Summary of Mosquito problems presented at Land Court

Overview

Dr. John Edman, testifying as an Expert Witness, pointed out not only the risks of mosquito-borne disease we were already aware of, but several we were not aware of, which will result from the design of Avalon-at-Great-Meadows. Dr. Edman's expertise is based on 24 years of studying mosquito-borne diseases in Massachusetts and all over the world. Until 1999 he was Professor of Entomology at the University of Massachusetts in Amherst. He was recruited to California to head up the Division of Vector Borne Diseases for the State of California. He is currently Professor of Entomology at the University of California, Davis, and holds a dual appointment in the School of Veterinary Medicine.

As an example of his research involving graduate students while in Massachusetts, Dr. Edman guided a study by one of his PhD students to test the hypothesis that topography information generated by Geographical Information System (GIS) photos, in combination with information about mosquito populations, could be used to predict neighborhoods at increased risk for mosquito-borne diseases. The student obtained the exact locations of cases of Eastern Equine Encephalitis (EEE) in Massachusetts throughout the 1980's and 1990's from the Massachusetts Department of Public Health, which helped fund the study. Then, using mosquito traps, he quantified mosquito populations within a one kilometer radius of each case. Using the GIS maps, mosquito species were correlated with geography. The work, published in the Journal of the American Mosquito Control Association in 2000, not only revealed this approach will be valuable to mosquito control efforts, but provided essential information about Massachusetts mosquito populations involved in EEE transmission and their habitats.

To understand the increased mosquito risks associated with Avalon-at-Great-Meadows described by Dr. Edman, it is necessary to briefly review the site location and the life cycle of mosquitoes.

The Location of Avalon-at-Great-Meadows

The site is surrounded on one side by the Atlantic White Cedar Swamp, and on other sides by wetlands which are contiguous with the Great Meadows National Wildlife Refuge. The same wetlands penetrates into the site, dividing it into a southeasterly uplands peninsula of approximately two acres and a northwesterly uplands body of approximately nine acres. The Swamp is a known breeding ground for the mosquitoes which carry Eastern Equine Encephalitis (EEE) virus, most notably, *Culiseta melanura*. Bedford has a history of at least two human cases of EEE, one in the late 1930's, and another in the 1980's. Both residents lived

within half a mile of the swamp. According to the Massachusetts Department of Public Health website (www.ma.state.us/dph), the same mosquito species has been shown to be infected with West Nile Virus (WNV) in Massachusetts, the new epidemic of mosquito disease which entered the U.S. in 1999. The Bedford horse who died of WNV encephalitis in 2000 also lived within half a mile of the Swamp.

The Mosquito Life-Cycle

Female mosquitoes involved in transmitting EEE and WNV require a blood meal in order to lay fertile eggs. Most mosquitoes feed on birds, but some mosquitoes feed on both birds and mammals, and a few, such as *Aedes vexans*, prefer mammals. The easier it is to obtain a blood meal, the more eggs the mosquito can produce in a season. The eggs are deposited in specific habitats according to the species of mosquito. Once deposited, the eggs must "mature" for a few days to weeks, but are then ready to hatch quickly into tiny, worm-like larvae when conditions are right. Eggs can be viable for years and then hatch within minutes of the first encounter with moisture.

The larvae eat voraciously, grow, and then enter a pupa stage. These stages require water, although only a small amount. Pupa do not eat, but metamorphose into adults which hatch at the surface of the water and fly away. In general, mosquitoes lay their eggs in transitional water sources such as drainage ditches and shallow woodland pools and the edges of marshlands because permanent water sources, such as year-round ponds and rivers, contain predators, such as other insect larvae or fish, which eat mosquito larvae.

(a movie of this process can be found at www.cdc.gov)

Transmission of EEE and WNV

EEE virus is endemic to Massachusetts which ranks second in the nation in disease incidence. From 1964 to 1981 there were only four reported cases of EEE, but from 1982 to 2002 there have been 19 cases, including one in Bedford. Most reported cases have been in the southeastern counties where the majority of White Cedar Swamps are found. EEE infects birds, which generally do not die, through the bite of infected mosquitoes such as *C. melanura*. The disease is spread to mammals by other mosquitoes such as *Culex salinarius*, *Coquillettidia perturbans*, *A. vexans* and *Aedes canadensis* which bite both birds and mammals, including people. These mosquitoes are not restricted to living in the swamp.

An outbreak of EEE requires an infected bird population in proximity to a human population. Most infected humans have some symptoms and most of those who develop encephalitis die. Victims are hospitalized for weeks, frequently requiring life support; most survivors have severe

neurologic deficits for life. Children appear to be particularly susceptible. If humans are not nearby, the mosquitoes will bite birds or other mammals instead. It is likely that most outbreaks of EEE in the wild are unnoticed.

WNV was introduced into the U.S. in 1999, probably by an infected mosquito entering Kennedy Airport in New York. It has killed tens of thousands of birds of many species since it entered the country. In 2000, Massachusetts reported infected birds and horses, but no humans. In 2001 there were three humans hospitalized with WNV encephalitis with one death, and in 2002 to date there have been 23 persons with fever and encephalitis and three deaths. The marked increase in incidence is alarming. Moreover, in contrast to EEE, most WNV infected persons have mild or no symptoms. It is estimated that only 1 in 200 persons has symptoms severe enough for hospitalization. Thus, the 23 persons identified represent on the order of 4000 infected persons in Massachusetts.

Unlike EEE, cases of WNV do not cluster in southeastern counties in Massachusetts. Deaths have been reported for residents of Woburn, Boston, Malden and Weymouth. Many pools of *Culex pipiens* in and around metropolitan Boston have tested positive for WNV. *C. pipiens* is commonly found in residential habitats, although it prefers to feed on birds. The mosquitoes which transmit WNV from infected birds to humans are not known with certainty, but available evidence points to *C. salinarius*, *Aedes triseratus*, *Aedes albopictus* and *A. vexans* as likely candidates. As with EEE, WNV transmission to humans depends upon humans living in proximity to infected birds. Middlesex county has been a consistent hotspot for WNV infected birds, suggesting a relationship with the county's abundant wetlands habitats in addition to White Cedar Swamps.

Mosquito control in Bedford

Bedford's Board of Health contracts with the Middlesex Mosquito Control Program to control mosquito populations in Bedford, including the White Cedar Swamp. The most effective form of control is helicopter application of Bti (Bacillus thuringensis israelis), a bacteria which specifically infects and kills mosquito larva. *C. melanura*, the mosquito which transmits EEE among birds, breeds in the base of swamp trees. The Bti can only penetrate to the base of the White Cedar Swamp trees from helicopters in the early spring, before the leaves are on the Red Maples which also grow in the swamp.

Mr. David Henley, the Middlesex Mosquito Control Program officer responsible for Bedford, continually monitors mosquito populations throughout the season. He expressed concerns about Avalon-at-Great-Meadows in a letter to John Zupkus, Bedford's Mosquito Commissioner, in the fall of 2000. His concerns centered on the possibility that run-off from the project could stimulate a second hatching of *C. melanura* eggs later in the

summer, at a time when helicopter spraying of Bti would be blocked by tree leaves. The only other form of control in this instance would be street spraying of pesticide to kill adults, but such spray can only penetrate the periphery of the swamp. Although his concerns were brought to the attention of the Bedford Zoning Board of Appeals, the Bedford Board of Health, and AvalonBay on multiple occasions, they were largely ignored. Especially ignored was the ability of transient run-off events to stimulate eggs to hatch. Since the swamp is approximately 200 acres, run-off from the project would not substantially raise the level of water in the entire swamp (although some mosquito experts hold the view that any elevation at all will increase mosquito hatchings), but this does not take into account the effects of run-off events which sweep into the Swamp and could hatch millions of mosquito eggs. Since the Detention Basin nearest the swamp (#11, see the Drainage Summary) appears to be actually designed to allow run-off over the side, as well as through the pipe, an increase in mosquito hatchings at least on the side of the Swamp nearest the residential community seems certain.

Dr. Edman's concerns about Avalon-at-Great-Meadows

Dr. Edman expressed four areas of concern about this project during his testimony and during his meetings with us:

1. Bringing a large population of people next to the Swamp and surrounding wetlands increases their risk of being bitten by infected mosquitoes.

2. Bringing a large population of people next to the Swamp and surrounding wetlands will provide increased opportunity for human blood-meals for mosquitoes. Such an opportunity does not now exist in this location. This will result in an increased number of eggs being laid by mosquitoes which feed on humans, thus increasing the overall population of human-biting mosquitoes in Bedford.

3. He agreed with Mr. Henley's concerns that transient run-off events into the swamp, which do not now occur because the water is absorbed by the uplands, could bring about an increased number of summer hatchings of *C. melanura* and other Swamp mosquitoes. This could increase the number of birds infected with both EEE and WNV. An increase in the number of infected birds in the presence of increased numbers of mosquitoes that bite both birds and humans presents a clear public health risk.

4. In addition, the project design will actually create mosquito habitat which does not now exist (see Drainage Summary on this website):

a) The Catch Basins provide new breeding opportunity for the *Culex* species, some of which bite humans, which prefer to breed near residential areas and are known to be infected with WNV in Massachusetts

b) If the Detention Basins drain as planned, they will provide the moist soil needed for several species of mosquitoes to lay their eggs, including some species which prefer mammals. The eggs mature in two to three weeks. The next rain event will either allow them to immediately hatch, or will sweep them out into the wetlands where they can complete their life cycle. The grassy swails designed to control run-off from the Catch Basins will also provide the moist soil needed for this cycle.

c) If the Detention Basins do not drain as planned and hold standing water for extended periods of time, they could support the entire life cycle of several mosquito species.

d) Over time, if the Detention Basins develop vegetation, such as cattails, they will also provide habitat for *C. perturbans*, a mosquito which attaches to underwater vegetation and is thought to be an important vector for EEE infection of humans. In Dr. Edman's experience, the type of Basins described for Avalon-at-Great-Meadows frequently develop such vegetation after a few years.

e) The drainage pipes from the ForeBays to the Detention Basins and from the Detention Basins to the surrounding wetlands (see the Drainage Summary) allow small pools of water to develop both at the inlet, because they are usually slightly above grade, and at the outlet where the water creates an erosion depression. These small puddles are frequent breeding sites for mosquitoes.

Larvaciding the Catch Basins and Detention Basins after each rain event may help control mosquito populations. But larvaciding will not control the risks from the eggs deposited in the damp Detention Basins that are then swept into the surrounding wetlands, or the increase in the availability of human blood meals for mammal-biting mosquitoes who may then deposit their eggs in the Swamp or surrounding wetlands.

The Land Court Judge listened carefully and took notes during Dr. Edman's testimony. The AvalonBay attorney, Martin Fantozzi, repeatedly objected to Dr. Edman's testimony on the grounds he was not an expert in Risk Assessment and that, in fact, there were no accepted methods for assessing increased risk of mosquito-borne diseases in the U.S. Dr. Edman agreed, but was able to cite many examples of increased risk of mosquito-borne diseases such as malaria and dengue fever in other areas of the world he has studied. Attorney Fantozzi then tried to emphasize how rare mosquito-borne encephalitis is, but Dr. Edman's response was that it is less rare in risky circumstances (more than 3,000 cases of encephalitis caused by West Nile Virus have been reported this year in the U.S.) and that they are such terrible and expensive diseases it is far better to limit disease possibilities. Attorney Fantozzi then tried to argue that the water run-off collected by the Detention Basins meant that some of the surrounding

wetlands would be less wet and that circumstance could decrease the number of mosquito-breeding sites, but Dr. Edman's response was that he didn't think the current circumstances in the upland areas supported mosquito breeding sites at this time.

By the end of his several hours of testimony and cross-examination by Attorney Tillotson, it was clear to all in the court room that Avalon-at-Great-Meadows will increase mosquito habitats and thus the risks of mosquito-borne diseases in Bedford.

Dr. Dickson Despommier's testimony

After Dr. Edman's testimony, Dr. Despommier, AvalonBay's expert witness finished testifying. Dr. Despommier does not himself study mosquitoes, but he has written a book for layman about the entry of West Nile Virus into New York City.

Dr. Despommier had been in the court room during Dr. Edman's testimony. Instead of refuting Dr. Edman's assessment of the risks posed by the project, as the AvalonBay attorneys expected him to do according to pre-filed testimony, he essentially agreed with Dr. Edman and commented that he had learned a lot while listening to him. When Attorney Fantozzi tried to make the point that mosquito-borne encephalitis is defined as a rare disease by the Centers for Disease Control, Dr. Despommier's response was that with some diseases, such as the Plague, one case is "rare", but two cases constitute an "epidemic."

On cross examination by Attorney Tillotson, Dr. Despommier mentioned that he had gathered some of his information about WNV transmission from Dr. Andrew Spielman, a world expert at the Harvard School of Public Health. Attorney Tillotson then asked if he were aware that Dr. Spielman had been in communication with us about this project. He was not aware. Attorney Tillotson showed him the letter from Dr. Spielman which suggests caution in locating a large residential development, especially one providing affordable housing, next to Bedford's White Cedar Swamp. Dr. Spielman has studied Bedford's White Cedar Swamp for many years. After he read the letter from Dr. Spielman, Dr. Despommier agreed that residential developments should be reviewed by experts in mosquito-borne diseases, especially if they were to be located adjacent to known mosquito-breeding areas. After this comment, Attorney Tillotson then stated she had no further questions. AvalonBay's Attorney Fantozzi also had no further questions of Dr. Despommier.

At the end of the day, it was clear that both Expert Witnesses believe that as now designed, Avalon-at-Great-Meadows will increase the risks for mosquito-borne disease in Bedford.