogens prevalent in your area and this information can help you tailor your vector control activities to safeguard public health.</p>	<p><b>BASELINE ACTIVITIES</b></p>
	<p><i>Establish a relationship and arboviral case communication procedures with your local epidemiology division.</i></p> <p>To establish a relationship:</p> <ul style="list-style-type: none"> <li>» Contact your local epidemiology division.</li> <li>» Learn how arboviral case investigations are conducted.</li> <li>» Determine what information collected would be useful to a vector control program and what information they can share (it may be helpful to have a blank copy of the EPI investigation form). <ul style="list-style-type: none"> <li>• Pathogen</li> <li>• Suspected or confirmed case</li> <li>• Case home address and other frequented areas</li> <li>• Symptom onset date</li> <li>• Travel history, etc.</li> </ul> </li> <li>» Provide HIPAA training for vector control staff.</li> </ul>

<p><b>PARTNERSHIPS</b></p> <p>Additional partnerships could include state, regional, and national mosquito control associations and higher education facilities.</p>	<p><i>Establish case communication procedures.</i></p> <ul style="list-style-type: none"> <li>» Determine the need for communication agreement documentation (e.g., MOU), and regular review and updating procedures.</li> <li>» Create a communication procedure and standardized communication form (e.g., arboviral case notification form).</li> </ul>
	<p><b>ENHANCED ACTIVITIES</b></p>
	<p><i>Work with the epidemiology division to create a collaborative arboviral disease response plan.</i></p> <ul style="list-style-type: none"> <li>» Establish roles and responsibilities of all parties, including public messaging and communications.</li> </ul>
	<p><b>BASELINE ACTIVITIES</b></p>
<p><b>WORKFORCE DEVELOPMENT</b></p> <p>A robust vector control department will need staff who are trained to perform core functions of the program. Workforce development, including training and recruitment activities, can help keep your program sustainable in the long term.</p>	<p><i>Have sta with expertise for this program.</i></p> <ul style="list-style-type: none"> <li>» Identify positions that have the appropriate job specifications for the work that needs to be done.</li> <li>» Interns working with local colleges.</li> </ul>
	<p><b>ENHANCED ACTIVITIES</b></p>
	<p><i>Have a training budget for sta .</i></p> <ul style="list-style-type: none"> <li>» Training budget is determined primarily by two factors: Desired capability and the use of existing staff versus hiring a subject matter expert.</li> <li>» Capabilities by functionality <ul style="list-style-type: none"> <li>• Human surveillance – Cost will be minimal or free if coordinated with local or state epidemiologists.</li> <li>• Vector surveillance (including trapping and testing) – Vector surveillance training opportunities: Various training options are available, and in many cases, they can be low cost or free if coordinated with an existing program, if you reach out to professional organizations (e.g., American Mosquito Control Association), or an industry representative.</li> <li>• Habitat remediation – Training is available online, through literature review, or the above-mentioned groups.</li> <li>• Larvicide application – Same as above.</li> <li>• Resistance testing – Training is available online through CDC, but it is recommended to send a person to attend a live demonstration or workshop.</li> <li>• Adulticiding (chemical application) – Variable; State Department of Agriculture or other oversight group usually provides a low cost training to become a licensed applicator along with required Continuing Education Units (CEUs). <ul style="list-style-type: none"> <li>Contractor – The costs for hiring a company to perform this activity depends upon many factors and can be very expensive.</li> </ul> </li> <li>• Training Resources: <ul style="list-style-type: none"> <li>Funding - It may be possible to use CDC’s <a href="#">Public Health Emergency Preparedness or EPI/lab capacity grants</a>.</li> <li>Availability - There are a number of organizations that offer training opportunities and certifications (e.g., American Mosquito Control Association, Entomological Society of America).</li> </ul> </li> </ul> </li> </ul>

NACCHO has compiled a list of resources from our partners and members to assist mosquito control programs build their capacity. This information is highlighted in “Resources” below.

More resources on mosquito surveillance and control can be found by searching the [Vector Control Toolkit](#) in the NACCHO Toolbox. [The NACCHO Toolbox](#) is a free, online collection of public health tools that have been created and shared by members of the public health community. To view the Vector Control Toolkit, visit the NACCHO Toolbox and select “Vector Control Toolkit” from the Toolkit’s dropdown menu.

## Resources

1. [CONUS Manual for Evaluating Insecticide Resistance in Mosquitoes Using the CDC Bottle Bioassay Kit](#) [PDF – 19 pages] - <https://www.cdc.gov/mosquitoes/pdfs/CONUS-508.pdf>
2. Vectors of the United States Map and Informational Hub - National Environmental Health Association (NEHA) <https://www.neha.org/vector-map>
3. Vector Control Tools & Resources (VeCToR) Toolkit: 10 Essential Environmental Public Health Services – <https://www.neha.org/eh-topics/vectors-and-pest-control-0/essential-services>
4. Vector Control for Environmental Health Professionals – [www.cdc.gov/nceh/ehs/elearn/vcehp.html](http://www.cdc.gov/nceh/ehs/elearn/vcehp.html)
5. Continuation of Mosquito Surveillance and Control During Public Health Emergencies and Natural Disasters – [www.cdc.gov/mmwr/volumes/69/wr/mm6928a6.htm](http://www.cdc.gov/mmwr/volumes/69/wr/mm6928a6.htm)
6. Mosquito Control for Professionals – [www.cdc.gov/mosquitoes/mosquito-control/professionals/index.html](http://www.cdc.gov/mosquitoes/mosquito-control/professionals/index.html)

## Citations

1. Rodgers, Kim. “NACCHO Report: Shifting Our Approach to Mosquito Control Capabilities in the U.S.” NACCHO, 16 Oct. 2017, [www.naccho.org/blog/articles/naccho-report-shifting-our-approach-to-mosquito-control-capabilities-in-the-u-s](http://www.naccho.org/blog/articles/naccho-report-shifting-our-approach-to-mosquito-control-capabilities-in-the-u-s).

## Acknowledgements

This guide was supported by the efforts of NACCHO’s Vector Control Workgroup and sponsored by the Centers for Disease Control and Prevention (Grant No. 5 NU38OT00306-03-00). NACCHO is grateful for this support. The contents do not necessarily represent the official views of the sponsor.

## For more information, please contact:

**Danielle Chatelain**  
Program Analyst, Environmental Health  
[dchatelain@naccho.org](mailto:dchatelain@naccho.org)

To learn more about NACCHO’s vector control programs and services, visit [www.naccho.org/vector-control](http://www.naccho.org/vector-control).



The mission of the National Association of County and City Health Officials (NACCHO) is to improve the health of communities by strengthening and advocating for local health departments.

1201 I Street, NW, Fourth Floor • Washington, DC 20005

Phone: 202.783.5550 • Fax: 202.783.1583

© 2021. National Association of County and City Health Officials