ES-1. Long-Term Plan Summary

ES-1.1. Introduction/Organization

The Draft Generic Environmental Impact Statement (DGEIS) is organized as follows.

Section 1 discusses how SEQRA applies to this project.

Section 2 is the Description of the Action, including essential background information such as the current program and factors that constrained the action (i.e., matters of law, West Nile virus plans, and the kinds of mosquitoes found in Suffolk County).

Sections 3 through 5 describe the Environmental Setting (generally in Section 3 and relating to specifics for the Risk Assessment in Section 4 and Wetlands in Section 5) and provide important background information.

Section 6 contains experiments and field work conducted specifically for the Long –Term Plan.

Section 7 discusses the impacts of the Long-Term Plan.

Sections 8 and 9 discuss impacts associated with alternatives to the Long-Term Plan.

Sections 10, 11, and 12 discuss the minor impact topics (Social and Economic issues, Energy, and Solid Waste, respectively).

Section 13 summarizes the impact assessment.

Section 14 presents mitigations of any identified potential significant impacts associated with the Long-Term Plan.

Section 15 discusses Cumulative Impacts.

Section 16 discusses Unavoidable Adverse Impacts.

Section 17 discusses Irretrievable Commitments of Resources.

Section 18 is a guide to some key issues raised in Scoping.

ES-1.2. Long-Term Plan Summary

This Long-Term Plan's primary goals are to decrease potential risks to human health and public welfare from mosquitoes and mosquito control measures, and to reduce the use of pesticides for vector control. An ambitious target of a 75 percent reduction in larvicide usage (as measured in the number of acres treated) has been set. The area treated with adulticides has already been reduced by more than 50 percent in the past five years, and this Long-Term Plan seeks to further reduce use of adulticides.

The Long-Term Plan also seeks to use a series of Best Management Practices (BMPs) to restore approximately 4,000 acres of tidal wetlands that were grid ditched in the 1930s, and which now require routine larvicide applications by air. When implemented, the BMPs will reduce or eliminate the need for larvicide on these lands, and improve wetland values by enhancing biodiversity and limiting invasive species, including *Phragmites*. Wetland restoration strategies will be tailored to the specific needs of individual marshes with mosquito control as one element considered in the overall restoration strategy. The greatest reductions in larvicide use can be achieved by prioritizing project sites where mosquito production is greatest, the most pesticide is used, and relatively simple measures will reduce or eliminate larval habitat. Once a site is chosen, however, the design process should consider the preservation and/or enhancement of natural resource values as the most important factor in choosing which BMPs will be used for mosquito control.

Among the significant policy commitments contained in the Long-Term Plan are:

- The continuation of the "no new ditching" policy, and establishment of a presumptive interim policy of ditch reversion as opposed to ditch maintenance. It is expected that less than 50 acres of salt marsh per year will be subject to ditch maintenance, and then only when necessary to address a critical ecological or public health need (e.g., to restore tidal circulation or to eliminate a severe infestation).

- Institution of a framework for continuing coordination and input by the Citizen and Technical Advisory Committee structure to help guide the preparation of Triennial Plan updates.

- The creation of a Wetlands Screening Committee comprised of agencies, policymakers, estuary program representatives, and non-profit institutions. The Screening Committee will approve all major wetlands restoration proposals, with the overarching goal of enhancing salt marsh functions and values. Building on accomplishments of the Wetlands Management Plan, the Committee will also be charged with developing a strategy to begin addressing the management needs of all of the County's 17,000 acres of tidal wetlands, irrespective of Vector Control significance. This process will include refinement of preliminary wetland health indicators described in the Wetlands Management Plan.

Critical Long-Term Plan recommendations include the continued use and refinement of Integrated Pest Management (IPM) procedures, and improvements in surveillance (e.g., better documentation of mosquito populations and post-spray efficacy, and the establishment of additional mosquito traps at Fire Island National Seashore locations). In order to improve source control at breeding sites, the Long-Term Plan calls for enhanced catch basin larviciding. Expansion of public education and outreach is highlighted through improved used-tire management, greater use of providing information through Internet contact, and promoting source control methods at businesses and homes.

Early action projects are a hallmark of the Long-Term Plan. Examples include implementation of a new technology to guide pesticide applications. The "Adapco Wingman" system uses a computer model and real-time meteorological data to minimize pesticide usage and to optimize mosquito control.

In another early action, a progressive Open Marsh Water Management (OMWM) project restored 80 acres of salt marsh at the Wertheim National Wildlife Refuge, thereby controlling mosquito breeding and enhancing wetland values such as biodiversity. OMWM improves habitat for native vegetation and larvae-eating fish by creating ponds and tidal channels to eliminate mosquito breeding areas, and by filling stagnant ditches. The project was conducted in cooperation with the US Fish and Wildlife Service, and is the first of its kind on Long Island. Supported by extensive monitoring, this initiative will serve as a test of the viability of future OMWM projects on Long Island.

Tidal wetlands restoration strategies will proceed in accordance with three-year work plans. With the possible exception of Wertheim, no new major OMWM projects are expected during the 2007-2009 timeframe. Future OMWM recommendations will be subject to Wetlands Screening Committee approval, as part of the Triennial Plan update process.

The scope of this Long-Term Plan addresses wetlands that are subject to Vector Control operations. Approximately 4,000 acres of grid-ditched salt marsh are proposed for "reversion" via natural processes, i.e., no management for vector control is needed. As previously stated, another 4,000 acres of wetlands which are routinely larvicided will be evaluated for restoration via minor Best Management Practices (e.g., maintain/repair existing culverts) or, in the long-term, major restoration (subject to Screening Committee review). The county's remaining 9,000 acres of wetlands require additional assessment, and any major restoration projects proposed will be subject to SEQRA review. Remote sensing will allow for cost-effective monitoring of the County's wetlands and supplement field visits.

It is envisioned that the process of assessment and enhanced wetland management be completed within 12 years. For individual projects, wetlands management goals for mosquito control must be adapted to the management goals set by landowners and natural resource managers, and may not be driven by vector control considerations. The ability to successfully implement Long-Term Plan objectives will be dependent upon cooperation by many agencies and stakeholders.

The Long-Term Plan will continue to be a cooperative effort administered by Suffolk County Department of Health Services (SCDHS), in cooperation with Suffolk County Department of Public Works (SCDPW). The new Suffolk County Department of Environment and Energy will be a lead partner. Suffolk County has already budgeted several new staff positions to begin implementation of the Long-Term Plan's recommendations although most can begin to be accomplished with existing resources. Grant programs and supplemental funding sources will be sought, in particular for wetland restoration projects.

Impetus for Long-Term Plan

Suffolk County sponsored this comprehensive evaluation of its Vector Control program to develop strategies to best protect public health, while optimizing environmental quality. Reasons for initiating the Long-Term Plan included:

- The West Nile virus threat, intermittent reappearance of Eastern Equine Encephalitis, and other vector-borne diseases, e.g., malaria. Suffolk County has had four deaths and 22 severe neurological illnesses attributable to West Nile virus between 1999 and 2005. Nation-wide, deaths total 664 through 2004, with over 5,000 severe neurological cases.

- A long-standing need to better manage the legacy of grid-ditched wetlands to optimize environmental quality and reduce pesticide usage. By the end of the 1930's, over 90 percent of the County's 17,000 acres of salt marsh were grid-ditched for mosquito control purposes. The ditch network is substantially intact, but over 4,000 acres of marsh still require routine larvicide applications.

Background - Plan Approach

The Long-Term Plan followed a classic management plan approach rather than just evaluate impacts of a pre-determined outcome, i.e., a Generic Environmental Impact Statement on a pre-specified plan. It was based on data collection, evaluation of alternatives, and quantitative health and ecological risk assessments. The process was transparent, with extensive involvement by both Technical and Citizens Advisory Committees.

A comprehensive literature review was undertaken to determine the state-of-the-art in the fields of mosquito control, disease transmission, toxicology, wetlands biology, marine ecology, and environmental chemistry. Critical information was collected on mosquito biology and diseases, innovative mosquito control practices, mosquito control pesticides including their application technologies, formulations, and potential impacts, and wetlands and salt marshes.

Extensive local information was also collected and organized. This process included establishing a mosquito control-oriented Geographical Information System (GIS), digitized mapping of the County's wetlands, and analyzing past and current mosquito control practices in the County. To support the analyses of potential impacts, four sections of the County were exhaustively described in terms of human use and ecological values, and 21 marshes were comprehensively studied.

Scientific studies and demonstration projects were conducted. Hundreds of samples were taken from air, water, sediment, and biota, and pesticides were measured to research level accuracy, i.e., one part-per-trillion. Mosquito control effectiveness of garlic oil, rosemary, and mosquito traps was tested. None of these "alternative techniques" showed promise for the County vector control program. Other studies were performed on benthic invertebrates, salt marshes with various larviciding histories, and stormwater in relation to ditches; vector control impacts were not found. Catch basins were evaluated, and documented to be problem mosquito breeding sites.

Health or Nuisance?

One of the goals of the Long-Term Plan, which addresses human health and public welfare, was to evaluate the possibility of differentiating "health-based" vector control from another commonly used term: "nuisance" control. A true distinction proved to be impossible because all mosquitoes found in Suffolk County that bite people are capable of spreading disease, and therefore, the public health risks from biting mosquitoes can never be said to be zero. Control prior to the actual detection of pathogens can also reduce the need for, and mitigate risks in, emergency response situations. Finally, health concerns from mosquito infestations exist (pain, itching, possibility of infections, etc.), irrespective of detected pathogens. Vector control clearly results in ancillary quality-of-life benefits, but this is not the primary reason for a mosquito control program. The Long-Term Plan thus approaches mosquito control in terms of the continuum from "vector control" (e.g., low but present disease and health concerns) to "public health emergency" (e.g., pathogen response in accordance with federal and state guidance). "Vector control," in this context, can be used synonymously with "*public health* nuisance control."

For vector control scenarios, strict numeric criteria for adulticiding have been adopted which require that quantitative mosquito thresholds be met prior to any adulticide application. Vector

Control will keep records to document all pesticide application decisions. Emergency response actions will be conducted in conformance with West Nile virus response guidelines.

Vector Control Agents: Results of Risk Assessment

The Long-Term Plan evaluated risks to public health associated with vector control alternatives from vector-borne diseases as well as exposure to pesticides, and weighed these risks against potential impacts to the environment. The approach is especially noteworthy in that it addresses physical, chemical, and biological stressors. The public health risk assessment determined that, in the absence of any vector control, Suffolk County could expect to see as many as 16 deaths from West Nile Virus each year, and 150 persons could contract serious West Nile illness. Impacts from EEE and other diseases could not be quantified, but the threats are grave.

The exhaustive toxicological (pesticide) risk assessment was based on extremely conservative, worst-case assumptions and showed no significant human health impacts and minimal ecological impacts. The results for Vector Control agents are summarized as follows:

- Human health: no impacts (acute, chronic, or carcinogenic) from any larvicide or adulticide agent.

- Ecological impact: no impacts for mammalian, avian, or reptilian wildlife from any pesticide. Possible aquatic impacts were associated only with the adulticides permethrin, and potentially moreso from malathion. However, the invertebrate impacts do not propagate up the food chain, and the model showed recovery to be complete by the following spring.

Bees are the standard for understanding agricultural pesticide impacts to flying insects and, based on theoretical potential effects to bees, all adulticides posed a potential risk to non-target flying insects. However, vector control adulticides are generally not applied when bees are flying (day time). No study has attributed significant impacts to insect populations from vector control adulticides at the concentrations and methods in which they are applied. Also, the literature suggests that effects of transient stressors on insect populations are fleeting, with populations recovering within days.

Part of the effort to develop the Long-Term Plan was to evaluate typical risk from the use of pesticides in everyday life. The exposures and corresponding human health risks from the use of pesticides for vector control purposes are small relative to other risks, such as those associated with exposure to pesticides in food, indoor residential use and some pet flea and tick products. The insect repellent DEET was also evaluated. Proper use of DEET products should not result in adverse health impacts.

An extensive "Caged Fish" study found no lethal or sublethal impacts to organisms attributable to applications of resmethrin and methoprene. In fact, researchers found that the pesticides actually decayed more rapidly in the environment than prior laboratory based studies suggested.

Conclusion

It is the policy of Suffolk County that pesticides should always be used sparingly, and only when needed. This study has demonstrated that the benefits of carefully controlled Vector Control program, conducted within an Integrated Pest Management framework, clearly outweigh the potential adverse impacts, which have not been found to be significant and which are mitigated by the IPM measures described in the Long-Term Plan. Moreover, marsh restoration can have a significant positive environmental impact, while controlling vectors and reducing or eliminating the need for pesticide usage. Therefore, implementation of the Long-Term Plan should achieve its major goals of reducing impacts to human health while significantly improving overall County ecological conditions.

ES-2. Need for Action

ES-2.1. Policy Justification for Mosquito Control

A mosquito problem is defined as a threat of disease and impacts to public welfare. Mosquitoes are identified as the most important vector of human disease, worldwide. Most of the human misery and death caused by mosquitoes is from the transmission of malaria. Fortunately, Suffolk County and the rest of the US managed to control this disease more than half a century ago. Although minor outbreaks of the disease still occur, the risks of malaria to Americans today are small. Similarly, other dread mosquito-borne diseases such as dengue fever and yellow fever are of only passing concern (Cashin Associates, 2005a).

The mosquito-borne diseases of concern in Suffolk County currently are encephalitic arboviruses. The two of most concern are Eastern equine encephalitis (EEE) and WNV. Outbreaks of EEE, which can have fatality rates ranging from 35 to 75 percent, have occurred recently in New Jersey and Massachusetts (Cashin Associates, 2005a), and in Nassau County in 2005 (although, fortunately, there were no human cases associated with this outbreak) (NCDH, 2005). Although there has not been a diagnosed human case of EEE in Suffolk County, horses have died from the disease here as recently as 2003. In 1999, WNV was introduced into the country, with the first human cases and deaths occurring in Douglaston, Queens. WNV is found throughout the continental US, resulting in over 16,000 human cases with 665 deaths through 2004; four of the people who died were residents of Suffolk County. These encephalitides not only have the potential to kill otherwise healthy individuals, but non-fatal impacts can include neuro-invasive effects, which can be permanent (Cashin Associates, 2005a).

It is also clear that there are numerous other mosquito-borne diseases that currently are not found in the US. The immediate lesson of WNV in Suffolk County is that mosquitoes here have the capacity to transmit exotic pathogens and pose a significant disease threat. It is understood that the introduction of invasive mosquito-borne disease is not a question of "if," but rather a question of "when." This is because modern transportation has removed geographical isolation. Along with generating undeniable benefits, this facet of modern life also means that disease organisms are often only one airplane flight away (Cashin Associates, 2005b).

In temperate climates, human disease is the end-product of a long series of epidemiological events that build in intensity over a period of months. The development of human illness due to this progression can be aborted by careful actions taken to control the disease vectors. Almost all public health plans recognize that waiting for disease to become evident in people means that control efforts begun at that time may be ineffective in preventing further human suffering. This is especially true for mosquito-borne diseases. Mosquitoes tend to be concentrated as immature organisms, and targeted control efforts using natural predators or narrow-spectrum agents are very effective; as adults, they tend to widely disperse, complicating efforts to alleviate the threat of harm, and often requiring the use of chemicals that may have wider non-target impacts (Spielman and D'Antonio, 2001; Rose, 2001).

Therefore, disease control efforts should begin when pathogens are circulating in adult mosquitoes. An integrated control program is required for efficient and proper control of endemic diseases such as WNV. Comprehensive surveillance can document areas that pose the greatest risk of disease amplification and transmission. Source reduction should be employed to reduce breeding opportunities for the amplification vectors (if possible) and for those bridge vectors that may eventually pose a risk to human populations. Similarly, larval control needs to be conducted prior to detection of the virus in adult mosquito populations, as larval population reduction efforts will not decrease the imminent risk posed by pathogen presence in amplification or bridge vectors. An integrated program such as this acknowledges that any need for adulticide applications signals inadequate efforts in other, better means of disease suppression. Thus, because WNV will likely occur in multiple sites in the County every year (with its ultimate geographic distribution apparently the result of complicated interplay and feedback between weather and mosquito, avian, and viral population dynamics), mosquito control conducted for the purpose of preventing cases of human disease needs to be conducted generally across the County and throughout the season.

Nonetheless, Federal and State guidelines have established separate protocols for addressing increasing risks from WNV and other mosquito-borne diseases. These include guidance on how to increase vigilance prior to the introduction of the disease to the general area, and also discuss ways to consider managing increasing risk in a season when the pathogen is detected locally (CDC, 2003a; NYSDOH, 2001a). As part of the process, when imminent risk reaches a certain level, the County Commissioner of the Department of Health Services is authorized to petition for a State Department of Health declaration of a "health emergency." This declaration changes certain lines of local authority (making mosquito control explicitly the responsibility of SCDHS, for example) and allows certain State permitting procedures to be expedited more rapidly. But the declaration does not signal the initiation of local interest in mosquito-borne disease, nor the beginning of control efforts focused on pathogen transmission. These activities must be an essential part of County vector control activities throughout the year.

Mosquitoes impact public welfare not only by disease transmission, but also through subclinical effects of mosquito biting. Mosquitoes are known to be infected by other viruses, bacteria, and pathogens and parasites, such as worms of various kinds, some of which are implicated in human illness. The salivary fluids released when a mosquito bites typically cause welts, and can cause rashes and various allergic reactions. Thus, even in the absence of defined diseases circulating in mosquito populations, human-biting mosquitoes can adversely impact public health (Eldridge and Edman, 2000).

Surveillance programs, especially post-WNV introduction, are designed to detect early signs of pathogens, and to determine if health risks presented by disease require actions to reduce the chance of human illnesses. However, human-biting mosquitoes come into contact with blood when they bite. In areas where there is disease transmission risk, the distinction between mosquito control for public health protection and mosquito control for the relief of human discomfort (sometimes called nuisance control) becomes unclear. All human-biting mosquitoes in Suffolk County have some vector capability for the arboviruses that are the modern day health threats in the northeast US (see Turrell et al., 2005). Thus, control of these human-biting mosquitoes is undertaken to impact on the overall risk of disease. Actions taken to reduce the populations of human-biting mosquitoes in Suffolk County reduce the risk of disease transmission, and result in public health benefits beyond minimization of subclinical effects. In addition, there is an ancillary, but important, improvement in the quality of life for those who live, work, or recreate where these mosquitoes live. For parts of Suffolk County, especially in areas in close proximity to the south shore, high numbers of mosquitoes that are very persistent and fierce in their search for blood meals (these are largely spawned from local salt marshes) can make it impossible to spend any amount of time outside, in the absence of mosquito control programs.

Public health protection emphasizes monitoring for pathogens among amplification vector populations, and controlling important bridge vector populations through source reduction (especially water management for salt marsh species), larval control where source reduction is not possible or was not effective, and, if a health risk assessment deems it necessary, adult control. There is significant overlap between this approach and the alleviation of severe public welfare effects. Historically, Suffolk County significantly reduced mosquito populations, particularly along the south shore, through its ditch maintenance program augmented by regular use of larvicides (Campbell et al., 2005).

State and County Public Health Law (PHL) identify mosquito control and the reduction of mosquito habitat (such as standing water) as abatement of public health nuisance. A public health nuisance is, by definition, a condition that adversely affects public health (irrespective of whether it causes fatal disease or some sublethal impacts). In this case it is the recognition of health effects from an ectoparasite (mosquitoes are grouped with pests such as lice, fleas, and bedbugs). Under State law, health officers have a duty to address the effects caused by these to the public. The presence of pathogens in mosquitoes is not required for this definition of public health nuisance, as the law implicitly recognizes there are health concerns that extend beyond the transmission of diseases such as WNV and EEE.

The Long-Term Plan uses the term "vector control" to describe adulticide applications in the absence of a detected pathogen. In general, "vector control" is interchangeable with "public health nuisance control," as these instances of adult control take place under conditions where there is a low imminent public health threat of the outbreak of serious disease (such as WNV or EEE), where the risk to the public cannot be said to be zero, and where sublethal impacts also occur.

In Suffolk County mosquitos develop in both fresh and salt water environments. In order for pathogens of present-day concern to become prevalent enough to pose a major health threat, they need to be amplified through avian reservoirs by fresh water mosquito species (Turrell et al., 2005). For EEE, it is clear that other mosquito species are needed to spread disease to people, and some of the most able of these species breed in salt water settings (Cashin Associates, 2005c). For WNV, the cycling of the pathogen is less well understood, but quite a few fresh and salt water mosquitoes have been determined to be (or are suspected of being) human vectors. Therefore, the integrated control program that focuses on reducing these human-biting mosquito populations, in both fresh and salt water environments, clearly reduces overall risks of disease transmission.

Therefore, to avoid impacts to public health and well-being, Suffolk County has decided to implement a comprehensive vector control program, the Long-Term Plan, grounded in the tenets of Integrated Pest Management (IPM). This hierarchical approach to mosquito management proposes:

- scientific surveillance to determine the locations and types of mosquito problems
- source reduction as the primary treatment means, including the use of water management to modify habitat to minimize mosquito breeding if appropriate
- when breeding occurs, larval control using products that have no human health effects and little environmental impacts will be undertaken
- if mosquitoes develop into adults, and careful assessment of the problem finds that adult control is required, then products will be used that have little to no impact to people, have an acceptably small impact to non-target organisms, degrade quickly, and are effective at killing adult mosquitoes

The Suffolk County Vector Control and Wetlands Management Long-Term Plan has two goals, with associated objectives to meet the goals:

Goal 1: decrease risks to human health and impacts to public welfare from mosquitoes and mosquito management

Objective 1. The prevention of serious disease in residents and visitors in the County.

Objective 2. Generally, problem populations of mosquitoes will be reduced where possible (when exceeding threshold/criteria described in Section ES-3.7, below) because large numbers of human-biting mosquitoes, in association with people and areas where mosquito-borne diseases have been detected, represent increases in overall health risks for those people. Enhancement of public welfare is an important auxiliary benefit. This objective relates to "Vector Control;" which can also be considered "Public Health Nuisance Control."

Objective 3. The County's program will follow the principles of IPM, seeking to address mosquito problems by means of appropriate controls applied at times of greatest effectiveness and with the least impact to human health and the environment.

Objective 4. A program of scientific surveillance will be employed, with the intent of accurately and specifically defining potential mosquito problems.

Objective 5. Source reduction will be the primary focus of mosquito control. A key element will be public education, outreach, and assistance for habitat reduction around homes and businesses. The second key element is the adoption of a program of Best Management Practices and, in appropriate areas, progressive water management projects, to be implemented in coordination with (and approval from) local and State agencies, and with the participation of other stakeholders.

Objective 6. The use of biorational larvicides, specifically targeted towards the insects of concern, will allow for reduction of any identified mosquito problem prior to dispersal as adults, when control is more difficult.

Objective 7. The use of adulticides, will be considered, when all other methods of control have been ineffective or when other control methods cannot be implemented, if Vector Control (Public Health Nuisance) thresholds are exceeded, or if emergency response conditions exist.

Objective 8. The mosquito control program will minimize potential impacts to human health from disease and from control methods.

A significant ancillary benefit of the Long-Term Plan is to facilitate enjoyment of the County's natural environments, and to support local businesses and enterprises that depend on tourism and recreation, which can be adversely impacted by mosquito infestations.

Goal 2: simultaneously reduce impacts to the environment and increase potential ecological benefits associated with the selected management techniques

Objective 1. The County will adopt an overall plan for marsh management that will emphasize the need to preserve or increase acreage of wetlands, including vegetated wetlands, and to foster biodiversity and a mosaic of ecological communities. Vector control efforts will be accommodated within this framework, but will not necessarily be the primary determinant in marsh management decision-making. In salt marshes, most areas will either be subject to reversion or low impact Best Management Practices. In certain areas, the judicious employment of progressive water management will be conducted, with the intent to increase overall habitat diversity, generated by an ecological setting composed of tidal creeks, ponds, low and high marsh, pannes, mudflats, salt shrub, associated freshwater wetlands, and adjacent beaches or sand berms (although every marsh may not have all habitats). This will provide a variety of microhabitats and ecotones, which will support appropriate plant and animal diversity, as measured by monitoring and project evaluations. Projects conducted under the Long-Term Plan will also seek to reduce invasive species, especially *Phragmites*, in the managed wetlands.

Objective 2. The aim of the water management program is to reduce the routine use of larvicides, ultimately resulting in significant reductions in the overall acreage where larvicides are applied each year. However, each marsh will be examined on a case-by-case basis, and major decisions of marsh management projects must be reviewed and approved by a Screening Committee. Biodiversity, vector control, and *Phragmites* control are all important marsh management goals. Each needs to be considered for all projects. For example, marsh restoration projects may be implemented for biodiversity purposes, with design elements that achieve net mosquito-neutral effects. Other projects will be considered because they will reduce mosquito populations (and which also create environmental benefits). The initial list of priority salt marshes for consideration for progressive water management, however, is comprised of those sites where aerial applications of larvicides are currently used to treat mosquito breeding.

Objective 3. To ensure that water management projects achieve natural resource goals, the County intends to continue to rely on advisory groups such as the Technical Advisory

Committee and the Wetlands Subcommittee to provide input and direction for the program, and to support the activities of the Wetlands Management Plan Screening Committee.

Objective 4. Where mosquito breeding occurs despite water management efforts, or where no such actions can be taken, biorational larvicides will be used to minimize or eliminate non-target impacts to the surrounding ecosystems.

Objective 5. If adult mosquito population control proves to be necessary, the County will use adulticide products that have no significant, long-term impacts to the environment.

Objective 6. The mosquito control program in general will be guided by an appreciation for the overall management of risk, minimizing potential impacts to the environment and natural systems and improving them where possible, while protecting human health and public welfare.

ES-2.2 Legal Justification for Mosquito Control

New York State PHL authorizes agencies to investigate and ascertain the existence and causes of disease outbreaks, including vectors, and to take measures necessary to protect the public health. New York State Department of Health (NYSDOH) enforces compliance with the PHL. The powers and duties of NYSDOH are set forth in Article 2, §201 of the PHL, including supervision of the reporting and control of disease (PHL §201[c]) and controlling and supervising the abatement of nuisances likely to affect public health (PHL §201[n]).

PHL Article 15, sections 1520 et seq., authorizes a county to form a Mosquito Control Commission (MCC), and sets forth the powers and duties of said commission. The commission may use appropriate means to suppress mosquitoes, with the limitation that said measures "shall not be injurious to wildlife" (PHL sec. 1525[2]). In Suffolk County, mosquito control was a function of the Suffolk County MCC. That Commission is still referenced in the Suffolk County Charter (SCC), but is no longer active. Amendments to the County Charter in 1973 established the SCDHS. Subsequently, vector control activities were the responsibility of the Division of Public Health in SCDHS.

However, in 1992, amendments to Sections C8-2 and C8-4 of the SCC established the SCDPW Division of Vector Control (SCVC), and authorized the Division to "use every means feasible and practical" to suppress mosquitoes and other arthropods (SCC §C8-2, §C8-4; L.L. No. 16 of 1992). That Local Law also noted as follows:

> Although the authority for the county to establish a vector control program is contained within the New York State PHL, this law does not mandate that vector control activities be performed under the auspices of the local Health Department. However, in the event that an arthropod-borne disease is found to constitute a major public health threat, the DHS shall directly supervise vector control (L.L. No. 16 of 1992, Section1).

SCVC is responsible for controlling mosquito infestations that are of public health importance, pursuant to the powers granted to the County under the PHL. In the event of a vector control emergency, "as defined" by the Commissioner of SCDHS, the direct supervision of vector control shall be by the SCDHS (SCC § C8-2[Y], L.L. No. 16 of 1992).

SCDHS is responsible for monitoring and prevention of human diseases, including those transmitted by mosquitoes, such as WNV and EEE. SCDHS monitors the blood supply, handles reports of WNV and EEE infected birds and horses, and responds to health emergencies through its Division of Public Health. In the event that an arthropod-borne disease is found to constitute a major public health threat, the vector control program would be under the control of SCDHS (SCC, §C8-2[y], L.L. No. 16 of 1992). SCDHS, Division of Environmental Quality, through its Office of Ecology, manages a number of water quality and restoration programs that involve wetlands managed by SCVC. The Office of Ecology is the program office for PEP, and is the major County participant in the South Shore Estuary Reserve and the Long Island Sound Study.

According to the SCC, SCVC shall have

> charge and supervision for vector control throughout the County of Suffolk. The Department shall have the power and authority to enter without hindrance upon any or all lands within the county for the purpose of performing acts which in its opinion are necessary and proper for the elimination of mosquitoes and other arthropods, provided that such measures are not injurious to wildlife. In the event of a vector control emergency, as defined by the Commissioner of Health Services, the direct supervision of the vector control shall be by the Department of Health Services. (SCC §C8-2(Y).

The charter also specifies the powers of SCVC, and relates its responsibilities. SCVC

> shall use every means feasible and practical to suppress mosquitoes, ticks and other arthropods which are vectors of human disease requiring public action for their control. In carrying out its responsibility hereunder, the Division shall have the power and authority to enter without hindrance upon any or all lands within the county for the purpose of draining or treating the same and to perform all other acts which, in its opinion and judgment, may be necessary and proper for the elimination of mosquitoes and other arthropods, but such measures shall not be injurious to wildlife (SCC §C8-4(B) (1))

The responsibilities listed for SCVC include submitting an Annual Plan of Work to the Legislature each year, and various public noticing requirements, both for the truck and aerial applications, under a declared health emergency, and for vector control purposes.

ES-3. Long-Term Plan Elements

ES-3.1 Management Plan Approach

Suffolk County sponsored a comprehensive evaluation of its Vector Control program to develop strategies to best protect public health, while optimizing environmental quality. Triggers for initiating the Long-Term Plan included:

The WNV threat, intermittent reappearance of EEE, and other vector-borne diseases (e.g., malaria). Suffolk County had four deaths and 22 severe neurological illnesses attributable to West Nile virus between 1999 and 2005. Nation-wide deaths from 1999 to 2004 total 664, with over 5,000 severe neurological cases. EEE has not resulted in any human cases in the County, but animal cases have occurred, and detections of the virus in mosquitoes have often occurred. Malaria, apparently transmitted by local mosquitoes, was detected in two children in 1999 (CA-CE, 2005a).

A long-standing need to better manage the legacy of grid-ditched wetlands to optimize environmental quality and reduce pesticide usage. By the end of the 1930s, over 90 percent of the County's 17,000 acres of salt marsh were grid ditched for mosquito control purposes. The ditch network is substantially intact, and large sections of the ditch network were routinely maintained to control mosquitoes; nonetheless, marshes totaling over 4,000 acres were routinely larvicided. Other jurisdictions manage salt marshes differently (Cashin Associates, 2004a), and there was a clear need to learn what practices could be best implemented in Suffolk County.

Continuing public concerns regarding synthetic organic compounds, and their impacts to human health and the environment. Some of the pesticides used for mosquito control are synthetic organic compounds, and therefore public concerns have been expressed regarding potential impacts from the use of these pesticides, and also from other products used by the County for vector control (CA-CE, 2002).

Two neighboring municipalities, New York City and Westchester County, faced with the same issues, chose to develop GEISs on their existing programs (NYCDOH, 2001; Westchester, 2001). Suffolk County chose a different approach, following a management plan concept (the National Estuary Program model) that has proven to be very successful in developing complex environmental management plans involving potentially conflicted stakeholders (SCDHS, 2002). This approach is based on:

- Initial data collection
- Analysis of the relevant data sets
- Development of alternatives
- Evaluation of the alternatives
- Assessment of selected management tools

Public involvement is encouraged, with active oversight and advisement by groups such as a Technical Advisory Committee (TAC), a Citizens Advisory Committee (CAC), and a Steering Committee. These groups were all formed in conjunction with the Long-Term Plan project.

CA was selected by the County to be the lead technical consultant on the project. CA, in turn, assembled a team of experts to assist in the completion of the project. Sub consultants to CA included other environmental consulting firms, mosquito management experts, risk assessors, academics from universities such as Harvard, Stony Brook, and Rutgers, and Southampton College, and even government experts from SCDHS and USGS. Major project deliverables were prepared on time, and the project has remained on budget.

A major element of the project was a comprehensive literature review. Fields included in the review were:

- Mosquito ecology
- Standard and alternative mosquito control
- Mosquito-borne disease and disease transmission
- Human and environmental toxicology of mosquito control pesticides

- Wetlands biology
- Wetlands management
- Marine ecology
- Environmental chemistry.

Important individual elements included Suffolk County mosquitoes, factors controlling local prevalence of WNV and EEE, modern larvicides and adulticides, including application technologies and modeling, and impacts to salt marshes from grid ditching and Open Marsh Water Management (OMWM) (Cashin Associates, in prep[1]).

Extensive local information was collected, organized, and analyzed. This process included establishing a mosquito control-oriented GIS (Geographical Information System), digitized mapping of the County's wetlands, and analyzing past and current mosquito control practices in the County (Cashin Associates, 2005d). It was determined that the standard surveillance information collected by the County could not support sophisticated modeling of mosquito-borne disease prevalence and transmission. In addition, field surveys were conducted to support the analysis of potential impacts of a selected management approach. Four subsections of the County (Manorville, Huntington/Dix Hills, Mastic-Shirley, and Davis Park), chosen because historically they represented different types of uses of pesticides for mosquito control purposes, were studied to detail human use and ecological values to support a proposed quantitative risk assessment of the impact of mosquito control pesticides (Cashin Associates, 2005e). Because of the importance of wetlands management, 21 selected marshes were comprehensively studied, and the data collected was to be used to determine the impacts of proposed management schema (CA-CE, 2005b).

Several other demonstration projects and scientific experiments were conducted to support development of the Long-Term Plan. Approximately one-quarter of the project budget was spent conducting this work. These expenditures funded the analysis of thousands of air, water, sediment, and biological samples. These included analyses of pesticides and other important chemicals using state-of-the art techniques, sometimes at the parts per quadrillion (pg/l) level.

One of the hallmark efforts was the Caged Fish experiment, where actual operational applications of larvicides and adulticides in August and September, 2004, were traced from the helicopter into salt marsh environments. The potential impacts of these applications were tested on sentinel organisms (grass shrimp and sheepshead minnows). Multimedia analyses allowed for the determination of the fate of the pesticides. Although the experiment was complicated by the difficult environment of salt marsh ditches, the observations and measurements of the test organisms found no effects from pesticides, a determination that was supported by associated laboratory work and benthic invertebrate population analyses (Cashin Associates, 2005f).

A second important effort was a progressive water management demonstration project at the Wertheim National Wildlife Refuge. The project was designed and conducted in cooperation with the US Fish and Wildlife Service (USFWS). Some 150 acres of salt marsh in the Refuge were extensively monitored for two years, with two areas intended to serve as control sites and two areas (totaling 80 acres) identified as prospective treatment areas. The monitoring and the ongoing research led to the cooperative development of a restoration plan that would achieve desired natural resource goals of USFWS, while also implementing water management techniques that would minimize mosquito breeding. Required State and Federal permits were obtained and 40 acres of marsh were restored in March, 2005; the second area restored was constructed in February and March of 2006. Initial results show much greater use of the restored area post-treatment by waterfowl and wading birds, and active use of the marsh by fish and other nekton that previous monitoring had not observed at this site. Mosquito control goals were also largely met, with larval presence suppressed almost the entire summer. Fish provided mosquito control by inhabiting the areas they were intended to be in (Cashin Associates, 2006a).

In addition to these two efforts, the mosquito control effectiveness of garlic oil, rosemary, and mosquito traps was tested. None showed promise for the County vector control program (CA-CE, 2005a). Studies were performed on benthic invertebrate distributions in salt marshes with various larviciding histories (Cashin Associates, 2005g), and water quality (associated with storm water) in relation to ditched and unditched salt marshes (Cashin Associates, in prep.); in both instances, vector control impacts were not found. Catch basins (CA-CE, 2005b) and recharge basins (CA-CE, 2005a) were evaluated, and the conditions under which they become problem mosquito breeding sites documented. Turtle use of upland ditch networks was studied

(Cashin Associates, 2006b), and an effort was made to determine the impacts of ditching and other management practices on wetland vegetation over relatively long time scales (Cashin Associates, 2006c). Finally, a new technology for pesticide application (the Adapco Wingman) was researched and purchased. This system uses a computer model and real-time meteorological data to minimize pesticide usage and to optimize mosquito control.

The data collection and analysis supported an evolution of the County's approach to mosquito control, confirming some aspects of its current program, and identifying areas where improvements might be made. As a potential plan coalesced, additional impact analyses were conducted, some of which became the basis for the environmental assessment of the selected Long-Term Plan.

In conjunction with the project, to ensure that public involvement in the development of the Long-Term Plan would be maintained, four important project committees were created:

- Technical Advisory Committee (TAC). The TAC was charged with reviewing documents and making recommendations on various scientific and technical issues that might arise with respect to the Long-Term Plan development and other project activities. Membership was primarily drawn from regional and local government agencies, although national and regional research and professional interests also were invited to join. Voting membership was restricted to those approved by the Steering Committee, although all meetings were open to all, and participation in discussions was not limited. Nearly 100 people attended one or more TAC meetings. The TAC met approximately six times per year.

- Citizens Advisory Committee (CAC). The CAC was intended to provide environmental advocacy organizations, civic associations, other non-governmental organizations, and local governments with a forum to review project progress, make recommendations on draft reports and plans, and to generally provide input to the consultants and their County managers. As a matter of course, local governments generally declined to participate in the CAC. The CAC requested, and was granted, a separate budget to pursue related educational and outreach issues and topics. More than 50 people attended one or more CAC meeting. The CAC met monthly.

- The Wetlands Subcommittee. This group was initially formed out of the TAC. Its focus was to be on wetlands issues and early action projects. The TAC expected that the Wetlands Subcommittee might provide more direct guidance to the consultants and the County on early phases of such aspects of the project. It was felt that an independent subcommittee was the most proper means of such involvement; otherwise the TAC might find itself reviewing its own recommendations and suggestions. The Wetlands Subcommittee never had a formal voting membership, but participation in its meetings was expanded beyond TAC membership by actively soliciting participation by local municipalities, especially planners and technocrats involved in wetlands work. More than 30 people attended one or more Wetlands Subcommittee meetings. From mid-2004 through mid-2005, the Wetlands Subcommittee met monthly.

- The Steering Committee. The Steering Committee had ultimate authority over the project. It approved memberships and by-laws of the TAC and CAC, and accepted the draft Long-Term Plan and associated DGEIS for consideration by the CEQ and Legislature. It was composed of the principal officers (or their representatives) from the Suffolk County Executive, the Presiding Officer of Legislature, CEQ, SCDHS, SCDPW, and the New York State Department of State (NYSDOS). The Steering Committee met approximately every four months.

Another project committee was the Monitoring Committee. This committee was intended to work on technical aspects of pesticides monitoring. Originally, it consisted of scientists and engineers associated with CA and its subconsultants, along with engineers and scientists from SCDHS and SCDPW. The New York State Department of Environmental Conservation (NYSDEC) became involved in the committee near the end of 2003, and thus it became a springboard to develop the workplan and to address permitting issues associated with the Caged Fish Early Action Project. This committee did not meet again after June, 2004.

NYSDEC was originally invited to be a voting member of the TAC and Steering Committee. NYSDEC determined that, because it might serve as a regulator on many project-associated issues, it did not wish to formally serve on any project committees. However, NYSDEC sent representatives to all meetings of the TAC, Wetlands Subcommittee, and Steering Committee, and to many sessions of the CAC and Monitoring Committee.

To foster open discussion of the plans and analyses being created by CA and its subconsultants, draft versions of the Long-Term Plan and its subcomponents (the Wetlands Management Plan and the Best Management Practices [BMP] Manual) were released for review and comment. The BMP Manual was initially released in June, 2005. The Wetlands Management Plan was released in July, 2005, and the Long-Term Plan was initially released for review in August, 2005. The draft version of the DGEIS was released in October, 2005. Extensive comments were received on all of these documents, and the versions presented here have been amended to address those comments and concerns.

The following is a précis of the Long-Term Plan, by constituent elements. The full Long-Term Plan is in Appendix A of this DGEIS.

ES-3.1 Public Education

SCDHS is primarily responsible for public education on mosquitoes and mosquito-borne disease. The County will promote information on personal protection and avoidance by distributing brochures and giving presentations on its “Dump the Water” and “Fight the Bite” programs. Additionally, the Long-Term Plan Citizens Advisory Committee created a new pamphlet titled, “Mosquito Control and Prevention at Home” that it will distribute to libraries and at health fairs.

In addition to the SCDHS efforts, SCVC offers public assistance to help homeowners who have mosquito problems, by visiting the property and removing breeding areas. If the homeowner is not available during the site inspection, SCVC ground crews leave a door hanger that describes the reason for the inspection and lists any work done.

Expansions of the existing program will include:

- SCDHS could improve public outreach is to participate in “Mosquito Awareness Week”
- Outreach to minimize inappropriately discarded tires

- Targeted education through Cornell Cooperative Extension to reduce irrigation ponding on fields

- Targeted outreach to commercial property owners and private homeowner associations to ensure that private storm water systems are properly maintained.

- Raise awareness in the County and in other municipal highway offices that poor maintenance of catch basins and other storm water systems not only exacerbates flooding problems and is not in compliance with USEPA Phase II regulations, but threatens public health.

- Areas that have historically experienced Vector Control adulticide treatments (roughly speaking, Babylon, Islip, and Brookhaven south of Sunrise Highway) should receive augmented, targeted education efforts. These efforts will focus on personal protections steps to minimize negative impacts from mosquitoes. In addition, the Commissioner of SCDHS will identify pertinent actions that residents should consider to reduce exposure to and impacts from any adulticide applications. Presentations at schools, to civic organizations, and other interested groups, and news releases to local newspapers will all be used to specially inform these citizens who are more likely to be exposed to mosquito bites and adulticide applications than other people living in Suffolk County.

- The County websites for SCVC and SCDHS will be better maintained and made more informative.

- Efficacy reports, as available, will also be posted on the SCVC website

- The no-spray registry of residences where adult mosquito control is not desired will be maintained and publicized.

- Lists of beekeepers and organic farms will be maintained.

Legally mandated notices for applications will be continued, and the SCDHS web site will be used to post maps and will be used to post spray schedules. In addition, a list serve feature will be installed on the SCDHS website to allow citizens the choice to automatically be informed of spray events. Notifications to appropriate media outlets will be continued.

Trigger for Public Education

Public education and outreach will be undertaken every year. Public outreach efforts will be increased as risks associated with disease transmission increase. Areas that typically receive vector control applications will be subjected to targeted, intense efforts to reduce the potential for impacts from either mosquito-borne disease or pesticide applications. The County will make a conscious effort to justify the mosquito control program better through greater analyses of its efforts and publication of these analyses in annual reports.

ES-3.3 Surveillance

The mosquito surveillance program will have two separate functions:

- Sampling mosquito populations
- Sampling for mosquito-borne disease

Mosquito population surveillance also differentiates between sampling larval populations and adult populations. There are a few ways that these distinctions are not absolute, but they generally serve to define the surveillance program. Population surveillance is the responsibility of SCVC; disease surveillance responsibility belongs to the ABDL.

Larval Surveillance

Teams of inspectors, consisting of three foremen with 11 field crews that each consist of two equipment operators or laborers, will continue to be assigned to geographic areas of the County to guarantee complete coverage of potential breeding habitats on a regular basis. Inspectors obtain samples from larval breeding areas, such as wetlands, primarily by dipping. Inspectors will quantify larval surveillance results in the field by counting the number of larvae per dip. They will also determine which of four larval stages are present. At times, other sampling methods will need to be employed to determine if specific species are present, or for specific media (such as with tires, or when sampling for *Cs. melanura* or *Coquilletidia perturbans*).

Catch basin sampling will be accomplished using aquarium nets attached to telescoping poles, and then rinsing the nets to wash the larvae into a bucket.

SCVC has identified over 2,000 breeding points throughout the County. Breeding locations are monitored on different schedules according to the type of mosquito problem that is usually associated with the particular site. Salt marshes that are candidates for aerial larviciding are monitored every Monday. Each field crew also is assigned a route of smaller salt marshes and fresh water sites that also tend to breed fairly regularly, which are monitored on a 10 day to two week cycle. Finally, there are certain locations that only support breeding under particular environmental conditions, and so are only monitored when the requisite trigger (very high tide or excessive rainfall, usually) has occurred. Higher tides and/or heavy rains often lead to widespread breeding, which can result in a need to monitor nearly all breeding sites throughout particular environmental settings, leading to personnel stresses.

Salt marshes will be sampled consistently, at sites chosen in the high marsh where mosquitoes breed. It is important to record presence/absence of larvae, the extent of the initiating tidal inundation, the dominant stage of the larvae, and the remaining water on the marsh. Brackish and fresh tidal marshes also need to be sampled similarly.

The County intends to increase the scope of its catch basin monitoring (from the current 10,000 to 40,000 to 50,000). Additional basins will be selected based on a history of viral activity in the surrounding area, the age of the system, if maintenance may have been deferred, and if the basins are located at the terminal end of drainage systems. The catch basins will be sampled beginning in late May or early June, and revisited and re-sampled, as resources allow, during the middle (July) and end of the season (September), for presence/ absence of larvae. It is also recommended that SCVC increase the number of recharge basins that are sampled.

The field crews will examine and determine the larval stages present in samples in the field. Collected larvae will be stored in glass sample jars. The samples will then be transported to the laboratory for species identification by an entomologist.

Adult Mosquito Population Surveillance

Populations of adult mosquitoes are monitored using New Jersey light traps and CDC light traps. The County currently has 27 New Jersey light traps, and the Long-Term Plan calls for augmenting this network with three additional trap locations on Fire Island.

CDC light traps are set in the evening and collected in the morning. CDC light trap samples analyzed for population purposes do not need to be preserved following collection. CDC traps are used for population monitoring when special problems have been identified, such as where the volume of complaints increases, or where there are other indications that a mosquito biting problem will not be detected by the fixed New Jersey trap network. The County also uses CDC traps extensively for pathogen detection (see below).

It is proposed that the County consider establishing identification stations – a single room within an existing municipal building, equipped to allow field technicians to identify mosquitoes to the species level.

CDC light traps are also good tools for testing the efficacy of adulticide applications. CDC traps should be optimally set within a proposed treatment area the night prior to the application. Traps should also be set post-application to determine the degree of population reduction caused by the treatment. Control locations should be identified so as to provide means of appropriately interpreting the trap data.

In certain locations (Bellport Village Brookhaven hamlet, East Patchogue, Mastic-Shirley, Oak Beach, and Oakdale), mosquito infestations prompting many biting complaints from residents are common. Formal landing rate sites should be created in these areas.

As part of the overall program for assessing adult mosquito populations, SCVC will seek to establish trap stations for background (ambient) levels of mosquitoes. This is a difficult task because there are few good candidate sites for such monitoring. Potential sites could include a FINS site and an upland portion of the William Floyd Estate.

Public complaints are a cornerstone of the County surveillance program as SCVC responds to complaints regarding biting adult mosquitoes, larval breeding, clogged culverts, flooded marshes/swamps, and other sources of stagnant water, received through the County's telephone complaint line. An inspector will visit the site within one to three days after receiving the complaint and submit a recommendation for action. Inspectors educate homeowners, determine the source of the problem, potentially adding the site to the mosquito breeding list. Complaint calls are logged by type. This permits maps to be prepared showing the timing and areas of complaints.

Disease Monitoring

Viral surveillance will continue to be conducted according to the latest CDC and NYSDOH guidelines and will likely continue to be primarily directed at EEE and WNV, with modifications to suit Suffolk County's unique environment. The large size of the County, coupled with resource limitations, has set some restrictions on where and how often traps can be placed or serviced. Travel times are an issue. If SCVC or ABDL personnel living on the East End could begin a day's work by collecting traps near home (and servicing them at night on the way home), more traps could be set and serviced.

A major means of monitoring for virus activity is through CDC traps. Mosquitoes are identified and sorted by species in the laboratory. The pools are then separated with the number of mosquitoes in each pool being noted. Current DNA analyses can identify WNV. Other viruses must be cultured and analyzed by NYSDOH in Albany. CDC gravid traps are also used, and mostly collect *Culex* mosquitoes that have had a blood meal and are seeking a location to oviposit. As with CDC light traps, gravid traps are adaptively placed in areas with a history of viral activity or the sampled presence of viral indicators, such as viral positive birds. The trapped mosquitoes are collected, sorted, kept cool and tested as are samples from CDC light traps. Gravid traps are currently only used for WNV surveillance. The ABDL begins each season using a suite of 27 fixed CDC traps. Others are added throughout the season as pathogen presence or signals indicate. For the initial implementation of the Long-Term Plan, the ABDL proposes to increase the initial set out to 35 trap locations.

Sampling frequency for these set locations is once a week, absent any indications of viral activity. If these are signs of local amplification, the frequency of sampling can be increased.

To augment virus activity surveillance, the ABDL has 144 CDC light and gravid traps. The Early Action projects required the acquisition of 12 additional CDC light traps. This suite of traps will be used, should optimal personnel needs be met, to expand maximal weekly set outs from the current 80 to perhaps as many as 110. The additional set out sites will be chosen based on history of viral activity or the presence of viral indicators, such as the finding of birds with WNV in the area.

The pools of mosquitoes generated by ABDL sampling are currently sent to NYSDOH for viral analysis. The County can send samples every day, but results are generally not available for at least three days. Expansion of the ABDL to Biosafety Level-3 laboratory (BSL-3) (see below) would allow for local processing of mosquito samples, with overnight (or faster) results possible.

SCDHS also remains in constant contact with NYSDOH to keep abreast of cases found elsewhere in the State as a gauge of possible threats faced here. SCDHS also maintains contacts with local veterinarians and stables for equine cases, and with hospitals for human cases of meningitis or encephalitis.

Through 2004, SCVC and SCDHS, in conjunction with NYSDOH and CDC, monitored for WNV using indicators such as unusual bird deaths or the number of dead birds, primarily corvids. The ABDL has developed the capacity to conduct tests for WNV, which have been confirmed with NYSDOH. However, recent observations suggest this surveillance tool has failed, because fewer crows succumb to WNV than in the past, especially in the early part of the season. Therefore, the County needs to develop some other form of surveillance to detect the virus, because, unlike EEE, it does not magnify in well-defined habitats.

Other non-migratory bird species, such as house sparrows, may be useful as indicators of viral presence. Viral activity in avian populations can also be monitored by:

- Netting
- Sentinel chicken flocks
- Obtaining blood samples from hatch year birds (juveniles)

Suffolk County needs to determine which option is best to meet its needs. For many reasons, the most reasonable choice appears to netting non-migratory birds. If this is chosen as a necessary program element, it most likely will require additional resources to conduct the work.

In 2004, the ABDL acquired a machine known as the Rapid Analyte Measurement Platform (RAMP) to test dead birds for WNV. RAMP is not used for mosquito testing because the technique it employs is not as sensitive as the technique used by Taqman (a laser-coupled spectrophotometer, to perform a rapid version of the Polymerase Chain Reaction [PCR]), another County tool. Taqman detects WNV in mosquitoes or birds in less than one day. Taqman and RAMP are specialized for WNV testing, but the County has a need to test for EEE, since it has often been detected. Therefore, the County would like to conduct general viral surveillance to ensure that other arboviruses do not become established in the local mosquito population without detection. This requires the use of virus culturing and standard PCR. The laboratory has the capability to perform standard PCR, but culturing and processing viruses also requires that laboratory be equipped and certified at BSL-3, and meet certain Homeland Security requirements. The Long-Term Plan envisions, that as part of an already planned laboratory upgrade, that the ABDL will be improved and certified to BSL-3 standards.

Until the laboratory has these certifications, the ABDL will improve the efficacy of sample processing and the speed with which results are obtained by sending batched samples to the state laboratory in Albany once per week early in the season (late May through July) when turn around time is not as critical. The ABDL will generally rely on the Taqman and RAMP analyses later in the season (August to October) when viral activity peaks and detecting viral presence in a short time period becomes critical. In addition, confirmation of WNV results and broader viral scans will be obtained by using daily (if necessary) shipments to the NYSDOH laboratory.

Mosquito Surveillance and Control Unit Upgrades

A unit within SCVC is the Mosquito Surveillance and Control Unit. This section should be asked to perform additional tasks under the Long-Term Plan, by adding a work unit, informally designated as the QA/QC (Quality Assurance/Quality Control) team.

Major tasks for the QA/QC team would include:

- special surveillance responsibilities such as early spring sampling for *Cs. melanura*, and seasonal sampling for *Cq. perturbans* and of tire stockpiles. *Cs. melanura* and *Cq. perturbans* cannot be sampled using standard dip techniques. Effective tire sampling also requires some specialized techniques.

- larvicide effectiveness measurements

- adulticide need testing, using CDC light traps

- in association with adulticide need testing, treatment efficacy measures should be made

- research and demonstration tasks, such as developing an alternative bird sampling methodology, in conjunction with ABDL personnel, to keep WNV surveillance robust

Data Management

Monitoring data for larval mosquitoes are recorded on paper forms and directly entered into hand-held GPS units. The forms are returned to the office each day, and information from the hand-held units is downloaded into the Vector Control Management System (VCMS) software database. It has been suggested that the County investigate replacing these useful devices and system because it is difficult to interface the VCMS information directly into a standard GIS system.

Computer terminals placed at individual stations throughout the laboratory will be used to enter data resulting from processing samples obtained from surveillance activities. These terminals will be linked to the County's GIS system in order to make the data accessible to all SCVC and SCDHS personnel as soon as possible. All service request and response information will continue to be entered into hand-held GPS units in the field for download into the main system at a later time.

The Superintendent and the Director of the ABDL currently analyze collected data, with assistance from an entomologist, a GIS specialist, and ABDL staff. The type of data collected and resource allocation limit the scope of statistical analysis currently performed on collected data.

At this time, the ABDL Director produces a summary of the season's findings and annual work plans summarize operations from the previous year. However, a comprehensive annual report, including in depth statistical analysis of laboratory and field data, should be produced detailing these results. This report could be posted on the County's website.

Trigger for Surveillance

Surveillance activities will begin when environmental conditions indicate that mosquitoes are hatching or leaving dormancy in the spring. Population monitoring will be conducted through a combination of regular route servicing, and special efforts dictated by weather and tides. Sampling will also be initiated in situations where it seems that adulticiding may be necessary, as a final check to ensure that the vector control treatment parameters have been met. Pathogen monitoring will likewise be initiated each year when environmental conditions dictate vector species are propagating. Monitoring efforts will be stepped up as indicators of disease prevalence (dead birds, positive pools, animal or human cases) proliferate.

ES-3.4 Source Reduction

Household and Institutional Source Reduction

Public education is the first step in realizing household source reduction. It must be remembered that the foundation for successful source reduction is a good public outreach effort, which was discussed above.

SCVC receives on the order of 3,000 phone calls for service per year. These are logged into the SCVC computer system, assigned to an inspection team on the basis of the geographical location of the complaint. Each complaint that is received is responded to within one to three days. The initial response is to go to the complainant's house. State law allows SCVC wide latitude with regard to investigating and reacting to mosquito problems, so even if the complainant is not home some investigation will be undertaken.

In all cases, an immediate assessment of the problem is made: are mosquitoes present, and, if so, what species are involved, and what is the source of the problem. The primary investigative tool is larval dipping in potential source area water. Samples of larvae are returned to the laboratory for complete evaluation of the problem; however, field crews are trained in larval identification, as well. The larval stages and, very often, species involved can be determined in the field. The follow-up laboratory identifications ensures that novel or unusual species are identified and noted, and as QA/QC for the field identifications.

Most often, the source of the problem is immediately obvious. Removing the water causing any problem will break the breeding cycle, so draining a water source is the best solution for a local household mosquito problem.

Sometimes that is not possible, as when the source of water is as large as a swimming pool or relatively unmanageable as a recharge basin. Ecologically isolated, artificial bodies of water such recharge basins can be treated by stocking *Gambusia* (mosquito fish). If the water quality is marginally acceptable, these fish will consume larvae even when there is a great deal of vegetative cover. SCDHS, through the ABDL, purchases these fish from commercial suppliers. This decision should be carefully considered, however, and ecological and operational factors weighed prior to stocking fish (see Biocontrols, below).

When recharge basins are slow to drain, the basin owner should be asked to arrange for maintenance of the basin. A stop-gap measure, until maintenance can be arranged for, would be to apply larvicides to control breeding. Timed release formulations of larvicides such as Bti, Bs, or methoprene can be in order (see below). For purely artificial, non-ecological systems such as an abandoned cistern or swimming pool, larvicide applications are an effective means of breaking the breeding cycle.

Once an inspection team has investigated a site, it will discuss its findings and actions with the homeowner, with the intention of teaching the homeowner, should the cause of the problem be self-inflicted, or the neighbor (or municipality or agency), should the source be nearby and identifiable. Pre-printed check-off cards are used when the involved landowners are not at home. These cards invite follow-up phone calls to explain the findings and actions taken, and to try to ensure that the problem does not reoccur through homeowner education.

Rarely, and only with extensive although potentially time-compressed investigation, would adulticiding be considered in response to homeowner complaints. A nexus of complaints can be an important surveillance tool. For example, some mosquitoes, such as the tree-hole (and tire) mosquito *Oc. japonicus*, can be difficult to capture in the most common surveillance traps, and their presence is usually uncovered by investigating biting complaints.

It should to be noted that the County Administrative Code (Section A8-5) specifies that environmental improvements are one possible criterion to justify maintenance dredging. Public benefits must be demonstrated prior to allocation of County resources for maintenance dredging projects. Any future dredging proposal that cites vector control benefits as a public benefit will require separate review.

Water Management

The Wetlands Management Plan, together with its associated Appendix, the Best Management Practices manual, was appended in its entirety to the Long-Term Plan. Implementation of the Wetlands Management Plan is key for the County to achieve its ambitious goals.

The County recognizes the importance of healthy, good-functioning marshes. There are many factors that affect the health and functionality of a marsh. The current Wetlands Management Plan does not intend to address all of them, explicitly. Its overt scope is limited to immediate factors that affect and are affected by mosquito management, at this time. Within that somewhat limited scope, the Wetlands Management Plan clearly intends to make determinations regarding mosquito management in such a way that marsh health and functionalities are attended to. A major intent is that any work conducted on a marsh will be a restoration of environmental values to the marsh. This is because the enhancement of water quality and fish habitat values are the basic requirements for progressive water management to achieve mosquito control aims, by fostering killifish on the salt marsh in the areas where mosquito breeding had been occurring. However, the Wetlands Management Plan looks beyond those two goals and includes supporting larger ecological values in the course of implementing the available Best Management Practices (BMPs).

This larger goal can be achieved through cooperative project development. The County will only consider water management projects in a framework that includes active participation in the project development by the landowner/land manager, involved regulators, and other interested parties. Extensive procedures, informal for minor projects, but formalized for larger projects, have been established to achieve this end. These steps include the development of a County-wide, comprehensive management plan with the intent of improving and succoring marsh health throughout the County. The Screening Committee (see below) will be charged with developing the overall strategy and developing the conceptual models for program managers to work from (with administrative support from SCDHS).

The essence of the Wetlands Management Plan is that the County intends to continue to focus its program on water management. However, no longer will the standard treatment be maintenance of the legacy grid ditch system. Rather, the default choice for each marsh instead will be reversion – allowing natural processes to occur. If a mosquito problem is occurring, and action is warranted, then progressive water management will be conducted, following the procedures and processes outlined in the Wetlands Management Plan and its associated BMP Manual.

Implementation is expected to take 12 years to address the vector control and ancillary wetland management needs for all 17,000 acres of tidal wetlands in Suffolk County. It seems likely that until an overall County wetlands management strategy is developed by the Screening Committee, major marsh restoration projects will be limited to Wertheim National Wildlife Refuge. Some of the projects undertaken in the first three years that use “no to little impact” or “minor impact” Best Management Practices may exceed size thresholds (set at 15 acres) and so require Screening Committee consideration, as well.

Progressive water management will be considered for implementation at the 4,000 acres of tidal wetlands that have been identified as major mosquito breeding problem areas. The 4,000 acres were identified because they constitute the area occupied by the 46 marshes that currently receive regular aerial applications of larvicides to control mosquito breeding. The goals of this initiative are pesticide reduction by reducing or eliminating the need for such applications, and habitat enhancement, including maintaining or increasing biodiversity and *Phragmites* control. It is estimated that approximately 4,000 acres of tidal wetlands will undergo reversion, because of low mosquito breeding potential and/or distance from points of dense populations of people. In those areas, natural processes will gradually undo the construction of ditches across the marshes. In the long run, reversion is not necessarily ecologically optimal; other restoration options may need to be considered for purposes other than vector control, in the context of the overall comprehensive marsh management plan.

The remaining 9,000 acres will be assessed over the coming decade, with some being actively restored, and others subjected to reversion processes. The policy in these areas will be one of presumptive interim reversion (i.e., no ditch maintenance unless deemed necessary for ecological or mosquito control purposes). It is expected that less than four percent of the County's tidal wetlands (on the order of 500 acres) will be subject to ditch maintenance over the next decade.

These acreages overstate the extent of the proposed management actions. Mosquito breeding only occurs in the intermittently flooded portions of salt marshes – the high marsh. Unlike grid ditching, progressive water management is intended to alter only the portions of the marsh where mosquito breeding occurs. Primarily, progressive water management achieves mosquito control through predation by naturally occurring killifish. The essence of the technique, therefore, is to provide habitat enhancement for these fish. This is generally achieved by providing access for the fish to breeding areas (sometimes by constructing shallow waterways to breeding loci, but also through pond construction), improving in-marsh water quality so that the fish can maintain themselves on the marsh (often by improving tidal circulation patterns), and by providing some refuges for the fish from their own predators (mostly through construction of some deeper sumps in ditches or other waterways, or in ponds). Another common part of progressive water management projects is to eliminate breeding habitat altogether. This can be achieved by digging ponds in areas where mosquitoes breed, or by using the spoils from pond or waterway construction to smooth the often irregular surface of the high marsh. Mosquitoes commonly breed in shallow (two to four inch deep), small, isolated "potholes" formed as *Spartina patens* (the signature high marsh plant in New England class salt marshes). Smoothing spoils into these potholes eliminates these breeding locations, and reportedly allows for enhanced growth of *S. patens*.

This holistic approach has been demonstrated for the first time on Long Island, as part of this Wetlands Management Plan, at the Wertheim National Wildlife Refuge. Permitting of this project was a major accomplishment, as a cooperative approach to project design allowed concerns raised by State regulators regarding potential impacts to existing important natural resource attributes of ditched marshes, and marsh loss in tidal settings, together with a lack of monitoring and documentation for past OMWM demonstration projects, to be addressed. The degree to which project plans addressed these concerns coupled with the first blush of success at the site in controlling mosquito breeding and enhancing natural resource values may allow NYSDEC to consider these options that might not have passed regulatory muster a short while ago. Continued cooperation between Federal and State agencies will be critical to ensure that projects similar to Wertheim will be implemented throughout Suffolk County.

The Wetlands Management Plan consists of seven sections, the first of which addresses goals and numerous objectives. In the second section, a framework for managing larger, more ambitious projects is discussed. A key feature is the creation a Screening Committee to review and approve the major projects, with a membership drawn from a diverse cast of interested parties. Collaborative project selection, design, and implementation are emphasized throughout, with all stakeholders being involved so that through cooperative efforts appropriate projects will be identified and constructed. The scale and overall approach of the particular project will often need to be determined by local resource managers or the landowner, and then SCVC will assist in creating a design to achieve the desired ends. The involvement of the Screening Committee ensures that overall policies and major projects will accord with the needs and programs of regulator, local government, marsh managers, and other interested parties. It also allows for adjustments as the County-wide approach to marsh management is promulgated.

Section 2 also establishes a comprehensive reporting framework to ensure that interested and involved parties will be able to participate in and understand the progress of the developing progressive water management implementation. It includes annual reports with an associated ongoing implementation strategy, and triennial reports on attainment of goals, work completed, and new directions being entertained. These procedures were proposed to explicitly promote cooperative project (and overall policy) development, and ensure that stakeholders were involved in marsh management, as proposed under the auspices of mosquito management. In all cases, projects can (and in many cases, must) have factors other than mosquito control included in the overall project design, and to ensure ecological concerns are paramount in project consideration. Participation by interested parties in the design and approval processes is intended to ensure that appropriate care is taken in making these choices to ensure the overall health of the marshes being so managed.

In section three, the 15 BMPs and four Interim Management/On-going Maintenance Actions are discussed (Tables ES-1through ES-4). The actions are aimed at reducing mosquito populations utilizing methods that either minimizes potential environmental change, or maximizes the enhancement of particular natural resource values. Implementation of these BMPs is expected to reduce aerial larviciding approximately 75 percent from current levels (as measured by acres of marsh treated in a year, in comparison to a baseline of 30,000 acres), and to result in healthier, better functioning wetlands throughout the County. Implementation of progressive water management is also expected to reduce conditions under which the County needs to apply adulticides.

Table ES-1. Management Activities for Minimal or No Action

BMP	**Action**	**Factors to Consider**	**Potential Benefits**	**Potential Impacts**	**Equipment to be used**	**General Compatibility With Tidal Wetlands 6 NYCRR Part 661**
BMP 1.	Natural processes (reversion/no action)	- Default option - Land owner prefers natural processes to proceed unimpeded - Natural reversion is actively infilling ditches - No existing mosquito problem	- Return to pre-ditch hydrology - More natural appearance/processes - Requires no physical alterations	- Possible increase in mosquito breeding habitat, creation of problem - Loss of ditch natural resource values - Loss of tidal circulation - Phragmites invasion if fresh water is retained on marsh - Drowning of vegetation if excess water is held on marsh	Not applicable	NPN
BMP 2.	Maintain/repair existing culverts	- Flooding issues - Are existing culverts adequate for purpose? - Are existing culverts functioning properly?	- Maintain existing fish and wildlife habitats - Maintain tidal flow and/or prevent flooding	- Continue runoff conveyance into water bodies - Roads & other associated structures	- Hand tools (minor maintenance) - Heavy equipment for repair	GCp
BMP 3.	Maintain/ reconstruct existing upland/ fresh water ditches	- Flooding issues - Are existing ditches supporting flood control? - Are existing ditches needed for agricultural uses?	- Maintain existing fish and wildlife habitats and hydrology - Prevent or relieve flooding - Support turtle habitat - Provide fish habitat	- Continue runoff conveyance into water bodies - Perpetuate existing degraded conditions - Excess drainage	- Hand tools (minor maintenance) - Heavy equipment for reconstruction (rare)	NPN (6 NYCRR Part 663)

Please note that other jurisdictions besides NYSDEC may also regulate activities in wetlands.

Table ES-2. Management Activities for Minor Impacts

BMP	Action	Factors to Consider	Potential Benefits	Potential Impacts	Equipment to be used	General Compatibility With Tidal Wetlands 6 NYCRR Part 661
BMP 4.	Selective Maintenance/ Reconstruction of Existing Salt Marsh Ditches	- Local government issues and concerns resolution - SCDHS Office of Ecology review - Mosquito breeding activity - Land owners long-term expectations - Overall marsh functionality - Ditch maintenance is to be selective and minimized	- Enhance fish habitat - Maintain existing vegetation patterns - Maintain existing natural resource values - Allow salt water access to prevent/control Phragmites - Reuse pesticide usage	- Perpetuate ongoing impacts from ditching	- Hand tools (minor maintenance) - Heavy equipment for reconstruction	NPN
BMP 5.	Upgrade or install culverts, weirs, bridges	- Flooding - Flow restrictions - Associated marsh impacts - Cooperation from other involved departments	- Improve tidal exchange and inundation - Improve access by marine species - Increase salinity to favor native vegetation - Improve fish habitat & access	- Negative hydrological impacts - Changes in vegetation regime	- Heavy equipment required	GCp
BMP 6.	Naturalize existing ditches	- Grid ditches - Mosquito breeding activity - Landowner needs - In conjunction with other activities	- Increase habitat diversity - Increase biofiltration - Improve fish habitat and access by breaching berms	- Hydrology modification - Minor loss of vegetation - Possible excess drainage	- Hand tools (minor naturalization) - Heavy equipment for major	NPN/GCp
BMP 7.	Install shallow spur ditches	- Mosquito breeding activities - Standard water management not successful (continued larviciding)	- Increase habitat diversity - Allow higher fish populations - Improve fish access to breeding sites	- Drainage of ponds and pannes - Hydraulic modification - Structure not stable	- Preferably hand tools	NPN/GCp
BMP 8.	Back-blading and/or sidecasting material into depressions	- Mosquito breeding activities - Standard water management not successful (continued larviciding)	- Improve substrate for high marsh vegetation - Compensate for sea level rise or loss of sediment input - Eliminate mosquito breeding sites	- Excessive material could encourage Phragmites or shrubby vegetation - Materials eroded so that application was futile	- Heavy equipment required	NPN or GCp
BMP 9.	Create small (500-1000sq. ft) fish reservoirs in mosquito breeding areas	- Mosquito breeding activities - In conjunction with other water management - Natural resource issues	- Increase wildlife habitat diversity/natural resource values - Improve fish habitat - Eliminate mosquito breeding sites - Generate material for back-blading	- Convert vegetated area to open water with different or lower values	-Heavy equipment required	Status Undetermined

Please note that other jurisdictions besides NYSDEC may also regulate activities in wetlands.

Table ES-3. Management Activities for Major Impacts

BMP	Action	Factors to Consider	Potential Benefits	Potential Impacts	Equipment to be used	General Compatibility With Tidal Wetlands 6 NYCRR Part 661
BMP 10.	Break internal berms	- Water quality (poor) - Standing water (mosquito breeding) - Impacts on structural functions	- Allow access by marine species - Prevent waterlogging of soil and loss of high marsh vegetation - Improve fish access to mosquito breeding sites - Prevent stagnant water	- Changes in system hydrology - Excessive drainage of existing water bodies - Introduction of tidal water into areas not desired	- Hand tools (minor) - Heavy equipment (major)	Pip
BMP 11.	Install tidal channels	- Improve water quality - Tidal ranges and circulation - Increase salinity (invasive vegetation) - Natural resources enhancement	- Improve tidal exchange - Improve access by marine species - Increase salinity to favor native vegetation - Improve tidal inundation - Improve fish habitat	- Changes in system hydrology - Excessive drainage or flooding of uplands - Increase inputs from uplands into water body	- Heavy equipment	P
BMP 12.	Plug existing ditches	- Improve fish habitat - Tidal ranges and circulation - Prevent upland inputs - Natural resources enhancement	- Return to pre-ditch hydrology & vegetation - Reduce pollutant conveyance through marsh - Provide habitat for fish & wildlife using ditches - Retain water in ditch for fish habitat - Deny ovipositioning sites	- Changes in system hydrology - Reduce tidal exchange - Reduce fish diversity in ditches due to lack of access - Impoundment of freshwater could lead to freshening & Phragmites invasion - Possible drowning of marsh vegetation	- Heavy equipment	P
BMP 13.	Construct ponds greater than 1000 sq.ft.	- Landowner's needs - Water fowl habitat - Natural resources enhancement - Aesthetic improvements	- Increase habitat values for targeted species and associated wildlife - Improve habitat for fish - Eliminate mosquito breeding sites	- Changes in system hydrology - Convert vegetated areas to open water with different and possibly lower values	- Heavy equipment	P
BMP 14.	Fill existing ditches	- Landowner's needs - Aesthetic improvements - To restore pre-ditch hydrology - Vegetated areas	- Return to pre-ditch hydrology and vegetation - Reduced likelihood of pollutant conveyance through marsh - Create vegetated habitat to replace that lost by ditches or by other alterations - Deny mosquito breeding habitat by eliminating stagnant ditches	- Potential to create new breeding habitats if ditches are not properly filled or by making the marsh wetter - Loss of ditch habitat for fish, other marine species & wildlife using ditches - Loss of tidal circulation - Phragmites invasion if freshwater is retained on marsh - Drowning of vegetation if excessive water is held on marsh	- Heavy equipment	P
BMP 15.	Remove dredge spoils	- Increase wetland habitat	- Convert low-value upland to more valuable wetland habitats - Eliminate mosquito breeding sites	- Could result in new breeding sites if not carefully designed - Major change in local topography	- Heavy equipment	P

Please note that other jurisdictions besides NYSDEC may also regulate activities in wetlands.

Table ES-4. Interim Management/Ongoing Maintenance Actions

Interim Action	Action	Factors to Consider	Potential Benefits	Potential Impacts	Equipment to be used	General Compatibility with Tidal Wetlands 6 NYCRR Part 661
IMA 1.	Natural processes (No action reversion)	-Presumptive interim action	- Non-intervention in natural system	- Non-intervention in natural system	- Non-intervention in natural system	- Non-intervention in natural system
IMA 2.	Selective ditch maintenance (Standard Water Management)	- mosquito breeding activity - water quality (poor) - improve fish habitat	- Enhance fish habitat - Maintain existing vegetation pattern - Improve fish access to breeding sites - Increase fish and wildlife habitat diversity - Increase biofiltration - Improve fish habit at and access by breaching berms	- Perpetuate ongoing impacts from ditches - Hydrology modification - Minor loss of vegetation - Possible excess drainage of marsh surface	- Hand tools (Minor) - Heavy equipment (Major)	NPN
IMA 3.	Culvert repair/maintenance when tidal restrictions are apparent	- improve water quality - restore pre-restriction hydrology -mosquito breeding activities	- Maintain existing habitat - Maintain existing flows and/or prevent flooding	- Continue runoff conveyance into water bodies - Potentially inadequate water transmission	- Heavy Equipment	NPN
IMA 4.	Stop-gap ditch plug maintenance	- prevent upland inputs - increase wetland habitat - sustain fish and wildlife habitat	- Return to pre-ditch hydrology & vegetation - Reduce pollutant conveyance through marsh - Provide habitat for fish & wildlife using ditches - Retain water in ditch for fish habitat - Deny ovipositioning sites	- Reduce tidal exchange - Reduce fish diversity in ditches due to lack of access - Impoundment of fresh water could lead to freshening & Phragmites invasion - Possible drowning of marsh vegetation - Impermanent approach (likely to fail within 5 years)	- Heavy Equipment	GCp

Please note that other jurisdictions besides NYSDEC may also regulate activities in wetlands.

Tables ES-1 to ES-4 explicitly show that all proposed management actions in wetlands are permissible under existing State regulations, albeit some may require a permit. FINS, on the other hand, at this time does not allow water management to occur within the National Seashore. The County is discussing with FINS how water management might be implemented in the Seashore to meet the goals of the Long-Term Plan and yet also to meet the natural resource preservation requirements in effect at FINS. No other jurisdiction within Suffolk County has any explicit prohibition on water management, although several would prefer that permits or other permissions be acquired for pertinent projects.

Section 4 and Section 5 of the Wetlands Management Plan address plan implementation and resource needs of SCVC to undertake this Wetlands Management Plan, respectively. The need for streamlined and dedicated State processes is highlighted. Vector control program needs may be eligible for restoration grant opportunities, as well as the Suffolk County Water Quality Protection and Restoration Program (the Quarter Percent Sales Tax). Section 6 establishes a Timeline for reaching Wetlands Management Plan goals, including the identification of good candidates for certain kinds of projects over the first three year time period. In Section 7, the County's salt marshes are prioritized in terms of those requiring restoration to address mosquito management needs, sites that appear to be best suited for reversion, and those areas requiring closer study before determining overall management needs.

In New York State, fresh water regulations do not allow for much manipulation of the existing hydrology of the marshes. This means that there are very few options in terms of mosquito-related water management and restoration. Source reduction and larviciding are the main means of addressing mosquito problems associated with freshwater wetlands (see above and below for the implementation of those program elements). The Long-Term Plan includes a desire to participate, if possible, in ongoing State reconsiderations of the existing wetlands regulations and their implementation. In addition, the Long-Term Plan also recognizes that the ecological savvy available in many local resource agencies could be well-applied in reducing any potential impacts associated with SCVC operations. Therefore, SCVC is seeking to communicate with these local resource managers to determine sensitive species and environments that should be allowed for as it conducts its operations.

Table ES-5 summarizes source reduction efforts under the Long-Term Plan, which are intended to be the primary means of addressing mosquito problems, by focusing on the mosquito species of concern as identified by SCVC and SCDHS.

Table ES-5. Source Reduction Summary

Species	**Source Reduction Efforts**	**Other Issues**
Aedes vexans	Upper salt marsh management	Fresh water habitat manipulation contrary to current State regulations
Anopheles punctipennis	Household efforts	Fresh water habitat manipulation contrary to current State regulations
Anopheles quadrimaculatus		Fresh water habitat manipulation contrary to current State regulations; prefers pristine settings, and so may involve R-T-E species
Coquillettidia perturbans		Fresh water habitat manipulation contrary to current State regulations; requires special sampling efforts
Culex pipiens	Household efforts, storm water structures	
Culex restuans	Household efforts, storm water structures	
Culex salinarius	Upper salt marsh management	
Culiseta melanura		Fresh water habitat manipulation contrary to current State regulations; habitat often associated with R-T-E species; requires special sampling efforts
Ochlerotatus canadensis		Fresh water habitat manipulation contrary to current State regulations
Ochlerotatus cantator	Salt marsh management	
Ochlerotatus japonicus japonicus	Container, tire management	
Ochlerotatus sollicitans	Salt marsh management	
Ochlerotatus taeniorhynchus	Salt marsh management	
Ochlerotatus triseriatus	Container, tire management	
Ochlerotatus trivittatus	Upper salt marsh management	Fresh water habitat manipulation contrary to current State regulations

Triggers for Source Reduction

Household and institutional source reduction measures will be initiated in several ways:

The detection by field crews of standing water that supports breeding

Determination that standing water could potentially support mosquito breeding

Prophylactic measures to ensure that stormwater management structures, agricultural irrigation practices, and littered tires do not cause mosquito breeding opportunities

The presumptive activity with regard to County salt marshes under the Long-Term Plan is reversion. If, however, a treatable wetland is determined to present a mosquito breeding problem, water management following the Wetlands Management Plan and utilizing the Best Management Practices Manual will be initiated if the project is assessed as an appropriate action. If consultation with the landowner and other involved parties determines that action is in order, and the proposed action is in accord with the Wetlands Management Plan and any other guidelines and regulations that such actions are subject to, then the procedures outlined above regarding project review will be initiated. Wetlands management projects may also be initiated for reasons other than mosquito control in this scenario, and SCVC involvement may be indicated to ensure that such projects do not lead to future mosquito breeding problems. If project reviews indicate that the proposed action meets all applicable guidelines and will address the mosquito problem without causing negative impacts to the wetland in question (as can best be determined, and with appropriate consultation outside of SCVC), SCVC in conjunction with the land manager will pursue the necessary regulatory procedures to gain permission for the action. The most applicable BMP or BMPs for the site will be determined, and the project will be undertaken. Monitoring, as required and as appropriate, will be conducted to ensure the project is successful in achieving its stated aims. SCVC will only undertake wetlands management projects following consultation and review with other involved and interested parties, including the appropriate Town natural resource division, and after explicitly reviewing ecological issues associated with the project.

All water management projects will be conducted in compliance with State regulations, and any necessary permits and approvals will be obtained prior to beginning work. All projects will be conducted with explicit project goals (determined prior to project initiation), and monitoring to ensure the goals are being met will be conducted (as well as any other required monitoring). Annual reports on water management activities will be prepared and disseminated.

ES-3.5. Biocontrols

Biological control considerations include many mosquito predators, and would-be predators; the most commonly used biological control adjuncts are mosquito fish, *Gambusia*. Care must be taken in placing this species in areas where endemic fish or other species may be impacted. The County should consider using species, such as the fathead minnow (*Pimephales promelas*) in place of *Gambusia*. Fathead minnows are also introduced species, but have proven themselves to be non-invasive (native species are not displaced when fathead minnows enter an ecosystem), according to NYSDEC. These would need to be raised, as is done in New Jersey. It is best if fish only be stocked in basins where they have been stocked before, and only after reconnaissance that shows there is no hydraulic exit from the basin (such as an overflow outlet) that could result in a release to ponds that may serve as fish-free environments. SCVC needs to ensure that it does not introduce fish into previously predator free environments that support amphibians and invertebrates that may be less noxious than mosquitoes.

Another group of biocontrol agents with promise for mosquito control is predaceous copepods. Copepods are easy to rear and to deliver to the target sites in the field, and they generally perform well when used with pesticides. However, they have not been shown to provide the degree of control that comes with other biocontrols such as fish. Copepods must multiply to effectively attack mosquito larvae populations, leading to a lag time between inoculation and effective control. There is some County interest in developing a copepod program in Suffolk County as some species may be effective for long-term control in catch basins. In areas with seasonal rain patterns, brine shrimp have also shown promise as similar larval predators.

Triggers for Biocontrol Use

Biocontrols will be very judiciously used. They will only be used when source reduction is not possible, but mosquito breeding needs to be addressed. In addition, other controls (species specific) will be used.

Fish will only be used in settings where they have expectations of survival (persistence of water and adequate water quality), and where native organisms will not be negatively impacted (as when there is a predator-naïve settings). Fish will only be used in settings where it is clear there is no opportunity for them to escape into broader ecosystems. In addition, in case this low probability event does occur, the County is to begin using organisms that are already widespread in County waters (where they appear to be causing no ecological impacts).

Copepods, if New Jersey research confirms their effectiveness, would only be used in underground drainage systems that are isolated from larger fresh water or salt water settings.

ES-3.6. Larval Control

The Long-Term Plan proposes to use three biorational products as its primary larvicidal treatments, *Bacillus thuringenesis var israelensis* (Bti), *Bacillus sphaericus* (Bs), and methoprene. These insecticides have been specifically selected as thy have minimal disruptive influence on the environment and ecology.

It is a general objective of the Long-Term Plan to avoid the use of pesticides, whenever possible. It is a basic tenet of IPM that an excessive dependence on pesticides is not wise from a programmatic point of view. An excessive reliance on pesticides can make a program vulnerable to control failure. For instance, logistical problems or weather conditions may prevent the application of pesticide in all areas where they are needed and at the proper times. Development of resistance to pesticides to the targeted organisms can be a problem. In addition, if a widely used material is found to have unacceptable impacts, or if it becomes unavailable due to market forces, a program that is overly dependent on that material can find itself without viable options. Sound management principles dictate that pesticides must be just one part of a comprehensive control program.

These management principles result in a Long-Term Plan that emphasizes water management as a means of reducing larvicide applications. Scientific surveillance measures are the means of ensuring that larvicide applications are truly necessary. Surveillance data analysis to establish site-specific values for dipping results may allow for further reductions in larvicide applications.

Especially if progressive water management succeeds as the County anticipates it will, the focus of larviciding activities will increasingly be in fresh water environments. Approximately three-quarters of all larvicide applications occur in fresh water settings currently, although the greater scope of larvicide applications in salt marshes means that most of the acreage treated is in salt marshes. Since the range of source reduction actions is somewhat limited in fresh water settings, it is possible that the potential scope of larvicide applications in fresh water will remain approximately constant under the Long-Term Plan.

Fresh water wetlands require special consideration for any pesticide treatment. These environments are more diverse than salt water mosquito breeding sites (see Section 5 of this document), and have the potential to be more sensitive to perturbations. Most of the species of special concern in the County are found in or near fresh water wetlands. Therefore, the County will, over time, through consultation with State, County, and town natural resource staff and other interested parties, develop GIS determinations of the fresh water areas that require more nuanced approaches to treatment decisions. A focus will be on the identification of vulnerable species, and to determine the points in their life histories that may make them more susceptible to potential impacts from vector control operations, and then to determine what modifications of vector control activities can be made to mitigate the potential impacts. For instance, because of special reproduction requirements for certain species, spring or early summer pesticide treatments may be counseled against. In other instances, early morning or evening applications may be preferred in order to avoid knock down of day-active insects by applications. These plans may become customized for particular settings. An expansion of GIS capabilities in the County may facilitate this approach. As inventories of the wetlands and the special habitat and other needs of important species are ascertained, special research conducted on behalf of the County may be able to craft modifications of its standard operating procedures to reduce the chances that any negative environmental impact will follow from treatments. As an important example of this, following consultation with NYSDEC, SCVC has removed all tiger salamander habitats from its larvicide list, to ensure that no possible impact from these pesticides to this rare species can occur.

Surveillance

All treatment decisions will be made on the basis of scientific surveillance to determine the need for the treatment. Appropriate surveillance requires sampling for the presence of larvae. Although standardized sampling methods have been developed (and discussed in the scientific and technical literature) for larval sampling of all kinds, the results of the testing are almost all sampler-dependent (CA-CE, 2004d).

SCVC has had good experience using a larval dipping index at Wertheim National Wildlife Refuge. Nonetheless, generally SCVC will continue to rely on absence/presence tests of larval habitats at this time. Qualitative assessments by samplers of relative population densities (none-some-many-throngs) will be used as a determinant of apparent populations. Samplers will also record actual numbers of larvae, as possible, per dip. For the identified breeding locations, data analysis of these numbers will be pursued, and it may be that site-specific triggers that appear to lead to reasonable reductions in larviciding frequencies can be developed over time. Samples will be collected for laboratory speciation, as well.

Until site-specific triggers are established, however, the determination of a need to control larvae will be the identification of a potential mosquito problem. This is determined by complaint history, close association with residential or recreational settings, or disease history or other risk factors, and the presence of human-biting mosquito larvae. The presence of human-biting mosquito larvae is a determination made most often by observations through sampling with identification of the larvae as a pest species by field crews, or by the subsequent laboratory analysis of the returned specimens.

Permanent and transient fresh water breeding habitats have been identified and catalogued by SCVC. The permanent water sites are visited on a regular basis. Transient water sites, which are not as extensive in Suffolk County due to the high permeability of the soils (generally) are sampled following significant rainfalls. History dictates the kinds of rains likely to produce breeding.

Mosquito Problem Identification

There are four types of areas where SCVC may apply larvicides. They are:

- catch basins and other, mostly underground, storm water control structures. Some 10,000 storm water structures have been identified as potential breeding problems by SCVC through surveillance work; surveillance efforts will be expanded to a total of approximately 40,000 to 50,000 sites. Where possible, maintenance records and plans of appropriate agencies will be accessed prior to the surveillance effort. If the basin shows signs of breeding, it and all connected basins will be treated to limit the risk of potential mosquito disease transmission. Open water systems, such as recharge basins, without histories of treatment, will be assessed similarly to environmental sites identified in complaints.

- sites identified by complaints (mostly household-institutional sites). Most complaint call investigations are easily resolved by identifying household breeding sites, and remediating them. In some situations, the household mosquito source is too large, and in those instances, treatment with a larvicide may resolve the immediate problem, and allow time to investigate for long-term management of the underlying problem. In other complaint situations, the source of the troubling mosquitoes may appear to be an environmental setting. If the site is not a known breeding site, then sampled larvae will be brought to the laboratory for official identification, and follow-up at the site shall be undertaken by senior level staff. Options available on this follow-up include minor water management to resolve a drainage or fish access issue, larvicidal treatment, or assignment to a follow-up surveillance list. The determination as to whether to treat the site will be through evaluation of ecological issues and the degree of seriousness of the problem. The senior staff will annotate the SCVC GIS with appropriate treatment trigger information, including quantitative or qualitative larvae presence factors, time of year, or other issues of note.

- breeding areas within marshes that are aerially larvicided. Sites that are considered for aerial applications of larvicides are those that are too large or inaccessible for ground application and breed mosquitoes consistently and persistently. There are approximately 4,000 acres of salt marsh that receive aerial larviciding at this time. A major focus of the water management plan is to substantially reduce this acreage. Until those projects have been undertaken, the sites will be monitored weekly by SCVC crews. Testing in the salt marsh will be on a presence/absence basis, with identification of the larval stage included to guide pesticide choices. Use of GPS equipment will allow for good determinations of the portion of the marsh that is breeding. Field observations regarding the intensity of breeding will also be useful for decision-makers. In addition, the state of the tide and the status of water on the marsh may be used in making treatment decisions. It may be that a careful analysis of treatment histories and subsequent adult mosquito infestations suggest that a certain amount of larvicide treatments can be eliminated for some of the marshes. Then analysis of larval survey records may help determine some kind of threshold value for each particular marsh, probably based on a mean number of larvae per dip.

- breeding areas that are not within marshes that are aerially larvicided. These are wetlands that do not require aerial treatments, either due to their small size or relatively minor mosquito problem. The kinds of mosquitoes that can be expected to be found at these sites have been well determined over time. Therefore, field crews can often make treatment decisions based on sampling results, and efficiently treat any problem that is brewing. Fresh water sites on this list are good candidates for reassessment of routine treatment measures. It will be important to factor into the decision-making regarding such sites that the control of bridge vectors probably plays an important role in the prevention of EEE County-wide, and so it is unlikely that major breeding sites for known EEE vectors will be allowed to flourish without intervention. Nonetheless, as with the frequency of larviciding in certain salt marshes, some of these fresh water sites may be places where treatment patterns can be altered to ensure that there are no non-target impacts to important elements of the ecosystem.

Larval Treatment Selection

The choice of methods for larval control is based on several factors:

- Species of mosquito present
- Kind of habitat to be treated
- Stage of larvae present
- Efficacy of the considered treatment

- Residual effects (potency and duration)
- Potential environmental impacts of the considered treatment
- Resistance management

Species composition is important for gaining some understanding of breeding patterns. For example, if the larvae belong to a univoltine, brooding mosquito, generally long acting pesticides would be wasteful as there will be no further breeding once this episode passes. For multivoltine, steady-breeding mosquitoes, it is not important to know what stage is currently dominant, as breaking the breeding cycle is more important. For brooding, multivoltine mosquitoes such as *Oc. sollicitans*, knowing what stage the current brood is in becomes very important, so as to disrupt what may be a large emergence.

Bti and Bs need to be ingested to be effective. This limits their utility to Stage I, Stage II, and Stage III larvae. In the salt marsh, Bti seems most effective on stages I and II, when the marsh is very wet, and when temperatures are relatively low. If these pesticides are considered for use, then they either need to be applied to situations where they will eventually choke off further breeding, or where most of the current mosquitoes will be directly affected by them.

One reason for the County to use multiple larvicide products is to allow for resistance management. The County tends to alternate between Bti and methoprene in salt marshes, for example. Bti is effective with Stage I, Stage II, and Stage III larvae, so when development is slower in spring and later summer, Bti is preferred. Methoprene prevents larvae from developing, and is a contact pesticide; so it is effective for all stages of larvae, especially late stages. It is used when larvae are developing quickly, as the lag between detection of larvae in the marsh and treatment with Bti in summer could result in ineffective treatments, as no susceptible organisms would remain because they had all become Stage IV or later organisms. Reliance solely on methoprene could run a considerable risk of developing resistant mosquitoes, by eliminating all mosquitoes except those that methoprene does not kill. Bti uses five distinct toxins to kill mosquitoes; it is generally believed that so many toxic compounds will not allow for resistance to develop, and so from that standpoint Bti has advantages. County will also use a duplex formulation of Bti and methoprene in summer when generations appear to be overlapping, or development is especially rapid. This can also aid in resistance management to either material should any occur, since it is unlikely that mosquitoes can develop resistance to both products simultaneously.

Larvicide Uses

Storm water structures should receive either Vectolex WSP (Bs) pouches or Altosid (methoprene) briquets as a preferred treatment. If the recharge basin being treated appears to have clear water, treatment with Bti donuts is possible, and may indeed be preferred due to the general difficulty of inducing resistance with Bti.

Field crews will have equipment allowing treatment of any site with Bti, Bs, or methoprene. Treatment will depend on the combination of the stage(s) of the larvae, and environmental conditions. Vectolex may be preferred in swampy situations, as it has greater penetration through undergrowth due to the weight of the pellets. The crew leader is responsible for carefully estimating the area of the application (based on dimensions of the application, so that 100 feet by 100 feet is one-quarter of an acre, for example), and determining the amount of product to be used. In-house and NYSDEC pesticide applicator training enable these calculations to be made in a manner consistent with the law and the appropriate label.

Aerial application decisions will be made based on surveillance data. As stated earlier, Bti is often used for early season applications, and methoprene is often the choice for middle of the summer. Applications should be made at very low altitudes to minimize drift.

Efficacy Measurements

The three major larvicide efforts could be included:

- Catch basins
- Non-aerial larvicide applications (routine monitoring responses, and complaint follow-up)
- Aerial applications

The QA/QC team will have access to application data so that testing is appropriate to the treatment.

Larval Control Triggers

Larval control will only be initiated on the basis of surveillance information. Primarily, the most important information will be the absence or presence of larvae. At the initiatiation of the Long-Term Plan, it seems likely that the only location where numerical triggers will be employed (based on dipping counts) will be Wertheim National Wildlife Refuge, where SCVC and USFWS determined a site-specific trigger for aerial larvicide applications. SCVC will make a concerted effort to quantify larval sampling data, and as resources allow, will analyze those data to determine if other triggers can be applied to other areas that are regularly treated. It needs to be acknowledged that although dipping data are quantitative, they are also relative and subjective, and usually are not replicable. This is the basis for the County's concerns regarding general larval control triggers, as very careful and close analyses of data sets for particular settings need to be made to create appropriate values to manage larval populations well.

Some treatments can be made on field crew initiative, following complaint investigations. Others need to be made by more senior personnel (such as aerial larvicide determinations). The general intent of larval control is to prevent the generation of a mosquito problem (that is, a situation where adult mosquitoes affect human health risks or quality of life).

Table ES-6 lists the surveillance results weighed by decision-makers for the variety of larval habitats that may need larval control. Generally, the surveillance data are qualitative in nature (for instance, "much of the marsh" has larvae "present," which indicates a need for action). The choices for action are generally determined by the stage of larvae causing the problem.

Table ES-6. Larvicide Decision Table

Location	Surveillance Result	Quantitative?	Resultant Action
Aerially-larvicided salt marsh	Presence Area Present Stage	@ Wertheim NWR Potentially expandable	Stages I- II: Bti Older: methoprene
Other salt marshes	Presence Stage	No	Stages I- II: Bti Older: methoprene
Permanent Fresh Water Habitat	Presence Stage Environmental Considerations	Possible	Stages I- III: Bs Older: methoprene
Transient Fresh Water Habitat	Presence Stage Environmental Considerations	No	Stages I- III: Bti Older: methoprene
Catch Basins	Presence	No	methoprene time release
Recharge Basins	Presence Environmental Considerations	No	Stock fish Transient: Bti donuts Permanent: Bs Methoprene time release
Artificial (e.g., swimming pools)	Presence	No	Empty If not possible: Bti, methoprene

ES-3.7. Adult Control

The decision to apply adulticides must be based on information drawn from scientifically-based surveillance activities. Having stated that, the decision will not be based on a single treatment threshold. Applying an adulticide to control mosquitoes is a decision based on the mosquito species, the numbers of mosquitoes present, the threat or presence of a human pathogen, the age and history of the mosquito population of concern, and the time of year. In addition, historical and current trends in the mosquito populations, the current weather, the predicted weather, both short-range and over an extended period of time (seasonality), the environmental setting, and the people in the area where the pesticide will be applied also need to be factored into this equation. The assessment of these various factors form a risk determination by program managers, where potential benefits (and potential costs) of applying the pesticide are weighed against the probable costs (and potential benefits) of not applying the pesticide. In addition to this complex set of variables, there is also, to a certain degree, the expressed preference of the community that may or may not receive the treatment. However, it should also be understood that firm criteria for vector control adulticide applications will include 25 human-biting mosquitoes per trap night when New Jersey trap data are available, or 100 human-biting mosquitoes when CDC trap data are available.

The purpose for controlling adult mosquitoes is always to prevent impacts to people from their presence. Suffolk County has a pesticide phase out law that sets a goal of limiting or eliminating pesticide use when possible. Adherence to this principle is an important element of the decision-making, and means that managers tend to avoid applications whenever the impacts from mosquitoes are not exceptional.

Mosquito adulticides must be used in residential areas to control mosquitoes that are biting people. This means that human exposure to the materials is inevitable, and efforts to minimize exposure to pesticides are prudent. In addition, it is at least theoretically possible that there are as yet unknown adverse impacts that could result from use of these materials, so that it is wise to place limits on their use.

Treatment Decisions

It must be emphasized that whenever adulticiding is being considered, it is in the context of IPM. In any situation where adult control is being considered, mosquito control has already been undertaken through public education, source reduction (including aggressive, progressive water management programs), and larviciding. Adulticiding is being considered as the last means of achieving protection of human health and public welfare. It is certainly not the management tool of first choice for Suffolk County.

There are two possible conditions for adulticiding to occur under. One is when a declared health emergency applies, and the other is for vector control purposes. In either case, a multivariate assessment of scientific surveillance information will drive the decision-making.

Typically adulticide treatments are differentiated between those that are undertaken for the protection of human health and those that are needed for public health nuisance abatement to provide for relief of human discomfort (vector control). As discussed earlier, the planners of the County mosquito program have found it difficult to clearly separate mosquito control conducted for human health protection from that conducted for preservation of quality of life. This is especially difficult when considering the program as a whole, since many treatment decisions need to be made prophylactically under conditions where WNV (or another arbovirus) may eventually emerge as an imminent health threat. Differentiation between adult control for vector control as compared to human health protection is also very difficult to do. Legally, it is simple, as vector control adulticiding does not occur on the basis of a public health emergency declaration by the Commissioner of SCDHS. However, mosquitoes that are controlled for human health protection (those which carry the greatest risk of disease transmission) tend to be very aggressive human biters. This means that reducing their numbers to reduce disease threats also reduces the level of discomfort experienced by people. This means that adult control for human health protection also provides quality of life benefits. Secondly, the conditions that cause the most discomfort to people in Suffolk County (large numbers of *Oc. sollicitans* mosquitoes in coastal communities) also contain a certain amount of disease risk and potential impacts to health, under all situations. It is clear that elimination of aggressive biting mosquitoes clearly improves public welfare for those in the afflicted areas. But vector control also provides a degree of protection of public health. Instead of being discrete, the separate kinds of treatments actually describes a continuum of control rationale, where neither a purely health protection event nor a purely nuisance control event can be considered likely to occur. But it is also true that every adulticide application is either a "vector control/public health nuisance control" treatment (made under the authority of SCVC) to primarily preserve quality of life (but also reducing potential human health impacts), or a "public health emergency" treatment (made under the authority of the Commissioner of SCDHS) to primarily reduce risks of human disease (but also reducing the quality of life impacts attributable to the adult mosquitoes, as well).

Under a declared health emergency, the benefits associated with pesticide use include disruption of transmission of disease. However, such adulticide treatments are not made wherever indications of disease are found, but rather where the risk factors indicate that the greatest possible risk is located. Under the WNV conditions that currently exist in the County, treating wherever indications of disease are found might mean treating most of the County each summer.

Control decisions are not made merely on the number of mosquitoes, or the amount of human biting that is occurring. These are important issues, but they are not definitive. Other information is required in order to determine if adult control is necessary:

- Species of mosquitoes present, from trap data
- Relative numbers of mosquitoes, by species, from trap data
- Population trends, from past data sets and control sites
- Aggressiveness of the mosquito population, inferred from trap data, based on species composition, based on complaint logs, and/or from landing rates
- Activity pattern of the species of concern (preferred feeding habits, resting habitats, etc.), from trap data
- Presence or absence of virus, from laboratory analysis of mosquitoes, dead birds (may no longer be realistic), sentinel birds, and/or wild avian surveillance, or the presence of human cases
- Analysis of the risk posed by the particular virus, based on professional judgment and CDC-NYSDOH guidance
- Parity of mosquitoes (percent of the population that has previously had a blood meal)
- Bird migration patterns
- Current weather and short-term weather forecasts
- Long-term weather trends (time of year considerations)

Not every decision can have (or needs to have) a complete information set, and sometimes decisions may be tentatively made and then confirmed based on very immediate data collection. The kinds of applications that have historically been made will be revisited in light of the Long-Term Plan decision process, to illustrate how the process should function.

Vector Control Treatments

There are several areas in the County, mostly along the south shore, that typically experience inundations by broods of salt marsh mosquitoes several times in a year. Knowledge of the mosquito broods comes to SCVC management in several ways:

- Reports from field crews prior to the outbreak, suggesting large numbers of larvae were present on the salt marsh (as a prelude to larviciding)
- Follow-up reports from field crews conducting larval surveillance on the marshes, indicating high numbers of biting adult mosquitoes on the marshes
- Increases in biting complaints from the community (these are logged and mapped by SCVC)
- Requests from elected officials (mayors, legislators and others) or community groups
- New Jersey light trap data, indicating increases in *Oc. sollicitans* numbers in the sentinel traps

All complaints are followed up. Therefore, field crews will be dispatched to the areas where complaints are being logged, and will confirm (or not) that an infestation has occurred (people with party or holiday plans have been known to try to arrange for prophylactic applications to ensure no mosquito disruptions). Informal landing rate tests across open fields are a good test for the presence of *Oc. sollicitans* during the day. If trap counts are excessive (25 biting adults per trap night, compared to a more usual zero to five count, in New Jersey light traps, and 100 mosquitoes per night in a CDC light trap), and mosquitoes have been confirmed, the general area where the infestation is occurring is mapped, based on complaints received and the follow-up visits by field crews. Since truck applications are the typical means of responding, the road network of the area is used to determine the potential boundary of the application. Weather forecasts will be accessed to determine if conditions seem to be acceptable for a potential application, and to ensure a cold front or other storm situation will not occur to eliminate the need for the application. It is also assumed that the time of year indicates that the infestation is not about to become less due to cooler temperatures, as might be the case in September or later in the season, or in May or early June (mosquito activity slows with decreasing temperature, and rises with increasing temperatures). Population trends for the particular area will be observed to ensure that typically these conditions do persist (most of the areas where such control treatments are considered are well-known to SCVC administrative staff). No-spray addresses and key environmentally sensitive areas are factored in, and then the application area is noticed, so that an application can occur the next evening.

At this time, the QA/QC team should locate a suitable area in or near the center of the application block, and set up a CDC light trap for confirmatory sampling. This trap would also be used for baseline data as a measure of treatment efficacy. Another trap, outside but near to and in a somewhat similar setting, could be established for a control site. In the morning, the two traps would be collected. The species and number of biting mosquitoes would be noted. A target for the decision to continue with application plans would be the presence of 100 or so biting mosquitoes in the CDC trap of interest. Anything substantially less than this, or a notable shift in the speciation of the trapped mosquitoes, requires reassessment of the application decision.

Assuming that the trap confirms the decision, and the weather is appropriate, the application will occur on the second evening. The next night, CDC traps would again be set, and the collected data used to calculate the efficacy of the application. The intent of the control program is to reduce targeted species' numbers by an order of magnitude (measured trap counts, as adjusted by the control results, would be expected to be 90 percent less than the original counts). These actions are intended to reduce impacts to the quality of life experienced in the neighborhood, and also to reduce disease risk by eliminating older mosquitoes from the available population. Breeding may also be slightly curtailed (but unless the marshes are also targeted, not enough of the salt marsh mosquito population will be killed to seriously impact overall breeding). Populations out on the marshes can only be successfully curtailed through effective water management and larvicide applications.

It is possible that areas outside of typical locations impacted by biting mosquito problems will appear to need treatment. In these cases, initiation of recognition of a problem will probably begin with complaint calls, and continue with follow-up on the calls. It is less likely a set New Jersey light trap will be set conveniently to assess the problem, and so the analysis may not proceed quite as quantitatively as described above. It is all the more important to analyze overall mosquito population trends for this season and previous seasons, in these cases, and to set the pre-application CDC light traps, and carefully analyze the data from those traps prior to confirming any application decision.

Fire Island Communities

Historically, SCVC has routinely applied adulticides as vector control treatments in certain of the Fire Island communities. As part of the application process for a special use permit for mosquito control in FINS, the County is meeting with NPS staff to determine mutually agreeable procedures for conducting operations in various settings, under various conditions. The structure and content of the Long-Term Plan are to be the guides for this site-specific plan. However, it is not yet known what conditions and at what locations adulticides may be applied in FINS at this time.

Declared Health Emergencies

Control decisions under a declared health emergency are different from those employed for a vector control decision. SCDHS has overall responsibility, is responsible for ensuring that the risk assessment has been properly conducted, and reviews the operational plan proposed by SCVC to meet the required risk reduction. The risk assessment first requires that mosquito-borne disease has been detected in the County. On rare occasions the identified mosquito problem has involved malaria; however, the modern mosquito-borne diseases of concern are arboviruses. The most prominent of these, and the ones most likely to be detected in the County, are WNV and EEE.

The County's disease management protocol is based on the NYSDOH four-tiered WNV response strategy. It differs is some minor respects from that overall approach, but essentially follows the overall strategy. Because WNV and EEE have been historically detected in Suffolk County, the County essentially begins each mosquito season in Tier II of the NYSDOH tiered approach.

Over the period 2000 to 2004, the signal of WNV presence in birds was finding dead crows that tested positive for virus. It appears that nearly all susceptible crows have died from the disease, or, in any case, the survivors and their off-spring do not readily perish from WNV, at least as often as they used to. This means that new sentinels must be developed. Whatever method is selected (see the Surveillance section, above), testing of these samples could continue to occur in-house, with some samples sent to NYSDOH in Albany for confirmation and more inclusive general viral scans.

If no alternative bird surveillance tool is developed, the County will need to step up its use of CDC light and gravid traps, collecting more samples, more frequently, and from many more locations. Currently, CDC light traps are set at fixed stations in areas where EEE and WNV have reoccurred, and more are set to investigate bird deaths and positive bird samples. Gravid traps are also set to particularly target *Cx. pipiens* (for WNV surveillance). Absent bird deaths to target sampling, means of generally conducting surveillance across the entire County will need to be established. This will require some method of increasing the density in both time and space of the CDC trap network. Increasing the number of CDC trap samples collected is very labor intensive, both in terms of managing the traps (set-outs and sample collections) and in processing the collected samples. The nature of mosquito-borne disease is also that a low infection rate in mosquitoes can result in very high infection rates in target species, so that sampling mosquito pools is not very efficient at identifying areas where infectious agents are present and circulating. For these reasons, identification of alternate bird sampling methodologies is preferable.

If surveillance reveals the presence of WNV (birds or mosquito pools), the County will petition to the State Commissioner of Health for a declaration of a Health Threat. This allows the County to apply for reimbursement of certain expenses in SCDHS relating to mosquito control, and places SCVC formally under the direction of the Commissioner of SCDHS. It is also a necessary first step prior to any declaration of a Health Emergency. This also moves the County to Tier III of the NYSDOH tiered response strategy.

A health threat declaration will also be sought in sampling results from *Cs. melanura* pools shows that EEE is amplifying in bird populations. This is signaled by detection of a *Cs. melanura* positive pool from samples sent to Albany for analysis.

The declaration of a health threat will also be accompanied by stepped-up public education and outreach, through SCDHS press releases and web site publications. These are intended to draw attention to the heightened state of concern regarding mosquito-borne disease. In addition, SCDHS will contact its physician and hospital reporting network, and touch base with local veterinarians. This ensures that any human or sentinel animal cases of mosquito-borne disease are promptly reported.

Detections of clusters of positive WNV pools for *Cx. pipiens* would signal the potential for adulticide control. In that case, the presence or absence of potential bridge vectors would be an important consideration, especially if the bridge vectors tended to have a higher parity rate. For flood water mosquitoes, a determination as to whether a brood was waning naturally, and need no control for numbers to be of little concern, would also be a factor, although not necessarily a compelling one. With bridge vectors, older mosquitoes are much more dangerous than young mosquitoes, so a large population of virgin mosquitoes is much less risky than a small population entirely populated by blooded mosquitoes. Time of year is important, as it has been suggested that *Cx. pipiens* changes its feeding habits after the first week of August or so, and feeds more regularly on humans. This makes it a more dangerous mosquito, especially as the species (in general) transitions from bird feeding to human feeding (increasing the potential to pass virus along). In late summer, as night temperatures drop, *Oc. sollicitans* begins feeding more commonly during the day. This makes control harder, as the mosquito is less likely to be flying when the insecticide would be applied. Thus, late summer-early fall adulticiding is less common for *Oc. sollicitans* vector control purposes. These conditions move the County to Tier IV of the NYSDOH tiered strategy.

Another factor considered in control decisions is the size of population (and its composition, if greatly different from the County as a whole) in the near vicinity of the problem. Generally, the more people potentially exposed to the disease threat, the greater the likelihood of an adulticide application. If positive results occur in a bridge vector pool, then this too signals a potential need for adult control. If the virus were to be detected in *Oc. sollicitans*, especially, given its very aggressive biting habits and generally large numbers, concerns would be raised. The age of the brood, the time of year (control is more difficult late in the year when the mosquitoes fly at night as less often), and weather patterns (mosquito activity can be reduced by colder weather, or heat can make them more active) all need to be factored into the decision.

For EEE, the threat of a bridge vector brood near a cycling center is a strong impetus towards declaration of a health emergency. Generally, Suffolk County has focused on EEE control in the near vicinity of the amplification area. Information gathered through the Long-Term Plan project provides support for the benefits of controlling *Oc. sollicitans* in all areas when EEE threatens, especially where coastal red maple or Atlantic white cedar swamps occur. *Oc. sollicitans* has been persuasively portrayed as the most dangerous and most effective potential vector for EEE. The need to control *Oc. sollicitans* and other bridge vectors generally was underscored through discussions of the potential for dispersing young birds to carry the virus to anywhere along their migration route from natal swamps (where they may have contracted EEE). Any dead horses, or dead farmed pheasants or emus, would also signal the need for a health emergency declaration to address EEE, as all of these quickly succumb to the disease. Disease in horses is of special concern, as it signals presence of the virus in a bridge vector.

Working with SCVC, SCDHS would determine the best application zone, and determine the most appropriate application approach, based on the target mosquito. Hitherto, Suffolk County has focused its control efforts on bridge vectors, meaning that applications are conducted primarily right after sunset, when nearly all important mosquito species are active. Where *Cx. pipiens* is clearly the mosquito of concern, the timing of an application may be retarded to effectuate a better control on this later-flying mosquito. The target area will be based on surveillance data, tempered by natural features (although a waiver from fresh water setbacks will be received for any disease threat application, major bodies of water serve as natural barriers to mosquito migration and so there is no need to apply pesticides over them needlessly) and label restriction areas such as croplands, if they can be avoided. Notices will be filed, and the expedited NYSDEC permit waiver process pursued. Generally, staff from NYSDEC will make themselves available on very short order to enable a coordinated consultation regarding the proposed application zone to address sensitive species and habitat concerns.

Similarly to vector control applications, the QA/QC team will set out a minimum of two sets of CDC light traps. Not only will these traps serve as efficacy measures for the treatment to follow, but sampling the trapped populations for species and parity can reinforce (or cause re-evaluation) of the application decision. Parous mosquitoes of concern should be present to cause the application to move forward – although it should be understood that at any given time approximately 50 percent of a *Cx. pipiens* population is parous. Pools from the traps will also be tested for virus presence, although if State facilities are used the results will not be received in a decision-timely manner. Efficacy will be at least partially determined if parity is lower after the application, and, if pathogens were detected in pools before the application, they are not detected in pools after the application event.

It must be understood that all decisions to apply adulticides in Suffolk County are made in the context of an IPM system. Adulticide applications are always the last, least desired control measure. Great efforts will have been made to avoid their use, beginning with public education, source reduction (including water management), and larval control steps. The decisions are not made arbitrarily, but in light of collected data from a surveillance system that has been bolstered from one described as among the best in the country. Adulticiding will only be undertaken to avoid worse consequences, in full knowledge of the benefits and risks associated with the action. These considerations mean that the County decisions clearly comply with all Federal and State guidelines issued to help managers make the best possible choices under difficult conditions.

Selected Pesticides

It is the policy of Suffolk County that pesticides should always be used sparingly, and only when needed. Careful consideration of the available registered products for mosquito control yielded the following alternatives. Resmethrin is to be the primary material for truck and aerial ULV applications. This is based on its record of effectiveness, and the results of the risk assessment (which showed that impacts to human health or the environment were unlikely). Its rapid degradation in the environment provides a margin of safety in avoiding adverse impacts.

Sumithrin is to be the primary material for hand-held applications, as the label for this product (Anvil) allows for use with small aerosol droplets, while resmethrin (Scourge) does not, currently. Because of the similar risk profile found for sumithrin compared to resmethrin, sumithrin would be an acceptable alternate if resmethrin was not available.

Permethrin had higher ecological risks associated with its use, and also has label setback requirements that make it less practicable for use in shoreline settings. However, permethrin is a widely produced product, and so is likely to remain available if the other three pyrethroids were not.

Natural pyrethrum did not receive as extensive a review as the other pyrethroids. It appears to have a similar risk profile. It degrades very rapidly, giving it a margin of error with regard to potential risks. Its labels also allow for application over crops, which is not the case for other pyrethroids. It is expensive (as compared to other pyrethroid products), and is sometimes not readily available.

Malathion is of a different chemical class than the pyrethoids (as an organophosphate), which means if pyrethroid resistance became an issue, it would be useful to have as an approved product. It also is labeled for thermal fogging, which is a useful application technique in some settings (underground structures or tire piles). It is technically more difficult to use as a ULV product, and the risk assessment indicated it has higher risks with regard to potential human health or ecological impacts than the other products. Malathion is identified in the Long-Term Plan only as a specialty tool, for instances where the other pesticides would not be effective or cannot be used.

Malathion, permethrin, and sumithrin are also approved by NYSDEC for hand-held applications

Application Methods

The County uses three application methods, with variations associated with several of the different means. In all instances to address resistance concerns, and to achieve the best possible results, the County will apply the pesticides at the maximum rate allowed by the product label.

There are some general constraints on all application events. Low temperatures inhibit mosquito activity; SCVC has set 65 degrees F as the minimum for operations. Winds cannot exceed 10 mph, as mosquito activity is lower when conditions are windy, and the pesticides will disperse too quickly. Mosquitoes are not as active in the rain, and rain will remove pesticides from the atmosphere, making the application pointless. Therefore, rain is counterindicative for applications.

On Fire Island, where vehicle access is difficult, a golf cart type platform is used to hand haul a London Aire Colt Hand Portable ULV Aerosol Generator to apply adulticides. This is an ultra-low volume (ULV) treatment. Hand applications are only conducted as vector control treatments. Health emergency applications over Fire Island would most probably be conducted by helicopter, as the scope of the event would almost certainly exceed one community.

The planned hand-held application will be discussed by managers and applicators prior to the applicators leaving SCVC offices. The application route will be specified, along with any setbacks, no-spray properties, and other areas that will not be treated. The specific path to be followed will not be mapped, but will depend on operator judgment (resort communities present special problems such as parties and other congregations that need to be adjusted for in the field).

The protocol to ensure label compliance requires a "walking pace," estimated to be approximately two mph. A two-man crew will conduct work, one ensuring that the applicator functions properly, and the other noting the route that was being followed, and anticipating obstacles and areas requiring the applicator to be shut down, including pedestrians or people out of doors. It is SCVC policy not to spray where people may receive direct exposures. Spraying begins at dusk, or sometimes a little before (sumithrin, the preferred insecticide for hand-held applications, degrades readily and rapidly in sunlight, and so such applications are less effective in daylight).

The hand-held routes are not performed with GPS equipment, and so the application route needs to be filed with GIS staff for mapping. Enhancement of SCVC equipment to allow GPS tracking of these sometimes intricate routes would be beneficial.

Setbacks from salt water are currently set at 100 feet. Setbacks from fresh water wetlands are set at 150 feet. These setbacks were negotiated with NYSDEC as a means of addressing perceived needs to regulate adulticide applications that fall within the 50 feet regulated buffer surrounding NYSDEC-mapped fresh water wetlands, and to similarly abide by label restrictions regarding applications directly to water. The specific modeling results associated with the risk assessment, and the risk assessment computation of ensuing impacts, provide a means to reconsider these bounds. SCVC should initiate discussions with NYSDEC staff at its earliest opportunity to determine if the setbacks need to be increased to provide more protection to the aquatic communities, or reduced to provide more complete control, especially in what may be key buffer area adult mosquito habitat.

On the mainland, essentially all vector control efforts are conducted using truck applications. Almost all air applications would require receiving a waiver from fresh water wetlands regulations, which NYSDEC has not been willing to issue for non-health emergency adulticide efforts, pending completion of this EIS. Even with the formulation of the EIS, the County sees no immediate need to abandon truck applications as the predominant means of applying vector control treatments. Aerial applications are most efficient when used over wider areas; many vector control applications are made over relatively restricted areas. Where tree canopies tend to be closed (as in some residential areas), truck applications can be more effective. Aerial applications, in the areas SCVC treats most often for vector control purposes, would necessarily result in treating wetlands.

SCVC pickup trucks are fitted with London Fog Model 18-20, ULV truck mounted aerosol generators that are equipped for adulticiding with an Adapco Monitor III GPS tracking and computer logger for ground-based adulticiding. The equipment is calibrated prior to the beginning of the season. Droplet spectrums are rechecked periodically. For mosquitoes such as *Oc. sollicitans* and *Ae. vexans*, the nozzle angle is set at 45 degrees to create a lower pesticide cloud. Should applications for canopy-dwelling mosquitoes (such as *Cx. pipiens* and *Cs. melanura*) be desired, the angle of the nozzle will be increased to 60 degrees from horizontal.

Maps of the target area will be generated by GIS prior to staff leaving SCVC offices. The maps will have no-spray lines, setback boundaries, and buffers surrounding other areas of concern clearly marked with strong colors to ensure the notations are discernable within the truck at night. SCVC tries to be sensitive for individual community needs. For example, spraying in Westhampton Beach was rerouted to avoid exposure for worshippers walking to synagogue one Friday.

The operation requires two people. One will operate the truck and application machinery. The other will be responsible for route maintenance and avoidance of obstacles, including timely warning of pedestrians or people in yards (it is SCVC policy not to spray people in the outdoors).

Spraying usually will begin at dusk, or sometimes a little later, and will continue for several hours to complete the route. This is for several reasons:

- Resmethrin, the Long-Term Plan preferred insecticide, including for truck applications, degrades rapidly under daylight conditions, and so efficacy would be lost through daylight applications.

- Most mosquito species, especially *Ae. vexans* and *Oc. sollicitans*, are most active at that time.

- Waiting for dark tends to minimize pedestrians and other outside venturers.

Pre-dawn applications target the same mosquito species, but often would be conducted at temperatures that are too low to meet current operational requirements. Thus, it is proposed that almost all applications occur in the evening. Mosquitoes active later in the night, such as *Cx. pipiens* and *Cs. melanura*, could be targeted by having the application start several hours later (around 10 pm).

The vehicle must be moving at least seven mph for the sprayer to operate (that allows for proper dispersion of the spray cloud), and will cease operations if 20 mph is exceeded. The target speed is 10 mph. The sprayer is computerized, and so will calculate the release rate necessary to meet label limits. The sprayer also generates a GIS map of the route it followed, including on/off sites. It calculates the amount of pesticide applied. This information is downloaded on completion of the application, and is verified by the field crew prior to finalization by data management staff.

Setbacks from salt water are currently set at 100 feet. Setbacks from fresh water wetlands are set at 150 feet. SCVC will discuss the utility of setbacks from salt water and fresh water wetlands with NYSDEC in light of the risk assessment modeling and ecological risk calculations.

Some of the ground-based application events are under Health Emergency conditions. For those events, SCVC has almost always received a waiver from fresh water wetlands restrictions, and need not abide by the voluntarily assumed setbacks for either fresh or salt water. As a practical matter, setbacks often ensue in any case due to the relationship between roads and waterways (roads seldom follow waterways without a buffer of some kind, and very often a residential lot is a very substantial buffer). In addition, SCVC voluntarily adheres to measures requested by NYSDEC to limit environmental impacts, even when not required to by law, provided that can be done without compromising effectiveness. For Health Emergency applications, no-spray list restrictions need not apply, if waived by the Commissioner of SCDHS. Although this is not required by law, SCVC attempts to contact no-spray list members in an area targeted for an emergency treatment, in order to allow these individuals to take protective measure such as staying indoors, if they so choose.

Aerial applications are almost always under Health Emergency conditions. This is because it is generally impossible to set helicopter swaths to abide by the NYSDEC setbacks, and because many vector control treatments can be more limited in area than those conducted with a focus on addressing arbovirus presence.

The area selected for treatment is defined differently for each application mode.

- Hand held applications (strictly on Fire Island) cover the entire residential area in each community, excepting housing in buffers (for wetlands, open-water, and no-spray addresses), and the specific addresses on the no-spray list.

- The general area for a truck application for vector control purposes is generally defined by the locus of complaints. Complaints, while not sufficient to cause an adulticide application, are the most efficient means of defining areas with higher mosquito biting rates. Once a general area of interest has been defined, the application area is refined by including modifiers such as mandatory and voluntary setbacks (such as those around wetlands, open water, and no-spray list members), no-spray list addresses, environmentally-sensitive areas, farms, and other areas that should not be treated. The area road network also factors into the application area determination. This is because issues such as large distances between streets, so that the application will not cover contiguous areas and so be less effective, may determine areas that it is not worthwhile to apply pesticides over. The tentative application determination is reviewed with SCDHS (typically, the ABDL director) for concurrence, and is used as a basis for public noticing. Application areas may continue to be refined until just before the run begins, although early determinations have the benefit of resulting in better route maps for the applicators.

- Health Emergency application areas are determined by SCDHS staff in consultation with SCVC. A focus of the determination is the extent of viral presence. The area to be treated also is set based on assumptions regarding the ranges of the potential human vectors. Complaints are sometimes referenced, as these can help identify areas where bridge vectors are especially active. Consultations with FINS, if required, can further define the application area. NYSDEC is routinely involved in the application area determination because there will generally need to be a permit granted for waiver of NYSDEC Freshwater Wetlands regulations. Practical considerations that need to be addressed regarding the capabilities of the helicopter that will apply the pesticides usually lead to a final application area determination. The practical considerations include (but are not limited to) the amount of pesticide that can be loaded onto the aircraft, the area that can be covered, and the geometry associated with making turns and applying pesticide in swaths. With the Adapco Wingman system operating, the actual final route followed by the aircraft will be determined in the air, due to real-time feedback from the model, based on area weather observations and project placement of the released pesticide. The Wingman model may also prove to be useful in developing efficient application area determinations.

The County uses a helicopter for aerial applications. It is a 3,200 lb. aircraft with an 18 foot six inch radius rotor operated by North Fork Helicopters, Ltd., of Cutchogue. The helicopter is fitted with two Beecomist nozzles nine feet from the centerline, oriented straight back. They have a flow rate of 25.2 oz/min. Prior to 2005, the applications means was by 300 foot swath released from 75 feet to 150 feet above the canopy at 70 mph. Modeling results indicated that off-target drift could be minimized by applying a 600 foot swath at 35 mph. It has been subsequently determined that in most situations, it will not be possible to slow the helicopter to 35 MPH for flight safety reasons. In addition, concerns were raised that slower speeds could increase droplet deposition, which could lead to greater non-target impacts. Instead, off-site drift will be reduced through the use of the Adapco Wingman system. Because the aerosols are intended to be composed of droplets so small they tend to remain suspended (they are brought to the ground more by turbulence than gravitational effects), drift caused by winds sometimes means the maximum pesticide concentrations do not occur in the center of the target area (Mount, 1996). This can be addressed through dispersion modeling, and leads to purposeful upwind offsets to bring the pesticide fully into the target area. To optimize this process, SCVC has acquired a state-of-the-art in-aircraft navigational-modeling system, produced by Adapco (the Wingman system). This system provides instantaneous course corrections to the pilot based on real time ground and balloon weather information generated in (or near to) the application zone.

The Adapco system has demonstrated its effectiveness (based on unpublished company data) at optimizing pesticide delivery so that little to no pesticide is wasted. The Adapco system maintains the desired application concentration in the area where mosquitoes have been identified as being. This means that it is efficient for its intended purpose, and necessarily minimizes drift, as is possible given the application method. This means the least amount of pesticide as is possible (for a given application rate over a particular area) will be used.

The general flight pattern will be set with the pilot at the application area prior to loading pesticides into the helicopter, although the final route will depend on the on-board modeling output. The Adapco system, similar to the GPS guidance system in use at this time, will produce flight paths with on/off markings, and compute the amount of pesticide applied. The Adapco Wingman system ground module can also be used as a means of setting the proposed application area by forecasting an optimal swath pattern, given estimated weather. The timing of application events will follow those set for truck applications, above.

The use of the Adapco system, which will optimize any required applications, in concert with the advances in surveillance to ensure applications are only made when truly needed, and the intended reduction in mosquito populations of greatest concern through the use of progressive water management, are all expected to result in less use of adulticides over the life of the Long-Term Plan.

Resistance Concerns

All pesticide uses have an inherent risk of generating resistance in the target species. Resistance is minimized by using appropriately high enough concentrations of pesticide. Resistance can also be minimized by alternating pesticides applied in order to reduce the potential of repeated use of only one formulation to select against that formulation. The probability of a mosquito being less sensitive to two different insecticides is reduced in comparison to the chances of being less sensitive to one, especially if they have different modes of action.

The formulators of the Long-Term Plan believe that the Caged Fish experiment justifies a reliance on resmethrin as an adulticide. Reliance on one compound does raise resistance concerns. These are mitigated by the few adulticide applications made by SCVC over the course of a year, and by the small area impacted by adulticide events. This allows for a great many adult mosquitoes to reach maturity without contact with resmethrin. These mosquitoes will serve as a reservoir of genes to ensure that resistance does not become a dominant trait in Suffolk County mosquito populations.

However, this informal check on resistance is not sufficient. Therefore, SCVC should develop an improved resistance monitoring program. This kind of work is very specialized, and needs to be exceedingly precise and refined. This is because learning that the County has developed a sizable population of resistant mosquitoes would mean that it would be difficult to implement measures to relax selection and allow the return of susceptible mosquitoes. Good resistance monitoring determines if a problem is developing, and allows actions to be taken so that all pesticide tools can continue to be effective in achieving desired ends. New Jersey has an especially sophisticated program facilitated by Rutgers University Mosquito Research and Control Unit, and it is recommended that the County enter into a program with that group. The larger mosquito management companies (such as Clarke Mosquito Control) also offer such services.

Efficacy Testing

In order to explicitly validate the County's adulticide program, the County should perform efficacy tests in association with every adulticide application. Two CDC light traps would be set prior to every application, one in a control area, and one in the middle of the target zone. The samples from the night before would then be compared to samples from the night after. Adjustments to the data sets would be made based on the control site results. The focus of the results would be on reductions in numbers of mosquitoes, and, when a health emergency has been declared, reductions in the parity and infection rates for the target species.

SCVC also maintains a colony of *Cx. pipiens* in the laboratory. These mosquitoes are more usually used for laboratory investigations of such issues as pesticide effectiveness. However, mosquitoes can be put into cages, and set outside at appropriate or important sites to document adulticide application effectiveness. The results are generally recorded as the percent of exposed mosquitoes that succumb over a two or three hour interval. Caged mosquito testing is much more labor intensive than trap tests. The information generated by cage testing only bears on the immediate effectiveness of the application, and so is either very specific to the application, or is limited to the immediate time frame of the application (depending on one’s point of view). Additionally, trap data have applicability for other aspects of mosquito control work. In sum, SCVC would conduct relatively few cage tests in any seasons (one or two are likely to be standard).

Each aerial application efficacy result set should be released within a week or so of the application. Results should also be released on an annual basis for the program as a whole. The individual events could be discussed in detail at that time.

Triggers for Adult Control

Adult control occurs under two sets of circumstances. One is for vector control (predominantly to address quality of life impairments). The second is under a Health Emergency (predominantly to address potential impacts to human health). The triggers for each are based on different multi-variate analyses of a host of surveillance data and environmental and historical trends and patterns. Table ES-7 states the factors and their general use.

Table ES-7. General Adulticide Decision Parameters

Type of Parameter		**Factor for Vector Control Applications?**	**Factor for Applications under Health Emergency?**	**Criteria**	**Comment**
Basic Surveillance Parameters	Number of mosquitoes	Yes	No	Counts in light traps significantly above norm; landing rates; complaints	Not a fixed value; somewhat species specific; ~ 25 per NJ trap, ~ 100 per CDC trap; landing rate 5+/min.; complaints invaluable where traps are not set; intend to set CDC traps before all non-Fire Island applications
	Species present	Yes	Yes	Light trap content analysis	Information on basic mosquito biology essential: Vector Control targets aggressive biters; Health Emergency targets specific (bridge) vectors; ; intend to set CDC traps before all non-Fire Island applications
	Complaints	Yes	Yes	Number/location of calls	Evaluate in historic context; complaints must be supported with appropriate surveillance data; complaints document extent of problem better than traps can
	Historical population trends	Yes	No	Surveillance data records	Data patterns often signal that problem is about to abate, or is likely to worsen
Species Specific Parameters	Aggressiveness of target species	Yes	Yes	Documented biting patterns of trapped mosquitoes	Aggressive biters indicate greater problem, increased likelihood for bridge vector participation
	Activity patterns of target species	Yes	Yes	Documented host seeking patterns, flight ranges of trapped mosquitoes	Guides actual control decision; e.g., evening vs. later at night; day-time flying may inhibit control; spot treatments only effective for short flight range species; large flight ranges require applications to cover larger, continuous areas to be effective
	Vector Potential	No	Yes	Infection rate, vector competence, % mammalian meals of trapped species	Establishes relative risk for species present
	CDC Vector Index	No	Maybe	MIR, trap counts for all potential vectors	CDC light trap counts * MIR, summed over all vector species; higher index correlates to more human infections following week; requires high mosquito/human infection rates for use; can use only with multiple trap data sets

Type of Parameter		**Factor for Vector Control Applications?**	**Factor for Applications under Health Emergency?**	**Criteria**	**Comment**
Species specific parameters, continued	Parity rates	Sometimes	Yes	Age (blood meal history) of biting population	For Health Emergency, high parity rates indicate majority of biters had prior blood meal – direct indication of increased Vector Potential; for Vector Control, an aging population, even if smaller, will be treated since it represents increasing vector potential
	Life Cycle Type	Yes	Yes	Trap analysis	Brooded mosquitoes eventually die off on own, continuous breeders build populations over season
Public Health Parameters	Bird testing	No	Yes	Presence/absence of virus	Provides early warning in terms of bird to bird transmission; documents active disease foci in County
	CDC mosquito pool testing	No	Yes	Presence/absence of virus	Amplification vectors provide early warning, document active disease foci in County; bridge vectors indicate virus present in human biting species, is signal that human health risk is imminent
	Veterinarian reports	No	Yes	Ill/dead target animals	Non-mammals provide early warning, document active disease foci in County; mammalian cases indicate virus present in bridge vectors, signal that human health risk is imminent
	Physician reports	No	Yes	Human cases	Realized human health threat
	Disease history	No	Yes	Number of human/ important animal cases in prior years	Indicates that local conditions are favorable for pathogen amplification and transmission
	Avian dispersal/migration patterns	No	Yes	Time of year regarding dispersal of hatch year birds and known migration periods	Identifies new areas for concern, signals need to control known bridge vectors
Climatic Parameters	Current weather	Yes	Yes	Temp = 65+ Wind < 10 mph No rain	Application time decision
	Short-term weather forecast	Yes	Yes	Presence of fronts & storms; barometric patterns	Application planning
	Time of year	Yes	Yes	Spring, Summer, & Fall activity patterns for trapped mosquitoes	Species-specific behavior; generally, cooler weather retards activity, warmer weather increases activity; virus presence not as significant when activity decreases

Type of Parameter		**Factor for Vector Control Applications?**	**Factor for Applications under Health Emergency?**	**Criteria**	**Comment**
Ecological Parameters	Environmental factors in target area	Yes	No	Environmentally sensitive settings (R-T-E species)	Prior mapping is essential to clearly identify all environmentally sensitive areas; usually addressed through NYSDEC; Town and other expert cooperation is sought
	Population	Yes	Maybe	Number of impacted people/population density	For Vector Control: no people means no problem; for Health Emergency, threat may be sufficient
	Application restrictions	Yes	In some settings	Farms; no-spray list; NYSDEC wetlands, wetlands buffers; open water buffers; FINS	Vector Control no-spray areas include crop areas, no-spray list, buffers – discontinuities may make application ineffective; FINS Health Emergency criteria are more stringent than County criteria

Vector control treatment decisions are made by SCVC. The predominant intention of conducting a vector control treatment is to reduce inordinate impacts to quality of life, although necessarily reductions in risks to human health will also be accomplished. Vector control applications will almost always be limited to areas where salt marsh mosquitoes have become infested (almost always only on the south shore). Criteria for conducting a vector control treatment include:

1. Evidence of mosquitoes biting residents (there is no problem unless people are affected):

   Service requests from public - mapped to determine extent of problem

   - Requests from community leaders, elected officials

2. Verification of problem by SCVC (service requests must be confirmed by objective evidence):

   - New Jersey trap counts higher than generally found for area in question (at least 25 females of human-biting species per night).
   - CDC portable light trap counts of 100 or more.
   - Landing rates of one to five per minute.
   - Confirmatory crew reports from problem area or adjacent breeding areas.

3. Control is technically and environmentally feasible (pesticides should only be used if there will be a benefit):

   - Weather conditions predicted to be suitable (no rain, winds to be less than 10 mph, temperature to be 65ºF or above).
   - Road network adequate and appropriate for truck applications.
   - "No- treatment" wetlands, wetlands and open water buffers, and no-spray list members will not prevent adequate coverage to ensure treatment efficacy.

- There are no issues regarding listed or special concern species in the treatment area.
- Meeting label restrictions for selected compounds (such as avoiding farmland) will not compromise expected treatment efficacy.

4. Likely persistence or worsening of problem without intervention (pesticides should not be used if the problem will resolve itself):

- Considerations regarding the history of the area, such as the identification of a chronic problem area.
- Determination if the problem will spread beyond the currently affected area absent intervention, based on the life history and habits of the species involved.
- Absent immediate intervention, no relief from the problem can be expected (such as when proximity to uncontrolled sources such as Fire Island National Seashore wetlands will result in ceaseless migrations into the area).
- Crew reports from adjacent breeding areas suggest adults will soon move into populated areas.
- Life history factors of mosquitoes present – i.e., if a brooded species is involved, determining if the brood is young or is naturally declining.
- Seasonal and weather factors, in that cool weather generally alleviates immediate problems, but warm weather and/or the onset of peak viral seasons exacerbate concerns.
- Determining, if the decision is delayed, if later conditions will prevent treatment at that time or not. Conversely, adverse weather conditions might remove most people from harm's way.

In essence, criteria 1 and 2 are necessary thresholds which must be met, prior to a treatment being considered. With enhanced surveillance, there will be rigorous, numeric validation of mosquito control infestation near a potentially affected population in all cases. Treatment will not occur unless criteria 1 and 2 are satisfied through a combination of surveillance indicators, although not all surveillance techniques may be feasible in every setting and situation.

Criteria 3 and 4 are "treatment negation" criteria. If certain conditions are met, treatment will not occur, even if treatment is otherwise be indicated by criteria 1 and 2. Careful records on criteria and thresholds (and related conditions) which trigger each treatment will be kept, for every adulticiding event.

The need for health emergency treatments is determined through the NYSDOH tiered approach to risk assessment for mosquito-borne disease. Table ES-8 describes the NYSDOH decision-making structure.

Table ES-8. NYSDOH Four-Tiered WNV Strategy

Tier	Circumstances	Response
I	No historical or current evidence of virus No neighboring Health Unit with historical/current evidence of virus	Level 1 education campaign Enhanced passive human/bird surveillance Consider adult mosquito surveillance (species, distribution) Lower priority for lab testing Consider larval surveillance Consider local environmental assessments Consider local disease risk assessments
II	Historical evidence of virus Neighboring Health Units with historical evidence	Level 1 enhanced education program (general community & provider community) Local environmental assessments Local disease risk assessments Active human (if evidence in-unit)/bird surveillance Larval surveillance Larval habitat source reduction Larval control Adult surveillance and lab testing
III	Current virus isolation/evidence of infection in individual locations	Level 2/3 education program (general public & provider community) Active human/bird surveillance Larval surveillance Larval habitat source reduction Larval control Adult surveillance and lab testing Adult control, ground application
IV	Current virus isolation/evidence of infection in multiple locations	Level 2/3/4 education program (general public & provider community) Active human/bird surveillance Larval surveillance Larval habitat source reduction Larval control Adult surveillance and lab testing Adult control, ground application

Historical occurrences of EEE and WNV mean Suffolk County begins each season in Tier II.

If evidence of circulating pathogens are detected (positive mosquito pools, dead birds, animal or human illness), the Commissioner of SCDHS petitions the Commissioner of NYSDOH for a Health Threat determination. Receiving this moves the County into Tier III. If evidence of viral amplification continues, and it is clear that bridge vectors make the potential for transmission to people possible (due to factors such as population, parity, and/or detection of virus), a qualitative risk assessment is conducted that factors in historical patterns, current weather, seasonal factors, population density and expectations, and professional judgement regarding the overall risk of disease and the potential to reduce that risk through an adulticide application. If, in the professional judgement of the Commissioner of SCDHS, the disease risk can be sufficiently mitigated by insecticide use, then a Health Emergency application will be made.

These decisions are tempered by the County policy regarding minimization of pesticide use, and by the understanding that unwarranted human and ecological exposure to pesticides should be avoided (the general finding of minimal risk to people or the environment from the County's preferred adulticide agent, resmethrin, notwithstanding).

ES-3.8. Administration

Organization

SCVC works closely with SCDHS to ensure ongoing health related surveillance input for SCVC decisions are made. SCDHS operates the ABDL at the Yaphank facility and is also responsible for medical surveillance, environmental monitoring, community outreach and public education, while the SCVC concentrates its efforts on mosquito control. An additional cooperative relationship exists between SCVC and SCDHS and NYSDOH to alert the County of statewide occurrences of WNV and EEE.

In the future, it is recommended that SCVC concentrate its resources on surveillance activities that involve assessing the population density and distribution of larval and adult vectors, while SCDHS continues to monitor and locate disease activity in mosquitoes and sentinel animals such as birds. Mosquito population surveillance (New Jersey traps, larvae, complaints, special traps set in problem areas) is intimately associated with the control operation and should be funded by SCDPW and be primarily a SCVC responsibility. While both SCVC and the ABDL will continue to be involved with mosquito surveillance, SCVC surveillance staff should be organized as a work unit that collects and receives New Jersey trap collections, larval samples from the SCVC crews, and conducts special larval and adult collections designed to manage the control effort. The ABDL will employ more technically demanding sampling methods, such as cold chain, which involves keeping specimens cold to prevent viral degradation.

In order to implement the recommendations of this Long-Term Plan, it is expected that significant additional resources of both personnel and equipment will be approved by the County to improve vector control practices in accordance with the findings of this study. SCDPW and

SCDHS have prepared specific proposals detailing the number and titles of new personnel required to implement this program. The actual creation and filling of these proposed positions, however, is dependent upon the County budget process.

The ABDL presently operates using a combination of SCDHS and SCVC staff to conduct viral and population surveillance. This practice creates a situation whereby the same staff members collect information related to the control aspect of the program as well as information for the disease aspect of the program. This results in programmatic competition for limited staff time. The ABDL and SCVC both need increased resources, and especially staff, to implement the draft management recommendations. Given the high priority of viral surveillance, resources are often not available to provide data and analysis directly related to the control program. In addition, the lines of supervision, control and budget are complex and not conducive to optimal use of resources. Under the proposed organization, the ABDL would be clearly tasked with viral surveillance and would control all resources needed to conduct that work. This would allow assignment of SCVC staff for activities critical to that unit, and relieve the ABDL of tasks more directly related to the control program than to disease surveillance. When the ABDL identifies viral activity, the information can be easily combined with that collected by SCVC to guide response measures. In fact, increased and more sophisticated surveillance by SCVC on vector populations should lead to a more targeted response to viral activity.

SCVC staff will manage its workload to allow it to assist with viral surveillance, if needed, during the peak viral season (August and early September). However, peak viral season historically has coincided with the times when the demands on SCVC staff associated with the complexities involved in adulticide planning, permitting, and follow-up have also peaked. If this seasonal pattern continues under the Long-Term Plan, it would limit SCVC's ability to provide assistance. ABDL staffing levels should not be based on an assumption that SCVC staff will be available for all peak viral surveillance workloads. During times of a declared public health threat, all surveillance and control resources will be controlled by SCDHS, as outlined in the County Charter. High priority viral sampling may have to take priority over other surveillance. SCDHS will be required, of course, to continue to ensure that all aspects of the Long Term Plan are complied with, to the maximum extent practical.

In summary:

- It makes organizational sense for SCVC to collect and manage the data it needs for its day-to-day control operation.
- It makes organizational sense for SCDHS to survey for human pathogens.
- Most of SCVC's effort is preventative and conducted based on the abundance and distribution of vectors, rather than in direct response to pathogens, and so is conducted prior to and independent of the detection of pathogens.
- SCVC's sampling needs are directed mostly toward those areas where mosquitoes are most abundant, while the ABDL is most concerned with determining where pathogens may be present.
- Vector sampling is time-critical, in that daily control decisions depend on it.
- The samples collected for monitoring purposes by SCVC do not require being kept in cold storage after collection, as those collected by the ABDL for viral detection do.
- A division of labor between the sampling programs allows each one to operate in a manner that optimizes its efforts.

The current level of coordination between the ABDL and SCVC regarding adulticide decisions when there is no declared health threat appears adequate. The standard e-mail notices for the adulticide operations should include a brief description of the surveillance indicators for the operation, a practice that has begun this season. During a declared health threat, adulticide decisions are controlled by SCDHS as required by the County Charter. It has been standard practice at these times for SCDHS to delegate control decisions based on mosquito population levels to the SCVC Superintendent. Decisions regarding applications in direct response to viral findings and human disease risk have been made by SCDHS, with technical input from SCVC.

The County currently has a capital project in progress to upgrade SCVC facilities and the ABDL. Upgrading the laboratory will provide it with the BSL-3 certification required to become fully autonomous. Obtaining this certification would allow samples to be processed in-house, decreasing the amount of time required to obtained results significantly. The BSL-3 certification would also provide the ABDL with the ability to test samples for all types of mosquito-borne viruses, such as EEE. Under the current scenario, sending samples to Albany is a necessity because the state laboratory tests for all types of mosquito-borne viruses, such as EEE and St. Louis Encephalitis, while the Taqman and RAMP methods only detect WNV. Testing for all types of mosquito-borne viruses ensures that field detection systems and laboratory detection systems are working, and that unexpected arboviruses do not pass unnoticed. SCVC and the ABDL should share lab facilities, wherever these facilities ultimately are built, to avoid duplication and facilitate coordination.

Professional Education

Continuing education provides professional staff with the opportunity to gather information on current and novel mosquito control techniques. Professional education for mosquito control workers includes:

- pesticide training programs
- short courses in mosquito control
- "Right to Know" training for hazardous substances
- attendance at state, regional and national mosquito control conferences

Pesticide applicators are required to acquire 18 hours of continuing education every three years in order to maintain licensing. Formal courses offered in the immediate area that would be of value to SCVC and ABDL personnel include species identification short courses taught at both Rutgers and Cornell. Travel restrictions make attendance at these courses difficult. Although Cornell is located in-state, the distance from the County means overnight stays are a necessity. The Rutgers courses can be commuted to, but constitute out-of-state travel, which is currently restricted by County policy.

Specifically, the productivity of SCVC staff and the existing mosquito control program would benefit by allowing additional travel. Two regional meetings should be attended by two additional professional staff, such as an entomologist and biologist. There should be regular participation in additional regional (Northeastern Mosquito Control Association, Mid-Atlantic Mosquito Control Association, and New Jersey Mosquito Control Association, as examples) and national meetings (CDC annual WNV conference, AMCA national and Washington meetings, and the Society of Vector Ecologists, as examples) by the Superintendent. Suffolk County should also participate in the Associated Executives of Mosquito Control in New Jersey, an organization of superintendents and other key mosquito control officials that meets on a monthly basis. The Associated Executives provides a forum for officials with similar issues and problems to share information. It helps prevent "re-inventing the wheel" by more than one agency, saving time and money for all concerned. Technical staff should also attend professional training offered at Rutgers and/or Cornell in mosquito biology and identification to improve their mosquito identification and sampling skills. Such training will be especially valuable for field technicians responsible for retrieving traps from distant locations, such as the north shore, and utilizing proposed identification stations.

ES-3.9 Adaptive Management

The Long-Term Plan is not intended to be static. This is for two basic reasons. One is that changes in disease occurrence, technology, or conditions may require adaptations to the Plan as currently envisioned. It may be that the basic direction described here is still the means by which the County wishes to achieve its ends, but exact methods need refining. If that is the case, the Plan does not need to be entirely reworked, but merely massaged to account for the changes.

Secondly, some parts of the Plan forthrightly express that necessary information to complete the planning process was not yet available, or could not be compiled at this time. As that information becomes available, changes in or more complete descriptions of plans will be constructed.

The mechanisms by which the Long-Term Plan can be amended include:

- Changes referenced in the Annual Plan of Work. Each Plan of Work will be required, in order to meet SEQRA requirements, to comply with conditions and thresholds set in the Long-Term Plan. This does not prevent minor changes to the Long-Term Plan from being introduced through the Annual Plans of Work. Each Annual Plan of Work will be appended to the Long-Term Plan to make that mode of change explicit.

- The Wetlands Annual Strategy Plan. This plan will advance the broad plans outlined in the Wetlands Management Plan through particular project designs and plans. This document was also identified as a means for adjusting the overall Goals and Objectives of the Wetlands Management Plan. Each Wetlands Annual Strategy Plan will be appended to the Long-Term Plan.

- The triennial Long-Term Plan update. This report also provides a mechanism for adjusting plan Goals and Objectives, and determining if adjustments need to be made to specific areas of the Plan. Each one will also be appended to the Long-Term Plan.

All three of these reports will be reviewed by the Steering Committee, and submitted to the Legislature for approval. This ensures that necessary adjustments to the Plan are incorporated in the same open and public process that produced the Long-Term Plan, and that adequate review is undertaken prior to adoption of any consequential change.

ES-4. Potential Impacts of the Long-Term Plan, and Mitigation of the Potential Impacts

The following section summarizes the potential impacts found for the actions associated with the Long-Term Plan, described immediately above (in brief), and also presents mitigations for the potential impacts. Certain details have been omitted, for brevity's sake. The full impact assessment can be found in the main body of the DGEIS (in Section 7).

ES-4.1 Potential Impacts Associated with Public Education and Outreach, and their Mitigation

Potential Impacts

The effects of the public education and outreach programs are are positive. People who are not exposed to mosquitoes cannot be negatively impacted by them. It appears *Cx. pipiens*, the house mosquito, can be significantly controlled by homeowner actions, and, as the mosquito tends not to travel far, the benefits of household water management are experienced by those who conduct it. *Cx. pipiens* is an essential element in the propagation of WNV, if not the principal human vector. This means there are opportunities to decrease human health risks through the education programs.

Avoidance of mosquitoes, and the use of DEET when exposed to mosquito conditions, appears to provide protection from mosquito-borne disease (NYSDOH, 2001a). However, in some situations, avoidance of mosquitoes requires severe limitations on outside activities. Although most mosquitoes are not active during the day, *Oc. sollicitans* (the salt marsh mosquito) is a very aggressive day biter when disturbed from daytime resting places (often in lawns or open fields). Therefore, if a brood of *Oc. sollicitans* has invaded a neighborhood, there may be times when it is not possible to have peaceful enjoyment of one's yard.

The compound DEET (N,N-diethyl-m-toluamide) was first registered as an insect repellent in 1957. It is used to repel biting insects, such as mosquitoes, ticks and flies (USEPA, 2004a), by interfering with the insect's ability to sense or locate animals to feed on. DEET can be used in homes, applied directly on the skin and clothing, and can be used to protect animals (such as dogs, cats and horses). The percentage of DEET in products can vary, ranging from about five to

100 percent (USEPA, 1998a). It is remarkably effective and studies have shown consistent abilities to allow people to share space with mosquitoes seeking blood meals and yet avoid nearly all bites (Fradin and Day, 2002).

Up to 20 percent of a dermal application of DEET can be absorbed through the skin (USEPA, 1998a). It is generally eliminated through urine within several hours, and does not accumulate (Qiu et al., 1998). Use of sunscreens with added DEET enhances absorption (NYSDOH, 2001b).

There have been some reports of seizures in children using DEET products (Oransky et al., 1989). The number of cases of effects appears to be quite small, given broad estimates of 50 to 100 million users each year. USEPA (1998a) concluded that although DEET was implicated in certain seizure cases, insufficient evidence existed to conclude that DEET caused the seizures. Nonetheless, USEPA suggested it is prudent to exercise caution in the use of DEET directly on the skin. There are some indications that long-term use may have some negative effects, although these reports are either from animal studies or anecdotal. Studies of synergistic effects of DEET with other chemicals (from Gulf War Syndrome research) are not conclusive (Gillette and Bloomquist, 2003).

The US Army has found it difficult to ensure that soldiers use DEET as ordered. Compliance rates, even when under orders, have been low as 50 percent. Aesthetic problems, including the feel of the repellent on the skin and its odor, are cited (as well as fears associated with some of the concerns raised above). The Army is now developing its own alternative to DEET (Debboun and Klun, 2005).

Some repellents are said to be "just as good" as DEET. Most do not measure up in independent research (Fradin and Day, 2002). Some that have fared well include:

- BiteBlocker (a botanical product) (Fradin and Day, 2002)
- Picaridin (a European repellent) (recently receiving approval as effective in New York State)
- Oil of Eucalyptus (a botanical also recently receiving approval as an effective repellent)

Citronella has been found to be very effective, despite word of mouth to the contrary (Fradin and Day, 2002). It may be that reactions between an individual's skin/skin chemicals/other applied soaps, perfumes, etc., result in particular combinations that serve to repel mosquitoes. This may account for products that have fierce loyalties, but test poorly. However, for citronella, Health Canada has raised concerns regarding potential negative impacts to people from use of the material on the skin (Health Canada, 2004). Overall, NYSDOH still recommends the use of DEET (NYSDOH, 2001b).

Public education and outreach associated with current operations appear to reduce impacts associated with mosquito-borne disease, albeit in ways that cannot be quantified. Work in Canada did find significant reductions in WNV risks when residents used two of three personal protection steps (avoiding mosquitoes, wearing long-sleeved shirts and long pants, and applying repellent) (Loeb et al., 2005). However, general compliance rates for such advisories have not been well determined. Some surveys in Louisiana suggest that decision making regarding personal protection is complex, formed by sociological issues as well as scientific and technical education on disease transmission (Zielinski-Gutierrez, 2002). Nonetheless, the outreach program may reduce impacts associated with pesticides applications if various guidances are heeded.

Mitigation

Although it is not clear that any health impacts result from the use of DEET, the County will echo the NYSDEC position and urge the public to use caution when applying DEET to skin. Most importantly, the public will be reminded that label directions must be followed. Any potential impacts associated with DEET use are mitigated by reductions in disease risk associated with its effective deterrence of mosquito bites.

The County will also seek to mitigate potential impacts to those areas that commonly receive one (or more) Vector Control adulticide application in a season. Targeted outreach will stress the importance of avoiding exposure to mosquitoes, and in taking mitigating steps if exposure cannot be avoided. The Commissioner of SCDHS will also craft an advisory detailing the means that SCDHS recommends (or suggests) to minimize risks for potential impacts from exposure to adulticides.

ES-4.2 Potential Impacts Associated with Surveillance, and their Mitigation

Potential Impacts

Surveillance is central to treatment decisions. It determines the initial, potential need for treatment, bounds the areas of concern, and provides the input to form the justification for or against the application of pesticides (or other actions to control mosquito populations).

Such surveillance is essential to the practice of IPM. IPM requires that treatments be commensurate with the problem. Without accurate surveillance, there is no means of determining the scope of the problem, and therefore no means of determining what treatment is best. Because of this central role in grounding the entire process, surveillance must be viewed as an entirely favorable process.

The current approach reduces impacts associated with mosquito-borne disease by allowing prophylactic measures to be taken prior to any disease incidence. It also reduces disease risk by limiting vector populations by determining where incipient mosquito problems may be brewing. Good surveillance reduces the use of adulticides by allowing problems to be addressed more appropriately and earlier. An argument could be presented that surveillance, by identifying problems, causes more pesticide use since otherwise the problem might never have been detected. However, mosquito problems are generally defined by the presence of people. Therefore, surveillance identifies problems using scientific techniques, problems that eventually would be identified through complaint calls from the affected population. Essentially, surveillance drives IPM. The accepted principle of IPM is intervention should be appropriate and early, rather than late.

Efficacy testing will be implemented (both for larvicides and adulticides). Although adulticide efficacy testing is a goal of current operations, the press of limited resources means it is often foregone. Efficacy testing will be a higher priority issue under the Long-Term Plan.

Disease surveillance will also be improved from current methods. There will be changes in EEE monitoring, in response to reconsideration of the dynamics of that disease, including reassessment of potential amplification loci. It appears likely that dead birds will no longer be as useful as WNV surveillance tools; a major issue for the program will be to determine if another indirect measurement of virus presence can be developed, or whether CDC trapping needs to be increased to meet new surveillance demands. The development of in-house virus testing will continue through the proposed BSL-3 laboratory project; until that is implemented, faster turn around times will be used through NYSDOH to increase the information value of the pool testing.

Staffing for surveillance for both SCVC and the ABDL will be increased, and the division of authority more clearly defined in the laboratory facilities, to allow for efficient gathering and processing of both population and disease information. Data management will also be improved, especially through GIS. Public dissemination of much of the information generated in these programs will also be increased, to justify the program and its control decisions more clearly.

Although this effort will require the commitment of additional resources by the County, including a substantial capital investment for a new, specialized laboratory (the added value to the information used for decision making justifies the cost). Current decision making is done in accord with NYSDOH and CDC guidance, but sometimes relies on qualitative information, or data that is a little older than would be preferred. This requires the professionals within SCDHS and SCVC to exercise their experience and judgment in order to make the best possible decisions. Better surveillance can make the quality of the information better, and so ensure that the professionals have the best possible means of making the best possible decisions for what may be crucial public health situations for the residents of the County.

The Long-Term Plan surveillance program should provide the means of reducing mosquito-borne disease impacts from the current, relatively low risk. Improved surveillance may reduce pesticide usage slightly, although that is difficult to forecast. In the case of EEE situations, more complete surveillance may actually lead to more pesticide use, to prevent the disease from impacting public health. Replacing ditch maintenance with a more complete, progressive water management option should mean that surveillance will have, insofar as it promotes effective progressive water management, certain positive environmental effects.

Mitigation

Surveillance will cost money and effort, and require minor expenditures of energy. Changes proposed by the Long-Term Plan are incremental from current levels, however. These are all mitigated by the immense benefits brought to a program making decisions on the basis of scientifically collected information.

ES-4.3 Potential Impacts Associated with Source Reduction, and their Mitigation

Potential Impacts

Benefits to source reduction efforts in water management structures are fairly clear, as *Cx. pipiens* is the primary zoonotic vector of WNV, and uses these habitats to breed in. Recharge basins also support other fresh water mosquitoes. Human discomfort, at a minimum, can be decreased by controlling mosquitoes in these habitats and if bridge vectors are produced, control efforts can reduce risks to human health.

The need for expanded treatment of storm water systems, documented nationwide (see Metzger et al., 2002), was proven through the surveys of such systems discussed in Section 6, above. Storm water system managers are well aware of the need to conduct maintenance on the systems (Brzozowski, 2004), which commonly includes regular cleaning of the catch basins and regarding or recharge basins. However, as is often the case, maintenance is often deferred due to short-term budgetary concerns despite calculations showing later actions result in higher costs (Reese and Presler, 2005).

Impacts associated with the use of larvicides in general, and methoprene in particular, are discussed below. Impacts associated with the use of biocontrols are discussed below.

Tires are replacing tree holes as a preferred breeding environment for certain mosquitoes. Tires always have a "down" side in which water can collect, and are impervious, so that the collected water must evaporate to remove potential habitat. The mosquitoes using tires to breed in include some of the more aggressive human biting species, such as *Ochlerotatus japonicus* and *Ochlerotatus triseriatus*. Both are known vectors of WNV. *Oc. triseriatus* is also known as a vector of La Crosse virus, although that encephalitis is not found in Suffolk County. *Oc.*

triseriatus transmits La Crosse virus vertically, that is from mother to daughter. Especially severe outbreaks tend to cluster, which suggests that a particularly virulent strain may be transmitted through generations at a local breeding point, such as a small tire dump (Kitron et al., 1997).

Benefits from the augmented source control program of the Long-Term Plan are likely to exceed those associated with the current program. There is a discernable cost, especially associated with the expansion of the catch basin program. This will require additional staff to conduct the same kind of work. However, by increasing geographical coverage of the catch basin program, the areas where *Culex* mosquitoes are controlled may be expanded. Illness from WNV has been experienced in areas of Suffolk County where only *Culex* are present in large numbers; this suggests local sources for the mosquitoes, and, in some of these areas, the current criteria for catch basin treatments are not met. Although there is no proof that catch basin breeding results in more disease, Los Angeles (for one) found an extraordinary correlation between elimination of *Culex* breeding in storm water systems, and reductions in local cases of WNV (Kluh et al., 2005) (but Los Angeles also appears to have different *Culex* species acting as vectors for the disease). Benefits from this proposed plan of action include potential reductions in mosquito-borne disease impacts, such as reducing the potential for La Crosse virus to become established locally, and particularly reducing risks associated with WNV. Improved catch basin and recharge basin maintenance by the responsible parties could result in less use of larvicides in those environments. Potentially, improved source reduction could also limit the need for adulticide applications to control WNV risks. Potential impacts include the wastes that may need disposal due to increased stormwater system maintenance. These sediments are growing more difficult to properly dispose, as the realization that they may be enriched in hydrocarbons and metals is limiting beneficial reuse possibilities, and landfills are now few in number in Suffolk County. Collected tires, too, are a growing waste management problem, as disposal in New York is not allowed (they must be recycled, and are not supposed to be incinerated or landfilled).

Mitigation

The Long-Term Plan proposes to make a large increase in the scope of catch basin sampling. Catch basins clearly support the breeding of *Culex spp*. mosquitoes, which have been implicated as the primary vector for WNV in the US. Currently the County monitors catch basins if they are in an area with a high water table. The Long-Term Plan, on the basis of information collected as part of the Plan development, calls for much more effort to monitor catch basins. This will require significant expenditures of personnel effort, with associated monetary costs. These should be mitigated by reductions in disease risk if additional *Culex* breeding locations are identified and treated.

Collection of littered tires can cause a waste management problem, and the maintenance of stormwater structures can also generate some-what problematic materials. The scope of these problems, in light of waste management as a whole County-wide, is not great. The impact of problems associated with these waste streams is mitigated by the potential for improved mosquito management, and especially in the reductions of risks to human health.

ES-4.4 Potential Impacts Associated with Water Management, and their Mitigation

Potential Impacts

There are approximately 17,000 acres of vegetated tidal wetlands in Suffolk County. There are another 18,000 acres of regulated fresh water wetlands. The impact analysis in the DGEIS proper (Section 7) focuses on 22 different marshes in the County, as specific examples from which generic analyses ere made. The 22 marshes consist of 21 Primary Study Areas (PSAs), plus the OMWM demonstration sites at Wertheim National Wildlife Refuge. In the interest of brevity, and absent the background descriptions of the 22 sites that set the particular analyses in perspective, a more general discussion will be followed here.

Modern mosquito management is guided by the principles of IPM. The tenets of IPM call for actions to be consonant with the threat, and appropriate for the degree of control desired. In most instances, IPM finds that control of a problem nearest to the beginning of the problem is the most effective means of control. This is generally called source reduction, and implies that addressing the source of the problem may limit impacts both spatially and temporally. Source reduction proceeds in two ways. One is control of limited problems with immediate causes, such as assisting a homeowner to eliminate standing water in the vicinity of a house. The second is water management to eliminate larval habitat (Rose, 2001).

Mosquitoes have a life cycle with two distinct parts. They spend their adult lives as air-borne winged insects. As larvae, they live in aquatic settings (Clements, 1992). Shallow, temporary, still water is favored habitat for many species for several reasons. One is that larval mosquitoes do not have gills, and so need to breathe air. Shallow environments provide access to the surface for oxygen needs and to the bottom for cover and foraging. Temporary waters reduce the number of predators, which allows mosquitoes to avoid diverting resources towards defense mechanisms. Still waters allow for connection of siphons to through the surface film to access the atmosphere for breathing.

Wetlands, once scorned and unvalued, have become prized regions in the 21st Century. This is due to their ecological and human resource values. Most derive from their geographical position at the interface between land and water (Teal and Teal, 1969). Persistent water solves many biological problems associated with life on land, and inputs of land-derived chemicals into water addresses issues caused by dilution and flow. The interface physically serves as a barrier for erosive and flooding impacts of water to land, and also serves as a means of dispersing many effects that the land can cause to areas of water.

Mosquitoes have caused and still cause sickness and misery for people. It was recognized around 1900 that mosquitoes were the vector for important human diseases such as yellow fever and malaria (Spielman and D'Antonio, 2001). It was also known that mosquitoes are relatively concentrated as larvae, and much more dispersed as adults. These facts, together with the relatively low value placed on wetlands, gave license for mass alterations of these habitats in the name of mosquito control in the early 20th Century. Wetlands were filled, drained, and ditched to reduce mosquito populations by eliminating habitat that could support larvae, and also to create land areas that had greater perceived value (Richards, 1938).

Mosquitoes still can impact the lives of most people living in Suffolk County, by threatening health and well-being. The risk of suffering these impacts is, on the whole, less in the first decade of the 21st Century than 100 years earlier, as arboviruses, while still sometimes deadly, kill fewer people than formerly died from mosquito-borne disease (Gubler, 2001), and pestiferous biting populations have been reduced (Campbell et al., 2005). Nonetheless, mosquito control principles still recognize that it is easier and more efficient to control mosquitoes as larvae. A major change is the recognition of the value of wetlands, and so modern, progressive water management intends to enhance ecological values of the wetlands being manipulated instead of ignoring these values (Wolfe, 1996).

SCVC is responsible for wetlands management in three distinct environments. It has responsibilities for a variety of non-mosquito control structures and conditions, such as culverts, dikes, and dredge spoil disposal areas. SCVC has responsibilities for these areas because it is the major wetlands management agency in County government. SCVC is responsible for addressing flooding, drainage, and habitat issues associated with these areas, and to ensure that these areas do not constitute major mosquito breeding problems.

The second environment where SCVC has responsibilities is the marshes where grid ditching occurred. This legacy from past practices covers over 95 percent of all the coastal marshes in the County. The grid ditched areas often need continuing management to:

1. reduce mosquito impacts to people; and
2. ensure the marshes are healthy, productive, and retain desired functionalities.

These responsibilities are often carried out on property owned and managed by entities other than the County, and under regimens of regulations established not necessarily to properly manage the marshes, but rather to protect them from damage.

Finally, there are marshes where SCVC does not act. Sometimes this is by self-imposed choice, and sometimes this is by fiat. Some of the restrictions are not complete restrictions on all actions, but only to a subset of the activities undertaken by SCVC, such as prohibitions on maintaining the grid ditch network at a particular marsh.

As part of the Long-Term Plan, Suffolk County has established a mechanism by which an overarching management program will be established for the County. Through the Steering Committee for the Wetlands Management Plan implementation, the County will develop a management plan that ensures the natural resources, functions, and values of the County's marshes are preserved, and enhanced where such improvements are required. As part of this effort, management of County marshes for the purposes of mosquito management will be closely reviewed, and projects will only be implemented where natural resource values will not be degraded. The Wetlands Management Plan was crafted so as to ensure these results ensue from management activities under the Long-Term Plan.

Water management relies on two different techniques to reduce larval populations. One is to physically reduce breeding habitat. The second is to employ biological controls on larvae – predominantly, having marsh fish feed on the larvae before they can develop. The latter, if proper fish habitat can be maintained, appears to be more effective as a long-term control measure than the first (Dale and Hulsman, 1990).

Two general approaches to water management are customary in the northeast US. One is called standard water management. This is the installation of ditches, and subsequent maintenance of the ditch network. At this time, there is little need or desire to continue installing grid ditch networks, and so standard water management is the maintenance of the grid ditch legacy (Ferrigno and Jobbins, 1968).

Ditches were installed with steep sides, typically up to three feet deep and two to eight feet wide (Dale and Hulsman, 1990). On Long Island, three to four feet was the most common width (Taylor, 1938). Distances between ditches were commonly 100 to 300 feet. Soil permeability was supposed to determine the selected width, with less permeable soils requiring closer ditching (Dale and Hulsman, 1990). Ditching was intended to reduce mosquito breeding by draining standing water on the marshes (Dreyer and Niering, 1995), and also by allowing fish access to breeding areas (Richards, 1938); ditching may also reduce oviposition sites by reducing the area of the marsh where damp soils can be found (Dale and Hulsman, 1990).

The effectiveness of ditching as a mosquito reduction technique has been disputed (Nixon, 1982; Daiber, 1986), although most accounts agree that the combination of marsh filling and ditch construction in the early 20th Century did suppress mosquito populations sufficiently to allow for much greater development in many shoreline areas. This was particularly noted for the south shore of Long Island (Taylor, 1938).

The overall impact of this ditching on the condition and health of salt marshes has been the subject of acrimonious disputes. Generally, ditching is said to have changed marshes in four ways (which sometimes intersect and overlap). They are:

1. reductions in the amount of mosquito breeding;
2. alterations of the salt water table found in the marsh peats
3. vegetation distribution changes
4. changes in use of the marsh by important species or species guilds

(Cashin Associates, 2004a)

The strength of opinions offered on both sides (e.g., Bourn and Cottam, 1950; Provost, 1977) suggests that the impacts do occur, but are not equally as great everywhere because of mitigating factors associated with particular marsh settings and ecologies (although see Nixon, 1980, who characterized the disputes as being supported by predispositions to find or not find impacts).

Ditching, as originally conceived, was intended to alter the hydrology of the marsh. There is some disagreement even about this. For the south shore of Long Island, for example, it was suggested that ditches do not "drain" the marsh, but instead relocate water from the marsh surface to the ditches (Taylor, 1938). This presumably addresses the low tidal range and persistence of water in the ditches of these marshes. In other settings, where greater tidal ranges mean the ditches often dry during low tides, it seems supportable to discuss ditches draining away water from the marsh (Dale and Hulsman, 1990).

Most of the observed impacts of (or impacts attributed to) ditching stem from water table differences. Loss of surface water, for example, results in loss of habitat for muskrats (Bourn and Cottam, 1950) and diminished water fowl use of the marsh (Clarke et al., 1984). Other birds, for complex reasons, may not find the habitat as amenable, as was suggested for sharp-tailed sparrows (Post and Greenlaw, 1975). Changes in the water table may promote different vegetation on the marsh. Woody, upland-type vegetation are often found out on the marsh after ditch installation (Miller and Egler, 1950), and *Phragmites* invasion is believed to be fostered by ditching (Bart and Hartman, 2002). *Phragmites* colonization after ditching may be supported by drying out of the marsh in general, or it may be that *Phragmites* first colonizes drier areas along the ditches, and then spreads into the interior of panels, although the water table there is no lower or fresher than it was pre-ditching. There is ample evidence that *Phragmites* propagation by runner does not require the drier, less salty conditions that seed germination needs (Warren et al., 2001). The drier area along the ditch may be from drainage, or from the establishment of a berm along the ditch edge from poor spoils placement or the hypothetical settling out of particles as the tide wells up out of the ditch.

Ditching seems to have fostered *S. patens* expansion in some areas (Redfield, 1972). At Gilgo, an unditched area has a measurably higher *S. patens* to *S. alterniflora* area ratio than a ditched area did (Merriam, 1974). On Long Island's south shore, where many of the marshes are "green lawns" of *S. patens*, ditching has been cited as a primary cause (Taylor, 1938). However, an analytical study of Long Island's marshes found that, 30 or more years after ditching, the proportion of low marsh had increased at the expense of high marsh. The calculation was admittedly skewed by the filling of marshes, which was assumed to reduce the acreage of high marsh more than low marsh (O'Connor and Terry, 1972). Since the distinction between *S. alterniflora* zones and *S. patens* zones is generally established by the frequency of daily inundations (*S. alterniflora* can overcome the constant root zone anoxia that results from constant flooding) (Witje and Gallagher, 1996a; Witje and Gallagher, 1996b), and not by salinity differences (Pennings and Bertness, 1999), unless the installation of ditches caused changes in tidal inundation on top of the marsh by affecting the tidal prism, reports that ditching increased either high marsh or low marsh areas are not easy to explain.

In some areas, ditches may expand low marsh vegetation (*S. alterniflora*) by providing for higher salinity water deeper into the marsh, promoting waterlogged soils near the ditch sides (Miller and Egler, 1950). Another reason given for this impact is that ditches increase tidal penetration into and on top of the marsh (Kennish, 2001) (see just below). There may be other reasons than ditches for increases in *S. alterniflora* acreage, as there is some evidence that nutrient additions allow it to outcompete *S. patens* and therefore expand its range without further tidal inundation (Bertness et al., 2002).

Sometimes it has been asserted that ditching affects the tidal inundation of the marsh. It has been suggested that ditches absorb more of the tidal prism by increasing the depth below the marsh surface (Collins et al., 1986). This seems unlikely, given the immense volume of tidal inundations compared to the total volume found in the ditches.

Salt marshes, through marsh surface plant-sediment reactions, are often credited with water treatment capabilities. The accumulation of sediment in marshes generally indicates that nutrients and particle-associated contaminants will also accumulate in a marsh (Nixon, 1980). However, the effectiveness of the removal of contaminants and sequestration of various substances depends on various attributes of the marsh. Very roughly speaking, younger marshes that have more restricted connections to an estuary appear to accumulate materials more than older marshes with better estuarine connections (Valiela et al., 2000).

It should be understood that the greatest source of water to the surface of the marsh is tidal inundation. Therefore, the water most often treated by the marsh will be estuarine. This does not mean that salt marshes do not filter land-generated contaminants. This function is often listed as an important attribute of salt marshes. This concept seems to have been developed by considering how a constructed wastewater wetland works, in that it treats water flowing from the upland area towards the downslope area (Zdragas et al., 2002). However, especially on Long Island where nearly one-half of all ground water discharges as submarine flows, and run-off comprises at most only about five percent of stream flows (Buxton and Smolensky, 1999), recycling of off-shore estuarine water up onto the marsh is likely to be the most prevalent, albeit indirect, mechanism for salt marsh treatments of pollutants in some flows (see Montague et al., 1987). Ditches may reduce the time water spends on the reactive marsh surface, and so result in a decrease of the absorption of materials by the marsh. However, this can also be seen as beneficial, if the marsh is also serving as a positive exporter of valuable carbon, nutrients, and other needed material to the estuarine ecosystem (Odum et al., 1979; Odum, 2000). There is no direct evidence, especially on Long Island, that ditches by themselves serve as pathways for land-based pollutants to reach the estuary through some mechanism that short-circuits the treatment of storm water run-off.

In some instances, storm water management systems have been designed so as to discharge directly to the marsh, or to ditches in the marsh. Generally, such connections are targeted for remediation through the USEPA Phase II storm water planning process (NYSDEC, 2001), although in some instances, as in Mastic Beach, it is difficult to determine what alternatives might exist.

Adding ditches to the marsh increases the perimeter areas of the marsh. In many cases, these kinds of "edge" habitats are valued, because they increase exchange between two different ecotones. For estuarine fish, for example, ditches (and other marsh channels) increase access to the productivity of the marsh (Whalley and Minello, 2002), and so would be habitat enhancements if the water quality in them is adequate.

The aesthetics of ditching are usually judged to be inferior. Salt marshes are generally perceived as being part of the natural, wilder world surrounding Long Island suburbia. The presence of geometrical structures across such environments is an unacceptable reminder of their managed nature to many people.

In addition, the County also has the choice of not altering a marsh, and allowing natural processes to proceed in that environment. For many, this is considered to be the course of least impacts. Non-intervention in natural systems is often judged to potentially provide the most environmental benefits to the affected system. However, since Suffolk County's marshes are already managed systems, and since natural marsh systems produce mosquitoes, it is not always the choice of least impacts. Still, reversion is to be considered the presumptive interim action for County marshes, until long-term restoration management plans can be devised for each one, or unless conditions dictate otherwise.

Allowing natural processes to control the future of the marsh, so that the ditches will infill and so disappear (often referred to as marsh reversion), is intended to restore pre-ditching hydrology and vegetation. This is also seen as a no action management course, because it proceeds by passively allowing the marsh to return to its natural state. Philosophically, many believe that non-intervention in natural systems allows for the greatest amount of environmental benefits to accrue. This is an important element in how NPS manages its properties, for example. In a sense, reversion is the absence of active water management. Although this is a passive action, it has the potential to cause great changes to the existing status of the marsh.

Reversion is intended to minimize the effects of previous ditching activities on the marsh – both positive and negative, as not all aspects of a ditched marsh are perceived as being negative. The success of reversion as a restoration technique is dependent on the pace and kinds of natural processes at work in the particular marsh. In some settings, ditches seem to maintain themselves. Channels of a marsh in Barnstable, Massachusetts, were stable for over 100 years (Redfield, 1972). This may be generally true for ditches (Dale and Hulsman, 1990), especially if the correct length for a particular tidal regime was constructed (e.g., a maximum of a quarter-mile for Long Island's south shore) (Taylor, 1938). There are general reasons why salt marshes tend not to erode into surrounding waterbodies:

- high biomass of root materials per unit area
- large amounts of plant litter on the sediment surface
- relatively coarse particle sizes when compared to other wetland environments

(Odum, 1988)

Greater amounts of peat seem to correlate with particular marshes' resistance to erosion (Frey and Basan, 1985).

However, ditches often seem to widen in some marshes, especially at the ditch mouth, and this has been noted to occur at many Long Island marshes, according to comparisons of historical and current aerial photographs (Cashin Associates, 2006d). This may be due to natural processes working to create typical marsh channel morphologies in the ditch (Pethick, 1992). The steep-sided shape of the ditches can become more bowl-like, in many instances (Miller and Egler, 1950). In some instance, ditches even erode headward, due to storm water runoff causing erosion (Mariani et al., 2003; Odum et al., 1979).

However, in many instances, parts of the ditch network infill. This can be caused by:

- siltier soils (Kuenzler and Marshall, 1973)
- shoreline drift filling the mouth of the ditch (Carlson et al., 1990)
- slumping in of the ditch sides (Lathrop et al., 2000), particularly because of rain storms at low tide (Pomeroy and Imberger, 1981)
- ice erosion (Teal, 1986)
- design flaws (primarily ditches being too long for the tidal regime, so that water flows are not sufficient to remove any accumulating sediment) (Taylor, 1938)
- plants bridging the ditch and then trapping sediments (Daiber, 1986)
- sediment collection from the marsh (Redfield, 1972)
- the general nature of the ditched marsh system (Bourn and Cottam, 1950; Miller and Egler, 1950)

Filling or collapsing ditches are cited as a reason for maintaining or reconstructing the ditches as a water management technique. Ditch maintenance is the only kind of water management explicitly allowed under New York State Tidal Wetlands regulations (6 NYCRR Part 661). For that reason, SCVC has relied on ditch maintenance as its primary means of water management.

Allowing natural processes to determine the management of the marsh may not be optimal for every marsh. The presence of ditches in almost all parts of the County's marsh system means that the environment has already been altered, and it is unclear that allowing natural processes to occur will result in remediated, good functioning salt marshes, especially on a time scale acceptable to people, in all instances. In addition, it is generally thought that most natural salt marshes will produce large numbers of mosquitoes, although the truth of this assertion is difficult to prove. Chapman (1974) asserted that "wild" salt marshes produce tremendous numbers of mosquitoes, and evidence from before the advent of large-scale ditching indicates that salt marshes on the East Coast generated so many pestiferous mosquitoes as to make their general surroundings uninhabitable (Daiber, 1986). Anecdotal information from times over the past half-century in Suffolk or Nassau Counties when ditch maintenance slacked suggests that mosquito breeding increased markedly then, too (mosquito problems may have been checked by additional pesticide use, however). The Wetlands Management Plan is based on the concept that mosquito reduction can be desirable, although not necessarily under all conditions. The general rule suggests that natural processes should be judiciously used as a long-term management selection, based on the distinctive hydrology, morphology, water chemistry, physical settings and surroundings, and substrate properties associated with each marsh. Better candidates may include those marshes where natural processes have often been allowed to be the dominant management means already, and the state of the marsh reflects robust health and a thriving ecosystem. However, in the short-term, especially when carefully monitored, reversion may be the most appropriate interim management choice. It is the choice that can most easily be "undone" (by selecting an active marsh management means). Active marsh management techniques can not necessarily be undone, if desired.

Changes in the overall hydrology of the marsh are anticipated with marsh reversion. These can result in some potential negative impacts. During the design phases of the Wertheim OMWM project, State regulators often raised the issue of drowning the marsh by retaining water on it. *Phragmites* prefers fresher conditions for seed sprouting as compared to other tidal vegetation, and ditches may enhance higher salinity conditions (Havens et al., 2003), and so allowing ditches to infill could create a fresher marsh, one more suitable for *Phragmites*. The aesthetic impact of ditches would continue for at least several years. It is also possible that the entire length of a ditch will not completely infill naturally over time.

Factors that support successful use of natural processes as a management tool include:

- historical marsh health in the absence of ditch maintenance
- large tidal exchange rates, fostered by some combination of a large tidal range, a good estuarine connection, few barriers to internal water flows, and/or an extensive natural creek system
- infilling ditches from upland ends (potentially eroding at the mouths)

- relatively few people to be impacted by mosquito breeding
- killifish habitats other than ditches
- patient managers willing to allow processes to occur deliberately

The absence of some of these factors suggests that natural processes may not be the optimal management tool to use at the marsh being considered.

The second active approach to water management is more progressive and nuanced than standard water management. This is a suite of techniques developed to address perceived impacts of grid ditching, and also to more effectively control mosquito populations. This class of actions has been grouped as Open Marsh Water Management (OMWM), which consists of actions that enhance marsh conditions for fish that consume mosquito larvae in salt marshes. Creation of better fish habitat in a grid ditched marsh involves choices as to whether to keep the system open to full tidal effects or to close the system to retain water on the marsh. Many designs try to have elements of both open and closed (ditch plug) systems. Inherently, many have determined that enhancing the marsh for killifish also generally improves the marsh overall, and so, for many evaluators, OMWM is an environmental restoration technique that provides benefits, and does not have impacts (Wolfe, 1996). However, it needs to be understood that any manipulation of a complex ecological system has the potential to cause change in that system – and sometimes change for the worse.

15 Best Management Practices (BMPs) and four Interim Management/Ongoing Maintenance Activities (IMAs) were identified as the most promising means of managing the County's wetlands. Each activity is, in a sense, an alternative to the others. It is clear that selections of management alternatives must be in site-specific ways that are dependent on resource evaluations. The issue of concern in water management is selecting a marsh management technique that carries the least environmental risk compared to the potential environmental benefit, while also meeting mosquito control aims (Dale and Hulsman, 1990). The tables on pages ES-41 through ES-44 in this document summarize the BMPs and IMAs developed; the potential impacts noted here are discussed extensively in Section 7.6.2 of the DGEIS.

ES-4.5. Biocontrols

Impacts

There are some impacts associated with the stocking of *Gambusia* for mosquito control. These fish are not native to Suffolk County. The history of biological control contains a litany of situations where introduced species may have provided intended benefits, but the inadvertent impacts exceeded any possible gains (Howarth, 1991; Louda et al., 2003). *Gambusia* not only represents a potential invasive species that if released to streams or ponds could compete with local species (Courtney and Meffe, 1989), but it represents an important ecological threat even in isolated waters (per Goodsel and Kats, 1999). Many rare-threatened-endangered species in Suffolk County use vernal ponds or coastal plain ponds for habitat. In vernal ponds, for example, the lack of year-round aquatic habitat limits the ability of predators to exploit the ecological niche (Diamond and Case, 1986). Many species, especially invertebrates and amphibians, therefore use these environments and their relatively safe harborage for breeding (Stewart and Springer-Rushia, 1998). Although recharge basins are not natural settings, those that do not retain water, if they drain slowly enough, can function ecologically as vernal pools; those that retain water sometimes mimic coastal plain pond environments because the level of the water often fluctuates due to stormwater inputs that then slowly recharge to the underlying sediments. Introducing fish into these environments can have devastating effects on the unprotected species used to a relatively predator-free environment (Knapp and Matthews, 2000).

The County is investigating whether fathead minnows (*Pimephales promelas)* can be used as effectively as *Gambusia.* One issue may be whether its preference for bottom waters will reduce its larval predation. If the basin is deep enough, there may be a habitat disconnection between where the potential predator prefers to be, and where the larvae are generally found. Although fathead minnows are not native to Suffolk County, history has shown they do not have the potential that *Gambusia* does as an invasive species. Fathead minnows would represent the same ecological threat *Gambusia* does in terms of disruption of predator-free environments, however.

If the minnows are introduced judiciously and appropriately, the impacts from the Long-Term Plan would appear to be less than those associated with current operations. It remains to be seen whether the minnows (or other potential replacements, such as pumpkinseeds) are as effective as mosquito fish at controlling mosquito larvae. Generally, introducing a predator into an environment is not as effective for pest control purposes as enhancing the environment to make it more amenable for a predator that already exploits the ecological niche. This is because the introduced predator, if it is successful at controlling the pest, will either die or must find alternate food sources. If it dies off, then it must be reintroduced if the pest reappears. If it is not to die off, finding alternate food sources generally means it must compete with a native species for the resource (although ecological cycles are not necessarily zero-sum situations, and "room" may be found for the predator). Therefore, stocking fish into fresh water environments is much more disruptive to the ecosystem than, for example, enhancing water quality in a salt marsh to allow *Fundulus* to exploit a greater area of the marsh, and so find different food sources.

The County is also interested in predacious copepods, which have been reported anecdotally to thrive in catch basins. New Jersey is experimenting with these organisms, and, if successful, SCVC could consider inoculating catch basins that retain water with copepods (in place of larvicides). One problem is that the inoculated copepods must reproduce to ensure effective control, which can take a period of time (and thus may allow some *Cx. pipiens* to grow to adulthood). Although a population lag for predators in response to the new availability of prey appears to be a biological necessity, the species of copepod being tested does reproduce quickly, and is very fecund (which is why it is being considered).

Biocontrols can therefore have some effective on mosquito populations, and therefore reduce the potential impact of mosquito-borne disease. They can, when effective, mean that larvicides do not need to be used, and so reduce the potential for impacts associated with pesticides.

ES-4.6 Larval Controls

Impacts

The potential for impacts from Bti, Bs, and methoprene was assessed through a combination of a quantitative risk assessment (conducted using four specific locations within the County, to serve as treatment and geographical surrogates for the remainder of the County), some field observations and experiments, and analysis of the published scientific literature.

Quantitative Risk Assessment

An Evaluation Management Plan was developed by the County, essentially as a straw-man plan to support detailed assessment of a defined set of management options. Pesticide use was one component of the overall Evaluation Management Plan. The pesticide use scenarios defined in the Evaluation Management Plan were constructed largely based on past practices within the County, and were designed to reflect possible maximal potential application scenarios for the future. Because a goal of the Long-Term Plan is to reduce pesticide applications, past practices were believed to represent a reasonable upper-end management scenario.

The Evaluation Management Plan focused on pesticide applications in four separate study areas. The study areas were chosen as representative of past and potential future application areas within Suffolk County.

The four study areas evaluated were:

- Mastic Shirley. Mastic Shirley is located on the south shore of the Long Island mainland, in the central portion of the Town of Brookhaven, within the Mastic Beach-Shirley peninsula.
- Davis Park. Davis Park is located in the Town of Brookhaven, within the barrier island system of Fire Island National Seashore.
- Dix Hills. Dix Hills is a highly developed suburban area encompassing South Huntington, as well as portions of West Hills, Huntington Station, and Melville.
- Manorville. The Manorville study area is located in the Town of Riverhead, south of the former Calverton Naval Weapons Industrial Reserve Plant and east of the Robert Cushman Peconic River County Park.

The Evaluation Management Plan considered a variety of options for the method, frequency, and timing of pesticide applications. The application frequencies listed for each study area were calculated based on application frequencies in Suffolk County during the period 1999 to 2004. Information on the time between applications, application season, and application time of day were generated, based on past practices and/or standard conventions. The range of application methods considered also was based largely on past practices. The study areas were partially selected because they represented a range of potential application scenarios.

The analytic framework for the risk assessment was fashioned around the risk assessment paradigm developed initially by the National Academy of Sciences (NAS, 1983). In this context, risk assessment is the process of assigning magnitudes and probabilities to the adverse effects of human activities. This process involves identifying hazards, such as the release of a pesticide, and using measurement, testing, and mathematical or statistical models to quantify the relationship between the initiating event and the effects.

The NAS framework serves as the foundation for virtually all risk assessments conducted in the US, including regulatory programs within USEPA and the FDA. It routinely is used to support the development of risk-based management strategies focused on reducing overall risks to human health and the environment and, as such, provides an appropriate analytic framework to assess risks potentially associated with pesticide use for vector control in Suffolk County.

The NAS paradigm divides risk assessment into four major steps:

1. Hazard identification
2. Dose-response assessment
3. Exposure assessment
4. Risk characterization (including an analysis of uncertainties).

Hazard identification is the process of determining whether exposure to a stressor can cause an increase in the incidence of a health or ecological consequence. For this risk assessment, the stressors of concern are pesticides that are used for vector control.

For both the human health and ecological risk evaluations, the first step of the hazard identification was the development of a conceptual model that characterizes how a pesticide can be released into the environment, how it will behave once released, how it can reach human or ecological receptors, and what types of effects might be associated with exposure.

The conceptual model was developed from information about the planned pesticide use, the potentially affected populations (both human and ecological), and the potential exposures. It was used to focus the impact analysis on a defined set of stressors, receptors, and health and ecological endpoints.

Dose-response assessment is the process of characterizing the relationship between exposure and the incidence of an adverse health or ecological effect in the exposed human or ecological population. It takes into account the toxic mechanisms by which a chemical can affect human or ecological receptors and the potency for causing toxic effects. It also considers how a toxic response changes as a function of exposure intensity, frequency, and duration, as well has how toxicity can vary by life-stage (e.g., children, pregnant women) or health status (e.g., immuno-compromised individuals).

For both the human health and ecological risks assessments, the output of the dose-response assessment was an identification of numerical criteria that were used in the risk assessment. To the extent possible, these criteria were derived from published guideline values recommended by governmental agencies, such as USEPA and the Agency for Toxic Substances and Disease Registry (ATSDR), or other expert public health or toxicological research groups (e.g., WHO, or the International Agency for the Research on Cancer [IARC]).

Exposure assessment is the process of measuring or estimating the intensity, frequency, and duration of exposure to a stressor. In this risk evaluation, exposures were modeled by calculating chemical release, transport, degradation and transformation, along with the rate and magnitude of contact by humans and ecological receptors. Models developed by USEPA and other expert organizations were used.

Risk characterization is the process of estimating the incidence of a health or ecological effect under the various conditions of exposure described in the assessment. It is performed by combining the exposure and dose-response assessments. The uncertainties of the risk estimates are also fully explored in this step.

As defined by USEPA (1998b) and others, the important factors critical to the development of a conceptual risk assessment model include information defining the characteristics of the:

(1) Stressor (in this case, a pesticide) as it enters and moves in the environment (from the Literature Search, see CA-IC, 2004 and CA-SCDHS, 2005);

(2) Types of effects that could be associated with exposure to the stressor (from the Literature Search, see CA-IC, 2004 and CA-SCDHS, 2005);

(3) Potentially exposed populations that could contact (i.e., be exposed to) the stressor (from descriptions of the four study areas, see Cashin Associates, 2005i, Cashin Associates, 2005j, Cashin Associates, 2005k, and Cashin Associates, 2005l); and

(4) Endpoints that are most important to characterizing risks (from the Literature Search, see CA-IC, 2004 and CA-SCDHS, 2005).

All of the target pesticides are proposed for direct release into the environment and thereby have the potential to reach human or ecological receptors. The likelihood, magnitude, and duration of any potential exposure are dependent to a large degree on how the compound is released, where it is released and how it behaves once it is released.

Overall, the collective fate data suggest that these larvicides will dissipate relatively rapidly from the treated environment. However, under management scenarios in which the target larvicides are applied repeatedly during the mosquito season (e.g., up to 20 times per year in Mastic-Shirley), aquatic environments would experience multiple, short-term (pulsed) exposures to peak maximum concentrations. No cumulative build-up or residues are likely.

When present at sufficiently high concentrations, the target pesticides can potentially cause a variety of toxic effects in both humans and wildlife. Bti exerts its toxicity through the production of endotoxins that are specifically toxic to black fly and mosquito larvae (CA-IC, 2004). It is produced commercially in large fermentation tanks, and as bacteria live and multiply in the right conditions, each cell produces an asexual reproductive spore and a crystalline structure containing protein toxins called endotoxins (specifically delta-endotoxins) (Weinzierl et al., 1997; Mittal, 2003). Commercial products containing bti may consist of the endotoxins and spores (USEPA, 2000b), or just the endotoxins (NCIPM, 2004). The endotoxins associated with the Bti spore must be ingested by larvae before they act as poisons (and are therefore referred to as “stomach” poisons). After ingesting Bti, enzyme activity and alkaline conditions in the larvae's gut break down the crystalline structures, and activate the endotoxins (Mittal, 2003; Weinzierl et al., 1997). Once the endotoxins are activated, they rapidly bind to the cells lining the midgut membrane and create pores in the membrane, upsetting the gut's ion balance. This results in paralysis of the gut, thus interfering with normal digestion and feeding (Brown, 1998; Weinzierl et al., 1997; Lacey and Merritt, 2003; Dale and Hulsman, 1990).

Bti's selectivity in terms of its ability to target the larvae of certain insect species, particularly mosquito and black fly larvae, is attributable to the types of endotoxins it produces and the particular physiological conditions required to activate the endotoxins (CA-IC, 2004). There is some evidence of Bti effects to non-target aquatic dipterans that include midges (Chironomidae), biting midges (Ceratopogodinae), and dixid midges (Dixidae), which are commonly associated with mosquitoes within the aquatic environment. These organisms are taxonomically similar to mosquitoes and black flies and can possess the gut pH and enzymes necessary to activate the endotoxins. Adverse effects to these groups, however, have only been noted at dosages 10 to 1,000 times greater than the application rate specified for mosquito control (FCCMC, 1998).

Because of its selectivity, Bti generally is not considered a risk to non-target organisms, and USEPA has concluded that that Bti does not pose significant adverse risks to non-target organisms or the environment, especially since rates higher than those used for vector control are needed to produce any adverse effects (USEPA, 1998c). Recent literature confirms Bti's limited overall toxicity to wildlife (Brown et al., 2002; Russell et al., 2003; Lacey and Merritt, 2003).

Bti does not appear to be toxic to humans. USEPA (1998c) reported that there was no evidence that it is pathogenic to mammalian species, not that it caused adverse effects on body weight gain or tissue or organ damage upon necropsy of treated animals (CA-SCDHS, 2005). WHO (1999) has concluded that Bt products are unlikely to pose a health risk to humans

Bs is generally not considered a risk for non-target organisms. The commercially available form of Bs, VectoLex, has been extensively tested and is considered non-toxic to non-target organisms (Westchester, 2001; NYSDEC, 1996b). USEPA concluded that Bs does not pose any significant risk to non-target organisms or the environment (USEPA, 2000a).

There is no evidence that Bs is infectious, pathogenic or toxic to humans (CA-SCDHS, 2005; McClintock et al., 1995). Further, USEPA (1998d) concluded that residues of Bs on food would not be expected to result in harm, considering the low mammalian toxicity of Bs and its ubiquitous occurrence naturally.

Methoprene disrupts insect maturation and reproduction by mimicking the activity of natural juvenile insect hormone (CA-IC, 2004). At sufficiently high concentrations, it also has been shown to be toxic to fresh water invertebrates and fish, estuarine and marine invertebrates, and amphibians (USEPA, 2002a). Fresh water invertebrates are especially sensitive to methoprene, with a lowest observable adverse effect concentration (LOAEC) of 51 ppb reported (USEPA, 2002a). Overall, the potential for aquatic toxicity is mitigated by the rapid degradation of methoprene in surface water (Extoxnet, 1996a).

Methoprene is generally considered to be slightly toxic to non-toxic to terrestrial wildlife. The oral median lethal dosage (LD_{50}) for rats is greater than 10,000 mg/kg (USEPA, 2002a). Methoprene is considered slightly toxic to birds (Extoxnet, 1996a). In mallards, an acute oral LD_{50} of greater than 2,000 mg/kg in the diet was determined. Dietary no observed effect concentrations (NOECs) (based on reproductive endpoints) range from three ppm for mallard ducks to 30 ppm for bobwhite quail (USEPA, 2002a). Some data also suggest that methoprene may be toxic to bees. Schulz et al. (2002) reported that methoprene affected honeybee foraging activity.

Overall, methoprene is not expected to be toxic to humans. Its insecticidal properties are due to its action as an insect juvenile hormone analogue, which is a mechanism that is selective to insects (WHO, 1984). Methoprene has been shown to produce liver and kidney toxicity in laboratory animals under certain exposure conditions (CA-SCDHS, 2005). Methoprene does not appear to be carcinogenic or to cause endocrine or reproductive effects.

All of the study areas support mixed human uses. Predominant land use within the study areas include:

- Residential;

- Commercial;
- Industrial;
- Parks and other recreational areas; and
- Undeveloped open space.

Overall, these land uses generally are representative of the County as a whole, and are considered here to represent the suite of potential land uses potentially associated with vector control activities in the future. The principal receptor populations in the study areas include residents, workers, and recreational users (e.g., boaters, anglers, swimmers).

None of the study areas support large agricultural operations, which do occur in some of the less developed portions of the County. Because of their lower population density, agricultural areas are not typically the focus of vector control operations, and therefore this land use is not considered in this assessment. Small-scale community gardens and backyard gardens do occur in the study areas, and are included in residential and open space land use categories as noted. Calculated health risks potentially occurring in community and back-yard gardeners will overestimate any exposures that could occur in people consuming agricultural commodities from regional farms, if vector control pesticides were ever to be used in these areas in the future. This is because the general public would only obtain a small proportion of its total produce from any one regional farm, whereas a potentially much higher proportion could be obtained from backyard or local community gardens.

A diversity of natural habitats occurs within and around the study areas. This diverse mixture is due to a natural diversity of habitats within Suffolk County coupled, in part, with land preservation programs that set aside especially important ecological habitats and communities. For example, the Wertheim National Wildlife Refuge occurs in the northeast section of the Mastic-Shirley study area. FINS abuts portions of the Mastic-Shirley and Davis Park study areas. The Great South Bay-East, which comprises half of the largest protected coastal bay in New York State, also falls within the buffer area of both the Mastic-Shirley and Davis Park study areas. The Otis G. Pike Wilderness area, which is the only federally designated wilderness area in New York State, is approximately one-half mile east of the Davis Park study area. The Peconic River, which is the largest groundwater fed river in New York State, occurs adjacent to the Manorville study area and supports a unique assemblage of coastal plain kettle ponds. Table ES-9 summarizes the diversity of habitats that occur across all study area.

Table ES-9. Ecological Habitats Associated with Study Areas

Ecological Risk Assessment Habitat Settings		**Study Areas**			
		Davis Park	**Mastic-Shirley**	**Dix Hills**	**Manorville**
Aquatic Settings					
Fresh water					
Lentic	pond, kettle pond, vernal/ephemeral pool, depression	X	X	X	X
	lake				X
Lotic	stream		X		X
	river				X
Marine-Estuarine					
Coastal waters	embayment	X	X		
	tidal creek		X		
Transitional Settings					
Inland Wetlands					
Riverine	wetlands along river/stream channels				X
Lacustrine	wetlands along lakes/reservoirs				X
Palustrine	wet meadows, bogs, bottomlands, red maple swamps		X	X	X
Coastal Wetlands					
High marsh, salt meadow		X	X		
Intertidal marshes		X	X		
Mudflats/Beach/Dune					
Intertidal bars, mudflats		X	X		
Dune, fore-dune, scrub pine		X			
Terrestrial Settings					
Upland					
Upland forest& woodlands			X	X	X
Upland old fields, meadows, agricultural lands				X	X
Landscaped/residential			X	X	X
Ruderal field				X	

Within these diverse habitats, an even greater diversity of potential ecological receptor populations exists. For the purposes of this risk assessment, potential receptors were broadly grouped by taxa to address the diversity of ecological receptors potentially present. These groupings were based on study-area specific knowledge of the habitats and representative species, as well as consideration of the types of data that are available to support the subsequent ecological risk assessment.

For terrestrial habitats, including and transitional (wetland) environments, the potential receptor groups are:

- Mammals (e.g., deer, raccoon, mice);
- Birds (e.g., insectivorous songbirds, waterfowl, and other water-associated birds);
- Reptiles (e.g., turtles, snakes);
- Non-target insects (e.g., honeybees, butterflies, dragonflies); and
- Plants.

For aquatic habitats, including transitional (wetland) environments in fresh water, marine, and estuarine settings, receptor groups are:

- Fish (e.g., bluegill, rainbow trout, mummichog);
- Amphibians (e.g., frogs);
- Crustaceans (e.g., crayfish, crabs, lobster);
- Aquatic insects and larvae (e.g., benthic organisms, stoneflies);
- Mollusks (e.g., snails, clams, oysters); and
- Aquatic plants (e.g., algae).

Within these potentially exposed populations, there are subgroups of individuals or species that might be especially sensitive or susceptible to effects from exposure to the target pesticides. This could be due to a variety of factors including a unique development life stage (e.g., fetus, child) or physiological condition (e.g., elderly, immuno-compromised or pregnant individual), a unique behavior (e.g., soil ingestion in children), or overall population status (e.g., endangered species).

In human health assessment, risks to such sensitive members of the population are commonly addressed by making adjustments to the assumptions that are used to characterize exposures in potentially susceptible population subgroups, and by making adjustments to the numeric dose-response criteria that are used to assess toxicity. USEPA typically attempts to protect individuals who represent high-end exposures (typically around the 90th percentile and above) and those who have some underlying biological sensitivity (USEPA, 2004b). In so doing, USEPA aims to protect sensitive members of the population, as well as the rest of the population. USEPA's approach for addressing risks to sensitive members of the population was adopted for this risk assessment. As a consequence, this risk assessment has addressed potential risks to members of potentially sensitive subpopulations, as well as the populations as a whole.

In ecological risk assessment, endangered and threatened species typically are regarded as especially sensitive receptors, given the already vulnerable status to their population. For these reasons, risks to endangered and threatened species were specially evaluated along with risks to other non-endangered or non-threatened wildlife.

Typically, in human health risk assessment, the endpoint of interest is protection of individual members of the population from the adverse effects of chemicals (USEPA, 2004a). The adverse effects of the chemicals are most commonly classified into two broad types of health effects: cancer effects and non-cancer effects. Non-cancer health effects encompass a variety of health endpoints, such as neurological, reproductive, immunological, endocrine, and developmental effects.

In contrast to human health assessment, the endpoint of interest in ecological risk assessment is protection of ecological populations (collections of individual organisms belonging to a given species), communities (collections of populations), or ecosystems (USEPA, 1998b). The attributes to be protected are typically related in someway to the long-term stability or sustainability of the population, community, or ecosystem. These include attributes such as abundance and age-structure within populations, and species diversity and abundance within communities. Effects on individual organisms are generally not relevant unless they are sufficient in magnitude to adversely impact long-term stability or sustainability at higher levels of ecological organization.

The assessment endpoint for the human health assessment was protection of individual members of the population, including sensitive subpopulations, from the adverse health effects from exposure to adulticides and an associated synergist.

The assessment endpoints for the ecological risk assessment were:

- Maintenance of abundance of fish, invertebrate, and amphibian populations that utilize habitats potentially affected by application of target pesticides.

- Maintenance of abundance of terrestrial wildlife populations, including mammals, birds, and reptiles that utilize habitats potentially affected by application of target pesticides.

- Maintenance of abundance of non-target terrestrial insect populations that utilize habitats potentially affected by application of target pesticides.

- Maintenance of diversity and biomass within the vegetative communities in areas potentially affected by application of target pesticides.

- Maintenance of abundance of the populations of endangered or threatened species that utilize habitats potentially affected by application of target pesticides.

Results of the Human Health Risk Assessment

Protection of human populations from potential exposures to larvicides was not evaluated because, as apparent from the earlier review, these compounds have been shown to be relatively non-toxic to humans. Further, because larvicides are applied directly to water and rapidly degrade and/or become biologically unavailable, there is very little potential for human exposure to these compounds. The NAS paradigm for risk assessment cannot determine risks when the dose-response and exposure assessments do not provide quantitative grounds for completing a risk assessment (NAS, 1983), as is the case with human health and these larvicides.

Table ES-10. Summary of the Human Health Risk Assessment for Larvicides

Agents Considered	Most Critical Endpoint Considered	Pathway Considered Potential Risk	Locations with Potential Risk	Conclusion in Risk Assessment	Comments	Role in Management Plan
Methoprene	NA	Not expected to be human health risk due to limited exposure	No locations were of concern	Not expected to be human health risk	Not quantitatively evaluated because exposure expected to be minimal	Preferred larvicide based on effectiveness for all larvae Stages, used in combination with Bti
Bti	NA	Not expected to be human health risk due to limited exposure	No locations were of concern	Not expected to be human health risk	Not quantitatively evaluated because exposure expected to be minimal	Preferred larvicide effective for Stage I, II & III larvae
Bs	NA	Not expected to be human health risk due to limited exposure	No locations were of concern	Not expected to be human health risk	Not quantitatively evaluated because exposure expected to be minimal	Preferred larvicide effective for Stage I, II & III larvae. Especially good in polluted, freshwater habitats used by Culex spp.

Results of the Ecological Risk Assessment

A total of 17 predominant habitats across aquatic, transitional and terrestrial habitat settings were identified and evaluated. These 17 habitats are the predominant ecological habitats present throughout the County, and as such are good surrogates for evaluating potential ecological risks not only in each study area, but also in other areas of the county that might receive target pesticide applications in the future.

Information on application method, timing, and frequency of control agent defined in the Evaluation Management Plan was utilized to define the introduction of target pesticides into the environment, and subsequently, to support predictive modeling on environmental behavior, fate and transport. The ecological risk assessment initially relied upon quantitative air modeling (Cashin Associates, 2005m) to determine resultant control agent deposition rates and air concentrations following various application scenarios.

Both the use information and modeling were subsequently incorporated into comprehensive environmental fate and transport modeling to predict environmental concentrations of control agents over time in both aquatic and terrestrial settings. Degradation rates in the soil, sediments, and surface waters via abiotic (e.g., photolysis, hydrolysis, and redox reactions) and biotic processes (e.g., aerobic and anaerobic metabolism) were assumed to follow first order kinetics (consistent with Lyman et al. [1982], Howard et al. [1991], and others).

Wildlife exposure methods developed by USEPA (1993, 1997, 1999a) and others (e.g., Suter, 1993; Sample and Suter, 1994; Sample et al., 1997; Hoerger and Kenaga, 1972; Fletcher et al., 1994) were used to calculate exposures to wildlife species (e.g., mammals, birds). Estimated surface water concentrations were used to assess aquatic life exposures. All surface water exposure concentrations were calculated to be the freely dissolved fraction in water column, as this is the fraction that is most bioavailable to water column aquatic life (USEPA [2004c] and others).

Most typically, the available toxicological data for ecological receptors is based on responses in individual organisms, whereas the focus of ERAs is most commonly on potential impacts on higher levels of ecological organization (e.g., populations and communities), as is the case in this ERA. To support extrapolation of individual-level based endpoints to population or higher ecological effects, a common approach in ecological risk assessment is to select toxicological data derived from studies that examined growth, reproduction, or survival, as these endpoints are most directly relevant to assessment of population-level impacts. This was the approach adopted in this ERA.

In selecting ecotoxicological data for use in the risk assessment, a number of additional screening criteria were employed:

- Preference was given to dose-response data for technical material or active ingredient data versus formulated products.

- Preference was given to studies employing species common in New York, although data for species that inhabited areas outside of New York was used if no data were available for New York-state species within a given taxa.

- Aquatic toxicity data for marine/estuarine species was summarized separate from that for fresh water species.
- If multiple data points were available for a given species and the data regarded to be of sufficiently high quality, then the average was used.
- For acute data, preference was given to 96 hr LC_{50} values, if available, rather than less conservative 24 or 48-hr values.
- Preference was given to toxicological levels that were reported for measured levels, as opposed to levels reported as "greater than" values.
- A variety of additional data quality considerations were considered based on adherence to standardized toxicological testing and reporting protocols to as described by Durda and Preziosi (2000).

Risks for all receptors were evaluated initially by comparing estimated exposures to selected toxicity criteria. This approach is called the Hazard Quotient (HQ) approach and computationally, is simply the ratio of estimated exposure concentration (EEC) or dose (EED) to the TRV:

$$HQ = \frac{EEC \text{ or } EED}{TRV}$$

HQs were calculated for each target pesticide product assuming that each was used exclusively during a given spray season.

The HQ approach is truly a screening-level assessment approach appropriate for determining which chemicals or pathways do not pose a risk. HQs that are less than one indicate that ecological risks are unlikely. HQs greater than one indicate that there may be concern for potential ecological effects under the conditions of exposure evaluated (USEPA, 1998b). Because the exposure and toxicity data used to support HQ calculations are based on responses in individual organisms, rather than ecological populations or communities (which are the focus of this assessment), they cannot be used to definitively characterize potential ecological risk.

In this ERA, receptors for which calculated HQs were less than one were assumed not to be at risk from exposure to the target pesticides, and were not evaluated either. If the calculated HQs exceeded one, additional evaluations were conducted.

Because larvicides are applied directly to water and because significant off-target drift is not expected, larvicide risks to terrestrial wildlife are anticipated to be negligible, and were not evaluated in this assessment.

Two levels of risk assessment were conducted for aquatic organisms. In the first, simplistic and conservative modeling was used to provide upper-bound estimates of potential surface water concentrations and aquatic life risks associated with larvicides in each of the four study areas.

A total of five generic scenarios were evaluated for each study area:

- potential maximum and average indirect deposition to an open water body (e.g., pond);
- potential maximum and average indirect deposition to a shallow wetland;
- average deposition and resultant runoff from impervious surfaces into small open water body;
- maximum label rate-based hand application of larvicides into a small open water body; and,
- potential maximum indirect deposition into a small open water body and a shallow wetland and subsequent food chain exposures to raccoon, sandpiper and belted kingfisher.

No HQ greater than one was found under any scenario for any of the four areas.

Refined estimates of acute and chronic risks were evaluated for larvicides. Risks were calculated for the following receptor groups:

Fresh water

- fish
- amphibians
- crustaceans
- mollusks
- aquatic insects/larvae
- aquatic plants
- *Marine/estuarine*
- fish
- crustaceans
- mollusks
- aquatic insects/larvae
- aquatic plants

In order to provide refined estimates of dissolved concentrations of control agents, a series of sequential algorithms was employed to account for partitioning between the dissolved phase water, suspended solids, and benthic sediment. The resultant dissolved phase concentration in the water column is used to derive exposure concentrations used in the characterization of aquatic life risks. The dissolved water column concentrations were also considered to be representative of potential sediment pore water concentrations, and were subsequently used in the characterization of risks to benthic organisms. Some uncertainty remains with respect to potential direct toxicity posed by actual sediment pore water concentrations and indirect toxicity posed by that fraction of a control agent sorbed to sediments (e.g., ingestion of sediment by benthos and resultant gastric extraction of control agents). In certain instances benthic risks based on dissolved water column concentrations could underestimate benthic risks based on direct (i.e., pore water) and indirect (i.e., sediment ingestion/gastric extraction) sediment toxicity. This could particularly be the case for those control agents with higher affinities to bind to sediments and those with greater persistence in sediments. However, assessing benthic risks associated with direct and indirect sediment toxicity presents a number of additional uncertainties (e.g., variability and uncertainty in organic carbon and dissolved organic carbon, establishing chief route of exposure). Some uncertainties could be addressed using mechanistic modeling, though such assessments would most likely benefit from empirical toxicity studies.

The algorithms are based upon equilibrium partitioning theory and are driven by the partitioning potential of control agents in sediment/water systems. The algorithms are largely based upon dissolved surface water concentration algorithms presented by USEPA (1999b, 1999c), modified to take into account cumulative mass loading of control agents into surface water bodies via deposition from application and deposition from runoff. The algorithms explicitly address chemical partitioning between water, sediment, and total suspended solids (TSS) in a water body.

For the purposes of evaluating acute risks, 48 hour average concentrations were derived. For chronic risks, 14 day average concentrations were derived to evaluate risk to aquatic invertebrates and amphibians, and 90 day average concentrations were derived to evaluate fish.

No acute or chronic larvicide risk that was calculated had a HQ greater than one.

Table ES-11. Summary of Ecological Risk Assessment for Larvicides

Agents Considered	**Terrestrial Birds, Mammals, Reptiles**	**Terrestrial Insects**	**Aquatic Life**	**Comments**	**Conclusion in Risk Assessment**	**Role in Management Plan**
Methoprene	No risk*	Not expected to be terrestrial risk due to limited exposure	No risk*	Terrestrial risks not quantitatively evaluated because exposure expected to be minimal	No ecological risks*	Preferred larvicide based on effectiveness for all larvae Stages, used in combination with Bti
Bti	No risk*	Not expected to be terrestrial risk due to limited exposure	No risk*	Terrestrial risks not quantitatively evaluated because exposure expected to be minimal	No ecological risks*	Preferred larvicide effective for Stage I, II & III larvae
Bs	No risk*	Not expected to be terrestrial risk due to limited exposure	No risk*	Terrestrial risks not quantitatively evaluated because exposure expected to be minimal	No ecological risks*	Preferred larvicide effective for Stage I, II & III larvae. Especially good in polluted, freshwater habitats used by Culex spp.

* That is, predicted exposures were below levels of concern established by USEPA and/or others and so do not indicate that there is an increased risk of unacceptable ecological impacts from use of the pesticides under the conditions evaluated in this assessment

The risk assessment found no human or ecological potential impacts from the use of these larvicides.

Field Work

Four field studies were conducted that looked for impacts associated with the use of larvicides to control mosquitoes. These were:

- the Caged Fish experiment, which tested the impacts of actual applications of methoprene on organisms in the field, and in the laboratory (Cashin Associates, 2005n)

- the fate and transport work associated with the Caged Fish study. This does not directly determine impacts associated with methoprene, but may be important in future evaluations of potential impacts (Cashin Associates, 2005o)

- Benthic population evaluations, conducted as an off-shoot of the Caged Fish experiment, which sampled benthic populations in areas exposed to methoprene (and resmethrin) and those in areas not exposed to methoprene, and looked for differences using multi-variate statistics (Barnes, 2005)

- A keystone sampling experiment, in which three important marsh invertebrate organisms were sampled for in five pairs of marshes, to determine if long-term exposure to larvicides (Bti and methoprene) affected the abundance of the organisms differentially (Cashin Associates, 2005g)

In short, none of these experiments found any impact to the environment from exposure either to methoprene by itself, or in when methoprene and Bti were applied. An example description of these studies can be found in Section 6 of the DGEIS.

Mitigation

Aerial applications of larvicides appear to have the potential to cause impacts to certain bird species, and can be mitigated in two ways through the Long-Term Plan. One is by identifying important populations, and then altering application techniques to avoid any startling. This is already the practice of SCVC when piping plover nesting sites may be in potential flight paths. SCVC has requested that local experts work more closely with it to identify any significant populations or environments that may be impacted by its operations; although the focus of this effort is on fresh water settings, the same experts may be useful in identifying at risk populations in salt marshes, and the times when they are most sensitive to disturbance. Secondly, it is hoped that full implementation of progressive water management across the salt marshes will lead to a reduction in aerial larviciding. This has been the experience in neighboring jurisdictions where these procedures are used regularly. The goal is to reduce aerial larviciding by approximately 75 percent; that would lead to at least a commensurate decrease in potential impacts from startling birds with aircraft.

Generally, any potential larvicide impact will be mitigated by the proposed large-scale reduction in applications, as the need for such applications is reduced. Another overall mitigation is the benefit to human health resulting from disease risk reductions when potential vector populations are reduced.

As mentioned above, potential impacts associated with larval controls in fresh water settings are going to be actively mitigated by encouraging information exchange between experts with knowledge of at risk organisms or settings, and SCVC. As each party understands habitat needs of the organisms, and proposed treatments by SCVC, it is anticipated that alterations can be made in the means SCVC uses to control mosquitoes to minimize the potential for impacts. These alterations could be shifts in the time of day that applications are made, to avoidance of treatments for certain settings at certain times, to more studied selection of treatments and times or applications to optimize mosquito control while minimizing the opportunities for impacts to occur. SCVC has, for example, worked closely with NYSDEC to avoid treating any tiger salamander habitats at times when impacts might affect breeding, or development and emergence of young. This is true although there do not appear to be any reasons to believe larvicide applications directly affect amphibians.

ES-4.7 Adult Control

Impacts

Similarly to the larval control impact assessment, the potential for impacts from the use of adulticides was determined through the combination of quantitative risk assessment, field observations and experiments, and analysis of the published scientific literature. The compounds considered were resmethrin, sumithrin, permethrin, natural pyrethrin (all in conjunction with PBO as a synergist), and malathion.

Quantitative Risk Assessment

Generally, the risk assessment was conducted for adulticides as it was for the larvicides. Some additional analyses were added to address some specific issues that arose with the adulticides that were not pertinent for the larvicide analysis (primarily, some additional, more sophisticated ecological modeling and a computation of cancer risks for permethrin).

The conceptual model showed that target pesticides could be released and move throughout the environment and potentially reach residents, workers, and recreational users in Suffolk County.

Permethrin, resmethrin, and sumithrin induce toxicity by disrupting sodium transport at the nerve axon in both the peripheral and central nervous system (CA-IC, 2004). Initially, they cause nerve cells to discharge repetitively; and later, they cause paralysis. When applied alone, pyrethroids may be swiftly detoxified by enzymes in the insect, and for this reason pyrethroids are typically applied along with a synergist, such as PBO, that inhibits enzyme degradation and thus enhances efficacy (USEPA, 2002a).

Overall, pyrethroids are low in toxicity to mammals, and are practically nontoxic to birds. However, at sufficiently high concentrations, laboratory data indicate that pyrethroids are toxic to aquatic life and non-target insects, including honeybees (USEPA, 2002a).

Pyrethroids interfere with nerve and brain function. For people, exposure to very high levels of these compounds for a short period in air, food, or water may cause dizziness, headache, and other neurological effects in people during the period of exposure and for short-time following exposure. There is no evidence that pyrethroids affect reproduction in humans, but some animal studies have shown reduced fertility in males and females (CA-SCDHS, 2005).

WHO (2005) has concluded that there is “no clear indication of carcinogenicity relevant for human risk assessment” for pyrethroid pesticides. Permethrin also has been evaluated by IARC (1991), and classified in Group 3, indicating that it is not classifiable as a carcinogen in humans. USEPA has classified permethrin as a possible human carcinogen based upon limited data from animal studies.

PBO’s synergistic action is due to its ability to inhibit metabolic enzyme activity in insects, thereby allowing the active ingredients to remain available and cause enhanced toxic effects. Overall, PBO has limited toxicity to terrestrial wildlife. It is considered to be moderately to acutely toxic in fish, and highly toxic in aquatic invertebrates (CA-IC, 2004).

As in insects, PBO also can inhibit metabolic enzyme in mammals, however higher doses are required relative to insects (CA-SCDHS, 2005).

Studies in animals indicate the liver to be the primary target organ for toxicity. Exposures through ingestion and inhalation have been shown to lead to enlarged livers, and at some doses, enlarged kidneys in laboratory animals. Developmental and reproductive effects, including behavior effects in offspring and fetotoxicity, have been noted in animal studies; however these effects have been observed at relatively high doses. No information on developmental or reproductive effects in humans was found. Some studies in animals indicate that PBO depletes immune system T-cells in the spleen and thymus. These immune system cells have been implicated in some autoimmune diseases, such as multiple sclerosis (CA-SCDHS, 2005).

IARC considers there to be insufficient evidence to classify PBO as to its carcinogenic potential. USEPA classifies PBO as a probable carcinogen (CA-SCDHS, 2005).

Malathion's insecticidal activity is due to is inhibition of the neuroenzyme AChE. At sufficiently high concentrations, malathion can cause toxicity in aquatic and terrestrial wildlife. In general, aquatic life exhibits greater sensitivity to malathion than terrestrial wildlife. USEPA (2000b, 2002b) has reviewed extensive data and has classified malathion as very highly to moderately toxic for both fresh water and estuarine/marine fish species.

Malathion exhibits generally low to moderate toxicity to terrestrial wildlife (USEPA, 2000b; USEPA, 2002b). Malathion has been shown to result in slight toxicity to mammals (USEPA, 2000c). High acute doses in the range of 150 to 2,100 mg/kg bw-d may cause death. Malathion can affect the central nervous system, the immune system, adrenal glands, liver and blood following chronic exposure to lower dosages. Reproductive effects are not expected unless exposure to high dosages (500 to 1000 mg/kg) occurs for extended periods of time (USEPA, 2000b).

Malathion is considered to be highly toxic to bees on an acute contact basis either through exposure to direct spray or through foliar residue contact within eight hours after spray is applied. Field incidents of extensive honeybee mortality following malathion applications have also been documented (USEPA, 2000b).

Since malathion is a cholinesterase inhibitor and, therefore, its primary toxic effect following human exposures to sufficiently high concentrations is on the nervous system (CA-SCDHS, 2005). Inhibition of cholinesterase can lead to various forms of toxicity affecting muscles, the central nervous system, and endocrine glands. Exposure to the skin or eyes may produce some irritant effects. Some animal studies have shown that under certain conditions, malathion may cause allergic reactions and affect the endocrine system. USEPA (2000b) considers malathion to have evidence suggestive of carcinogenicity, but not sufficient evidence to assess human carcinogenic potential. IARC and ATSDR consider the evidence to be insufficient to determine carcinogenic potential (CA-SCDHS, 2005).

Results of the Human Health Risk Assessment

The pathways identified in Table ES-12 were used to identify potential risks to humans from adulticide use.

Table ES-12. - Exposure Pathways Evaluated in HHRA

Exposure Medium & Route	Resident		Park Visitor				Com. Gardener	School Attendant / Worker			Homeless	Worker	
	Young child	Adult	Young child	Older child	Adolescent	Adult	Adult	Older Child	Adolescent	Adult	Adult	Adult comm./ ind.	Adult public
Incidental ingestion of surface soil	?	?	?	?	?	?	?	?	?	?	?	?	?
Dermal contact with surface soil	?	?	?	?	?	?	?	?	?	?	?	?	?
Ingestion of residues on hands via surfaces	?	?	?	?	?	?	?	?	?	?	?	?	?
Dermal contact with residues on surfaces	?	?	?	?	?	?	?	?	?	?	?	?	?
Ingestion of tap water	?	?	--	--	--	--	--	--	--	--	?	--	--
Dermal contact with tap water	?	?	--	--	--	--	--	--	--	--	--	--	--
Ingestion of swimming/wading water	?	?	?	?	?	?	--	--	--	--	--	--	--
Dermal contact with swimming/ wading water	?	?	?	?	?	?	--	--	--	--	?	--	?
Ingestion of produce	?	?	--	--	--	--	?	--	--	--	?	--	--
Ingestion of fish/ shellfish	?	?	--	--	--	--	--	--	--	--	--	--	--
Inhalation of residues on particulates in air	?	?	?	?	?	?	?	?	?	?	?	?	?
Inhalation of aerosols (Acute only)	?	?	--	--	--	--	--	--	--	--	--	--	--
Oral ingestion of spray on soils/objects (Acute – 3 separate pathways)	?	--	--	--	--	--	--	--	--	--	--	--	--
Dermal contact with spray (Acute)	?	?	--	--	--	--	--	--	--	--	--	--	--

Acute risks were evaluated for inhalation exposures of aerosols during an application, dermal contact with turf following an application, and incidental ingestion exposures as a result of post-application hand-to-mouth, object-to-mouth, and soil ingestion behavior in children. None of the target pesticides results in elevated risks to human health following short-term exposures during and immediately after an application. Chronic risks were evaluated first through a Tier I risk calculation, which provided upper-bound estimates of longer-term risk. Importantly, this analysis used exposures that represent the highest accumulated residue predicted to occur throughout the application season, and assumed that a person would be exposed to that maximum residue throughout the entire season, and only at that single location from the study area (one out of more than 220 modeled locations) where the predicted concentration would be highest. Further, the Tier I analysis used modeled air deposition rates calculated for Davis Park, which were higher than those calculated for any other study area. The Tier 1 analysis showed the following:

- None of the synthetic pyrethroid products in combination with PBO resulted in elevated risks to human health

- Malathion Tier I HQs exceeded 1 for the young child resident and the community gardener.

    - Young child resident risks were due to potential produce ingestion and ingestion of residues on hands via surfaces

    - Community gardener risks were driven by produce ingestion.

Therefore, potential malathion exposures in young child residents and community gardeners were selected for further evaluation in a Tier II analysis.

The Tier II analysis used different exposure scenarios. One was termed the reasonable maximum exposure (RME) case and the other the central tendency exposure (CTE) case. For RME scenarios, the values used to calculate exposures include values that represent the high end of the range of all possible values. Here they were the maximum value of the means of calculated exposures from the 200 test sites in each study area. CTE exposure parameters are typically based on averages or means derived from a range of values. For this assessment, the mean values for exposure across each area were used. The Tier II analysis indicates that malathion does not pose a significant health threat to study area receptors. No unacceptable increase in health risks were predicted for any receptor group in any study area under the CTE conditions. Under RME conditions, HIs were less than one for all study areas receptors and pathways except for the community gardener at Davis Park, where an HI of three was predicted due to produce ingestion. This risk was predicted based on modeled air deposition of malathion from one out of more than 200 modeling receptor points, and is not truly representative of study area exposure conditions. More typical exposures throughout the remainder of the study area are not predicted to be associated with an increase in human health risks.

Recently, USEPA (2005a) released a preliminary draft of a RED and accompanying risk assessment for permethrin in which the pesticide was evaluated for carcinogenic effects. The cancer toxicity criterion utilized in the assessment was based on evidence of reproducible but benign tumor types (in lung and liver) in laboratory mice, equivocal evidence of carcinogenicity in rats, and supportive information based on structure activity relationships (USEPA, 2004d). This recent USEPA assessment is provisional and has not been finalized or subject to peer review or public comment. For these reasons, the HHRA focused on evaluation of permethrin for non-cancer effects.

To address the uncertainty surrounding the cancer classification for permethrin, the cancer risk evaluations presented by USEPA (2005b) were reviewed. USEPA evaluated potential cancer risks in residents potentially exposed to permethrin following ULV spray via truck foggers and via aerial application for vector control. USEPA also evaluated a number of exposure scenarios associated with permethrin use directly by residents in their home and in agricultural settings. While these latter scenarios are certainly not directly applicable to potential exposures following exposure to vector control ULV sprays, they can provide some perspective on the potential magnitude of risk.

USEPA estimated cancer risks for a single exposure event assuming exposure occurred on the application day. USEPA then calculated the number of application day exposures it would take to reach a 10^{-6} risk level, which equates to a chance of one in a million that an exposed person could develop cancer as a result of the exposure. For risk management purposes, USEPA typically considers risks in the range of 10^{-6} to 10^{-4} (1 in 10,000) to be acceptable.

Table ES-13 summarizes these results for exposure scenarios of potential relevance to this HHRA of vector control activities in Suffolk County. This table also presents the application rates that were assumed in the USEPA assessment and compares them to the permethrin application rate of 0.007 pounds (lb) active ingredient (AI) per acre (A) potentially used by Suffolk County to support vector control activities.

Table ES-13. Summary of USEPA Cancer Risk Assessment Results for Residential Exposures to Permethrin under a Variety of Use Scenarios and Application Rates and Comparison to Suffolk County Application Rates

Exposure Scenario[a]	**Exposure Route[a]**	**Application Rate (lb AI/acre) [a]**	**Cancer Risk – Application Day***	**# Application Day Exposures per Year to Reach 1E-06 Risk[a]**	**USEPA-assumed Application Rate Compared to Suffolk County[b]**	**Approximate Number of Exposure Days per Year to Reach 1E-06 Using Suffolk County Application Rate[b]**
Residential turf (high contact activities)	dermal	0.87	7.10E-08	14	124	1,751
Residential turf (mowing)	dermal	0.87	2.40E-09	# 417	124	51,786
Home garden (fruit & nut harvesting)	dermal	0.4	2.80E-08	37	57	2,114
Home garden (vegetable harvesting)	dermal	0.23	6.70E-08	15	33	493
Mosquitoes (ULV truck fogger)	inhalation	0.1	5.20E-08	20	14	286
Mosquito (ULV aerial)	inhalation	0.1	8.50E-16	# 1.E+09	14	2.E+10
Agricultural use	dietary (food/water)	2	1.80E-06	0.56	286	159

[a] = as reported in USEPA (2005b), except as noted.
[b] = calculated ratio of USEPA assumed application rate to Suffolk County's rate.
# = Integral-calculated values. USEPA did not report any calculated value that exceed 365 application days per year.

As can be seen, the application rates under the USEPA scenarios are significantly higher than the application rates potentially used by Suffolk County for vector control, being between 14 and

286 times larger. Even with that, the predicted cancer risks are well below the target risk level of 10^{-6} in virtually all cases.

Under the two estimated mosquito ULV application scenarios evaluated by USEPA, inhalation cancer risks are predicted to be in the range of 10^{-8} to 10^{-16}, or two to more than ten orders of magnitude below the target risk level of 10^{-6}. Under USEPA scenarios, it would take between 20 to a billion application day exposures in any given year to result in a 10^{-6} inhalation cancer risk following ULV applications for mosquito control. Assuming the Suffolk County application rate and accepting all other USEPA assumptions, 286 to more than 10 billion application day exposures would have to occur in any one year to result in a 10^{-6} cancer risk. Clearly, these are not plausible. Even recognizing that exposure assumptions used by USEPA could differ from those included in this risk assessment for Suffolk County, and that there are inherent uncertainties associated with any risk evaluation, this magnitude of difference clearly indicates that permethrin ULV application for mosquito control in Suffolk County would not associated with any unacceptable increase in inhalation cancer risks. A similarly large number or application day exposures would be necessary to result in unacceptable cancer risks under the other residential use scenarios evaluated by USEPA when considering the Suffolk County application rates and using all other assumptions used by USEPA. Therefore, permethrin application for mosquito control in Suffolk County will not be associated with unacceptable additional cancer risks for these additional residential exposure scenarios.

USEPA predicted a risk in the range of 10^{-6} for dietary exposures to permethrin when used in agricultural applications. These risks were predicted using surveys of permethrin residues in foodstuffs as reported by USDA, and so were not calculated directly as a function of application rate. Permethrin application rates in agricultural settings range up to 2 lb AI/A. This is 286 times higher than the application rate potentially used by Suffolk County for vector control activities. Based on this, permethrin application for mosquito control is not predicted to be associated with unacceptable cancer risks for dietary exposure scenarios.

Overall, collective consideration of the recent USEPA assessment indicates that vector control application of permethrin in Suffolk County will not be associated with an increased cancer risk. While the USEPA results are not directly transferable to Suffolk County, given differences in the exposure routes and scenarios evaluated, the magnitude by which Suffolk County application rates fall below those assumed by USEPA is sufficiently large to conclude that permethrin risk for mosquito control in Suffolk County does not pose a cancer risk.

Table ES-14 summarizes the human health risk assessment for adulticides.

Table ES-14. Summary of the Human Health Risk Assessment for Adulticides

Agents Considered	Most Critical Endpoint Considered	Pathway Considered Potential Risk	Locations with Potential Risk	Conclusion in Risk Assessment
Adulticides				
Resmethrin	incr. liver wgt, blood chemistry changes, behavioral effects	No pathways or populations presented acute or chronic risks of concern	No locations had risks of concern	The use of resmethrin products for vector control does not pose a health risk under study conditions
Sumithrin	increased liver wgt and adrenal cortex toxicity	No pathways or populations presented acute or chronic risks of concern	No locations had risks of concern	The use of sumithrin products for vector control does not pose a health risk under study conditions
Permethrin	neurological impairment	No pathways or populations presented acute or chronic risks of concern	No locations had risks of concern	The use of permethrin products for vector control does not pose a health risk under study conditions
Malathion	cholinesterase inhibition, maternal toxicity	no acute risks, some risks to RME child resident and adult community gardener	Davis Park only	Malathion does not pose a significant health threat to study area receptors
Synergist				
PBO	reproductive and developmental toxicity liver and body wgt dec., laryngeal hyperplasia	No pathways or populations presented acute or chronic risks of concern	No locations had risks of concern	The use of PBO-containing products for vector control does not pose a health risk under study conditions

Results of the Ecological Risk Assessment

The conceptual model showed that target pesticides could be released and move in the environment and potentially reach a variety of ecological receptors in terrestrial and aquatic habitats in Suffolk County. Therefore, evaluations of those potential ecological receptors were modeled, as discussed above for the larvicides.

Ingestion of pesticides was determined to be the main exposure route for terrestrial organisms. No dietary risks were predicted for any mammalian or avian wildlife species. Neither acute HQs nor chronic HQs for mammalian and avian wildlife are not predicted to exceed a value of one for any control agent applied in the four study areas. Based on these results, it is concluded that the maintenance of abundance of terrestrial wildlife populations will not be negatively impacted as a result of terrestrial applications of adulticides.

Terrestrial non-target insects could be potentially exposed to the primary control agents following application. The assessment endpoint was identified as maintenance of abundance of terrestrial non-target insects that utilize habitats potentially impacted by application of primary list control agents. Because toxicological information for other terrestrial insects is generally limited, honeybees were used as a surrogate for other non-target insects, such as butterflies, damselflies, and dragonflies. Under instantaneous, maximum average conditions, honeybee HQs were predicted to be above one for all adulticides in all study areas, ranging from four to 200, with the highest HQ of 200 occurring for malathion applied in Davis Park using a golf cart sprayer. Under instantaneous, average conditions, honeybee HQs range from one to 30, with the highest HQ of 30 predicted for malathion applied to Mastic-Shirley by helicopter. Under the instantaneous average condition, permethrin + PBO and malathion have predicted HQs above one for all study locations (permethrin + PBO HQ range is two to seven; malathion HQ range is eight to 30). Sumithrin + PBO has predicted HQs of greater than one for Davis Park, Dix Hills, and Mastic-Shirley under aerial application scenarios, with all HQs less than or equal to four. Resmethrin + PBO has predicted HQs above one for Davis Park and Mastic-Shirley aerial applications (HQs of three).

Under both maximum average and average conditions, potential risks could also exist for sensitive insect species, such as adult threatened dragonfly species and adult and caterpillar stages of endangered or threatened butterfly species.

Three levels of analyses were conducted to evaluate potential risks to aquatic life. Multiple levels of analyses were conducted given the complexity of fate and transport modeling and risk estimation techniques required to provide perspective on the full continuum of potential aquatic risks:

- Level 1 – worst case aquatic life exposures and risk – acute exposures only

- Level 2 – refined evaluation of aquatic life exposures and risk – acute and chronic exposures

- Level 3 – evaluation of potential aquatic community level responses.

The Level 1 evaluation (a worst-case and conservative evaluation), found the following:

- Potential acute risks were identified for malathion following application and resultant drift to open surface water bodies and shallow wetlands under fresh water and marine/estuarine settings

- Acute risk associated with runoff from impervious surfaces was also identified for malathion

- Some acute risks were additionally identified for permethrin + PBO following application and resultant drift to open surface water bodies under fresh water and marine/estuarine settings

- Potential acute risks could additionally exist for malathion and permethrin + PBO under the above scenarios for sensitive aquatic life, such as larval or nymph forms of threatened dragonfly species

- Inclusion of important factors such as degradation and chemical partitioning would likely result in lower estimates of risks

- No acute aquatic life risks were identified for:

    - Resmethrin + PBO

    - Sumithrin + PBO

- No risks associated with aquatic food chain exposures were identified.

Only malathion presents predicted acute HQs greater than 1one, for all receptor groups except aquatic plants, with highest risks predicted for crustaceans and aquatic insects/larvae. Ranges of acute HQs greater than one are predicted for each of the study areas as follows:

- Davis Park (golf cart sprayer application): eight to nine for fresh water species; two to 100 for marine/estuarine species
- Dix Hills (helicopter application): eight to 100 for fresh water species
- Manorville (helicopter application): three to 50 for fresh water species
- Mastic-Shirley (helicopter application): 10 to 100 for fresh water species; three to 100 for marine/estuarine species
- Mastic Shirley (truck application): three to 50 for fresh water species; four to 40 for marine/estuarine species].

Overall, predicted acute risks from malathion are typically highest in shallow water bodies, such as inland and coastal wetlands/marshes and streams. Malathion risks are predicted to be generally highest in Mastic-Shirley following helicopter application. Risks are generally highest for crustaceans and aquatic insects/larvae.

In summary, refined estimates of potential chronic risks to aquatic life were predicted predominantly for malathion, with some limited risks for permethrin + PBO in Mastic-Shirley following aerial application in fresh water and wetlands and streams (including off-target streams in the quarter mile buffer zone) and marine/estuarine wetlands. Overall, risks are typically highest in shallow water bodies, such as inland and coastal wetlands/marshes and streams. Risks are generally highest for crustaceans and aquatic insects/larvae. Chronic HQs greater than one are not predicted for the remaining adulticides.

The refined aquatic life risk evaluation determined:

- Malathion potentially poses a potential for elevated acute and chronic risks to aquatic life under the application scenarios evaluated. Predicted risks are typically highest in shallow water bodies, such as inland and coastal wetlands/marshes and streams following helicopter application. Risks are generally highest for crustaceans and aquatic insects/larvae.

- Permethrin + PBO potentially poses some potential elevated chronic aquatic life risk following helicopter application, though predicted risks were lower in magnitude and prevalence than malathion risks.

- Potential elevated acute and chronic risks could exist for permethrin + PBO under the above scenarios for sensitive aquatic life, such as larval or nymph forms of threatened dragonfly species.

- Resmethrin + PBO and sumithrin + PBO do not pose any unacceptable elevations in aquatic life risks under the application scenarios evaluated.

The potential for aquatic life population and community level impacts was additionally assessed through the modeling of an adulticide application in Suffolk County. The focus of this evaluation was on potential indirect deposition of permethrin into shallow water bodies, such as shallow wetlands, vernal pools, and shallow ponds, present in the Mastic-Shirley study area. This scenario was selected based upon the results of the Level 2 assessment, which demonstrated the highest potential for chronic risks to aquatic life from synthetic pyrethroid use exists under this scenario (i.e., HQs up to 20 for aquatic invertebrates). Permethrin was modeled instead of malathion because synthetic pyrethroids are more likely to be used more extensively than malathion by Suffolk County.

For this modeling evaluation, potential long-term population and community-level impacts were evaluated using the USEPA AQUATOX model. AQUATOX is a process-based ecosystem model that predicts the fate of various pollutants, such as nutrients and organic toxicants, and their effects on aquatic populations and communities, including those for fish, invertebrates, and aquatic plants. Unlike most water quality models, AQUATOX treats aquatic organisms as integral to the chemical/physical system. Its potential applications include analyzing the cause and effect relationships between the chemical and physical environment and biological responses (USEPA, 2004e; USEPA, 2004f; Pastorok et al., 2003).

Version 3.1.4, in a beta version (prior to formal release) was used for this simulation. This latest version offers a number of upgrades over previous versions, particularly with respect to the greater flexibility and dynamism added to the fate, transport and uptake components of the model and the inclusion of an estuarine modeling component.

This modeling evaluation examined impacts from permethrin reaching a small water body, such as a shallow wetland, following aerial application in Mastic-Shirley. The results of the aquatic life risk assessment demonstrated that PBO, as formulated with permethrin in the product Permanone, does not contribute to observed risks, and so permethrin alone was modeled. The modeled shallow open surface water body was considered representative of fresh water mixed brackish environment. Aquatic species incorporated into the modeling included the following:

- benthic organisms (amphipods, chironomids)
- suspended feeders (daphnia, copepods)
- predatory invertebrate (Odonata)
- mollusks (mussel)
- gastropods (snail)
- small forage fish (silverside)
- large forage fish (perch)
- large bottom fish (catfish)
- small game fish (bass, young of year)
- large game fish (bass, adult).

Periphyhton and aquatic plants (e.g., diatoms, blue green algae) were also included as primary producers in the simulation. Permethrin, however, has very low toxicity to aquatic plants (e.g., blue-green algae 96 hour EC_{50} of 1,600 µg/L). Changes in abundances of aquatic plants attributable to permethrin were not anticipated and therefore aquatic plants were not included for detailed evaluation and interpretation.

No long-term significant differences in abundance were observed among treated and control organisms. Summary descriptive statistics of annual abundance predictions for treated (organisms denoted with a "P") and control (organisms denoted with a "C") simulations are presented in Table ES-15. No long-term differences in the predicted annual abundances of Daphnia and copepods under treated and control simulations were observed. Some short-term reductions were predicted for Daphnia in the treated simulation, with recovery to pretreatment levels occurring within one to two months. No significant annual differences in abundances were observed for chironomids. Amphipods under treated conditions had a slightly lower average annual abundance than that predicted for the control (i.e., 1.0 versus 1.7 g/sq.m), but this difference was not statistically significant. Some short-term reductions were predicted for both chironomids and amphipods in the treated simulation, with recovery to pretreatment levels occurring within two months to 10 weeks. No long-term significant differences in abundances were observed for mussels, gastropods, and dragonflies (Odonata) under treated and control simulations. Some short-term reductions were predicted for Odonata in the treated simulation, with recovery to pretreatment levels occurring within two to three months, possibly due to the inclusion of modeled immigration. No long-term significant differences in abundances of fish (i.e., silversides, white perch, catfish, largemouth bass) under treated and control simulations were observed.

Table ES-15. Summary Descriptive Statistics of AQUATOX Predicted Annual Abundances for Organisms Evaluated Under Treated and Control Simulations.

Organism‡	Mean	Min	Max	-95% CL	+95% CL	Variance	Std	SE
Peri, Green (g/sq.m) P	4.9453	0.2000	20.3088	4.4961	5.3945	19.0960	4.3699	0.2284
Peri, Green (g/sq.m) C	4.7152	0.2000	19.3508	4.2609	5.1694	19.5294	4.4192	0.2310
Phyt, Blue-Gre (mg/L) P	0.000005	0.000003	0.00002	0.000005	0.000006	0.0000001	0.000003	0.0000001
Phyt, Blue-Gre (mg/L) C	0.000005	0.000003	0.00002	0.000005	0.000006	0.0000001	0.000003	0.0000001
Myriophyllum (g/sq.m) P	40.2479	0.1000	60.4107	38.8211	41.6747	192.6800	13.8809	0.7256
Myriophyllum (g/sq.m) C	40.1604	0.1000	62.3070	38.7406	41.5802	190.7791	13.8123	0.7220
Chironomid (g/sq.m) P	0.3961	0.0000	6.5725	0.2763	0.5158	1.3569	1.1649	0.0609
Chironomid (g/sq.m) C	0.4310	0.0000	8.5166	0.2976	0.5644	1.6843	1.2978	0.0678
Amphipod (g/sq.m) P	1.0445	0.0434	5.8178	0.9312	1.1577	1.2135	1.1016	0.0576
Amphipod (g/sq.m) C	1.7498	0.0421	8.0540	1.5497	1.9500	3.7919	1.9473	0.1018
Daphnia (mg/L) P	0.0024	0.0000	0.0300	0.0018	0.0030	0.0000	0.0056	0.0003
Daphnia (mg/L) C	0.0024	0.0000	0.0300	0.0019	0.0029	0.0000	0.0047	0.0002
Copepod (mg/L) P	0.0015	0.0000	0.0359	0.0010	0.0021	0.0000	0.0051	0.0003
Copepod (mg/L) C	0.0013	0.0000	0.0359	0.0008	0.0018	0.0000	0.0049	0.0003
Mussel (g/sq.m) P	0.4686	0.0802	2.0000	0.4183	0.5188	0.2388	0.4887	0.0255
Mussel (g/sq.m) C	0.4592	0.0763	2.0000	0.4085	0.5099	0.2433	0.4932	0.0258
Gastropod (g/sq.m) P	3.5436	1.0000	6.1142	3.3901	3.6970	2.2280	1.4926	0.0780
Gastropod (g/sq.m) C	3.5318	1.0000	5.8914	3.3809	3.6827	2.1556	1.4682	0.0767
Odonata (g/sq.m) P	0.1062	0.0239	0.4479	0.0947	0.1176	0.0125	0.1118	0.0058
Odonata (g/sq.m) C	0.1015	0.0202	0.4479	0.0897	0.1132	0.0130	0.1142	0.0060
Silverside (g/sq.m) P	4.4197	0.8521	7.9172	4.1978	4.6417	4.6623	2.1592	0.1129
Silverside (g/sq.m) C	3.1173	1.2624	6.1384	2.9892	3.2453	1.5520	1.2458	0.0651
White Perch (g/sq.m) P	0.7124	0.2428	2.0193	0.6604	0.7643	0.2556	0.5055	0.0264
White Perch (g/sq.m) C	0.6826	0.2304	2.0193	0.6291	0.7361	0.2705	0.5201	0.0272
Catfish (g/sq.m) P	0.5916	0.5000	0.6293	0.5868	0.5963	0.0021	0.0463	0.0024
Catfish (g/sq.m) C	0.5910	0.5000	0.6311	0.5863	0.5958	0.0021	0.0461	0.0024
Largemouth Bass - YOY (g/sq.m) P	1.5971	0.9482	2.7340	1.5411	1.6531	0.2965	0.5445	0.0285
Largemouth Bass - YOY (g/sq.m) C	1.7957	1.0000	2.8195	1.7358	1.8557	0.3402	0.5832	0.0305
Largemouth Bass - A (g/sq.m) P	4.6181	0.5000	6.9188	4.3676	4.8687	5.9402	2.4372	0.1274
Largemouth Bass - A (g/sq.m) C	4.9589	0.5000	7.5089	4.6829	5.2349	7.2114	2.6854	0.1404

Notes:
‡ = Summary information presented for organisms present in surface water receiving permethrin (denoted as "P") and organisms present under control surface water (denoted "C").

The results of the quantitative risk assessment are presented in Table ES-16.

Table ES-16. Summary of the Ecological Risk Assessment for Adulticides

Agents Considered	Terrestrial Birds, Mammals, Reptiles	Terrestrial Insects	Aquatic Life	Comments	Conclusion in Risk Assessment	Role in Management Plan
Adulticides						
Resmethrin	No risk*	Risks to non-target insects, such as butterflies, bees, dragonflies; all locations	No risk*	Terrestrial insect risks used honeybees as surrogate. Endpt was maintenance of abundance.	Terrestrial insect risks can be mitigated by timing applications approp.	Primary material for truck and aerial ULV, based on effectiveness and results of risk assessment.

Agents Considered	Terrestrial Birds, Mammals, Reptiles	Terrestrial Insects	Aquatic Life	Comments	Conclusion in Risk Assessment	Role in Management Plan
Sumithrin	No risk*	Risks to non-target insects, such as butterflies, bees, dragonflies; all locations	No risk*	Terrestrial insect risks used honeybees as surrogate. Endpt was maintenance of abundance	Terrestrial insect risks can be mitigated by timing applications approp.	Primary material for hand held ULV. Would be first choice if resmethrin cannot be used.
Permethrin	No risk*	Risks to non-target insects, such as butterflies, bees, dragonflies; all locations	Only chronic risk to individual aquatic insects/larvae and crustaceans in shallow water (e.g., daphnid, opossum shrimp, mayfly)	Terrestrial insect risks used honeybees as surrogate. Endpt was maintenance of abundance	Terrestrial insect risks can be mitigated by timing applications approp. Aquatic risks will not result in community level impacts	Primarily will be used as an alternative for the other pyrethroids, due to setbacks and higher risks estimated in risk assessment.
Malathion	No risk*	Risks to non-target insects, such as butterflies, bees, dragonflies; all locations	Acute and chronic risk to individual aquatic insects and crustaceans in shallow water bodies (e.g., stonefly, amphipod, mysid shrimp)	Terrestrial insect risks used honeybees as surrogate. Endpt was maintenance of abundance	Terrestrial insect risks can be mitigated by timing applications approp. Aquatic, community level impacts not expected	Since a different class than the pyrethroids, could be used if pyrethroid resistance becomes an issue. Label restrictions make it less useful for ULV and risk assessment indicates higher risk.
Synergist						
PBO	No risk*	Risks to non-target insects, such as butterflies, bees, dragonflies; all locations	No risk*	Based on evaluation of PBO containing products	Terrestrial insect risks can be mitigated by timing applications approp.	Combined with pyrethroids to maximize ULV effectiveness

* That is, predicted exposures were below levels of concern established by USEPA and/or others and so do not indicate that there is an increased risk of unacceptable ecological impacts from use of the pesticides under the conditions evaluated in this assessment

Natural pyrethrum did not undergo a quantitative risk assessment. Instead, it was evaluated qualitatively.

Pyrethrums are a mixture of pyrethrins, which are naturally occurring insecticides produced by certain species of the chrysanthemum plant. The flowers of the plant are harvested shortly after blooming. The flowers are either dried and powdered or the oils within the flowers extracted with solvents. The resulting pyrethrin containing dusts and extracts usually have an active ingredient content of about 30 percent (Extoxnet, 1996b). These active insecticidal components are collectively known as pyrethrins.

Pyrethrum is extremely toxic to aquatic life, such as bluegill, while it is slightly toxic to bird species, such as mallards. Toxicity increases with higher water temperatures and acidity. Additionally, these compounds are toxic to bees. Pyrethrum has a toxic potency similar to synthetic pyrethroids (Extoxnet, 1996b).

Exposure to pyrethrins can lead to coughing, wheezing and shortness of breath if inhaled. Symptoms noted in humans are more frequently related to allergic responses and irritation than neurotoxic effects (USEPA, 2005c). The pyrethrum extracts have been shown to cause allergic skin rashes and asthmatic responses. These allergic reactions may be in response to "impurities" present in the pyrethrum extract, since the more refined products available commercially today do not appear to have this property (National Pesticide Telecommunications Network, 1998).

Pyrethrum is inactivated and decomposed by exposure to light and air. It is also rapidly decomposed by mild acids and alkalis (Extoxnet, 1996b).

Overall, the data suggest pyrethrum is likely to pose a lower risk than synthetic pyrethroids because it is more rapidly removed from the environment.

Mitigation

Any potential impact from the use of adulticides to control mosquitoes is mitigated by the conceptual underpinning that adult controls are always the last – and never the primary – option for mosquito control. Consideration of adulticides for control purposes means that all other options have not succeeded, and a problem exists of such a magnitude that it requires addressing.

The decision to apply adulticides will only be reached when a series of parameters have been exceeded, and checks have been made that demonstrate a clear need for the treatment. The decision-making process is laid out in detail in the Long-Term Plan.

There has been great concern that adulticides use might impact human health. This is because the mechanisms of action used by the selected pesticides, and certain laboratory tests, make it plausible that the compounds might affect human health. However, epidemiological work and theoretical analyses (such as the risk assessment) all tend to find no elevation of risks for impacts, because the concentrations that the adulticides are applied at, and thus the relative lack of exposure to them for people, means that any potential impact cannot be realized.

The risk assessment did find one potential exposure scenario that might lead to some human health impacts. That was for the maximally exposed individual in Davis Park who primarily consumed produce grown at his home in Davis Park, due to exposure from 14 applications of malathion over a season. This exposure was not accepted as a reasonable determination of human health impacts, however, because it was based on the highest potential dose for Davis Park under that scenario. Other factors not explicitly considered by the risk assessment, but which weigh on this scenario, are:

- an individual is extremely unlikely to primarily consume locally grown produce in Davis Park (soils are not suitable for vegetable growing, and so a large container garden would need to be created);
- malathion is not likely to be the primary pesticide used in Davis Park (sumithrin is the preferred kind)
- washing the produce should reduce exposure, although pesticide adsorbed by the produce will not be removed by washing

(Cashin Associates, 2005q)

Similarly, there is also a conceptual basis for concerns that adulticides may impact the environment. The selected pesticides have been shown to be toxic to non-target organisms at low concentrations. However, they are also applied at very low concentrations. Mosquito control applications, in fact, often use lower concentrations than is done for other pest control reasons, but mosquitoes are considered to be fragile insects that are impacted readily by pesticides. For instance, the maximum application of malathion for mosquito control is 0.23 lbs AI per acre (USEPA, 2005g), but for grasshopper control the dose is allowed to be from 0.58 to 0.87 lbs AI per acre (although population reductions of up to 75 percent were also achieved using 0.3 lbs AI per acre with an encapsulated version) (Reuter and Foster, 2000) and for treatments for crops such as brussel sprouts, cauliflower, ciollards, kale, kohlrabi, peppermint, and trefoil, it can be as high as 0.94 to 1.25 lbs AI per acre (Birchfield et al., undated). This is an indication that other insects require larger doses than mosquitoes do for control to ensue.

Modern mosquito control products are designed to degrade quickly, and not to leave residues (unlike earlier products, where persistence was designed into the compounds to increase effectiveness).

For those reasons, most accounts do no find impacts for adulticides to non-target organisms. This included field studies conducted specially for the project, and most of the analyses associated with the quantitative risk assessment of the selected compounds. The risk assessment did find two aspects of the analysis in particular that did suggest the potential for impact:

- Using a honeybee model, all of the analyzed compounds were found to potentially have impacts on flying insects at the time of application.

  Exposures were predicted assuming that adulticides are applied when honeybees and other non-target insects are active. Honeybees and a number of other non-target insects are predominantly active during the daytime. Exposures and risks were predicted based upon instantaneous conditions. However, adulticides are generally not persistent in terrestrial environments. The use of instantaneous exposure conditions precludes the incorporation of degradation of adulticides, which in turn would likely reduce the potential for risk (Cashin Associates, 2005q).

  Analysis of the air model and its potential to overestimate deposited concentrations suggests that under many of the considered scenarios, resmethrin and sumithrin can be understood not to truly present a risk to flying insects. Considering the rapid degradation measured under local conditions for resmethrin, the analysis (presented in Section 7 of the DGEIS) found it very unlikely that resmethrin actually causes impacts to flying insects, and similar considerations appear to hold for sumithin, as well. Tests of bee exposure to mosquito control pesticides tend to find losses more than those experienced at unexposed hives, but within ranges of natural mortality (as when one study reported statistically elevated bees deaths for exposed hives, but mortalities that were less than the "100 bee per day" apiary mortality standard) (Zhong, 1999; Hester et al., 2001; Caron, 1979; Smith and Stratton, 1986). Nonetheless, it is clear that impacts to certain insects could occur from mosquito control applications. There appears to be only one study of the effect of a pyrethroid on non-target insects (Jensen et al., 1999). In that study, biomass trapped following a pyrethroid application was less than before the application. However, biomass trapped at a control site was also reduced on the evening following an application. UV light traps were used for this experiment, and so only species attracted to UV light were tested. Both the control and the test site recovered to pre-application biomasses within one week. Similar results occurred following application of dibrom in Cicero Swamp, New York (near Syracuse), down to the coincidental reduction of biomass at the control site, and recovery to pre-application biomass within one week (O'Brien & Gere, 1995). Neither test suggests that mosquito control pesticides have large impacts on night-flying insects, but neither determined that they did not. Recruitment and dispersal by insects makes it difficult to tell the absolute effects of the application.

Impacts could be greater for repeated applications over short time spans, applications that are made over very large areas that would inhibit recruitment from outside of the application area, or incidences where short-lived, susceptible insects are treated as they emerge. Mitigation may be to avoid applications for vector control purposes at times or in areas where mayfly emergences are predictable, for instance. Mitigation would also involve working with natural resource agencies to identify insect populations that may be at risk from pesticide applications (New York State has identified insects of general concern, for example [NYSDEC, 2005]).

- Permethrin, under a limited scenario, and malathion more generally, appeared to have the potential to reduce aquatic invertebrate populations (including larval insects and crustaceans).

Modeling determined this reduction in invertebrate populations did not propagate in the food web, meaning there was no overall ecological impact from the potential invertebrate impact. Additionally, except for one population (amphipods), no difference in modeled populations (treated and exposed) was detectable within several months, and the difference the model reported for amphipods was not statistically significant. These potential impacts are mitigated by further considerations. Testing of resmethrin, for example, showed that it was exceptionally ephemeral in the environment. Modern pesticides are designed to degrade rapidly, and, for resmethrin, at least, the goal has been attained. Other selected pesticides may also degrade more rapidly than laboratory tests or theoretical considerations suggest.

Adulticides are applied over only a small portion of the County. In 2003, which had more adulticide use of any year since 1999, only six percent of the County received an adulticide application. The area of the County receiving Vector Control applications is even smaller (see Figure ES-1, which further compares the complaints received by the County regarding mosquito biting and the areas that received Vector Control applications in 2005). This means that any potential impacts are extremely limited in terms of geographical extent. The County is extremely judicious in its use of adulticides at present, and believes it will reduce its use further under the Long-Term Plan. Reduced adulticide use will be fostered by more reliable source reduction through progressive water management, and employment of the Adapco aerial application model, which will optimize adulticide applications, when they are necessary.

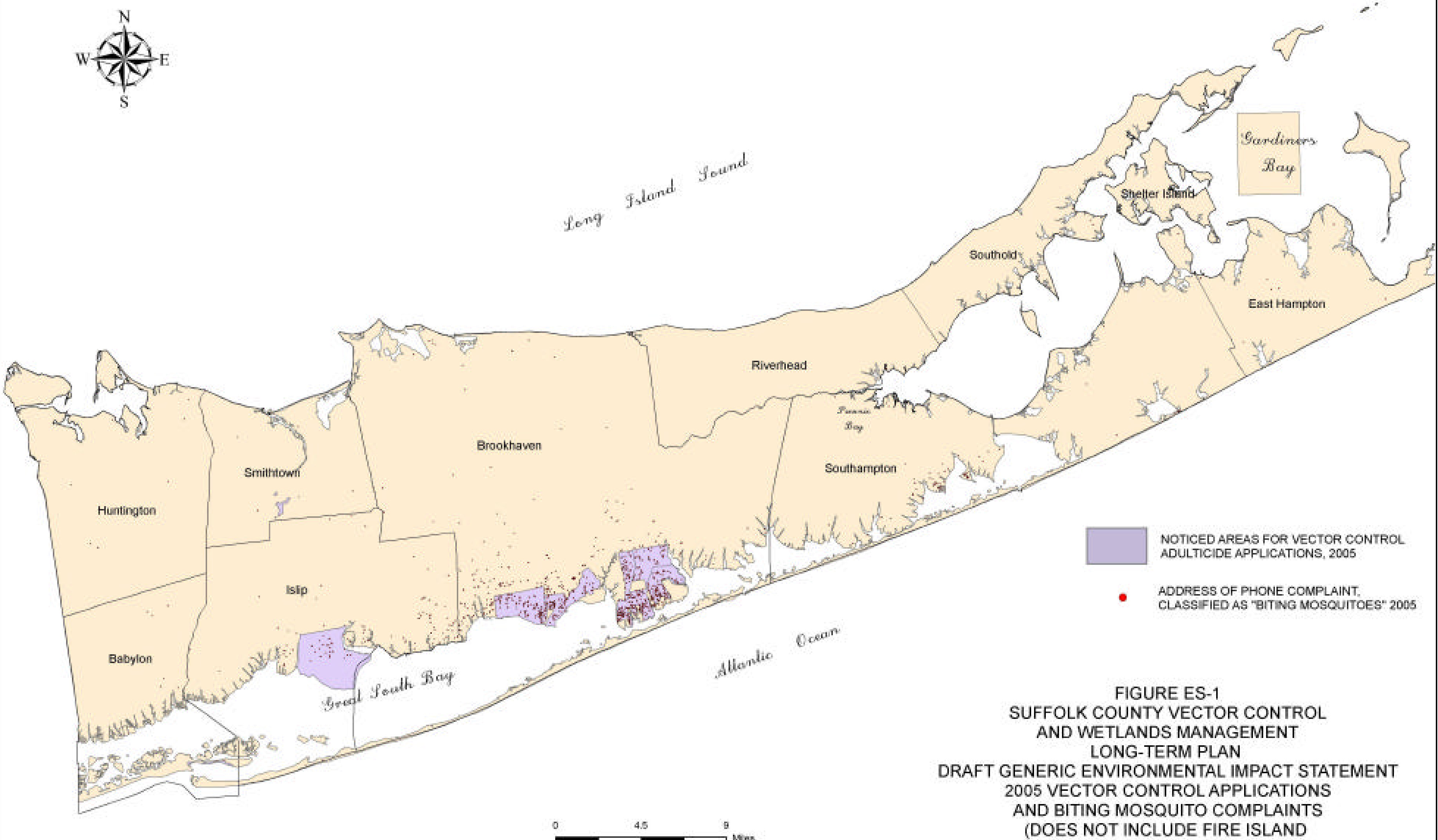

FIGURE ES-1
SUFFOLK COUNTY VECTOR CONTROL
AND WETLANDS MANAGEMENT
LONG-TERM PLAN
DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT
2005 VECTOR CONTROL APPLICATIONS
AND BITING MOSQUITO COMPLAINTS
(DOES NOT INCLUDE FIRE ISLAND
NATIONAL SEASHORE COMMUNITIES)

Furthermore, the use of adulticides provides benefits. They reduce risks for mosquito-borne disease, and other impacts to quality of life, as it is clear they can be effective means of reducing mosquito populations.

ES-4.8 Potential Impacts from Mosquito-Borne Disease under the Long-Term Plan

Two arboviruses, WNV and EEE, are the main human health concerns with mosquito-borne disease.

Since 1999, from its introduction in the general area of LaGuardia Airport in Queens, New York, WNV has spread throughout the US and North America (Marra et al., 2004). The transmission cycle of WNV requires mosquitoes, the vectors for the disease. At least 40 species of mosquitoes have tested positive for the virus in North America (Cornell, 2004). The major species associated with the spread of WNV belong to the *Culex* species; cases are linked to *Cx. pipiens, Cx. quinquefascatus,* and *Cx. tarsalis* (CDC, 2003a). Mosquitoes feed seeking essential nutrients for egg production. If an infected host is fed on, the mosquito can become a carrier for the virus, and can transfer the virus when it feeds again. Birds tend to develop measurable virus levels (viremia) shortly after being bitten by infected mosquitoes; therefore, they possess the ability to pass the virus onto other mosquitoes if bitten again. Such species are known as "reservoir hosts" because they can pass the virus back to mosquito vectors. Mosquitoes may also infect other animals, including mammals, which are classified as "dead end" hosts, because they do not support a high enough viremia level to successfully pass the virus back to mosquitoes when bitten (Cashin Associates, 2005a).

WNV causes several forms of illness in humans, which must run their course as there is no effective treatment for the disease. Symptoms can be relieved through various treatments appropriate for flu and flu-like effects (e.g., standard medication for headache, fever, body aches, etc.). West Nile fever, the least virulent form, is characterized by symptoms such as fever, body aches, headache, and, sometimes, swollen lymph glands and rash. West Nile fever generally lasts only a few days, although in some cases symptoms have been reported to last up to several weeks. West Nile fever does not appear to cause any long-term health effects and most patients recover fully with no sequelae (Huhn et al., 2003).

Some people may develop a brief, West Nile fever-like illness before they develop more severe disease, although the percentage of patients in whom this occurs is unknown (Huhn et al., 2003).

Occasionally, an infected person may develop a more severe course of the disease – West Nile encephalitis or West Nile meningitis. Encephalitis is an inflammation of the brain, and meningitis is an inflammation of the membrane around the brain and the spinal cord. There is no treatment for WNV infection itself; a person with severe disease often needs to be hospitalized. Care may involve providing intravenous fluids, respiratory support, prevention of secondary infections, and general nursing support of the symptoms (Huhn et al., 2003).

In Suffolk County, there have been 26 cases of WNV illness since 1999, and four people have died from the disease.

EEE is a mosquito transmitted pathogen that occurs naturally in a wide variety of birds along the eastern flyway of the United States (Morris, 1988; Scott and Weaver, 1989). The virus produces the clinical disease eastern equine encephalomyelitis in humans with a mortality outcome between 30 and 75 percent and is virtually 100 percent fatal in horses (Morris, 1988). Chamberlain (1958) felt that EEE reached highest levels in coastal areas where fresh water swamps joined salt marsh habitat. *Culiseta melanura*, a bird feeding mosquito that uses acid water swamps as habitat, has been identified as the primary enzootic vector, first in Georgia (Chamberlain et al., 1958) but also in New York (Morris et al. 1980). *Cs. melanura* appears to be a fixed avian feeder (Edman et al., 1972) and is probably not responsible for the transmission of EEE to either humans or equine hosts. Therefore, “bridge vectors” are necessary to transmit the virus from birds to people or horses. Although several species have been shown to be competent vectors of EEE, Crans (1977) used Koch’s postulates to show that *Oc. sollicitans* met basic criteria to indirectly prove vector status and suggested that the species should be controlled for the prevention of human disease whenever EEE is found to be active.

There has never been a human case of EEE in Suffolk County, although a horse case occurred in Nassau County in 2005, and a health emergency for EEE was declared in the Montauk area in 2003.

Novel mosquito-borne diseases for Suffolk County can be classified as those that are endemic but do not cause illness, and those exotic pathogens that may be introduced. Endemic diseases of concern include:

- Jamestown Canyon virus
- La Crosse virus

Exotic pathogens of concern include:

- Sindbis virus
- Rift Valley fever virus
- Japanese encephalitis virus
- Usutu virus

This list is not comprehensive, but is intended to identify reasonable prospects for introduction to Suffolk County. Although none of these diseases is currently found in the County, the introduction of a novel mosquito-borne disease seems to be a question of "when" not "if," given the realities of modern transportation and its role in the spread of infectious agents (Cashin Associates, 2005b).

Mosquitoes involved in disease transmission in Suffolk County are listed in Table ES-17.

Table ES-17. Mosquito Species of Concern in Suffolk County

Species	**Vector Status**	**Other Issues**
Aedes vexans	Known WNV bridge vector Probable EEE bridge vector	Aggressive, SC's major fresh flood water mosquito
Anopheles punctipennis	Possible WNV bridge vector	Pesky, enters houses
Anopheles quadrimaculatus	Malaria vector	Moderately aggressive
Coquillettidia perturbans	EEE bridge vector	Aggressive human biter, breeds in emergent fresh marshes
Culex pipiens	WNV amplification vector Probable WNV bridge vector	Breeds near (containers, catch basins, other standing water) and enters houses
Culex restuans	WNV amplification vector	Often breeds with *Cx. pipiens*
Culex salinarius	WNV bridge vector	Irritating biter, breeds in brackish flood water (rare here)
Culiseta melanura	EEE amplification vector Probable WNV amplification vector	Breeds in environmentally-sensitive habitats, making control problematic
Ochlerotatus canadensis	Probable EEE bridge vector Possible WNV bridge vector	Spring fresh water mosquito, extremely long lived, avid human biter
Ochlerotatus cantator		Spring salt water mosquito, moderately aggressive
Ochlerotatus japonicus japonicus	WNV bridge vector	Tree-hole (tire) mosquito, causes local biting complaints, moderately aggressive
Ochlerotatus sollicitans	EEE bridge vector Probable WNV bridge vector	SC primary pest species, extremely aggressive, salt water flood mosquito
Ochlerotatus taeniorhynchus		Aggressive salt water flood mosquito

Recent WNV infection rates for Suffolk County are shown in Table ES 18.

Table ES-18. Rates of WNV cases (per million population) in Suffolk County, 1999-2004

	1999	2000	2001	2002	2003	2004	Mean Rate	Maximum Rate
Suffolk County	0	0	0.56	4.62	5.49	0	1.78	5.49
Suffolk County Exposed Population*	na	0	0.84	6.85	8.14	0	3.17	8.14

* exposed populations are those living in a zip code where a positive dead bird or positive mosquito pool was found

These rates can be compared to those from serosurveys and public health records in northeastern North America (Table ES-19).

Table ES-19. WNV Rates (per million people exposed)

Location	Year	Infection Rate	Hospitalization Rate	Death Rate
Douglaston	1999	26,000	190	22
Connecticut	1999	0	0	0
Suffolk County	2000	1,200	0	0
Connecticut	2000	0	0.29	0
Suffolk County	2001	130*	0.84	0
Connecticut	2001	260*	1.8	0.3
Cuyahoga County	2002	19,000	100	6.4
Toronto	2002	31,000	200	0
Suffolk County	2002	1,000*	6.9	1.7
Connecticut	2002	750*	5.0	0
Suffolk County	2003	1,200*	8.1	1.6
Connecticut	2003	750*	5.0	0
Suffolk County	2004	0*	0	0
Connecticut	2004	44*	0.29	0

* = computed using a 150:1 ratio of infections to hospitalizations
all data rounded to two significant figures
(see Cashin Associates, 2005r)

It is clear that Suffolk County (and Connecticut) had much lower infection rates than Douglaston, Cuyahoga County, and Toronto. This is most likely due to a combination of differing mosquito ecology and mosquito control programs. However, both Suffolk County and Connecticut have competent vectors of WNV. Aggressive mosquito control programs most likely play an important role in the lower infection rates.

The Long-Term Plan is expected to improve mosquito control in general, compared to the existing program, and also should reduce disease risks. Implementation of progressive water management should, at worst, maintain, and actually is intended to decrease, salt marsh mosquito numbers. Other potential bridge vectors, such as *Ae. vexans*, will continue to be aggressively controlled. *Cx. pipiens* may be better controlled through wider use of larvicides in storm water systems, and more targeted applications of adulticides for viral control, in terms of timing and application means, in fresh water environments where trapping indicates that *Cx. pipiens* is the dominant mosquito present. Continuing public education should also pay dividends in reductions of mosquito environments in the near vicinity of residences and businesses. Therefore, it seems likely that WNV risks for people will be reduced through adoption of the proposed Plan.

Implementation of the Long-Term Plan may reduce risks somewhat from the current mosquito control situation for EEE, as well. This follows from the following elements:

- A strong EEE surveillance program in red maple swamps will be continued, allowing for early detection of the amplification cycle.

- If amplification is detected, surveillance will be extended to similar habitats following logical, local migration paths (mostly south and west), to determine if young-of-the-year birds are spreading the virus.

- Prophylactic control of obvious bridge vectors in the vicinity of historical amplification areas will be continued, using larvicides.

- When the risk profile warrants (if there are large numbers of bridge vectors in the vicinity of an amplification center), adulticides will be applied to reduce the risk of human or equine cases.

- Although the reduction of EEE risks may be an unintentional by-product, salt marsh mosquitoes will be controlled using larvicides, and, if warranted, adulticides; this appears to reduce the chances that this very efficient potential vector of EEE is not allowed to infect people.

Similarly, risks from endemic and novel diseases may be less under the proposed plan, for similar reasons. Good surveillance will determine the presence of the pathogens, and control of most bridge vectors means that opportunities for human infection are less than they might otherwise be.

ES-5. Alternatives Considered

During the development of the Long-Term Plan, alternatives to what became the Long-Term Plan were carefully considered. This is a necessary part of a Management Plan process. The Long-Term Plan (Appendix A) spells out some of the particular choices that were made; implicit in many of the discussions in the Literature Search is the weighing of options for managing Suffolk County's mosquitoes. Formally, for the SEQRA process, a few alternatives were considered. Several were variations on the overall IPM approach to vector control. Alternatives that were so considered included the "no-action" option of continuing the current program, various pesticides choices for larval and adult control, and considering different options in terms of restrictions on pesticides use. In addition, one technological alternative (limited use of Mosquito Magnets) was considered, as was one water management option (regular maintenance of all mosquito ditches in the County) under an IPM rubric.

The other major option considered was to have no organized mosquito control program. This is not an IPM approach, and so will be considered separately.

ES-5.1. No-Action Alternative (Continue the Current Program)

Suffolk County currently employs an IPM program to address mosquito control, one that was evaluated by mosquito control professionals from outside of New York as one of the best in the northeast US (CA-CE, 2004a). The Long-Term Plan and the current program have many features in common. Salient differences, and the effects on impacts from the differences include:

- Public education and outreach: the Long-Term Plan embraces many essentials of the current program, but proposes expanding the extent and intensity of outreach. Several new elements are proposed, including an expanded web presence, and, especially, a targeted outreach program to those areas that receive the most Vector Control adulticide applications. Overall the program will seek to justify itself by collecting and disseminating more information regarding program activities.

- Surveillance: the Long-Term Plan proposes expanding the New Jersey trap network, establishing baseline trap locations, and increasing the initial CDC trap set-out number. Efforts will be made to quantify larval sampling, and develop trigger values for larvicide applications. Alternatives to dead bird sampling for WNV will be explored. Confirmatory CDC trap sampling will be undertaken prior to any proposed Vector Control adulticide application, and landing rate sites will be established. Efficacy sampling (larval and adult treatments) will be done routinely.

- Source reduction: expanded tire management and catch basin surveillance and treatments will be the focus of non-water management source reduction changes from the existing program.

- Water management: the current program relied on extensive maintenance of the legacy grid ditch system for water management, although that program has been largely eliminated over the past several years. The Long-Term Plan proposes a shift to a more progressive water management approach. Where possible, the default action will be to allow marsh reversion to go forward. Where mosquito breeding constitutes a problem, such as at most of the 46 salt marshes in the County that currently receive aerial larvicide applications, more ecologically sensitive approaches to water management will be considered. If favorable reviews of these plans by outside agencies (such as the local natural resource department in the local municipality), other interested parties, and/or the Wetland Screening Committee are gained, then the County will implement these plans, utilizing Best Management Practices developed through the Long-Term Plan process. It is anticipated that the Wetlands Screening Committee will develop a County-wide, comprehensive marsh management plan that will allow vector control actions to move forward so as to restore and enhance the vital functions provided by salt marshes. The Long-Term Plan therefore intends to reduce larvicide use by approximately 75 percent from current levels by instituting more effective water management in troublesome areas, and also to improve ecological processes across the areas that are so treated.

- Biocontrols: the current program uses *Gambusia*, on a limited basis, as a biocontrol. The Long-Term Plan proposed some clear restrictions on biocontrol use, suggested switching to a more environmentally benign fish species, and also proposed using copepods in catch basins, if New Jersey research shows this approach to be safe and effective.

- Larval control: the current program uses the same three larvicides selected under the Long-Term Plan. However, the Long-Term Plan proposes reducing larvicide applications by 75 percent through more effective water management, includes consideration of numerical triggers for larvicide applications, efficacy testing, and resistance management. Larval applications will also be tempered by consultations with resource managers to ensure applications do not unnecessarily impact nesting birds or sensitive species. A special focus to identify species of concern in fresh water environments will be made.

- Adult control: The current program only considers the use of adulticide when all other control mechanisms have not succeeded, and a problem absolutely requires addressing. That general approach will be maintained under the Long-Term Plan. The mainstay pesticides for the adult control program, resmethrin and sumithrin, will be unchanged under the Long-Term Plan, and the Long-Term Plan also proposes to use permethrin and malathion as optional pesticides, as does the current program. The Long-Term Plan, however, also proposes to add natural pyrethrum as an optional pesticide. The basic application methodologies of the current program will be continued, with one change: the Long-Term Plan has installed a weather station-linked aerial; pesticide application guidance system (made by Aadpco) which will ensure, no matter whether the current program is continued or the Long-Term Plan is adopterd, that aerial pesticide applications are optimally made. This will reduce pesticide use and should increase application efficacy, while decreasing off-target drift. The Long-Term Plan will institute pre-Vector Control treatment sampling, and strictly comply with sampling limits for all applications (at least 25 female mosquitoes of human biting species per trap night for New Jersey trap data, and 100 such mosquitoes for CDC light trap collections). The Long-Term Plan will continue to follow NYSDOH and CDC guidance regarding Health Emergency risk assessments. Construction of a local BSL-3 laboratory is intended to improve the quality of information available to local program managers, while also decreasing turn-around times. This should allow for better, more accurate risk determinations to be made, as will expansions of the surveillance network and identification of an alternative to dead bird sampling.

- Administration: the Long-Term Plan proposes a refinement of responsibilities between SCDHS and SCVC to allow for better surveillance programs, and also suggests several internal changes in the organization of SCVC. The Long-Term Plan also recognizes the need for better professional training and education programs for staff. The Long-Term Plan calls for an adaptive management approach to instituting the Long-Term Plan, and insists on better reporting and outreach programs so that the public and interested parties are kept apprised of vector control practices and programs. Outside oversight of the program will be formalized under the Long-Term Plan, by continuing program advisory committees and instituting at least one new oversight group, the Wetlands Screening Committee.

The Long-Term Plan clearly provides opportunities for improvements compared to the existing program. Pesticide use is expected to be sharply reduced, and other aspects relating to overall environmental quality in the County, especially wetland ecological functions, are expected to be enhanced. Overall public health is expected to be protected even better under the Long-Term Plan than it is today. Therefore, although the no-action option represents a program that has been cited as a first class approach to vector control, the Long-Term Plan clearly represents a better means of achieving the County's goals.

ES-5-2. Other IPM Alternatives

Pesticide application alternatives

Alternatives consist of different pesticides than those considered for the Long-Term Plan, and different application strategies. Different pesticides considered were:

- Three larvicides
    - Temphos
    - Ethoxylated fatty alcohols

    - Golden Bear Oil

- Four adulticides

    - Naled
    - Fenthion
    - Chloripyrifos
    - Deltamethrin

Impacts associated with larvicide alternatives would almost exclusively affect larval control considerations.

Temephos is an organophosphate pesticide registered by USEPA in 1965 to control mosquito larvae, and is the only organophosphate with larvicidal use. Temephos is used in areas of standing water, shallow ponds, swamps, marshes, and intertidal zones. Abate is the trade name of the temephos product used for mosquito control. Temephos is applied most commonly by helicopter but can be applied by backpack sprayers, fixed-wing aircraft, and right-of-way sprayers in either liquid or granular form. Temephos breaks down within a few days in water, and post-application exposure is minimal (Cashin Associates, 2005q).

Although temephos does not appear to pose a risk to human health, USEPA (2002c) concluded that it is more toxic to aquatic invertebrates than alternative larvicides. For this reason, USEPA has limited temephos use to areas where less-hazardous alternatives would not be effective, specifying intervals between applications, and limiting the use of high application rates.

Based on this information, temephos appears to pose a greater risk of environmental impacts than the Bti, Bs, or methoprene (Cashin Associates, 2005q).

Monomolecular films are low-toxicity pesticides that spread a thin film on the surface of the water that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water surface, causing them to drown. Films may remain active typically for 10 to 14 days on standing water, and have been used in the US in floodwaters, brackish waters, and ponds. Two particular products are Arosurf MSF and Agnique MMF (Cashin Associates, 2005q).

USEPA (2002c) has concluded that monomolecular films, when used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes, or flooded areas that are not drinking water sources.

Additionally, USEPA (2002c) has concluded that monomolecular films, used according to label directions for larva and pupa control, pose minimal risks to the environment. They do not last very long in the environment, and are usually applied only to standing water, such as roadside ditches, woodland pools, or containers which contain few non-target organisms.

Overall, based on this information, monomolecular films are considered to not pose greater or lesser risks than Bti, Bs, or methoprene.

Oils, like films, are pesticides used to form a coating on top of water to drown larvae, pupae, and emerging adult mosquitoes. They are specially derived from petroleum distillates and have been used for many years in the US to kill aphids on crops and orchard trees, and to control mosquitoes. Products sold for these purposes include Bonide, BVA2, and Golden Bear-1111, (GB-1111) (Cashin Associates, 2005q).

USEPA (2002c) has concluded that oils, used according to label directions for larva and pupa control, do not pose a risk to human health. In addition to low toxicity, there is little opportunity for human exposure, since the material is applied directly to ditches, ponds, marshes, or flooded areas that are not drinking water sources.

USEPA (2002c) also has found, however, that oils may be toxic to fish and other aquatic organisms if misapplied. For that reason, USEPA has established specific precautions on the label to reduce such risks.

Based on this information, Golden Bear Oil could pose a greater ecological risk than Bti, Bs, or methoprene. However, risks would be mitigated if label directions are followed.

Therefore, none of the larvicide alternatives appear to offer any clear reduction in potential environmental risks compared to the selection of larvicides made in the Long-Term Plan.

Selecting different adulticide products appears to have effects only regarding adult control.

Naled is an organophosphate insecticide that is applied as an ULV spray. Naled starts to degrade immediately upon release of the spray droplets in the open air (FDACS, 2005). Once the spray droplets land on surfaces, naled degrades rapidly. Naled also rapidly degrades in water and in the presence of sunlight (Cashin Associates, 2005q).

USEPA conducted preliminary risk assessments for naled as part of its overall cumulative assessment for organophosphate pesticides (USEPA, 2002d). As part of this assessment, USEPA evaluated the relative potency of naled and other organophosphate pesticides, including malathion. The endpoint used to gauge relative potency of organophosphate pesticides was cholinesterase inhibition. The USEPA assessment found that naled is almost 300 times more toxic than malathion.

Given this, naled is assumed to potentially pose a greater risk to human health or the environment than malathion. However, Peterson et al. (2005) found no human health impacts associated with the use of naled for WNV control.

Fenthion is another organophosphate pesticide. It is classified by USEPA as a Restricted Use Pesticide (RUP) due to the special handling warranted by its toxicity. Fenthion is highly toxic to birds, estuarine/marine invertebrates, and non-target organisms. The mosquito adulticide use of fenthion has been implicated in several bird kill incidents (Extoxnet, 1996c). All mosquito control formulations, as well as nondomestic, nongranular formulations of 70 percent and greater are RUPs. RUPs may be purchased and used only by trained certified applicators. Fenthion may not be used on food crops (Cashin Associates, 2005q).

USEPA, in its overall cumulative assessment for organophosphate pesticides (USEPA, 2002d), found fenthion to be more than 1,000 times more toxic than malathion.

Based on these collective data, fenthion is assumed to pose a substantially greater risk to human health and the environment than malathion.

Chlorpyrifos is a broad-spectrum organophosphate insecticide. Chlorpyrifos is moderately toxic to humans, and repeated or prolonged exposure to organophosphates may result in the same effects as acute exposure including the delayed symptoms (Extoxnet, 1996d). Chlorpyrifos is very highly toxic to fresh water fish, aquatic invertebrates, and estuarine and marine organisms, and moderately toxic to birds (Cashin Associates, 2005q).

USEPA, in its overall cumulative assessment for organophosphate pesticides (USEPA, 2002d), found chlorpyrifos to be over 300 times more toxic than malathion.

Based on these collective data, chlorpyrifos is assumed to pose a greater risk to human health and the environment than malathion.

Deltamethrin is a pyrethroid insecticide that kills insects both on contact and through consumption and later digestion. As is common with many pyrethroids, deltamethrin has a high toxicity to fish under laboratory conditions. However, in the field under normal conditions of use, fish seem generally not to be harmed. Deltamethrin has, however, been reported to have an impact on aquatic herbivorous insects, and has been demonstrated to be toxic to bees (Extoxnet, 1996e). Toxic potency, generally, is similar to that of other synthetic pyrethroids (Cashin Associates, 2005q).

Overall, deltamethrin is considered to pose risks similar to those posed by other synthetic pyrethroids (Cashin Associates, 2005q).

Therefore, none of the alternative adulticides seem to reduce the risks of environmental impacts compared to those adulticides selected under the Long-Term Plan.

The different application strategies considered were:

- eliminate the use of all larvicides in fresh water environments, and no use of methoprene in salt water settings
- adulticide only in cases of declared human health emergencies (eliminates all adulticide applications considered under the evaluation management plan except for the aerial applications)

- adulticide only after human illness
- eliminate all adulticiding

In addition, the option not to change application means (i.e., not install the Adapco system) was considered.

Eliminating the use of all larvicides in fresh water environments, with no use of methoprene in salt water settings would primarily impact larval control.

The risk assessment found there were no ecological impacts from the use of Bti, Bs, and methoprene. If that is the case, then eliminating the use of the larvicides in fresh water environments would decrease mosquito control efforts without generating any offsetting environmental or human health benefits. It has been determined in this analysis that mosquito control appears to reduce human health impacts from mosquitoes. Therefore, a decrease in mosquito control would likely increase impacts associated with mosquitoes and mosquito-borne disease – again, without any offsetting environmental benefits.

It might be that the same degree of control could be realized through greater use of adulticides to address the increased populations of adult mosquitoes resulting from a lack of larval control. This is suboptimal for a number of reasons:

1. the risk assessment found some potential short term impacts to flying insects associated with all of the proposed adulticides

2. the risk assessment found the possibility of aquatic invertebrate impacts associated with the use of permethrin and malathion

3. adulticide use is effective for immediate reductions of risks associated with mosquito-borne diseases; adulticides are not as effective for long-term risk reduction because their effect is immediate, and localized to the area treated. Larval control addresses the mosquitoes prior to them becoming disease vectors (for almost all mosquito-borne disease) and when eventual wide-ranging populations are concentrated. This means control can be much more effective.

4. adulticide treatments only address the mosquitoes in the air when the adulticide is applied, and at the location where the pesticide is applied. This limits effectiveness in time and space.

5. the principles of IPM suggest that it is more effective and appropriate to address larval as opposed to adult pests.

6. larval pesticides are more targeted treatments than are adulticides, and thus the theoretical potential for impacts should be greater with the use of adulticides. This includes impacts to humans as well as to the environment.

7. because there is a greater theoretical potential for human impacts, accidents that may result in worker exposure to these compounds, or unintentional misapplications exposing the public, are more serious for adulticide use.

8. the County Pesticide Phase-Out Law inherently rejects the use of more toxic alternatives when less toxic substitutes are available. Larvicides would seem to be less toxic alternatives to adulticides, suggesting a legal concern for touting adulticides to replace larvicides.

The four other application alternatives apply to adulticide applications, and so primarily affect adult control considerations.

Adulticiding only in cases of declared human health emergencies is essentially the management option evaluated in the risk assessment for Dix Hills and Manorville, where one to two applications per year by helicopter were assessed. Therefore, for these locations, implementation of this management alternative would not be expected to result in different risks than those estimated in this human health and environmental risk assessment. Should a public health emergency or case of human illness not occur, no spraying would occur and therefore there would be no human or ecological risk from the use of adulticides.

A greater adulticide application frequency was evaluated for Davis Park, and for Mastic-Shirley. In Davis Park, application frequencies in the range of 11 to 14 applications per season were considered. Risks were predicted for non-target terrestrial insects (all adulticides) and for aquatic life (crustacean and insects – malathion only). However, predicted risks were generally the same order of magnitude in Davis Park as in the other study areas, suggesting that application frequency does not significantly influence risks for the target adulticides and receptors evaluated. This is not surprising, given that none of the target pesticides persists to any substantial degree in the environment. Therefore, multiple applications, even at a once per week application frequency, as evaluated under the Davis Park scenario, do not significantly increase risk potential. For Mastic-Shirley, impacts were predicted for non-target terrestrial insects (all adulticides) and for aquatic life (crustacean and insects – permethrin and malathion only). However, similar to the reasoning applied for Davis Park, the overall risk potential is not likely to be reduced much by decreasing the frequency of the applications.

Overall, adulticide use only during health emergencies or after public illness does not appear to significantly reduce health or environmental risks for those areas being treated compared to those risks estimated in this risk assessment. However, if this option did not merely reduce the number of applications, but eliminated them altogether, then the potential impacts associated with adulticide usage will also be eliminated.

However, the Long-Term Plan has clearly outlined a need for the County to control mosquitoes in situations other than those identified as Public Health Emergencies. Although the County certainly is not relying on adulticiding to achieve its mosquito control ends, there will be certain situations where the use of adulticides, outside of a Health Emergency, is necessary. To not conduct control at such times will cause impacts to the quality of life of many County residents, and also will cause various kinds of non-clinical health impacts. The analysis conducted by the County also suggests that not reducing human-biting mosquito numbers increases risks of disease transmission. This is clearest in the case of EEE and salt marsh mosquitoes, but also seems to be the case for other kinds of mosquitoes and other pathogens, as well. Therefore, restricting adulticide operations as outlined here would have the net effect of increasing public health impacts, as well as increasing effects on quality of life.

The analysis for adulticiding only after human illness is similar to the above, but there are additional potential impacts. For one, it is clear that there will be health impacts associated with this choice, as action will not be taken until after someone is ill. In addition, by waiting to take action, the efficacy of the adulticide will be reduced. This is because there is a lag between the transmission of disease and its reporting to health authorities. With WNV, for instance, it can take several weeks for someone to become ill and be diagnosed. This means that any treatment in direct response to a case is addressing conditions that are several weeks old – and, given the swiftness that mosquito ecology evolves across a summer, is probably no longer relevant. This makes for a logical disconnect in the motivation for treatment. If the treatment is not being made in direct response to the case (because those conditions resulting in the illness no longer hold), then other criteria are being used. If so, then it would make sense to use these other criteria, absent the wait for the human case, to determine if treatment should be made or not. Otherwise, it is as if some degree of societal pain must be undergone prior to conducting adulticide operations. This seems to be technically unsound, and morally and ethically bankrupt.

If the disease did not threaten humans except until people were becoming ill because pathogen presence within a person was necessary for transmission to occur – as might be an interpretation of malarial transmission – and if there were significant impacts associated with the proposed adulticide application, or if adulticide impacts were of a scale where human lives might be at stake, then the evaluation of this option might be more lenient. However, the quantitative risk assessment suggested that the use of adulticides only increased risks for transient potential impacts to aquatic invertebrates and flying insects. This potential impact must be perceived as more abhorrent than the risk of human disease for treatment not to be undertaken prior to a human case.

Another perspective that might support this kind of decision-making would be if adulticide treatments were thought to be ineffective at preventing disease transmission. However, if that were understood to be true, there would be no point in treating after a human case had occurred, either.

The County also considered eliminating adulticide use as a management option. In the risk assessment, adulticide use was shown to potentially be associated with some adverse ecological effects. In all but one case, aquatic ecological risks were principally due to potential malathion use. The pyrethroid compounds generally were not predicted to pose unacceptable aquatic ecological risks. Therefore, elimination of malathion as an adulticide could be associated with some potential risk reduction. In addition, all adulticides were predicted to be associated with a potentially increased risk to non-target terrestrial insects, and consequently, elimination of adulticide use in general would eliminate this potential impact.

The degree to which true impacts would be avoided by exclusion of adulticides is not completely known. As stated throughout, the risk assessment employed relatively conservative assumptions designed to overestimate rather than underestimate risks. Consequently, risks could be substantially lower than those estimated here, and the overall magnitude of risk reduction by elimination of adulticiding might be lower than suggested by the conservative risk numbers presented here.

As a general conceptual position, however, chemical risks will be lower if chemicals are not released to the environment. Therefore, complete elimination of adulticides will lower risks, although the magnitude of that risk reduction cannot be defined with great certainty.

The basis for adopting the stance that adulticides should not be used seems to be that adulticides are ineffective. In one sense, this is patently not true, as tests show adulticides are effective in eliminating mosquitoes. However, it is also true that mosquito populations often rebound following an adulticide application. If that were to be generally the case, then it might be argued that mosquito control using adulticides was largely ineffective.

Assume for a moment that mosquito populations generally rebound quickly. The effect sought by adulticide use may only be transient, therefore. That may be sufficient for disease risk reduction measures, especially if a brooded mosquito is the target of the treatment. The mosquitoes that were eliminated are probably the parous (older) mosquitoes that represented the disease threat, and the population rebound may be comprised of younger mosquitoes that do not cause as much concern. If the intent of the treatment was for Vector Control, then short-lived effectiveness of a treatment means that the goal is only achieved for a fleeting time period. However, as has been discussed extensively throughout this assessment, Vector Control treatments not only address quality of life issues, but also have some degree of disease risk reduction, as reducing populations of human-biting mosquitoes when all major species of human-biting mosquitoes are vectors clearly decreases risks faced by people.

Although data from Suffolk County are not organized to make a quantitative presentation, the County knows that these treatments are effective. The County does not use adulticide treatments on a regular basis, except in the Fire Island communities, where uncontrolled breeding in the near vicinity creates long-standing intolerable conditions for residents. Instead, the County uses adulticide to reduce peak populations or to prevent the imminent transmission of disease. Short-term reductions of peak populations are sufficient to ensure they are not immediately repeated. Elimination of the highest disease threats means that the risks of disease will be lower.

Elimination of adulticiding would reduce fleeting risks associated with pesticides use, but allow other problems and risks associated with mosquitoes to go unchecked.

Use Mosquito Magnets in Davis Park

Special traps have been developed in the last few years that are designed to attract and catch large numbers of mosquitoes, thus removing them from a fairly wide radius around the trap. Brands include Mosquito Magnet, Mosquito Megacatch, the Flowtron Power Trap, and the Dragonfly (CA-CE, 2005A).

All of these traps utilize some form of attractant that lures the host-seeking female mosquitoes to a capture or killing device (AMCA, 2005). In some cases, mosquitoes are captured by an impellor fan that draws them into a net, where they desiccate. Other trapping systems use a sticky surface to which the mosquitoes adhere when they land. Still others utilize an electric grid to electrocute mosquitoes drawn into contact (CA-CE, 2005a).

Attractants used are generally variations on a common theme of mimicking mammalian exhalations, scents, and body heat to provide host cues to questing female mosquitoes. The vast majority of these traps use co_2, produced either through the combustion of propane or via carbon dioxide (CO_2) cylinder and released at between 350m and 500 ml/min. The plume of CO_2 produced mimics human exhalation and makes these traps specific for capturing blood-feeding insects. Therefore, non-target insects such as moths and beetles will be largely unaffected. The CO_2 is often synergized with 1-octen-3-ol (octenol) (a derivative of gasses produced in the rumen of cows) to increase attractiveness by several orders of magnitude. The octenol is slow-released into the air along with CO_2 (CA-CE, 2005a)

An alternative management option considered by the County was use of mosquito traps in Davis Park. If used, these mosquito traps could release CO_2 and octenol into the atmosphere. Although CO_2 is a simple asphyxiate and cerebral vasodilator (BOCG, 2005), it would not reach toxic levels when released the ambient the environment during trap operation.

Similarly, no toxic effects are likely from release of octenol. USEPA (2003) has concluded that octenol, when released into air, is not harmful to humans, to other non-target organisms, or to the environment. There is the potential for toxicity if ingested, but this exposure route is highly unlikely.

Overall, no adverse health or ecological impacts are likely to be associated with the use of mosquito traps in Davis Park. Potential aquatic life risks associated with the use of malathion were predicted for Davis Park. Therefore, when evaluated specifically from a chemical risk standpoint, use of the mosquito traps would likely be a lower risk alternative than the use of malathion. No risks were predicted for the other target pesticides proposed for use in Davis Park; therefore use of mosquito traps in lieu of these other target adulticides will not significantly lower risks.

The Early Action project demonstration with the propane-powered traps found that they were ineffective at preventing mosquitoes from accessing an area (CA-CE, 2005a). This indicates that they would probably not perform satisfactorily at Davis Park. This means that this alternative is not acceptable because reductions in potential impacts to the environment would be minimal (malathion is not likely to be used at Davis Park, especially on a regular basis), and no control of mosquitoes might result.

It should be noted that some studies have found these devices to work well (CA-CE, 2005a). This suggests that, analogous to DEET alternatives, efficacy may result if particular, as yet unidentified factors collude with the product to cause some synergistic effects. Thus, it may happen that the considered array would be effective, due to some factors not included in the test at Sayville. Since there is no reason to assume that this will be the case, however, prudence dictates not adopting this strategy of mosquito control.

Water Management Option – Maintain All Ditches

Essentially, four water management options were considered under the DGEIS. The Long-Term Plan included conducting progressive water management. The No-Action alternative (the existing program) considered continuing ditch maintenance. The no vector control program (see just below) considered no active water management (all reversion). In addition, the option to maintain all ditches throughout the County was considered. This would expand the scope of the existing ditch maintenance policy. This policy would be adopted if the mosquito ditches were to be considered as any other part of the County's infrastructure, where it is sound to keep the infrastructure in good working order.

The problem with this approach is that expanding ditch maintenance, even in comparison to current ditch maintenance policies, would appear to offer few to no benefits for mosquito management and may result in considerably greater environmental costs. Environmental benefits would appear to be few: improvements in water quality, potentially, for certain areas of some marshes, and potentially gains in fish habitat (both for mosquito consuming fish and for estuarine fish). The benefits seem vastly outweighed by the potential effects.

As an example, maintaining ditches in a healthy, good functioning marsh where ditches have not been recently maintained would alter the existing hydrology, wildlife habitats, and vegetation patterns. Generally, maintaining every ditch in marshes across the County would likely lead to widespread changes in vegetation and hydrology. Ditch maintenance is not needed at many marshes because mosquito numbers are low and breeding is not a concern.

Thus, this alternative would appear to be a lesser choice in terms of mosquito control benefits, and also in terms of potentially causing environmental impacts because of insensitive application of a management technique where it is not needed, and where, if management is needed, better options may be available.

ES-5.3. No Vector Control Alternative

Conducting no vector control at all can be evaluated primarily by determining what the baseline risks from mosquito-borne disease, in the absence of vector control programs, might be, and by determining if any environmental impacts might occur in the absence of water management. If impacts were associated with these two factors, they could be compared to the identified impacts of the Long-Term Plan to see if no vector control might be a better alternative for the County to consider.

The potential for WNV infection for areas where there was no mosquito control is based on:

- two percent infection rates (20,000 cases per million exposed)
- of the two percent infected, 1 in 150 would suffer from neurological illnesses (meningitis or encephalitis), a 0.013 percent illness rate (130 hospitalizations per million exposed)
- of those hospitalized, approximately one in 10 would die, a 0.0013 percent fatality rate (13 deaths per million exposed)

(Cashin Associates, 2005r)

A model to compute the effects of such illness rates was established for the County, using exposure data based on zip codes where either positive birds or positive mosquito pools had been detected for 2000 to 2005. The results of the model are shown in Table ES-20.

Table ES-20. Model of Suffolk County West Nile Virus Incidence, No Mosquito Control (based on a population of 1,482,284)

Year	Population Exposed	Hospitalizations	Deaths	Resulting Immune Percentage
2000	1,135,878	151.5	15.1	1.5
2001	1,195,260	156.9	15.7	3.1
2002	1,168,088	150.9	15.1	4.6
2003	1,227,931	156.1	15.6	6.2
2004	191,328	23.9	2.4	6.5
Totals		639	64	6.5

These results suggest that as many as 64 people might have died in the absence of vector control activities, assuming that mosquito transmission of WNV in the County is similar to how the disease was transmitted in Douglaston in 1999, and in Cuyahoga County and Ontario in 2002.

To determine if these impacts can be expected to continue, even with increasing seroconversion rates (and associated immunities from WNV), the model was run until 2025. Although immunity increases over time, because the infection rate is only a little larger than the increase in uninfected people in the County (due to births and net migration into the County, even assuming similar immunity rates for the migrants), there is no appreciable drop off in the modeled impact from WNV for the next 20 years (Cashin Associates, 2005r).

It is not possible to quntify risks associated with EEE in the same fashion. It appears likely that no vector control program would result in some increased risks for this virulent disease, and for impacts associated with novel diseases, as well.

Analyses of public attitudes towards use of personal protection to avoid disease impacts, conducted in Louisiana, suggested that lack of knowledge was not the primary factor in avoiding taking steps to avoid disease risks. Rather, complicated sociological attitudes seemed to interfere with many people taking steps they recognized as useful (Zielinski-Gutierrez, 2002). It is not altogether clear that all of the factors that were found in Louisiana apply to Suffolk County, but many may. This suggests there are deep-seated barriers to effective avoidance of mosquito impacts, and the lack of an organized program cannot be balanced simply through public education to take personal responsibility for avoiding effects associated with mosquitoes and mosquito-borne diseases.

Impacts associated with reversion – managing marshes by allowing natural processes to occur without further manipulation – were discussed above under the Long-term Plan, as the County intends to use reversion as an extremely important element in its marsh management plans.

Marsh characteristics that seem to indicate good results from reversion are:

- historical marsh health in the absence of ditch maintenance
- large tidal exchange rates, fostered by some combination of a large tidal range, a good estuarine connection, few barriers to internal water flows, and/or an extensive natural creek system
- infilling ditches from upland ends (potentially eroding at the mouths)

- relatively few people to be impacted by mosquito breeding
- killifish habitats other than ditches
- patient managers willing to allow processes to occur deliberately

However, conducting no water management means that this strategy would be employed for all marshes throughout the County. There are many examples of salt marshes in the County where ecological and mosquito management impacts can be shown to occur because one or more of the factors listed above are absent from the marshes in question.

Therefore, the DGEIS concluded that a strategy of strict reversion would result in mosquito impacts to people (including potential health impacts), and ecological impacts to certain marshes – and the loss of ecological benefits associated with adoption of progressive water management, where indicated.

Thus, a no vector control option is clearly suboptimal.

ES-6. Triggers for Further Environmental Review

Suffolk County is expected to adopt findings on an environmental review of its Long-Term Plan for Vector Control and Wetlands Management. Under SEQRA, GEISs should "set forth specific conditions or criteria under which future actions will be undertaken or approved, including requirements for subsequent SEQR compliance" (6 NYCRR §617.10(c)). This may include "thresholds and criteria for supplemental EISs to reflect significant impacts … not adequately addressed or analyzed in the generic EIS" (ibid).

Further environmental reviews for actions taken under the Long-Term Plan relate to two types of actions:

- adoption of the Annual Plan of Work by the County Legislature
- permitting of water management projects (actions taken by the NYSDEC and potentially by local governments or agencies).

Criteria for Additional Environmental Review Relating to the Annual Plan of Work

Upon adoption of Findings, the Legislature (as Lead Agency) will have satisfied itself that the potential impacts of the Long-Term Plan have been adequately reviewed. From this perspective, if an Annual Plan of Work complies substantively with the Long-Term Plan, then potential impacts of that annual plan will have been adequately considered, as well.

The primary criterion for determining if an Annual Plan of Work is not substantively in accord with the Long-Term Plan should be the annual plan's compliance with the overall approach of the Long-Term Plan, and, where specified, a failure to use particular actions, or a major deviation from an important specific set of actions. In general, annual plans need to focus on the use of surveillance to determine where mosquito problems exist, and to primarily employ source reduction tools to reduce the impact of mosquitoes on people. An important source reduction tool must be implementation (over time) of the techniques for water management developed in the Best Management Practices manual, as outlined in the Wetlands Management Plan. Any plan that proposes to manage mosquitoes without surveillance or to not use water management as a means of obtaining long-term control of mosquito problems will require additional environmental review.

Other criteria that would lead to additional environmental review of an annual plan would be:

- failure to include public education and outreach steps to educate residents and visitors on the means that are available to avoid mosquito bites and diseases associated with mosquitoes
- reductions in staffing levels as allocated in the Long-Term Plan to population or disease surveillance
- failure to commit to respond to all mosquito complaints using personnel appropriately trained to identify and mitigate sources of mosquito problems
- no coordination with local governments on minor water management projects
- no review of major water management projects by agencies or organizations outside of Suffolk County government
- absence of a mitigation strategy for any failures to meet water management objectives, as identified in an annual Wetlands Strategy Plan or Triennial Program Report
- proposed use of a non-native biocontrol organism not already resident in Suffolk County natural environments
- proposed use of a larvicide other than *Bacillus thuringenesis var israelensis* (Bti), *Bacillus sphaericus*, or methoprene
- proposed use of an adulticide other than resmethrin, sumithrin, permethrin, natural pyrethrins, or malathion
- identification of a preferred adulticide agent other than resmethrin or sumithrin

- administrative changes that resulted in daily operational authority no longer residing with the Superintendent of the Division of Vector Control of the Suffolk County Department of Public Works (SCVC), or in operational authority under a declared health emergency no longer residing with the Commissioner of the Suffolk County Department of Health Services (SCDHS)

Environmental reviews may consist of a negative declaration if no significant environmental impacts will result (6 NYCRR §617.10(d)(3)) or a supplemental environmental impact statement if one or more significant adverse impacts may result (6 NYCRR §617.10(d)(4)). Use of an expanded EAF may be appropriate when a negative declaration is proposed.

Water Management Projects Criteria

Upon adoption of Findings, the Legislature (as Lead Agency) will have satisfied itself that the potential impacts of the Long-Term Plan have been adequately reviewed. From this perspective, the classification of allowable water management actions (as described in the Best Management Practices manual) as "no to little" potential impacts, "minor" potential impacts, and "major" potential impacts will have been accepted, and the descriptions of the potential for impacts (and the mitigation steps to avoid impacts) will have been deemed to be adequate.

Nonetheless, on a project by project basis, the following criteria need to be considered to determine if additional environmental reviews are warranted:

- the techniques to be employed have been classified as having the potential for major environmental impacts

- the total area of the wetlands that may be affected by the project exceeds 15 acres with hydrology being the primary consideration

- the project requires physical alteration of more than 15 acres of wetlands

- consultation with local authorities or review by the Screening Committee finds there is a potential for major impacts under the proposed course of action

Environmental reviews may consist of a negative declaration if no significant environmental impacts will result (6 NYCRR §617.10(d)(3)) or a supplemental environmental impact statement if one or more significant adverse impacts may result (6 NYCRR §617.10(d)(4)). In light of the extensive reviews of the techniques to be employed for water management in the GEIS and associated documents, use of an expanded EAF to cite relevant sections of the GEIS or to report on local data collection efforts that justify the project may be appropriate if a negative declaration is proposed.

ES-7. Roadmap to the DGEIS

ES-7.1. Essential Elements of a GDEIS

The SEQRA regulations lay out the necessary elements of an Environmental Impact Statement (6NYCRR 617.9(5)). They are:

- a description of the proposed action
- a description of the environmental setting
- where applicable and significant, an evaluation of the potential significant adverse impacts, including short-term, long-term, and cumulative impacts;
- where applicable and significant, an evaluation of adverse environmental impacts that cannot be mitigated
- where applicable and significant, an evaluation of irreversible and irretrievable commitments of resources
- where applicable and significant, an evaluation of growth inducing aspects
- where applicable and significant, an evaluation of impacts on energy use and conservation
- where applicable and significant, an evaluation of impacts on solid waste
- in Nassau and Suffolk Counties, impacts on and consistency with special groundwater protection area programs and plans
- descriptions of mitigation measures
- a discussion of feasible alternatives
- if the action is in an approved Local Waterfront Revitalization Program area, consistency with the local program policies

A Generic EIS may be broader and more general than site or project specific EISs, but should discuss the logic and rationale for the choices being offered. A GEIS may also use conceptual information, and may discuss hypothetical scenarios in general terms (6NYCRR 617.10(a)).

ES-7.2 Finding the Essential Elements

The essential elements of EISs have been included in the GEIS prepared for the Long-Term Plan. A brief concordance of the essential elements and the GEIS is presented in Table ES-21.

Table ES-21. Concordance of the Long-Term Plan GEIS with SEQRA Essential Elements

Essential Elements	
Proposed Action	Sections 2.8 – 2.10
Environmental Setting	Sections 3, 4, 5
Short-term and Long-term Adverse Impacts of the Action	Section 7
Cumulative Impacts	Section 15
Impacts that Cannot be Mitigated	Section 16
Irreversible Commitments of Resources	Section 17
Growth-inducing Impacts	Not applicable and significant
Energy Impacts	Section 11
Solid Waste Impacts	Section 12
SGPA Impacts	Not applicable and significant (see the discussion in Section 3.4.2
Mitigations	Section 14
Feasible Alternatives	The existing program (no-action): Section 21, Sections 7, 8 IPM alternatives: Section 8 No Vector Control: Section 9
Consistency with LWRPs	Section 2.7.4

Scoping was conducted for this project. The Final Scope was included as Appendix D. As part of the Scope a proposed outline for the EIS was prepared. The development of the project precluded using that particular outline to prepare this DGEIS; nonetheless, as that outline ensured all elements raised in Scoping were to be included in the DGEIS, a concordance showing where in the current document each subtopic can be found has been prepared. In addition, in Section 18 another concordance has been prepared that demonstrates that key issues raised in Scoping were explicitly addressed in the DGEIS.

Please note that no topic could not be addressed due to information unavailability, although some topics were discussed in more conceptual terms than others (as is allowed in the preparation of a DGEIS)

All referenced material was either included as an Appendix (the three basic plans that form the Long-Term Plan, Scoping, and the project Workplan), has been made available for downloading on the project website (www.Suffolkmosquitocontrolplan.org), or was published and is available through standard library resources. References have been provided for each section of the DGEIS. All materials (except books received through library loans) should be available through the Project Manager.

DGEIS Scoping Table of Contents Concordance to DGEIS dated May 3, 2006

The Scoping DGEIS Table of Contents was prepared early in a project that was by its very nature intended to deviate from preconceived project descriptions. It was anticipated that research, project activities, and early Action Projects would be combined to generate a Long-Term Plan that was not merely a validation of past practices.

Therefore, there were some changes in emphasis from the outline presented here, and the draft DGEIS does not follow the organization presented during Scoping, either. However, the content of the draft DGEIS appears to have addressed the substantive issues identified in December 2002.
The Scoping outline is presented below in **bold** *or* plain *typefaces. Cashin comments and the DGEIS sections/pages where the topics are addressed are in italics.*

GLOSSARY OF KEY TERMS
Included with table of contents in each volume
1. EXECUTIVE SUMMARY
Section ES
2. DESCRIPTION OF THE ACTION
2.1. SC Long Term Management Plan for use of adulticides for mosquito control
Section 2.10.6
2.2. SC Long Term Management Plan for use of larvicides for mosquito control
Section 2.10.5
2.3. SC Long Term Management Plan pesticide application techniques
2.3.1. Aerial
Section 2.10.5, 2.10.6
2.3.2. Truck-mounted
Section 2.10.5, 2.10.6
2.3.3. Other
Section 2.10.5, 2.10.6
2.4. SC Long Term Management Plan for use of traps for mosquito control
Traps were found to be ineffective (Section 6.11, 8.8.2)
2.5. SC Long Term Management Plan for marsh management for mosquito control
2.5.1. Marsh/Water Management
Section 2.10.3
2.5.2. Dredging & filling
Section 2.10.3
2.5.3. OMWM in various forms
Section 2.10.3
2.5.4. Natural reversion
Section 2.10.3
2.5.5. Other
2.6. SC Long Term Management Plan for public education

Section 2.10.1

2.7. SC Long Term Management Plan for public notification

Section 2.10.1

2.8. SC Long Term Management Plan for Citizen mosquito control efforts

Section 2.10.1

2.9. SC Long Term Management Plan operating costs

Section 2.10.7, Appendix A

2.9.1. Personnel

Section 2.10.7

2.9.2. Equipment and supplies

Throughout Section 2.10, Appendices A-C

2.9.3. Other

Section 2.10.7

3. HUMAN HEALTH SETTING

3.1. Demographics

3.1.1. Geographic distribution of general population

Section 3.2

3.2. Distribution of vectors

3.2.1. Distribution of mosquitoes infected with WNV, EEE, SLE, others

Section 2.4, 2.5, 5.6., 5.9

3.2.2. Distribution of infected birds, horses, and other disease-carrying organisms

Figures 7-12 to 7-16

3.3. Distribution of mosquito-borne disease infections, hospitalizations, and deaths

Confidentiality rules did allow for this to be produced, but see Figures 7-12 to 7-16 and associated discussions in Section 3.3.4 and 7.11.2

4. ENVIRONMENTAL SETTING

4.1. Land Uses

4.1.1. Distribution of upland recreation areas such as parks, playfields.

Discussed for Risk Assessment Study Areas Section 4.2

4.1.2. Distribution of public beaches

Discussed for Risk Assessment Study Areas Section 4.2

4.1.3. Distribution of freshwater wetlands

Mapped Section 3.1.5, discussed generally Section 5.8.3, discussed more completely for Risk Assessment Areas Section 4.2, PSAs, Section 5.10

4.1.4. Distribution of marine wetlands

Mapped Section 3.1.5, discussed generally Section 5.2, discussed more completely for Risk Assessment Areas Section 4.2, PSAs, Section 5.10; also see Appendix B

4.1 Geology

4.1.1 Distribution of soils relative to pesticide residuals

Suffolk County soils generally discussed Section 3.1.2, discussed in specific Risk Assessment Areas, Section 4.2, quantitative risk assessment included discussion of specifics relating to terrestrial pesticide transport, Section 7.9.2.1.8

4.1.2 Distribution of soils relative to permeability and groundwater recharge

Suffolk County soils generally discussed Section 3.1.2; groundwater systems discussed generally Section 3.1.3; discussed in specific Risk Assessment Areas, Section 4.2, quantitative risk assessment included discussion of specifics relating to terrestrial pesticide transport, 7.9.2.1.8

4.1.3 Topography and its relationship to pesticide drift due to runoff

LI topography mapped and discussed Section 3.1.1; discussed in specific Risk Assessment Areas, Section 4.2; quantitative risk assessment included discussion of specifics relating to terrestrial pesticide transport, Section 7.9.2.1.8, and runoff to surface water bodies, Section 7.8.2.1.5 and 7.9.2.1.8

4.2 Water Resources

4.2.1 Stormwater

4.2.1.1 Collection systems as mosquito habitats

Discussed generally Section 2.10.3, and specifically Section 6.9, 6.10

4.2.1.2 Water quality

4.2.1.2.1 General presence of contaminants

Section 3.1.4

4.2.1.2.2 Presence of VC chemicals

Section 3.1.4, 3.4.2

4.2.2 Surface water

4.2.2.1 Drainage areas and relationship to stormwater runoff

Section 3.1.4, generally, and specifically, Section 6.6, 6.9, 6.10, and for risk assessment areas, Section 4.2, and PSAs, Section 5.10

4.2.2.2 Water quality

4.2.2.2.1 General presence of contaminants

Section 3.1.4

4.2.2.2.2 Presence of VC chemicals

Section 3.1.4, 3.4.2

4.2.3 Groundwater

4.2.3.1 Water quality

4.2.3.1.1 General presence of contaminants

Section 3.1.3

4.2.3.1.2 Presence of VC chemicals

Section 3.1.3, 3.4.2

4.3 Air Resources

4.3.1 Air quality

4.3.1.1 General presence of contaminants

Section 3.1.8

4.3.1.2 Presence of VC chemicals

Section 3.1.8

4.3.2 Local Climatic Conditions

Section 3.1.8

4.4 Ecological Resources

4.4.1 Mosquitoes

4.4.1.1 Species, life histories, distribution
Section 2.4, 2.5, 5.5.3, 5.6, 5.9
4.4.2 Mosquito habitats (distributions, inhabitants, historic trends)
Section 2.4
4.4.2.1 Marine marshes
Section 2.4, 5.5.3, 5.6
4.4.2.2 Freshwater marshes
Section 2.4, 5.9
4.4.2.3 Stormwater catch basins, recharge basins, and treatment wetlands
Section 2.4, 6.8, 6.9
4.4.2.4 Other *(i.e.,* anthropogenic)
Section 2.4
4.4.3 Mosquito predators (species, life histories, distribution)
Section 2.4, 5.5.3
4.4.3.1 Birds
Section 2.4, 2.10.4, 5.5.3
4.4.3.2 Amphibians
Section 2.4
4.4.3.3 Insects
Section 2.4, 2.10.4, 5.5.3
4.4.3.4 Crustaceans
Section 2.4, 5.5.3
4.4.3.5 Fish
pp. 2.4, 2.10.4, 5.3
4.4.3.6 Mammals
Section 2.4
4.4.4 Rare and Endangered Plants and Animals
Section 3.1.7; also see specific risk assessment areas, Section 4.2
4.5 Community and Emergency Services
4.5.1 VC budget
Section 2.1
4.6 Aesthetics & Cultural Resources
4.6.1 Relationship of tourism expenditures to mosquito control
Section 10.1
4.6.2 Relationship of outdoor recreation expenditures to mosquito control
Section 10.1
5 LEGAL AND REGULATORY SETTING
5.1 Federal Authority
Section 2.7.1, 2.7.2, 2.7.3.1
5.1.1 EPA - Pesticide registration requirements and procedures
Section 2.7.1, 2.7.2
5.1.2 ACOE –Wetlands
Section 2.7.3.1

5.1.3 OSHA-Worker safety
Section 2.7.1
5.1.4 National Park Service - Pesticide use and wetland management on Park land
Section 2.7.3.1
5.1.5 Fish and Wildlife Service - Pesticide use and wetland management on FWS land
Section 2.7.3.1, 2.7.4
5.1.6 Geological Service - Groundwater monitoring
Section 6.3
5.2 State Authority
5.2.1 DEC - Environmental protection, wetlands, pesticide applications
Section 2.7.1, 2.7.3.2
5.2.2 DOH - Human health
Section 2.3, 2.6
5.2.3 DOS - Coastal activities
Section 2.7.3.2, 2.7.4
5.3 County Authority
5.3.1 Legislature - Overall program authority, funding, no-spray program
Section 2.6
5.3.2 DPW - Vector control program
Section 2.1, 2.6
5.3.3 DOH - Human health, groundwater monitoring
Section 2.1, 2.6
5.4 Townships
5.4.1 Trustees - Underwater land ownership and wetland management, zoning
Section 2.7.3.4
5.5 Villages
5.5.1 Zoning
Section 2.7.3.4
6 POTENTIAL ENVIRONMENTAL IMPACTS
6.1 Potential Human Health Impacts
6.1.1 Impact of pesticide usage for nuisance reduction and disease control
6.1.1.1 Adulticides
6.1.1.1.1 Impact on general population health
Section 7.9.2.1.6, 7.9.2.1.7, 7.9.2.3
6.1.1.1.2 Impact on health of sensitive subpopulations *(eg.* elderly and children)
Section 7.9.2.1.6, 7.9.2.4
6.1.1.1.3 Impact on incidence of mosquito-borne diseases (infections, hospitalizations, and deaths)
Section 7.9.2.7, 7.11.3
6.1.1.2 Larvicides
6.1.1.2.1 Impact on general population health
Section 7.8.2.1.4, 7.8.2.2

6.1.1.2.2 Impact on health of sensitive subpopulations *(e.g.* elderly and children)

Section 7.8.2.1.4, 7.8.2.3

6.1.1.2.3 Impact on incidence of mosquito-borne diseases (infections, hospitalizations, and deaths)

Section 7.11.3

6.1.2 Impact of trapping and other non-chemical control techniques

Section 8.8.2

6.1.2.1 Impact on general population health

Section 8.8.2

6.1.2.2 Impact on health of sensitive subpopulations *(e.g.* elderly and children)

Section 8.8.2

6.1.2.3 Impact on incidence of mosquito-borne diseases (infections, hospitalizations, and deaths)

Section 8.10.3

6.1.3 Impact of marsh management for nuisance reduction and disease control

Section 5.7.4.1, 7.6.2, 7.11.3

6.1.3.1 Impact on general population health

Section 5.7.4.1, 7.6.2, 7.11.3

6.1.3.2 Impact on health of sensitive subpopulations *(e.g.* elderly and children)

Section 5.7.4.1, 7.6.2, 7.11.3

6.1.3.3 Impact on incidence of mosquito-borne diseases (infections, hospitalizations, and deaths)

Section 5.7.4.1, 7.6.2, 7.11.3

6.1.3.4 Distribution of infected birds, horses, and other disease-carrying organisms

Section 5.7.4.1, 7.6.2

6.1.3.5 Distribution of mosquito-borne disease infections, hospitalizations, and deaths

Section 5.7.4.1, 7.6.2, 7.11.3

6.2 Potential Environmental Impacts

6.2.1 Land Uses

6.2.1.1 Impact of VC chemicals on use of upland recreation areas such as parks, playfields.

Section 7.9.2.1.6

6.2.1.2 VC chemicals use of on public beaches

Section 7.9.2.1.6

6.2.1.3 Impact of marsh management on extent of freshwater wetlands

Section 7.6.2

6.2.1.4 Impact of marsh management on extent of marine wetlands

Section 5.7.4.2, 5.7.4.5

6.2.2 Geology

6.2.2.1 Impact of VC chemicals on soils

Section 7.9.2.1.6

6.2.3 Water Resources

6.2.3.1 Stormwater

6.2.3.1.1 Impact of VC chemicals on receiving water quality

Section 6.6, 7.5.2, 7.8.2.1.5, 7.9.2.1.6

6.2.3.1.2 Impact of stormwater wetland design on stormwater treatment

Section 7.5.2

6.2.3.2 Surface water

6.2.3.2.1 Impact of VC chemicals on stream, pond, and lake water quality

Section 7.5.2, 7.8.2.1.5, 7.9.2.1.6

6.2.3.2.2 Impact of marsh management on stream, pond, and lake water quality

Section 5.7.4.5, 7.5.2

6.2.3.2.3 Impact of VC chemicals on estuarine water quality

Section 7.8.2.1.5, 7.9.2.1.6

6.2.3.2.4 Impact of marsh management on estuarine water quality

Section 5.7.4.5, 7.6.2

6.2.3.3 Groundwater

6.2.3.3.1 Impact of VC chemicals on drinking water quality

Section 3.4.2, 7.8.2.1.3, 7.9.2.1.4

6.2.3.3.2 Impact of VC chemicals shallow groundwater water quality

Section 3.4.2, 7.8.2.1.3, 7.9.2.1.4

6.2.3.3.3 Impact of VC application techniques on infiltration rates

Section 3.4.2, 7.8.2.1.3, 7.9.2.1.4

6.2.4 Air Resources

6.2.4.1 Air quality

6.2.4.1.1 Impact of VC chemicals on air quality

Section 4.4.4,7.9.2.1.7

6.2.5 Ecological Resources

6.2.5.1 Mosquitoes

6.2.5.1.1 Impact of VC on species distribution

Section 5.7.4.1, 7.6.2, 7.8.2.7, 7.9.2.6

6.2.5.1.2 Impact of VC on population cycles

Section 5.7.4.1, 7.6.2, 7.8.2.7, 7.9.2.6

6.2.5.1.3 Impact of VC on resistance to pesticide use

Section 7.8.2.8, 7.9.2.8

6.2.5.2 Mosquito habitats (distributions, inhabitants, historic trends)

6.2.5.2.1 Impact of VC on marine marshes

Section 5.7, 6.1, 6.2, 6.6, 6.7, 6.8, 7.6, 7.8.2.1.5, 7.9.2.1.8

6.2.5.2.2 Impact of VC on freshwater marshes

Section 7.6, 7.8.2.1.5, 7.9.2.1.8

6.2.5.2.3 Impact of VC on stormwater catch basins, recharge basins, and treatment wetlands

Section 6.9, 6.10, 7.8.2.1.5, 7.9.2.1.8

6.2.5.3 Mosquito predators (species, life histories, distribution)

Section 5.7, 7.6, 7.8.2.1.5, 7.9.2.1.8

6.2.5.3.1 Impact of VC on birds

Section 5.7, 7.6

6.2.5.3.2 Impact of VC on amphibians

Section 7.8.2.1.5

6.2.5.3.3 Impact of VC on insects

Section 5.7, 7.6, 7.8.2.1.5, 7.9.2.1.6

6.2.5.3.4 Impact of VC on crustaceans

Section 3.8, 5.7, 6.2, 7.8.2.1.5, 7.9.2.1.6

6.2.5.3.5 Impact of VC on fish

Section 5.7, 6.2, 7.8.2.1.5, 7.9.2.1.6

6.2.5.3.6 Impact of VC on mammals

Section 5.7, 7.9.2.1.6

6.2.5.4 Impact of VC on other animals

Section 5.7, 7.6, 7.9.2.1.6

6.2.5.5 Impact of VC on other plants

Section 5.7, 7.6, 7.9.2.1.6

6.2.5.6 Impact of VC on rare and endangered plants and animals

Section 7.7, 7.8.2.1.5, 7.9.2.1.6

7 MITIGATION MEASURES (Content will depend upon the components that are to be included in the Long-Term Plan, which have not yet been determined)

Section 14

8 UNAVOIDABLE ADVERSE IMPACTS

Section 16

8.1 Impact on non-target organisms

Section 16

8.2 Impact of pesticide residuals on soils and water

Section 16

8.3 Impact of pesticide residuals on human health

Section 16

9 ALTERNATIVES & THEIR IMPACTS

9.1 No action alternative – VC discontinued, no marsh management

Section 9

9.2 Current County program continued

Throughout much of Section 7 and also in Section 8

9.3 No pesticide alternative – active marsh management

Section 8.5

9.4 Alternative application rates of existing VC chemicals

Section 7.8.2.6, 7.8.2.7, 7.9.2.6, 8.8.2

9.5 Alternative application techniques for existing VC chemicals

Section 7.8.2.6, 7.8.2.7, 7.9.2.6, 8.7.2, 8.8.2

9.6 Alternative VC chemicals/substances

Section 6.11, 8.7.2, 8.8.2

9.7 Alternative marsh management techniques

Section 7.6, 8.5, 9.3

10 CUMULATIVE IMPACTS

Section 15

10.1 County-wide general pesticide use

See Section 3.4

10.2 Regional wetland initiatives, trends, and impacts

Section 5.7.2, 7.6

10.3 Regional stormwater policies

Section 7.5

10.4 "Mosquito monitoring" program in context of other County (etc.) efforts

Section 7.10, 17

11 IRRETRIEVABLE AND IRREVERSIBLE COMMITMENT OF RESOURCES

Section 17

12 GROWTH-INDUCING ASPECTS

Not in scope, but see Section 10.2.1

13 USE AND CONSERVATION OF ENERGY

Section 11

BIBLIOGRAPHY

With each section

APPENDICES

Five included:
A. The Long-Term Plan
B. The Wetlands Management Plan
C. The Best Management Practices Manual
D. Final Scope
E. Project Workplan

References for the Executive Summary

ATSDR. 2003. *Toxicological Profile for Malathion.* US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA. 287 pp. + appendices.

ATSDR. 2001. *Toxicological Profile for Pyrethrins and Pyrethroids*. US Department of Health and Human Services, Agency for Toxic Substances and Disease Registry, Atlanta, GA. 267 pp. + appendices.

Adamowicz, SC, and CT Roman. 2005. New England salt marsh pools: a quantitative analysis of geomorphic and geographic features. *Wetlands* 25(2):279-288.

Adamowicz, SC, and CT Roman. 2002. *Initial Ecosystem Response of Salt Marshes to Ditch Plugging and Pool Creation: Experiments at Rachel Carson National Wildlife Refuge (Maine).* US Geological Survey, Narragansett, RI. 102 pp.

Amweg, EL, DP Weston, and NM Ureda. 2005. Use and toxicity of pyrethroid pesticides in the central Valley, California, USA. *Environmental Toxicology and Chemistry* 24:966-972.

Amweg, EL, DP Weston, J. You, and MJ Lydy. 2006. Pyrethroid insecticides and sediment toxicity in urban creeks from California and Tennessee. *Environmental Science and Technology* 40(5):1700-1706.

Anderson, R., J. Helgen, S. Hurlburt, R. Moon, R. Naiman, W. Schmidt, K. Simmons, K. Solomon, H. Tordoff, M. Zicus, and J. Genereux. 1996. *An Assessment of Non-target Effects of the Mosquito Larvicides, BTI and Methoprene, in Metropolitan Area Wetlands*. Scientific Peer Review Panel of the Metropolitan Mosquito Control District, St Paul, MN. 61 pp.

Antunes-Kenyon, S., and G. Kennedy. 2001. Methoprene: A Review of the Impacts of the Insect Growth Regulator Methoprene on Non-target Aquatic Organisms in Fish-bearing Waters. Massachusetts Department of Food and Agriculture, Boston, MA. 76 pp. + appendices.

Arnold, SF, and JA McLachlan. 1996. Synergistic signals in the environment. *Environmental Health Perspectives* 104(10):1020-1023.

Azziz-Baumgartner, E. 2004. Mosquito control and exposure to pesticides: Virginia and North Carolina, 2003. Presentation at the *5th Annual Conference on West Nile Virus in the United States*, February 3-5, Denver, CO. Available at http://www.cdc.gov/ncidod/dvbid/westnile/conf/pdf/Azziz_Baumgartner_6_04.pdf. Accessed on 2/2/05.

BOCG. 2005. *Material Safety Data Sheet. Carbon Dioxide, Gas*. BOC Gases http://www.safety.vanderbilt.edu/pdf/hcs_msds/carbondioxidecompressedgas.pdf. Accessed 09/05.

Balcer, MD, KL Scmude, J. Snitgen, and AR Lima. 1999. *Long-term Effects of the Mosquito Control Agents Bti (Bacillus thuringiensis israelensis) and Methoprene on Non-target Macroinvertebrates in Wetlands in Wright County, Minnesota (1997-1998).* Metropolitan Mosquito Control District, St Paul. MN. 52 pp.

Barnes, RK. 2005. *Pesticides Used to Control West Nile Virus: Toxicity to the Estuarine Grass Shrimp, Palaemonetes pugio.* Masters Thesis. Stony Brook University.

Bart, DJ, and JM Hartman. 2002. Constraints on the establishment of *Phragmites australis* in a New Jersey salt marsh and possible links to human disturbance. *Wetlands* 22:201-213.

Bertness, MD. 1999. *The Ecology of Atlantic Shorelines*. Sindauer Associates, Inc., Sunderland, MA. 417 pp.

Bertness, MD, PJ Ewanchuk, and BR Silliman. 2002. Anthropogenic modification of New England salt marsh landscapes. *Proceedings of the National Academy of Sciences* 99(3):1395-1398.

Birchfield, N., R. Mahler, and B. Montague. Undated. *EFED's Response to "Comments from Cheminova A/S on EPA's Preliminary Risk Assessment for Malathion."* Memorandum to B. Shackleford and P. Moe, US Environmental Protection Agency, Washington, DC. www.epa.gov/pesticides/op/malathion/efed_response.pdf

Bourn, WS, and C. Cottam. 1950. *Some Biological Effects of Ditching Tide Water Marshes*. US Fish and Wildlife Research Report 19. 30 pp. + oversize figures.

Brody, JG, A. Aschengrau, W. McKelvey, RA Rudel, CH Swartz, and T. Kennedy. 2004. Breast cancer risk and historical exposure to pesticides from wide-area applications assessed with GIS. *Environmental Health Perspectives* 112(8):889-897.

Brown, W. 1998. *Mosquito Larvicides - Non-Target Organism Effects.* US Fish and Wildlife Service.

Brown, M., J. Carter, D. Thomas, D. Purdie, and B. Kay 2002. Pulse-exposure effects of selected insecticides to juvenile Australian crimson-spotted rainbowfish (*Melanotaenia duboulayi*). *Journal of Economic Entomology* 95(2):294-298.

Brush, T., RA Lent, T. Hruby, BA Harrington, RM Marshall, and WG Montgomery. 1986. Habitat use by salt marsh birds and response to open marsh water management. *Colonial Waterbirds* 9:189-195.

Brzozowski, C. 2004. Maintenance goes underground: owners and vendors talk about how to keep systems working. *Stormwater* 5(5):76-87.

Buchsbaum, R. 2001. Coastal marsh management. Chapter 11. In: Kent, DM (ed.). *Applied Wetlands Science and Technology*. CRC Press, Boca Raton, FL.

Buchsbaum, R, A. Cooper, and J. LeBlanc. 1998. Habitat issues faced by the Plum Island Sound estuary. pp. 148-158. In: Buchsbaum, R., T. Purinton, and B. Magnuson (eds.). *A Study of the Marine Resources of the Parker River-Plum +Island Sound Estuary: An Update After 30 Years*. Massachusetts Office of Coastal Zone Management.

Burdick, DM, M. Dionne, RM Boumans, and FT Short. 1997. Ecological responses to tidal restrictions of two northern New England salt marshes. *Wetlands Ecology and Management* 4(2):129-144.

Buxton, HT, and DA Smolensky. 1999. *Simulation of the Effects of Development of the Ground-water Flow System of Long Island, New York*. Water-Resources Investigations Report 98-4069, US Geological Survey, Coram, NY. 57 pp.

CA-CE. 2005a. *Alternative Mosquito Control*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3b (Early Action Projects). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. Paged in sections.

CA-CE. 2005b. *Survey of Catch Basins for Mosquitoes with Disease Potential*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 6 pp. + appendices.

CA-CE. 2005c. *Primary Study Areas*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 7 (Wetlands Classification). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. .

CA-CE. 2004a. *Suffolk County Vector Control Comparisons to Other Northeast Operations*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 4 (Current Operations). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 32 pp.

CA-CE. 2004b. *Long Island Mosquitoes*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 1. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 58 pp. + appendix.

CA-CE. 2002. Responses to Scoping Comments. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 1 (Workplan Development). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. Paged in sections.

CA-IC. 2004. *Ecotoxicity Review of Primary List Mosquito Control Agents*. Task 3, Literature Review, Book 7, Suffolk County Vector Control and Wetlands Management Long-Term Plan and Generic Environmental Impact Statement. Prepared by Cashin Associates and

Integral Consulting, for Suffolk County Department of Health Services, Yaphank, NY. Paged in sections.

CA-SCDHS. 2005. *Human Health and Domestic Animal Toxicity.* Task 3, Literature Review, Book 6 Part 2, Suffolk County Vector Control and Wetlands Management Long-Term Plan and Generic Environmental Impact Statement. Prepared by Cashin Associates and Suffolk County Department of Health Services, for Suffolk County Department of Health Services, Yaphank, NY. Paged in sections.

CDC. 2005. Human exposure to mosquito-control pesticides: Mississippi, North Carolina, and Virginia, 2002 and 2003. *Morbidity and Mortality Weekly Report* 54(21):529-532.

CDC. 2003a. *Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention, and Control*. Centers for Disease Control and Prevention, Fort Collins, CO. 74 pp.

CDC. 2003b. Surveillance for acute insecticide-related illness associated with mosquito-control efforts – nine states, 1999 – 2002. *Morbidity and Mortality Weekly Report* 52(27):629-634.

Campbell, SR, D. Ninivaggi, and JF Sanzone. 2005. The effectiveness of methoprene for the treatment of salt marsh mosquitoes in Suffolk County, New York. Poster No. 162. *71st Annual Meeting, The American Mosquito Control Association*. Vancouver, BC. April 3-7.

Carlson, DB, PD O'Bryan, and JR Rey. 1991. A review of current salt marsh management issues in Florida. *Journal of the American Mosquito Control Association* 7:83-89.

Caron, DM. 1979. Effects of some ULV mosquito abatement insecticides on honey bees. *Journal of Economic Entomology* 72:148-151.

Cashin Associates. In prep[1]. *Task 3 Task Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search). to be posted: www.suffolkmosquitocontrolplan.org.

Cashin Associates. In prep[2]. *Mosquito Ditch Conveyance of Pollutants Experiment*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects). to be posted: www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2006a. *2005 Data Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Wertheim NWR Open Marsh Water Management Demonstration Project). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 210 pp. + appendix.

Cashin Associates. 2006b. *Spotted Turtles: Use of Mosquito-control Ditches*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact

Statement, Task 3b (Early Action Projects). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. Unpaged, with appendices.

Cashin Associates. 2006c. *A Retrospective Study of Salt Marsh Response to Historical Anthropogenic Modifications at Seatuck and Wertheim National Wildlife Refuges*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2006d. *Salt Marsh Losses*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 9, Part 4. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 78 pp.

Cashin Associates. 2005a. *Diseases Transmitted by Mosquitoes*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 2 Part 1. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 19 pp.

Cashin Associates. 2005b. *Human Health Risks Associated with Mosquito-borne Pathogens in Suffolk County, NY.* Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 2 Part 2. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 59 pp.

Cashin Associates. 2005c. *Eastern Equine Encephalitis and Salt Marsh Mosquitoes*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 4 (Current Operations). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 17 pp.

Cashin Associates. 2005d. *Task 4 Task Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 4 (Current Operations). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 7 pp.

Cashin Associates. 2005e. *Task Report: Part I: Summary*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 31 pp.

Cashin Associates. 2005f. *Executive Summary*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects Caged Fish Experiment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 2 pp.

Cashin Associates. 2005g. *Non-Target Invertebrate Study*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 8 pp. + appendices.

Cashin Associates. 2005h. *Salt Marsh Health*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 9, Part 1. Suffolk County Department of Health Services, Riverhead, NY. www.suffolkmosquitocontrolplan.org. 50 pp.

Cashin Associates. 2005i. *Task Report: Appendix to the Quantitative Risk Assessment: Davis Park Risk Assessment Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2005j. *Task Report: Appendix to the Quantitative Risk Assessment: Dix Hills Risk Assessment Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2005k. *Task Report: Appendix to the Quantitative Risk Assessment: Manorville Risk Assessment Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2005l. *Task Report: Appendix to the Quantitative Risk Assessment: Mastic Beach Risk Assessment Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2005m. *Task Report: Appendix to the Quantitative Risk Assessment: Air Concentration and Deposition Modeling Report*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org.

Cashin Associates. 2005n. *Effects on Organisms*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects Caged Fish Experiment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 17 pp. + appendix.

Cashin Associates. 2005o. *Water and Sediment Concentration Measurements*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact

Statement, Task 12 (Early Action Projects Caged Fish Experiment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 31 pp. + appendices.

Cashin Associates. 2005p. *Deposition Rate Measurements*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 12 (Early Action Projects Caged Fish Experiment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 4 pp. + appendices.

Cashin Associates. 2005q. *Task Report: Part III: Human Health and Ecological Risk Assessment of Vector Control Pesticides Considered for Use by Suffolk County*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. Paged in sections + appendices.

Cashin Associates. 2005r. *Task Report: Part II: Mosquito Borne Disease Impacts Assessment*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 8 (Impact Assessment). Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 48 pp.

Cashin Associates. 2004a. *Natural and Managed Salt Marshes*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 9, Part 3. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 165 pp.

Cashin Associates. 2004b. *Mosquito Control Pesticides, Breast cancer & Childhood Diseases*. Suffolk County Vector Control and Wetlands Management Long-Term Plan and Environmental Impact Statement, Task 3 (Literature Search), Book 6, Part 1. Suffolk County Department of Health Services, Yaphank, NY. www.suffolkmosquitocontrolplan.org. 59 pp.

Cerrato, RM; HJ Bokuniewicz, and MH Higgins. 1989. *A Spatial and Seasonal Study of the Benthic Fauna of the Lower Bay of New York Harbor*. Marine Sciences Research Center Special Report 84 (89-1), SUNY at Stony Brook, Stony Brook, NY. 325 pp.

Chamberlain, RW. 1958. Vector relationships of the arthropod-borne encephalitides in North America. *Annals of the New York Academy of Science* 70:312-319.

Chamberlain, RW, WD Sudia, PP Burbutis, and MD Bogue. 1958. Recent isolations of arthropod-borne virus from mosquitoes in the eastern United States. *Mosquito News* 18(4):305-308.

Chapman, VJ. 1974 *Salt Marshes and Salt Deserts of the World*. 2nd. Ed. Strauss & Cramer GMBH, Leutershausen, Germany. 392 pp. + 101 pp. added for 2nd. Ed.

Clarke, JA, BA Harrington, T. Hruby, and FE Wasserman. 1984. The effect of ditching for mosquito control on salt marsh use by birds in Rowley, Massachusetts. *Journal of Field Ornithology* 55(2):160-180.

Clements, AN. 1992. *The Biology of Mosquitoes.* Vol.1*: Development, Nutrition and Reproduction*. Chapman & Hall, New York, NY. 509 pp.

Clifford, MA, KJ Eder, I Werner, HP Hedrick. 2005. Synergistic effects of esfenvalerate and infectious hematopoietic necrosis virus on juvenile Chinook salmon mortality. *Environmental Toxicology and Chemistry* 24:1766-1772.

Collins, JN, LM Collins, LB Leopold, and VH Resh. 1986. The influence of mosquito control ditches on the geomorphology of tidal marshes in the San Francisco Bay area: the evolution of salt marsh mosquito habitats. *Proceedings of the California Mosquito and Vector Control Association* 54:91-95.

Cornell. 2004. *West Nile Virus, Transmission, Infections, and Symptoms.* Cornell University Department of Communication and Center for the Environment, Environmental Risk Analysis Program. environmentalrisk.cornell.edu/WNV/Summary2.php

Cory, EN, and SL Crosthwait. 1939. Some conservation and ecological aspects of mosquito control. *Journal of Economic Entomology* 32:213-215.

Courtney, WR, Jr., and GK Meffe. 1989. Small fishes in strange places: a review of introduced poeciliids. Pp. 319-331. In: Meffe, GK, and FF Snelson, Jr. (eds.). *Ecology and Evolution of Live-bearing Fishes (Poeciliidae).* Prentice-Hall, Englewood Cliffs, NJ.

Crans, WJ. 1977. The status of *Aedes sollicitans* as an epidemic vector of eastern equine encephalitis in New Jersey. *Mosquito News* 37:85-89.

Daiber, FC. 1986. *Conservation of Tidal Marshes*. Van Nostrand Reinhold, New York, NY. 341 pp.

Dale, PER, and K. Hulsman. 1990. Critical review of salt marsh management methods for mosquito control. *Reviews in Aquatic Science* 3(2,3):281-311.

Debboun, M. and JA Klun. 2005. Personal protective measures and repellants used against mosquitoes in the US military. Presentation 121. 71st Annual Meeting, *The American Mosquito Control Association*. Vancouver, BC. April 5.

Deegan, LA, JE Hughes, and RA Rountree. 2000. Salt marsh ecosystem support of marine transient species. pp. 333-365. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Diamond, JM, and TJ Case. 1986. Overview: introductions, extinctions, exterminations, and invasions. pp. 65-79. In: Diamond, JM, and TJ Case (eds.). *Community Ecology*. Harper and Row, New York, NY.

Dreyer, GD, and WA Niering. 1995. *Tidal Marshes of Long Island Sound: Ecology, History, and Restoration*. The Connecticut College Arboretum, No. 34.

Dunnet, GM. 1977. Observations on the effects of low-flying aircraft at seabird colonies on the coast or Aberdeenshire, Scotland. *Biological Conservation* 12:55-63.

Durda, JL, and DV Preziosi. 2000. Data quality evaluation of toxicological studies used to derive ecotoxicological benchmarks. *Human and Ecological Risk Assessment* 6(5):747-765.

Edman, JD, LA Webber, and HW Kale. 1972. Host-feeding patterns of Florida mosquitoes. II. *Culiseta. Journal of Medical Entomology* 9(5):429-434.

Edwards, RG, AG Broderson, RW Barbour, DF McCoy, and CW Johnson. 1979. *Assessment of the Environmental Compatibility of Differing Helicopter Noise Certification Standards*. US Department of Transportation, Washington, DC. 58 pp.

Eldridge, BF, and JD Edman. 2000. *Medical Entomology, a Textbook on Public Health and Veterinary Problems Caused by Arthropods*. Kluwer Academic Publishers, Dordrecht, Netherlands. 659 pp.

Eskenazi, B., A. Bradman, and R. Castorina. 1999. Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environmental Health Perspectives* 107(Supplement)3:409-419..

Extoxnet. 1996a. *Pesticide Information Profiles: Methoprene*. http://extoxnet.orst.edu/pips/methopre.htm. Accessed on 7/12/04.

Extoxnet. 1996b. *Pesticide Information Profiles: Pyrethrins and Pyrethroids*. http://extoxnet.orst.edu/pip/pyrethri.htm. Accessed on 09/05.

Extoxnet. 1996c. *Pesticide Information Profiles: Fenthion*. http://extoxnet.orst.edu/pips/fenthion.htm. Accessed on 09/05.

Extoxnet. 1996d. *Pesticide Information Profiles: Chlorpyrifos*. http://extoxnet.orst.edu/pips/chlorphyr.htm. Accessed on 09/05.

Extoxnet. 1996e. *Pesticide Information Profiles: Deltamethrin*. http://extoxnet.orst.edu/pips/deltamet.htm. Accessed on 09/05.

FCCMC. 1998. *Florida Mosquito Control: The State of the Mission as Defined by Mosquito Collectors, Regulators, and Environmental Managers*. Florida Coordinating Council on Mosquito Control, University of Florida.

FDACS. 2005. *Frequently Asked Questions about Naled*. Florida Department of Agriculture and Community Service. http://www.flaes.org/pdf/Naled%20Response010803.pdf. Last accessed on 09/05.

Fell, PE, RS. Warren, WA. Niering. 2000. Restoration of salt and brackish tidelands in southern New England. pp. 845-858. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Ferrigno, F., and DM Jobbins. 1968. Open Marsh Water Management. *Proceedings of the New Jersey Mosquito Extermination Association* 55:104-115.

Fischer, JM, JL Klug, T. Reed-Andersen, and AG Chalmers. 2000. Spatial pattern of localized disturbance along a southeastern salt marsh tidal creek. *Estuaries* 23(4):565-571.

Fletcher, JS, JE Nellessen, and TG Pfleeger. 1994. Literature review and evaluation of the EPA food-chain (Kenaga) nomogram, an instrument for estimation pesticide residues on plants. *Environmental Toxicology and Chemistry* 13(9):1383-1391.

Forbes, V.E., and A. Cold. 2005. Effects of the pyrethroid esfenvalerate on life-cycle traits and population dynamics of *Chironomid riparius* – importance of exposure scenario. *Environmental Toxicoogy and Chemistry* 24(1):78-86.

Fradin, MS and JF Day. 2002. Comparative efficacy of insect repellants against mosquito bites. *New England Journal of Medicine* 347(1):13-18

Frey, RW, and PB Basan. 1985. Coastal salt marshes. pp. 225-301. In: Davis, RA (ed.). *Coastal Sedimentary Environments*. 2nd Ed. Springer-Verlag, New York, NY. 716 pp.

Fultz, TO, Jr. 1978. Mosquito source reduction and present water management regulations in coastal Georgia. *Proceedings of the New Jersey Mosquito Extermination Association* 65:36-39.

Glare, J.R. and M. O'Callaghan. 1999. *Report for the Ministry of Health: Environmental and Health Impacts of the Insect Juvenile Hormone Analogue S-Methoprene*. As cited in Westchester, 2001.

Gillette, JS, and JR Bloomquist. 2003. Differential up-regulation of striatal dopamine transporter and alpha-synuclein by the pyrethroid insecticide permethrin. *Toxicology and Applied Pharmacology* 192, 287-293, 2003.

Goodsell, JA, and LB Kats. 1999. The effect of introduced mosquitofish on Pacific treefrogs and the role of alternate prey. *Conservation Biology* 13(4):921-924.

Greenlaw, JS. 1992. Seaside sparrow: *Ammodramus maritimus*. pp. 211-232. In: Schneider, KJ, and DM Pence (eds.). *Migratory Nongame Birds of Management Concern in the Northeast*. USFWS Region 5, Newton Corner, MA. 400 pp.

Gubler, DJ. 2001. Human arbovirus infections worldwide. pp. 13-24. In: White, DJ, and DL Morse (eds.). *West Nile Virus: Detection, Surveillance, and Control*. Annals of the New York Academy of Science, V. 951. New York, NY. 374 pp.

Gunn, WWH, and JA Livingstone (eds.). 1974. *Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft, and Human Activity in the Mackenzie Valley and the North Slope*. Arctic Gas Biological Report Series #14. 280 pp.

Gupta, SK, MK Pandya, JP Jani, and SK Kashyap. 1980. Health risks in ultra-low-volume (ULV) aerial spray of malathion for mosquito control. *Journal of Environmental Science and Health* B15(3):287-294.

Hanonowski, JM, GJ Niemi, AR Lima, and RR Regal. 1997. Response of breeding birds to mosquito control treatments of wetlands. *Wetlands* 17(4):485-492.

Havens, KJ, H. Berquist, and WI Priest, III. 2003. Common reed grass, *Phragmites australis*, expansion into constructed wetlands: are we mortgaging our wetlands future? *Estuaries* 26(2B):417-422.

Hayes, TB, P. Case, S. Chui, D. Chung, C. Haefele, K. Haston, M. Lee, VP Mai, Y. Marjuoa, J. Parker, and M. Tsui. 2006. Pesticides mixtures, endocrine disruption, and amphibian declines: are we underestimating the impact? *Environmental Health Perspectives* doi:10.1289/ehp.8051 (published online 1-24-06).

Health Canada. 2004. *Proposed Phaseout of Citronella-Based Personal Insect Repellents.* Pest Management Regulatory Agency Information Note, 17 September.

Hershey, AE, AR Lima, GJ Niemi, and RR Regal. 1998. Effects of *Bacillus thuringiesis israelensis* (Bti) and methoprene on non-target macroinvertebrates in Minnesota wetlands. *Ecological Applications* 8(1):41-60.

Hester, PG, KR Shaffer, NS Tietze, H. Zhong, and NL Griggs, Jr. 2001. Efficacy of ground-applied ultra-low volume malathion on honey bee survival and productivity in open and forested areas. *Journal of the American Mosquito Control Association* 17(1):2-7.

Hoerger, FD, and EE Kenaga. 1972. Pesticide residues on plants: Correlation of representative data as a basis for estimation of their magnitude in the environment. pp. 9-28. In: Coulston, F., and F. Korte (eds.). *Environmental Quality.* Academic Press, New York. Volume I.

Hoppin, JA, DM Umbach, SJ London, MC Alvanja, and DP Sandler. 2002. Chemical predictors of wheeze among farmer pesticide applicators in the Agricultural Health Study. *American Journal of Respiratory and Critical Care Medicine* 165:683-689.

Howard, PH, RS Boethling, WF Jarvis, WM Meylan, and EM Michalenko.1991. *Handbook of Environmental Degradation Rates.* Lewis Publishers, Chelsea, MI.

Howarth, FG. 1991. Environmental impacts of classical biological control. *Annual Reviews of Entomology* 36:485-509.

Huhn, GD, JJ Sejvar, SP Montgomery, and MS Dworkin. 2003. West Nile Virus in the United States: an update on an emerging infectious disease. *American Family Physician* 68(4):653-660.

IARC. 1991. *IARC Monographs Permethrin.* International Agency for Research on Cancer, Lyon, France. Vol. 53:329.

James-Pirri, M-J, CT Roman, and RM Erwin. 2001. *Field Methods Manual: US Fish and Wildlife Service (Region 5) Salt Marsh Study*. US Geological Survey, Narragansett, RI.

Jensen, T., SP Lawler, and DA Dritz. 1999. Effects of ultra-low volume pyrethrin, malathion, and permethrin on non-target invertebrates, sentinel mosquitoes, and mosquitofish in seasonally impounded wetlands. *Journal of the American Mosquito Control Association* 15(3):330-338.

Karpati, AM, MC Perrin, T. Matte, J. Leighton, J. Schwartz, and RG Barr. 2004. Pesticide spraying for West Nile virus control and emergency department asthma visits in New York City, 2000. *Environmental Health Perspectives* 112(11):1183-1187.

Kennish, MJ. 2001. Coastal salt marsh systems in the U.S.: a review of anthropogenic impacts. *Journal of Coastal Research* 17(3):731-748.

Key, P., M. DeLorenzo, K. Gross, K. Chung, and A. Clum. 2005. Toxicity of the mosquito control pesticide Scourge to adult and larval grass shrimp (*Paleomonetes pugio). Journal of Environmental Science and Health, Part B* 40:585-594.

Kitron, U., J. Michael, J. Swanson, and L. Haramis. 1997. Spatial analysis of the distribution of LaCrosse encephalitis in Illinois, using a geographic information system and local and global spatial statistics. *American Journal of Tropical Medicine and Hygiene* 57:469-475.

Kluh, S., P. DeChant, and JE Hazelrigg. 2005. Routine mosquito control in underground storm drains in urban Los Angeles. Presentation 25, *71st Annual Meeting of the American Mosquito Control Association*. Vancouver, BC. April 4.

Knapp, RA, and KR Matthews. 2000. Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas. *Conservation Biology* 14(2):428-438.

Kreeger, DA, and RIE Newell. 2000. Trophic complexity between producers and invertebrate consumers in salt marshes. pp. 187-220. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Kuenzler, EJ, and HL Marshall. 1973. *Effects of Mosquito Control Ditching on Estuarine Ecosystems.* Report No. 81, Water Resource Research Institute, University of North Carolina. 83 pp.

Kushlan, JA. 1979. Effects of helicopter censuses on wading bird colonies. *Journal of Wildlife Management* 43:756-760.

Lacey, LA, and RW Merritt. 2003. The safety of bacterial microbial agents used for black fly and mosquito control in aquatic environments. pp. 151-168. In: Hokkanen, HMT, and AE Hajek (eds.). *Environmental Impacts of Microbial Insecticides: Need and Methods for Risk Assessment*. Kluwer Academic Publishers, Dordrecht, Netherlands.

Lathrop, RG, MP Cole, and RD Showalter. 2000. Quantifying the habitat structure and spatial pattern of New Jersey (U.S.A.) salt marshes under different habitat regimes. *Wetlands Ecology and Management* 8:163-172.

Lawler, SP, DA Dritz, and T. Jensen. 2000. Effects of sustained release methoprene and a combined formulation of liquid methoprene and Bacillus thuringiensis israelensis on insects in salt marshes. *Archives of Environmental Contamination and Toxicology* 39:177-182.

Lee, GF, and A. Jones-Lee. 2005. Urban stormwater runoff aquatic life toxicity: an update. *Stormwater* 6(6):62-67.

Lent, RA, T. Hruby, DP Cowan, and TS Litwin. 1990. *Open Marsh Water Management on Great South Bay, Islip, New York*. Seatuck Foundation, Islip, NY.

Lesser, CR. Undated. *Open Marsh Water Management: A Source Reduction Technique for Mosquito Control*. Delaware Department of Natural Resources. Unpaged.

Leiss, M., and PC Von Der Ohe. 2005. Analyzing effects of pesticides on invertebrate communities in streams. *Environmental Toxicology and Chemistry* 24(4):954-965.

Loeb, M., SJ Elliott, B. Gibson, M. Fearon, R. Nosal, M. Drebot, C. D'Cuhna, D. Harrington, S. Smith, P. George, and J. Eyles. 2005. Protective behavior and West Nile virus risk. *Emerging Infectious Diseases* 11(9):1433-1436.

Louda, SM, RW Pemberton, MT Johnson, and PA Follett. 2003. Nontarget effects – the Achilles heel of biological control? Retrospective analyses to reduce risk associated with biocontrol introductions. *Annual Reviews of Entomology* 48:365-396.

Luber, G., K. Johnson, C. Rubin, H. Schurz Rogers, M. Currier, and D. Barr. 2003. Pesticide exposure resulting from West Nile Virus mosquito control, Mississippi, 2002. Centers for Disease Control and Mississippi State Department of Health, Presentation at the *4th Annual Conference on West Nile Virus in the United States*, February 9-11, New Orleans, LA.

Lyman, WJ, WF Reehl, and DH Rosenblatt. 1982. *Handbook of Chemical Property Estimation Methods: Environmental Behavior of Organic Compounds.* McGraw-Hill Book Company. New York, New York.

Madder, DJ. 1980. Studies on the dissipation of diflubenzuron and methoprene from shallow prairie pools. *The Canadian Entomologist.* pp.173-177. As cited in Westchester, 2001.

Marani, M., E. Belluco, A., D'Alpaos, A, Defina, S. Lanzoni, and A. Rinaldo. 2003. On the drainage density of tidal networks. *Water Resources Research* 39(2):1040 (doi:10.1029/2002WR001051).

Marra, PP, S. Griffing, C. Caffrey, AM Kilpatrick, R. McLean, C. Brand, E. Saito, AP Dupuis, L. Kramer, and R. Novak. 2004. West Nile Virus and wildlife. *BioScience* 54(5):393-402.

McClintock, JT, CR Schaffer, and RD Sjoblad. 1995. A comparative review of the mammalian toxicity of *Bacillus thuringiensis*-based pesticides. *Pesticide Science* 45:95-105.

McIvor, CC, and WE Odum. 1988. Food, predation risk, and microhabitat selection in a marsh fish assemblage. *Ecology* 69(5):1341-1351.

McKelvey, W., JG Brody, A. Aschengrau, and CH Swartz. 2003. Association between residence on Cape Cod, Massachusetts, and breast cancer. *Annals of Epidemiology* 14:89-94.

Merriam, TL. 1983. Food habits of nestling seaside sparrows in unaltered and ditched salt marshes on Long Island, New York. pp. 115-122. In: Quay, TL, JB Funderbburg, Jr., DS Lee, EF Potter, and CS Robbins (eds.). *The Seaside Sparrow: Its Biology and Management*. Occasional Papers of the North Carolina Biological Survey, 1983-5. 174 pp.

Meyerson, LA, KA Vogt, and RH Chalmers. 2000. Linking the success of *Phragmites* to the alteration of ecosystem nutrient cycles. pp. 827-844. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Miller, WR, and FE Egler. 1950. Vegetation of the Wequetequock-Pawcatuck tidal marshes, Connecticut. *Ecological Monographs* 20:143-172.

Mitsch, WJ, and JG Gosselink. 2000. *Wetlands.* 3rd Ed. John Wiley and Sons, New York, NY. 920 pp.

Mittal, PK. 2003. Biolarvicides in vector control: challenges and prospects. *Journal of Vector-Borne Diseases* (40):20–32.

Montague, CL, AV Zale, and HF Percival. 1987. Ecological effects of impoundments: a review. *Environmental Management* 11(6):743-756.

Montgomery, WG. 1998. Rumney Marsh, Park Avenue restorations project. *Northeastern Mosquito Control Association*, December. pp. 10-11.

Morris, CD. 1988. Eastern equine encephalomyelitis, pp. 1-19. In: Monath, TP. (ed.). *Arboviruses: Epidemiology and Ecology*. Vol. 3. CRC, Boca Raton, FL.

Morris, CD, RH Zimmerman, and JD Edman. 1980. Epizootiology of eastern equine encephalomyelitis in upstate New York, USA. II. Population dynamics and vector potential of adult *Culiseta melanura* in relation to distance from the breeding habitat. *Journal of Medical Entomology* 17:453-465.

Moore, JC, JC Dukes, JR Clark, J. Malone, CF Hallmon, and PG Hester. 1993a. Downwind drift and deposition of malathion on human targets from ground ultra-low volume mosquito sprays. *Journal of the American Mosquito Control Association* 9(2):138-142.

Mount, GA. 1998. A critical review of ultra-low volume aerosols of insecticide applied with vehicle-mounted generators for adult mosquito control. *Journal of the American Mosquito Control Association* 14(3):305-334.

Mount, GA. 1996. A review of ultra-low volume aerial sprays of insecticide for mosquito control. *Journal of the American Mosquito Control Association* 12(4):601-618

control. *Journal of the American Mosquito Control Association* 12(4):601-618

Muller-Hohnsen, H. 1999. Chronic sequelae and irreversible injuries following acute pyrthroid intoxication. *Toxicology Letters* 107:161-176.

NAS. 1983. *Risk Assessment in the Federal Government: Managing the Process*. National Academy of Sciences, Washington, DC. 192 pp.

NCDH. 2005. *First Case of Eastern Equine Encephalitis Found in a Horse*. Press Release, Nassau County Department of Health. August 1. www.nassaucountyny.gov/agencies/Health/NewsRelease/2005/08-01-2005.html

NCIPM. 2004. *Bacillus thuringiensis subsp. israelensis – Biological insecticide fact sheet*. National Center for Integrated Pest Management. http://www.ncipm.org.in/BacillusSJS.htm. Accessed on 08/20/04.

NYCDOH. 2001. *Adult Mosquito Control Programs Draft Environmental Impact Statement (DEIS)*. New York City Department of Health, New York, NY.

NYSDEC. 2005. *Comprehensive Wildlife Conservation Strategy: Appendix A5: Comprehensive Wildlife Conservation Strategy Species Group Reports for Insects.* Revised Draft. New York State Department of Environmental Conservation, Albany, NY. 140 pp.

NYSDEC. 2001. *New York State Stormwater Management Design Manual*. New York State Department of Environmental Conservation, Albany, NY. Paged in sections.

NYSDEC. 1996a. *Urban/Storm water Runoff Management Practices Catalogue for Nonpoint Pollution Prevention and Water Quality Protection in New York State.* Urban/Storm water Runoff Management Practices Subcommittee of the New York State Nonpoint

Source Management Practices Task Force, New York State Department of Environmental Conservation, Albany, NY. 86 pp.

NYSDEC. 1996b. *Bacillus sphaericus (VectoLex) Registration of New Active Ingredient*. Bureau of Pesticides & Radiation, Pesticide Product Registration, New York State Department of Environmental Conservation, Albany, NY.

NYSDOH. 2001a. *New York State West Nile Virus Response Plan – Guidance Document*. New York State Department of Health, Albany, NY. 66 pp. + appendices.

NYSDOH. 2001b. *Health Advisory: Tick and Insect Repellents.* New York State Department of Health.

Narahashi, T. 1992. Nerve membrane Na+ channels as targets of insecticides. *Trends in Pharmacological Science* 13:236-241.

National Pesticide Telecommunications Network. 1998. *Pyrethrins and Pyrethrods.*

Niedowski, N. 2000. *New York State Salt Marsh Restoration and Monitoring Guidelines.* NYS Department of State, Albany, NY, and NYS Department of Environmental Conservation, East Setauket, NY. 135 pp.

Nixon, SW. 1982. *The Ecology of New England High Salt Marshes: A Community Profile*. FWS/OBS-81/55, US Fish and Wildlife Service, Washington, DC. 70 pp.

Nixon, SW. 1980. *Between Coastal Marshes and Coastal Waters – a Review of Twenty Years of Speculation and Research on the Role of Salt Marshes in Estuarine Productivity and Water Chemistry*. Hamilton, P. and McDonald KB, eds. Estuarine and Wetland Processes with an Emphasis on Modeling 653 pp.

O'Brien & Gere. 1995. *Determination of Effects of AerialApplications of Dibrom on Non-target Organisms in the Cicero Swamp*. Draft, submitted to Onondaga County Health Department, Syracuse, NY.

O'Connor, JS, and OW Terry. 1972. *The Marine Wetlands of Nassau and Suffolk Counties, new York*. SUNY at Stony Brook. 99 pp.

Odum, EP. 2000. Tidal marshes as outwelling/pulsing systems. pp. 3-7. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Odum, WE. 1988. Comparative ecology of tidal freshwater and salt marshes. *Annual Review of Ecology and Systematics* 19:147-176.

Odum, WE, JS Fisher, and JC Pickral. 1979. Factors controlling the flux of particulate organic carbon from estuarine wetlands. pp. 69-80. In: Livingston, RJ (ed.). *Ecological Processes in Coastal and Marine Systems.* Plenum Press, New York. 548 pp.

Oransky, S., B. Roseman, D. Fish, T. Gentile, J. Melius, ML Cartter, and JL Hadler. 1989. Epidemiologic notes and reports: seizures temporally associated with use of DEET insect repellent—New York and Connecticut. *Morbidity and Mortality Weekly Report* 38(39):678-680.

Oros, DR, and I. Werner. 2005. *Pyrethroid Insecticides: An Analysis of Use patterns, Distributioons, Potential Toxicity and fate in the Sacramento-San Joaquin delta and Central valley*. Contribution 415, San Francisco Estuary Institute, Oakland CA. 112 pp.

Pastorok, RA, MK Butcher, and RD Nielsen. 1996. Modeling wildlife exposure to toxic chemicals: Trends and recent advances. *Human and Ecological Risk Assessment* 2:444-480.

Pennings, SC, and MD Bertness. 1999. Using latitudinal variation to examine effects of climate on coastal salt marsh patterns and process. *Wetlands Biogeochemistry* 3:100-111.

Peterson, RKD, PA Macedo, and RS Davis. 2005. A human health risk assessment for West Nile virus and insecticides used in mosquito management. *Environmental Health Perspectives*, published online October 28. doi:10.1289/ehp.8667; http://dx.doi.org/

Pethick, JS. 1992. Saltmarsh geomorphology. pp. 41-62. In: Allen, JRL, and K. Pye (eds.). *Saltmarshes: Morphodynamics, Conservation, and Engineering Significance*. Cambridge University Press, New York, NY. 79 pp.

Pomeroy, LR, and J. Imberger. 1981. The physical and chemical environment. pp. 21-36. In: Pomeroy, LR, and RG Wiegert (eds.). *The Ecology of a Salt Marsh*. Springer-Verlag, New York, NY. 271 pp.

Pomeroy, LR, and RG Wiegert (eds.). 1981. *The Ecology of a Salt Marsh*. Springer-Verlag, New York, NY. 271 pp.

Post, W., and JS Greenlaw. 2000. The present and future of the Cape Sable seaside sparrow. *Florida Field Naturlist* 28(3):93-110.

Provost, MW. 1977. Source-reduction in mosquito control: past and future. *Mosquito News* 37(4):689-698.

Raloff. 2006. A little less green? Studies challenge the benign image of pyrethroid insecticides. *Science News* 169(5):74.

Redfield, AC. 1972. Development of a New England salt marsh. *Ecological Monographs* 42(2):1-23.

Reese, AJ, and HH Presler. 2005. Municipal stormwater system maintenance: an assessment of current practices and methodology for upgrading programs. *Stormwater* 6(6):36-61.

Reinert, SE, FC Golet, and WR DeRagon. 1981. Avian use of ditched and unditched salt marshes in southeastern New England. *Transactions of the Northeastern Mosquito Control Association* 17:1-23.

Relyea, R. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. *Ecological Applications* 15(2):618-627.

Reuter, KC, and RN Foster. 2000. Success with reduced rates of carbaryl, malathion, and acephate sprays. Section II.5. In: Cunningham, GL, and MW Sampson (Technical Coordinators). *Grasshoppers: Their Biology, Identification, and Management Handbook*. US Department of Agriculture, Washington, DC. Paged in sections.

Richards, AG, Jr. 1938. Mosquitoes and mosquito control on Long Island, New York, with particular reference to the salt marsh problem. *New York State Museum Bulletin* 316:85-172.

Rockel, EG. 1969. Marsh physiography: influence on the distribution of organisms. *Proceedings of the New Jersey Mosquito Extermination Association* 56:102-116.

Roman, CT, WA Niering, and RS Warren. 1984. Salt marsh vegetation change in response to tidal restriction. *Environmental Management* 8:141-150.

Rose, R. 2001. Pesticides and public health: integrated methods of mosquito management. *Emerging Infectious Diseases* 7(1):17-23.

Ross, DH, P. Cohle, PR Blasé, JB Bussard, and K. Neuffeld. 1994a. Effects of the insect growth regulator (S) methoprene on the early life stages of the fathead minnow *Pimephales promelas* in a flow-through laboratory system. *Journal of the American Mosquito Control Association* 10(2):211-221.

Ross, DH, D. Judy, B. Jacobsen, and R. Howell. 1994b. Methoprene concentrations in freshwater microcosms treated with sustained release Altosid formulations. *Journal of the American Mosquito Control Association* 10(2):202-211.

Russell, TL, MD Brown, DM Purdie, PA Ryan, and BH Kay. 2003. Efficacy of VectoBac (*Bacillus thuringiensis* variety *israelensis*) formulations for mosquito control in Australia. *Journal of Economic Entomology* 96(6):1786-1791.

SCDHS. 2002. *Peconic Estuary Program: Comprehensive Conservation and Management Plan*. Suffolk County Department of Health Services, Riverhead, NY.

Sample, B. and GW Suter. 1994. *Estimating Exposure of Terrestrial Wildlife to Contaminants*. Oak Ridge National Laboratory. ES/ER/TM-125.

Schaefer, CH, and EF Dupras. 1973. Insect development inhibitors. 4. Persistence of ZR-515 in water. *Journal of Economic Entomology* 66(1):923-925.

Schulz, D., J. Sullivan, and G. Robinson. 2002. Juvenile hormone and octopamine in the regulation of division of labor in honey bee colonies. *Hormones and Behavior* 42:222-231.

Scott, TW, and SC Weaver. 1989. Eastern equine encephalomyelitis virus: epidemiology and evolution of mosquito transmission. *Advances in Virus Research* 37:277-328.

Shisler, JK. 1973. Pioneer plants on spoil piles associated with mosquito ditching. *Proceedings of the New Jersey Mosquito Extermination Association* 60:135-141.

Simenstad, CA and RM Thom. 1996. Functional equivalency trajectories of the restored Gog-Le-Hi-Te estuarine wetland. *Ecological Applications* 6(1): 38-56.

Smith, JB. 1904. *Report of the NJ State Agricultural Experiment Station upon the Mosquitoes Occuring within the State, Their Habits, Life History, etc.* MacCrellish & Quigley, Trenton, NJ. 482 pp.

Smith, TM, and GW Stratton. 1986. Effects of synthetic pyrethroid insecticides on nontarget organisms. *Residue Reviews* 97:93-120.

Spielman, A., and M. D'Antonio. 2001. *Mosquito.* Hyperion, New York, NY. 247 pp.

Stewart, PG, and L. Springer-Rushia. 1998. *A Field Guide to Long Island's Freshwater Wetlands*. Museum of Long Island Natural Sciences, Stony Brook, NY. 90 pp.

Suter, GW. 1993. *Ecological Risk Assessment*. Lewis Publishers, Chelsea, Michigan.

Talent, LG. 2005. Effect of temperature on toxicity of a natural pyrethrin pesticide to green anole lizards (*Anole carolinensis*). *Environmental Toxicology and Chemistry* 24:3113-3116.

Taylor, J. 1998. *Guidance for Meeting U.S. Fish and Wildlife Service Trust Resource Needs When Conducting Coastal Marsh Management for Mosquito Control on Region 5 National Wildlife Refuges*. US Fish and Wildlife Services. 26 pp.

Taylor, N. 1938. A preliminary report on the salt marsh vegetation of Long Island, New York. . *New York State Museum Bulletin* 316:21-84.

Teal, JM. 1986. *The Ecology of Regularly Flooded Salt Marshes of New England: A Community Profile*. Biological Report 85(7.4), US Fish and Wildlife Service, Washington, DC. 61 pp.

Teal, J., and M. Teal. 1969**.** *Life and Death of the Salt Marsh.* Little, Brown, Boston, MA. 278 pp.

Turrell, MJ, DJ Dohm, MR Sardelis, ML O'Guinn, TG Andreadis, and JA Blow. 2005. An update on the potential of North American mosquitoes (Diptera:Culicidae) to transmit West Nile virus. *Journal of Medical Entomology* 42(1):57-62.

USEPA. 2005a. Permethrin. Notice of availability and of risk assessments and opening of docket. *Federal Register* 70(168):51790-51792.

USEPA. 2005b. *Permethrin: Updated Revised Occupational and Residential Exposure Assessment for the Reregistration Eligibility Decision Document*. US Environmental Protection Agency. June 29.

USEPA. 2005c. *Human Health Risk Assessment, Pyrethrins.* US Environmental Protection Agency Office of Pesticide Programs, Health Effects Division.

USEPA. 2004a. *DEET Factsheet* http://www.epa.gov/pesticides/factsheets/chemicals/deet.htm Office of Prevention, Pesticides, and Toxic Substances.

USEPA. 2004b. *Risk Assessment Principles and Practices*. EPA/100/B-04/001. Staff Paper, Office of the Science Advisor, US Environmental Protection Agency, Washington, DC.

USEPA. 2004c. *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency – Endangered and Threatened Species Effects Determinations*. US Environmental Protection Agency, Office of Prevention, Pesticides and Toxic Substances, Office of Pesticide Programs, Washington, DC.

USEPA. 2004d. *Permethrin - Third Report of the Hazard Identification Assessment Review Committee*. US Environmental Protection Agency HED Records Center Series 361. Science Reviews – File R100612. May 12.

USEPA. 2004e. AQUATOX (Release 2). Modeling Environmental Fate and Ecological Effects in Aquatic Ecosystems – Volume 1, User's Manual. EPA-823-R-04-001. US Environmental Protection Agency Office of Water, Washington, DC.

USEPA. 2004f. *AQUATOX (Release 2). Modeling Environmental Fate and Ecological Effects in Aquatic Ecosystems – Volume 2, Technical Documentation*. EPA-823-R-04-002. US Environmental Protection Agency Office of Water, Washington, DC. USEPA. 2002a. *IIFG Decision Document on Tolerance Reassessment for Methoprene*. US Environmental Protection Agency, Washington, DC.

USEPA. 2003. *Octen-3-ol (069037) Fact Sheet*. US Environmental Protection Agency. http://www.epa.gov/pesticides/biopesticides/ingredients/factsheets/factsheet_069037.htm. Accessed 9/05.

USEPA. 2002a. Pesticide Fact Sheets: Synthetic Pyrethroids for Mosquito Control. United States Environmental Protection Agency. http://www.epa.gov/pesticides/factsheets/pyrethroids4mosquitos.htm. Accessed on 7/12/04.

USEPA. 2002b. *Malathion for Mosquito Control*. United States Environmental Protection Agency. http://www.epa.gov/pesticides/factsheets/malathion4mosquitos.htm. Accessed on 7/13/2004.

USEPA. 2002c. *Larvicides for Mosquito Control*. US Environmental Protection Agency. http://www.epa.gov/pesticides/factsheets/larvicides4mosquitos.htm

USEPA. 2002d. *Status of Cumulative Risk Assessment for Organophosphate Pesticides*. US Environmental Protection Agency. http://www.valentbiosciences.com. Accessed 08/20/04.

USEPA. 2001. *Update of the March 1991 Methoprene R.E.D. Fact Sheet*. US Environmental Protection Agency, Washington, DC.

USEPA. 2000a. *For Your Information - Larvicides for Mosquito Control*. EPA 735-F-00-002. US Environmental Protection Agency, Washington, DC.

USEPA. 2000b. *Revised Human Health and Ecological Risk Assessment for Malathion*. US Environmental Protection Agency, Office of Pesticide Programs, Washington, DC.

USEPA. 2000c. *Malathion: Human Health Risk Assessment for the Reregistration Eligibility Document*. Chemical No. 057701, Case No. 0248. US Environmental Protection Agency.

USEPA. 1999a. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. EPA530-D-99-001B. US Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1999b. *Human Health and Ecological Risk Assessment Support to the Development of Technical Standards for Emissions from Combustion Units Burning Hazardous Wastes - Background Document*. US Environmental Protection Agency, Office of Solid Waste, Washington, DC.

USEPA. 1999c. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*. EPA530-D-99-001B. US Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC.

USEPA. 1998a. *Reregistration Eligibility Decision (RED) – DEET*. US Environmental Protection Agency, Office of Prevention, Pesticides, and Toxic Substances.

USEPA. 1998b. *Guidelines for Ecological Risk Assessment*. EPA/630/R-95/002F. US Environmental Protection Agency, Washington, DC.

USEPA. 1998c. *Reregistration Eligibility Decision (RED): Bacillus thuringiensis*. EPA738-R-98-004. US Environmental Protection Agency, Office of Pesticides, Prevention and Toxic Substances, Washington, DC.

USEPA. 1998d. *Bacillus sphaericus* (VectoLex) tolerance requirement exemption 8/98. United States Environmental Protection Agency. *Federal Register*, September 10, pp. 8594-48597.

USEPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Conducting Ecological Risk Assessment (RAGS 3A).* EPA 540-R-97-006. US Environmental Protection Agency, Office of Emergency Response, Washington, DC.

USEPA. 1993. *Wildlife Exposure Factors Handbook*. US Environmental Protection Agency, Office of Research and Development, Washington, DC. Volumes I and II.

USFWS. 1999. *Concerns and Issues about Mosquito Control on the National Wildlife Refuges in the Northeast*. US Fish and Wildlife Service, Region V. 53 pp.

Valiela, I., ML Cole, J. McClelland, J. Hauxwell, J. Celebrian, and SB Joye. 2000. Role of salt marshes as part of coastal landscapes. pp. 23-38. In: Weinstein, MP, and DA Kreeger (eds.). *Concepts and Controversies in Tidal Marsh Ecology*. Kluwer Acadmic Publishers, Boston, MA. 875 pp.

Vandenplas, O., JP Delwiche, J. Auverdin, UM caroyen, and FB Cangh. 2000. Asthma to tetramethrin. *Allergy* 55:417-418.

WHO. 2005. *Safety of Pyrethroids for Public Health Use*. World Health Organization, Communicable Disease Control Prevention and Eradiation, WHO Pesticide Evaluation Scheme and Protection of the Human Environment, Geneva, Switzerland. Available at: http://whqlibdoc.who.int/hq/2005/WHO_CDS_WHOPES_GCDPP_2005.10.pdf.

WHO. 1999. *Environmental Health Criteria 217, Microbial Pest Control Agent Bacillus thuringiensis.* International Programme on Chemical Safety, World Health Organization. Geneva, Switzerland.

WHO. 1984. *Data Sheets on Pesticides No. 47 Methoprene.* Food and Agriculture Organization, World Health Organization, IPCS INCHEM.

Ward, DH, RA Stehn, DV Derksen, CJ Lensink, and AK Loranger. 1986. *Behavior of Pacific Black Brant and Other Geese in Response to Aircraft Overflights and Other Disturbances at Izembek Lagoon, Alaska.* US Fish and Wildlife Service, Anchorage. AK. 34 pp.

Warren, RS, PE Fell, JL Grimsby, EL Buck, GC Rilling, and RA Fertik. 2001. Rates, patterns, and impacts of *Phragmites australis* expansion and effects of experimental *Phragmites* control on vegetation, macroinvertebrates, and fish within tidelands of the lower Connecticut River. *Estuaries* 24(1):90-107.

Weinzierl, R., T. Henn, and PG Koehler. 1997. *Microbial Insecticides*. ENY-275. University of Florida, Institute of Food and Agricultural Sciences (UF/IFAS).

Westchester. 2001. *Comprehensive Mosquito-borne Disease Surveillance and Control Plan*. Draft Generic Environmental Impact Statement. Westchester County Board of Health, White Plains, NY. Available at: http://www.westchestergov.com/planning/environmental/stingEIS/STING_DGEIS.htm#FGEIS.

Weston, DP, RW Holmes, J. You, and MJ Lydy. 2005. Aquatic toxicity due to residential use of pyrethroid pesticides. *Environmental Science and Technology* 39:9778-9784.

Whalley, SD, and TJ Minello. 2002. The distribution of benthic infauna of a Texas salt marsh in relation to the marsh edge. *Wetlands* 22 (4):753-766.

White, CM, and SK Sherrod. 1973. Advantages and disadvantages of the use of rotor-winged aircraft in raptor surveys. *Raptor Research* 7(3/4):97-104

Wiegert, RG, and BJ Freeman. 1990. *Tidal Salt Marshes of the Southeast Atlantic Coast: A Community Profile*. Biological Report 85 (7.29), US Fish and Wildlife Service, Washington, DC. 69 pp.

Witje, AHBM, and JL Gallagher. 1996a. Effect of oxygen availability and salinity on early life stages of salt marsh plants. I. Different germination strategies of *Spartina alterniflora* and *Phragmites australis* (Poaceae). *American Journal of Botany* 83(10):1337-1342.

Witje, AHBM, and JL Gallagher. 1996b. Effect of oxygen availability and salinity on early life stages of salt marsh plants. II. Early seedling development advantage of *Spartina alterniflora* and *Phragmites australis* (Poaceae). *American Journal of Botany* 83(10):1343-1350.

Wolfe, RJ. 1996. Effects of Open Marsh Water Management on selected tidal marsh resources: a review. *Journal of the American Mosquito Control Association* 12(4):701-712.

Yemaneberhan, H., Z. Bekele, A. Venn, S. Lewis, E. Parry, and J. Britton. 1997. Prevalence of wheeze and asthma and relation to atopy in urban and rural Ethiopia. *Lancet* 350:85-90.

Zdragas, A., GC Zalides, V. Takavakoglou, S. Katsavouni, ET Anastasiadis, and K. Eskridge. 2002. The effect of environmental conditions on the ability of a constructed wetland to disinfect municipal wastewaters. *Environmental Management* 29(4):510-515.

Zhong, H. 1999. Naled impact on honeybees research. *1999 Public Health Entomology Research and Education Center Annual Report*. Florida A&M.

Zielinski-Gutierrez, EC. 2002. Barriers and facilitating factors to West Nile virus personal protection. Presentation, *Fourth National Conference on West Nile Virus in the United States*. New Orleans, LA. February 10.