DELAWARE MOSQUITO CONTROL SECTION

SPRAY THRESHOLD CRITERIA

General Comments

What is Involved in Making Spray Decisions -- Determination of when and where mosquito control insecticide spraying might be needed, whether for larvicides or adulticides, is based upon extensive and intensive *surveillance-and-monitoring* efforts for immature or adult mosquito populations using several types of indicators for larval or adult mosquitoes, as well as sometimes the presence in the environment of mosquito-transmitted viruses of special concern to human health (e.g. eastern equine encephalitis, West Nile virus). No one factor is always decisive for when or where to spray, and often a combination of quantitative or objective data must be evaluated to make "spray/no-spray" decisions in quasi-subjective manner (including also factoring in current or predicted future conditions for weather or tides that affect windows-of-opportunity for when spraying might best be done).

What Does It Mean to Exceed Threshold Values -- A long history in Delaware (>45 years) of our "real world" experiences in developing and using the threshold criteria below indicates that when a criterion or combination of criteria are exceeded and we do not initiate some control actions by larviciding or adulticiding as appropriate, then mosquito infestations of a level unacceptable to the public's quality-of-life, comfort and well-being, and often detrimental to local economies too, will either soon ensue or continue unabated. Additionally, if these infestations are not satisfactorily prevented or controlled, there can then often be corollary substantive concerns about potential public health problems in the form of mosquito-borne diseases. Therefore, the numeric values for the thresholds provided below are always subject to further refinement or modifications by the Mosquito Control Section as circumstances or new information warrants, in that these criteria have evolved over time and will probably continue to do so.

What Mosquitoes Need Control -- By no means do all mosquitoes in Delaware need control, since of the approximate 57 mosquito species found in the state, only about 19 species are pestiferous or problematic to humans or domestic animals. Factors in determining how pestiferous a mosquito species might become include how abundant or numerous can the adult populations of these species become, and what are their flight ranges, host preferences, biting aggressiveness, or potential for transmitting diseases. Contending with one or more of these 19 pestiferous species results in mosquito control spraying in Delaware that routinely starts about mid-March with larviciding for woodland-pool-breeding species, then progresses to salt marsh larviciding starting as early as April in some years, with adulticiding of saltmarsh mosquitoes sometimes also needed as early as mid-April, and then continuing with various types of spraying around the state throughout the remainder of the control season up until as late as early November, including efforts to suppress container-breeding species in urban or domestic settings, and the control of mosquito production in myriad freshwater habitats.

Who Determines the Threshold Criteria -- By State statute, the Mosquito Control Section has the responsibility and authority for determining and using these threshold criteria for making decisions about when and where mosquito control spraying is *needed* for any-and-all lands in Delaware, whether the lands be federal, state, county, municipal or private properties. This is not necessarily one-in-the-same as determining when and where spraying will actually be *allowed* to be done (e.g. on federal National Wildlife Refuges, the U.S. Fish and Wildlife Service exercises final authority over whether any spraying will be allowed), or will even be acceptable for any given landowner. Nonetheless, in order to effectively treat public nuisances or prevent disease, the Mosquito Control Section has the statutory authority to enter upon all lands under the State's jurisdiction including private lands, and take whatever control actions are needed, including spraying without landowner permission or concurrence, doing such while avoiding any unnecessary damage; but for any source reduction projects involving habitat modifications, we try not to exercise such authority without cooperation or consent of landowners.

Threshold Criteria for Application of Larvicides

Wetland or "Pothole" Larval Dipper Counts (applicable to saltmarsh or freshwater wetlands *pestiferous* species) – for larval dipper counts (using basically a coffee-cup-size container on a stick designed to take shallow-water samples), where larvae can range from 1st to 4th instars and also include pupae, our finding any larvae in >25% of all sampled sites that then average >5 larvae/dip (for all dips, including "zeros") can warrant larviciding throughout the wetlands where the sampling runs were performed. Thus, these threshold criteria incorporate minimum triggers for both the spatial extent or frequency of any breeding observed (>25% of sampled sites), and for the intensity or amount of any breeding observed (average >5 larvae/dip) – i.e. **for any larviciding to occur in a sampled marsh or wetlands, breeding should be observed in >25% of all the breeding sites sampled, AND be occurring at an average intensity of >5 larvae/dip (incorporating all dips into this average).** Additionally, for saltmarsh mosquito breeding leading to larviciding efforts, an additional factor is added whereby >25% of the marsh surface in "tussocky" saltmarshes, or >25% of pothole habitats in firmer saltmarshes, should be estimated to be inundated or holding water, as a measure of the extent of potential breeding habitats actually holding water. [An estimate of the % pupae present in saltmarsh or freshwater breeding habitats also gives us an indication as to whether it might be too late to attempt effective larvicide treatments.] Experience has shown us that if we don't take timely larviciding actions before a mosquito brood of such problematic scope or intensity emerges, then it will be a matter of only a few to several days before adulticiding will then become necessary in either nearby or even quite distant locations depending upon the types of mosquito species involved, along with weather factors such air temperature or wind speed and direction.

These larval sampling thresholds are to be used as general guidance to help determine any need for larvicide treatments. Special situations can arise that require larvicide treatments at <25% of sites breeding and/or larvae occurring at average densities as low

as 1/dip. For example, flooding after large rainfall and/or tide events over expansive areas can cause mosquito larvae to disperse in a manner that dipper counts alone do not properly reflect the true overall larval population, having potential for massive eruption of adult mosquitoes. In addition, areas of dense vegetation can make it very difficult to evaluate larval populations by dipper counts because larvae are often hard to access and assess by traditional sampling methods. These situations will be evaluated on a case-by-case basis using our best professional judgement and may still warrant larvicide treatment, even though our normal threshold criteria might not be met.

Larval Sampling Stations -- Larval sampling stations are described in our larval sampling plans or given via larval inspection instructions from Section managers to field personnel, such that timely and good spatial representation of potential breeding sites is achieved, with the sampling sites selected having environmental characteristics known or thought to favorable for mosquito-breeding. By recent rainfall or tidal flooding patterns, we usually have a pretty good idea of the best timing to undertake our larval surveillance efforts to yield the best-return-for-effort. Refinements for the need to larvicide any geographic area or location where observed breeding exceeds threshold criteria can be made based upon the types of mosquito species found and their typical flight ranges, as well as a breeding site's proximity to human population concentrations, sometimes resulting in our not taking larval control actions even though threshold criteria are exceeded. For example, long-distance-flying saltmarsh mosquitoes (often roaming 3-5 miles up to 10-15 miles from their natal marshes) will typically warrant larviciding anywhere the breeding threshold criteria are exceeded; whereas some relatively short-distance-flying freshwater species (flying from only a few hundred yards up to 1-2 miles from their natal habitats) might not, especially in areas remote from human populations.

Larval Identifications -- The levels to which larval identifications need to be taken for operational purposes can vary depending upon the environmental setting and the operational utility of making such taxonomic identifications. For example, in salt marshes all 5 saltmarsh mosquito species encountered in Delaware are known to be problematic for humans, so for salt marsh surveillance any-and-all larvae can be of concern, and just counting larvae without regard to specific species suffices for most operations, which is especially true for the 3 saltmarsh *Ochlerotatus* (*Aedes*) species that dominate open salt marsh mosquito production, and to a lesser extent for the single *Culex* and single *Anopheles* species found in saltmarshes. The saltmarsh *Culex* and *Anopheles* species are more commonly associated with impounded or more permanent-water breeding habitats in our coastal wetlands, and also don't fly as far as the 3 *Ochlerotatus* (*Aedes*) species, so unless populated areas are within 1-2 miles from where saltmarsh *Culex* or *Anopheles* larvae are detected, in most cases it wouldn't be necessary to larvicide impounded or more permanent water salt marsh habitats (that also lacked significant *Ochlerotatus* (*Aedes*) breeding). Fortunately, it is relatively easy to distinguish in the field among *Ochlerotatus* (*Aedes*), *Culex* and *Anopheles* larvae at the genus level when doing dipper counts. In most freshwater environments, particularly in wet woodland pools, meadow swales or roadside ditches, finding and identifying in the field the larvae of *Ochlerotatus*, *Aedes* or *Psorophora* genera can indicate a problem regardless of species; and when populated areas are found within 1-2 miles of such

freshwater breeding habitats, so can finding and identifying in the field larvae of *Culex* or *Anopheles* genera regardless of species. Finding larvae of *Ochlerotatus, Aedes, Psorophora, Culex* or *Anopheles* genera regardless of species in or near populated areas, whether the larvae are found in standing water, ephemeral water, or container-breeding habitats (including for the latter any man-made structures holding water for more than 4 consecutive days, or in natural treeholes), can all be problematic. Overall for operational purposes in almost all types of breeding habitats, identifying larvae in the field just to the genus level quite nicely suffices. Finally, it should be noted that finding larvae of *Coquilletidia perturbans* can also be indicative of a problem situation, but because of their larval requirements for burying into sediments and attaching to rooted aquatic vegetation, these larvae are rarely observed in the field without purposely sampling for them, and such larval habitat also does not lend itself to larviciding, so adulticiding becomes the primary form of control for this species.

"**Container" Occurrences** (applicable to larvae of *pestiferous* species found in natural or man-made containers or other water-holding structures) – any larvae of *pestiferous* species (genera) observed in or sampled from container-like habitats might warrant control, especially if close to human habitations and standing water will remain for more than 5 consecutive days. Primary species of concern will be those found in genera *Culex, Ochlerotatus* or *Aedes.* If the "containers" lend themselves to dipper sampling, then larval counts **averaging >2 larvae/dip** might warrant control actions. If larval control cannot be achieved by source reduction (e.g. dumping or eliminating standing water), then larviciding might be needed, almost always done via ground- or hand-applications (exceptions involving aerial applications might occur for salvage yards, tire dumps, or sewage lagoons).

Threshold Criteria for Application of Adulticides

Landing Rate Counts (applicable to adult biting mosquitoes landing on a field inspector during a one-minute period in or nearby human habitations or within flight ranges of human population concentrations, with the counts taken anytime between early morning through early evening) – in **populated areas** (such as cities, towns or suburbs, or in exurban subdivisions or larger strip-developments**)**, landing rate count averages for biting mosquitoes of **>2-3 mosquitoes/minute** (translating into 60-90 or more mosquito bites in a half-hour in somebody's backyard) can trigger the need for adulticiding; whereas in relatively **unpopulated areas** (often rural locations with low population densities, and commonly in or near wet woodlands or marshy staging areas), landing rate averages for biting mosquitoes of **>5-10 mosquitoes/minute** (becoming 150-300 or more mosquito bites in only a half-hour) might be needed to warrant adulticiding. [In some locations at certain times, landing rate counts of **50-100 mosquitoes/minute** have been recorded!] The results obtained with landing rate counts can be almost immediately diagnostic of a need to adulticide.

How to Perform Landing Rate Counts -- The protocol for conducting landing rate counts consists of counting all mosquitoes observed landing on all readily visible parts of an inspector's body in one minute intervals, with the inspector standing still and making

very little movement, along with not using any type of repellent. At any particular site, specific standing locations for conducting the counts are selected favoring shaded spots near vegetation having little or no wind. When it is obvious that a landed mosquito is either biting or about to bite an inspector, the inspector is allowed to undertake subtle movements during the count to terminate or prevent the bite (which makes for very interesting movements when dozens of mosquitoes might be simultaneously trying to bite!); and care is also taken to the extent possible not to count any single mosquito more than once during any one-minute count.

When to Take Landing Rate Counts -- Because of normal working hours for State employees, most landing rate counts are conducted during the daytime, which in allowing for commuting time then leads to most counts being conducted in the field between about 8:30 am and 4:00 pm. This can work well for saltmarsh and wet woodland *Ochlerotatus* (*Aedes*) spp., for freshwater *Psorophora* spp. and *Aedes vexans*, and for the container-breeding *Aedes albopictus*, but often tends to underestimate the abundance on-wing that'll be found in the early evening, throughout the night, or early in the morning for *Culex* and *Anopheles* spp., and to a lesser extent for *Coquilletidia perturbans.* Whenever possible and practicable to do, particularly where pertinent for dealing with potential "hot" situations, landing rate counts are also conducted near or at dusk or in the early morning. But it can be safely assumed that any mosquito landing upon an inspector is one of the 19 problematic species, and hence any-and-all mosquitoes observed alighting during a landing rate count are included in the tally.

New Jersey-style Adult Light Trap Counts (collected via unbaited NJ adult light traps at a few dozen "permanent" locations around the state, typically set within populated areas, or sometimes set in locations indicative of potential problems for nearby populated areas) – having nightly NJ adult light trap counts containing **>25 females/trap of *pestiferous* species,** checked the following day after a night's trapping period, or which average >25 females/trap of pestiferous species for multi-night collections, are indicative of adult mosquito populations on-wing in the general vicinity that would have been intolerable to most people the night(s) before. Because of the lag time involved with collecting and analyzing adult light trap collections, these counts often are not as immediately diagnostic of any need to adulticide as are landing rate counts; but within about 48-72 hours of problems arising from excessive numbers of adult *pestiferous* mosquitoes on-wing, the light trap counts can serve as indicators of the need to adulticide, or can help document how effective an earlier control treatment might have been. However, even with such a delay in immediate operational utility, the light trap counts are still valuable for allowing us to examine many of the types of *pestiferous* mosquitoes that might be around, at least for the trap-susceptible species, allowing for year-to-year comparisons at any given location and month-to-month comparisons within any given year.

CDC-style Portable Adult Light Trap Counts (collected via CO_2-baited portable CDC adult light traps at temporary collection stations around the state, often set and tended in location types similar to where NJ adult light traps are deployed, and often set in response to other indicators of mosquito problems, particularly to determine or to verify "hot

spots") -- nightly CDC adult light trap counts collected the following day containing **>50 females/trap of *pestiferous* species** are indicative of adult mosquito populations on-wing in the general vicinity that would have been intolerable to most people the night before. [The CO_2-baited nature and other inherent design features of the CDC-style traps cause them to collect more mosquitoes per night than NJ-style adult light traps, but the NJ-style traps are more durable and less costly to operate than the CDC-style traps, and the State of Delaware also has a much longer historic database using NJ-style traps at well-established, fixed locations.] Because of the urgency with which these portable CDC-style traps are often set and tended to and then analyzed, they can be diagnostic of the need to adulticide within about 24-36 hours of their setting.

Public Complaints About Biting Mosquitoes – these are called into or otherwise communicated to either our upstate or downstate Mosquito Control Section operational headquarters (in Glasgow for New Castle County and northwestern Kent County, and in Milford for the remainder of Kent County and Sussex County) by citizens or elected officials, and usually involve people wanting to report or complain about unacceptable or intolerable numbers of biting mosquitoes on-wing, followed by their then requesting some adulticiding (although sometimes the reports involve concerns about observations of standing or stagnant water bodies that might produce mosquitoes, which they either want us to inspect and treat with larvicides or to somehow eliminate). Receiving complaints from the public is an invaluable way to help us focus and make best use of our limited control resources – depending upon weather conditions and other environmental factors during any given year, on a statewide basis the Mosquito Control Section typically receives from about 1500-3000 public complaints about too many biting mosquitoes, conveyed to us from early April into early November.

Reactions to Public Complaints -- Depending upon patterns for the geographic locations, densities and intensities of public complaints received, the Mosquito Control Section might then undertake some adulticide spraying. When practicable to do within limits of our staff availability and working resources, before making any final decision to spray just based upon public requests, we often try to integrate these calls for treatment with other available mosquito-problem indicators, such as landing rate counts or adult light trap counts. Over the period of many years of our doing this, we have also come to know many individuals whose requests for some adulticiding relief to suppress mosquito populations are unfailingly accurate and representative of truly intolerable quality-of-life conditions caused by too many biting mosquitoes, and we tend to pay extra attention to many of these regular "trusty" callers. We also take quite serious those requests coming from city or town officials for our adulticiding services, for those municipalities that have endorsed our annual Spray Policy's requirements and protocols. And to repeat here, whenever possible and practicable to do, our responding to public complaints by actually spraying is also first coupled with other indicators of adult mosquito abundances, including landing rate counts or adult light trap counts pertinent to the areas where adulticiding requests have arisen.

Indicators of Mosquito-Borne Diseases

The Mosquito Control Section conducts surveillance-and-monitoring for mosquito-borne diseases of note to humans that in Delaware primarily concerns two arboviruses -- eastern equine encephalitis (EEE) and West Nile virus (WNV).

Sentinel Chickens -- The Section operates a statewide network of a few dozen "sentinel chicken" monitoring stations each year, whereby from about late May into late October or early November about one-half of our sentinel birds are tested every week for the presence of antibodies indicative that they have might contracted EEE or WNV, yielding for us a good signal of the viruses' presence and transmission within the environment. The sentinel chicken flock locations are selected to give us good geographic coverage (or at least as much as we can afford) for general areas either known or suspect to have good virus potential. Each sentinel chicken station (or "flock") consists of a total of 4 birds that are humanely housed and cared for in 2 wire mesh cages per station, with 2 birds each week from each station having small blood samples drawn for virus testing, thereby causing any individual chicken to be sampled but once every two weeks. The bleeding does not kill or harm the birds, and any chickens that might contract EEE or WNV also do not die from these viruses.

Sick or Dead Wild Birds -- The Mosquito Control Section also operates from April through October a statewide network for collecting and reporting sick or dead wild birds suspect to have WNV, relying primarily upon public reports of suspect wild birds, collection of good candidate birds by the Section, and testing for the presence of WNV by the state's Division of Public Health Laboratory. The Section has a statewide geographic strategy for accepting and testing wild birds that helps to ensure good spatial coverage and timely monitoring.

Mosquito Collections -- Occasionally on an *ad hoc* basis, the Mosquito Control Section will also analyze mosquito collections for the presence of WNV or EEE, sometimes with an interest in the specific species of mosquitoes carrying the viruses, or sometimes with only a more general interest in documenting the presence of viruses at the genus or guild levels. Samples for such analyses are usually collected by portable adult light traps. This might be done in conjunction with or as follow-up to other indications of virus presence, particularly in known or suspect virus "hot spots."

Horse/Human Cases -- The Mosquito Control Section also receives timely reports from the State Veterinarian for the finding of EEE or WNV in unvaccinated horses; and we receive from the state's Division of Public Health timely reports of any EEE or WNV human cases.

What Does Presence of Virus Mean? -- Indications of the presence of EEE or WNV by any of the methods above is then factored both spatially and temporally into the types and extent of control actions that we take. In part we use such indications to try to increase the public's awareness to take some personal protection measures against being bitten, and for them to also practice good water sanitation around their homes or businesses to

reduce mosquito production. We also use such virus indications to increase to the extent possible and practicable our surveillance-and-monitoring actions for assessing mosquito populations, and to increase our mosquito control treatment efforts accordingly, since one of the more important factors in preventing mosquito-borne diseases is to reduce even further populations of bridge-vector species, in order to decrease the probability even further that people will get bit by disease-carrying mosquitoes (i.e. good nuisance control = good disease prevention or control). This increase in our control responses relative to findings of virus presence is typically achieved by our then *reducing* the spray threshold criteria associated with indicators of mosquito abundance, in that we then undertake spray actions at *lower* larval dipper counts, *lower* landing rate counts, *lower* adult light trap counts, *lesser* numbers of public complaints, etc. than what have been indicated above for when there are no indications of disease. By how much we actually lower these threshold criteria in response to virus presence is fairly subjective, based upon our semi-quantitative estimations of virus presence; but since *human health* is involved here, we of course tend to-err-on-the-side-of-caution (within limits of our available treatment resources and applicable environmental considerations).

Last revision – February, 2017