uplands or estuarine sources into the marsh. Another portion is organic, and tends to be derived from plants growing on the marsh. The deposition of organic materials on the marsh tends to be extremely local, so that what is buried at one place is generally what was growing there (very often root matter is what is preserved). The kind of matter that was the source of the material is often determinable, because marsh sediments quickly become anoxic with depth, and degradation processes under anaerobic conditions are much slower than oxic degradation. Much of the plant matter on a marsh is generally refractory, in any case. This means that the roots, stems, leaves, and seeds of particular kinds of plants can often be identified in marsh sediments.

In addition, the rate of accumulation of marsh sediment can be determined using radioisotopes. They land on the surface of the marsh from atmospheric deposition, and then are buried. Some of these isotopes are deposited at fairly regular rates, and so measuring the activity of particular isotopes and comparing that level to the activity when deposited, shows how long ago the layer of sediment was buried (because radioactive isotopes decay at known, constant rates). Other isotopes are enriched by particular processes. The most well-known and studied enrichment source is fallout from atmospheric testing of nuclear bombs. The start and cessation of this testing creates two clear horizons for several isotopes, in that they are extraordinarily enriched across that time interval.

Therefore, one kind of isotope analysis allows for understanding the deposition of material over a time interval. The other generates several fixed markers in the sediment. By assuming that at a particular depth, the plant material and the sediments analyzed for isotopic activity were both deposited at the same time, it can be determined what plants were growing on the marsh at a particular time.

It is a relatively simple matter to collect half-meter cores of marsh sediments. At an average accretion rate of three millimeters or so per year (the approximate rate of sea level rise in the New York City area for the past 150 years), 50 centimeters of peat potentially represents nearly 200 years of marsh vegetation history. The past 200 years along the Great South Bay in Suffolk County has seen very large expansions in suburban development, changes in inlet presence and geometry, several major hurricanes, and many large, powerful nor'easters. Area marshes have been filled, diked, used as pasture, ditched, and subjected to OMWM, in many cases.

It was thought that a major evaluation of marsh vegetation over time might determine if any of these processes had created changes across the marsh that resulted in identifiable impacts to the overall vegetation regime. Dating processes, although somewhat inexact, might allow for correlations between environmental factors and vegetation patterns to be made. Of particular interest to the Long-Term Plan were changes that might be associated with ditching, and those that might be attributable to OMWM. Therefore, one site that was selected was Seatuck National Wildlife Refuge (Seatuck). Seatuck was ditched in the 1920s, and was the site of a 1986 OMWM demonstration project. Wertheim (in particular, OMWM demonstration Areas 1 and 2) was chosen as the other site. It is similarly situated to Seatuck, and it was thought that the work at Seatuck might be able to inform the ongoing design at Wertheim. It was not known when the marsh at Wertheim was ditched, but aerial photography from ~1930 show that they were already installed by then. The locations of the two sites are shown on Figure 6-8.

This project was funded by the County Legislature. CA was project manager. Katherine McLetchie, from the Goodbred laboratory, Marine Sciences Research Center, Stony Brook University, was the lead investigator. She was funded through a CA subcontract with the State University Research Foundation. Steven Goodbred, PhD served as project supervisor. He was funded partially through the CA–Research Foundation subcontract, and partially through a direct subcontract with CA.

Wertheim has been described above (Section 5, and Section 6.1 immediately above). Seatuck is located in the town of Islip, on the South Shore of Long Island, 32 km west of Wertheim. It was originally maintained as a “gentleman’s farm,” part of a large estate. In 1968, the property was acquired by USFWS, as part of the Long Island National Wildlife Refuge complex for the management of migratory birds. Seatuck is only 24 hectares of land, approximately seven hectares of which are salt marsh. Champlin Creek runs parallel along the eastern border of the marsh and the Great South Bay provides the southern boundary. As at Wertheim, vegetation patterns follow the New England salt marsh model. However, as at Wertheim, high marsh areas contain many stands of mixed *Spartina alterniflora* and *S. patens*.

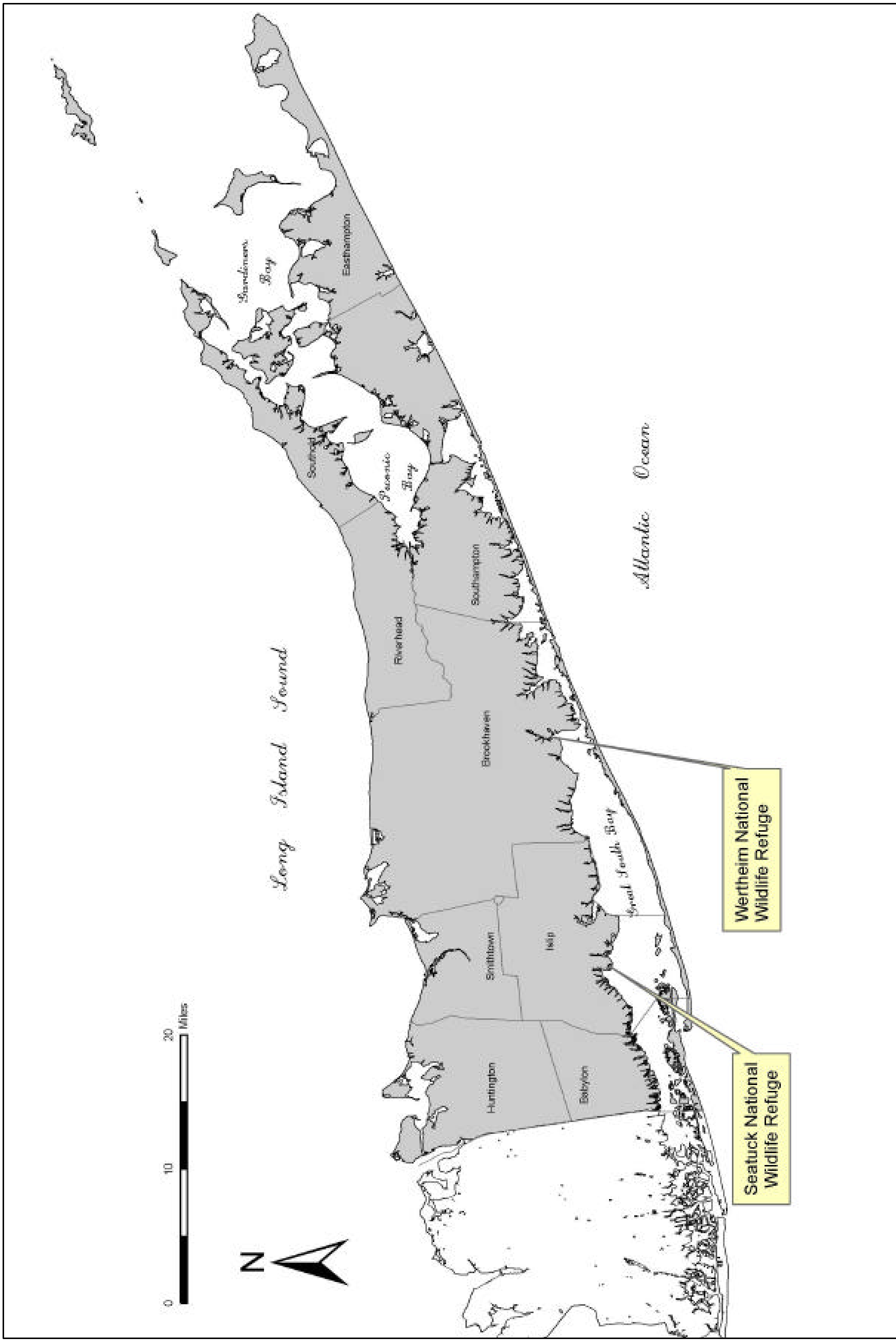

FIGURE 6-8
DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT
WERTHEIM-SEATUCK
MARSH RETROSPECTIVE PROJECT

Thick stands of *Iva frutescens* dominate the upland borders, as well as the edges of ditches. *Phragmites* is found in dense stands along many of the ditches, with smaller offshoots seen encroaching onto the marsh. Large quantities of *Phragmites* were observed at the boundaries of the marsh, a possible indicator of tidal restriction since *Phragmites* is generally considered a plant that prefers fresh and brackish water (Saltonstall, 2003), and its growth can be stunted by seawater (Chambers et al., 1998). In 1992 the Seatuck Tidal Channel was opened, thus restoring regular tidal flow to the marsh. However, fresh water is currently impounded on the marsh due to an obstructed drainage pipe. The mean tidal range at Seatuck is 0.30 m and the spring tidal range is only slightly higher at 0.34 m. Heavy rains were observed to fill in depressions and small ponds on the marsh surface, providing duck habitat. When rains did not occur, the marsh appears to be much drier, and the ponds form large panes, used by migratory birds for foraging. Despite the 1986 OMWM installation, it was observed that the shallow pools are not deep enough to support fish.

6.5.2. Methods

Field Transects

Fieldwork was conducted from June 2004 into the fall of 2004. All fieldwork was conducted nearest to low tide as possible for consistency.

Representative transects were identified that would include ditches, open marsh, and areas near open water. Three transects were set for Seatuck (Seatuck A, Seatuck B, and Seatuck C), and two for Wertheim. The two Wertheim and Seatuck A transects were 150 m long; Seatuck B was 72 m long, and Seatuck C 33 m long.

A Dutch peat corer was used to take 50 cm deep cores every 3 m along the transects. Each core was photographed with a digital camera, at high resolution setting. These cores were used to determine stratigraphy and plant root and rhizome composition. The cores were placed back into the marsh once notes were made and photographs were taken. Every 15 m, the core was reserved for laboratory analysis dry organic and water content analysis. Five cm sections were made and bagged separately.

The computer program Canvas was used to piece together the photographs of each core into a single image, thus providing an instant view of marsh history and allowing for rapid assessment of qualitative changes during approximately the past 200 years. Information from these transects, both the qualitative observations made in the field and from the photographs, and quantitative measurements of water and organic content, gave insight into changes through both time and space at each marsh. This information also allowed for informative decisions to be made concerning the locations for larger cores.

Larger Cores

Large-volume peat cores (50-60 cm in length and 16 cm in diameter) were taken using a PVC pipe from representative locations determined from the initial coring, which appeared to capture major features of marsh stratigraphy, while avoiding anomalies such as marsh edges and ditches. Care was taken to avoid compaction of the core during the extraction process. Upon removal from the ground, the cores were left inside the PVC pipe and the top was sealed with a test plug while the bottom was wrapped in plastic and duct tape in order to secure the core for transport back to the lab. The cores were stored at 4°C.

Four cores were taken at Wertheim (two on each transect) and two cores were taken along Seatuck A transect. Only two cores were taken from Seatuck due to its relatively smaller size, and the appearance of fairly uniform marsh history developed through the original coring exercise.

In the laboratory, the large cores were extracted from the pipes and sectioned into one-centimeter thick increments for the top 20 cm and two-centimeter increments for the remainder of the core. A large serrated knife was used to slice the cores, and both a ruler and caliper were used in order to ensure the proper width. Each section was placed in a labeled bowl and homogenized. Each sample was then divided into three equal parts for dry organic/water content, ^{210}Pb or ^{137}Cs for sediment dating, or grain size analysis. Samples were stored at 4°C until needed for analyses.

Water and Organic Content

Water and dry organic content was determined by weighing approximately 10 g of wet sample in a ceramic crucible and then drying it in a 60°C oven for approximately 24 hours. At the end of the drying period, the samples were reweighed and then placed in a muffle furnace for 6 hours at 450°C in order to burn off the combustible organic component of the sample. After the crucibles cooled sufficiently for handling, they were reweighed. Water content and dry organic content (loss on ignition [LOI]) were then calculated.

Radioisotope Dating

Sediment dating was achieved using both alpha and gamma spectroscopy. Analysis by alpha spectroscopy used ^{210}Pb ($T_{1/2}$=22.3 yr) via its granddaughter ^{210}Po, where as analysis by gamma spectroscopy used ^{210}Pb and ^{137}Cs ($T_{1/2}$=30 yr) radioisotopes (Cochran et al., 1998). Given its half life of 22.3 yr, the naturally occurring radioisotope ^{210}Pb can be used to date sediments as far back as 100 years, although the best accuracy is achieved to 80 years ago (Orson et al., 1998). ^{210}Pb is a product of the ^{238}U decay series, with its parent isotope being ^{226}Ra ($T_{1/2}$=1602 yr). ^{210}Pb is removed from the atmosphere via precipitation and dry deposition, and is supplied to the marsh where it subsequently adheres to particle surfaces. Supported levels of ^{210}Pb are produced within the sediments from the decay of ^{226}Ra, which naturally exists in sediments (Appleby and Oldfield, 1992). Sediment dating with ^{210}Pb was used to determine ages and calendar years for the sediment. In turn, sediment ages were used to calculate short-term accretion rates. These short-term accretion rates are the basis for the "constant flux" method, which assumes that the supply of ^{210}Pb to the marsh surface has been constant with time. Long-term average accretion rates were derived from ^{210}Pb by plotting a regression line of the natural log of the activity in a given core (positive values only), also known as the "constant activity" method (Appleby and Oldfield, 1992; Armentano and Woodwell, 1975; Cochran et al., 1998).

^{137}Cs dating is based on the known chronology of atmospheric inputs of cesium from the testing of nuclear weapons. Atmospheric testing started in the early 1950s and peaked in 1963, just before the introduction of the 1964 Test Ban Treaty (Orson et al., 1998). Therefore, ^{137}Cs is a useful isotope for dating sediment accreted between 1963 and present day. Since these cores were taken in 2004, approximately the past 40 years could be dated using ^{137}Cs. In order to get an average long-term accretion rate (cm/yr) since 1963, the depth in the core associated with the ^{137}Cs peak was divided by 41.

It is useful to use both ^{210}Pb and ^{137}Cs analyses on any given core so that one may be used against the other for quality control. Although ^{137}Cs dating has been criticized due to its potentially diffusive nature in the sediment, the discernible peak that results using this method suggests that it can be successfully used, especially when coupled with ^{210}Pb dating (Cochran et al., 1998; Roman et al., 1997).

One Wertheim core was dated only using ^{210}Pb, using alpha spectroscopy, but all five other cores were dated using both ^{210}Pb and ^{137}Cs, by gamma spectroscopy.

Sediment ages were estimated using the constant flux method which assumes that the flux of ^{210}Pb to the marsh has remained constant over time, thus allowing for different accretion rates (Armentano and Woodwell, 1975). Using the constant flux method, an age for the base of each sample was calculated.

Calendar years were assigned for each depth interval by subtracting the age of the sediment from the year the core was taken. Marsh accretion rates were determined for each depth interval using the dating information.

Grain Size Analysis

Grain size distribution is used as an indicator of sediment source and energy regime of the marsh. For example, sand is often an indicator of a high energy regime, such as a large storm or hurricane (Donnelly et al., 2001). Grain size analysis was performed at 5 cm intervals on wet samples from each core. Samples for grain size distribution were sieved through a 63 µm screen, using DI water, thus allowing silt and clay particles to pass through. Approximately 15 to 30 g of sample was used, depending on the amount of organics in each one. Larger grains (sand) and organic material were collected on top of the sieve, and significant sand inputs were dried and saved in plastic bags. Due to technical difficulties, no analysis was made for WA-B.

Once each sample was sieved, it was transferred to a beaker and a small amount of household bleach was added to oxidize any remaining organics. Samples were stirred daily for 5-7 days and on the last day, the water/bleach liquid was decanted and fresh DI water was added to rinse the sediment. After 24 to 48 hours of allowing the sediment to resettle in its clean water, a majority of the water was decanted and then each sample was spun down in multiple tubes on a centrifuge for 10 minutes. The liquid was decanted from the centrifuge tubes and the remaining sediment was scraped into small beakers, using a small amount of 0.05 percent calgon solution to aid in the transfer. The calgon solution consists of sodium hexametaphosphate and thus helps to keep particles from aggregating. Within 24 to 48 hours of this final step, the samples were sonicated for 10 to 15 minutes and then analyzed on a SediGraph 5100 in order to determine the actual size-distribution of particles less than 63 µm. The sample was placed in the mixing chamber of the machine where a magnetic stirring bar suspends the particles. The suspended sample was then drawn into the analyzing cell via tubing and the cell was placed in front of an X-ray beam that measures particle concentration. The particle size associated with each concentration measurement is the size of the largest particle present at the cell height and time of the measurement. Since the smaller particles have fallen, the concentration measured at the specified point is the concentration of particles smaller than or equal to that size. Each sample analysis lasted approximately 11 minutes and ended in a series of reports generated by the computer program. For the interest of this project, the cumulative mass finer report was viewed and three size classes were recorded (20 ϕ, 4 ϕ, and 0.5 ϕ) and used for data interpretation.

6.5.3. Results

Field Transects – Surface Vegetation and Paleobotany

Transects were chosen in order to encompass a representative sample area of the particular marsh community. At Wertheim, transect W-A was set up in Area 1, and W-B in Area 2. W-A is in an upstream area, and ran perpendicular to the stream. It encompassed an open, relatively undisturbed area that included mixed surface vegetation, including *S. patens*, *Scirpus robustus*, *Distichlis spicata*, *P. purpurascens*, *H. palustris*, and a scattering of *Phragmites*. Little *S. alterniflora* was present, suggesting that this was high marsh. Multiple cores along the transect revealed dense roots and organic rich peat of primarily *S. patens* from 0-20 cm, with a transition to *S. robustus* at approximately 20-25 cm. In general, from 30-50 cm the cores became muddier, with less organic matter and varying amounts of *S. robustus* throughout. Peat density thinned upwards through the cores beginning at approximately 20 cm.

Transect W-B was closer to the bay and also ran perpendicularly inland. At approximately 66 m, the transect traversed a wide ditch. The surface vegetation was characterized by a mixture of *S.*

patens and *S. alterniflora*, with *S. alterniflora* dominating closest to the bay. Cores revealed a fairly uniform transect with the general pattern being dense organic matter for roughly the top 20 cm, transitioning to less compacted *S. patens* peat and/or *S. robustus* for the remainder of the core. In several of the cores, *S. alterniflora* was found between 20 and 30 cm.

At Seatuck, transect S-A was nearest to the bay and ran parallel to the bay, from the drainage ditch through a wall of *I. frutescens*. The surface vegetation was mainly a mix of *S. patens* and *S. alterniflora*, with some stands of *Phragmites*. The transect traversed a major ditch at approximately 93 m. Cores along the transect varied in respect to types of preserved roots and rhizomes found at specific depth intervals. However, the general pattern consisted of dense peat (typically *S. patens*) for the top 20 to 30 cm, transitioning to *S. alterniflora* in some cases, or remaining as *S. patens*, and ending with a freshwater peat layer beginning at approximately 45 cm. Between 45 m and 90 m along the transect, *Phragmites* was found beginning somewhere between 12 and 20 cm (the depth varying with specific cores). Just past the ditch, several cores contained varying sand layers beginning at approximately 20 cm.

Transects S-B and S-C were located further inland than S-A, close to a large upland pond. S-B ran parallel to the bay, from the drainage ditch to the upland shrubbery. As this transect was only 72 m long, transect S-C was set up perpendicular to S-B, crossing it approximately at the half-way point (45 m, actually). S-C was 33 m in length, and together with S-B provided a nice cross-section of the upland marsh. As was the case with S-A, the surface vegetation here was characterized by a mix of *S. patens* and *S. alterniflora.* There were many low lying spots and small ponds that interrupted transect. Cores from these two transects were fairly uniform. The top 20 cm revealed a mixture of *S. patens* and *S. alterniflora* with *Phragmites* interspersed in many of the cores at this interval. In transect S-C, *Phragmites* was more prevalent and continued often to depths of 40 cm. Between 40 and 45 cm a black freshwater peat layer was identified. *S. patens* dominated at mid-depths between 20 and 40 cm.

Field Transects – Organic and Water Content

At Wertheim, percent water and percent LOI data correlated, so that samples with lower water content tended to also have lower organic content. Variability of the organic content was high, from 9 percent to 82 percent for transect W-A, and 11 percent to 62 percent for W-B. At

Wertheim, both transects show a marked increase in organic content, beginning at approximately 25 cm, and increasing throughout to the surface. Percent water was more uniform in time and space, although lower percentages did accord with lower organic content. The correlation was not linear.

At Seatuck, there was also a positive correlation exists between percent water and percent LOI. Organic content showed a similar range of values as found at Wertheim, but without the trends found at Wertheim. Water content upland (transects B and C were similar in variability to those at Wertheim, while transect S-A had a much greater range of values.

Large Cores – Paleobotany

Large-diameter cores taken from pre-selected areas of each marsh allowed for more detailed analyses to be performed. Core WA-A was taken at approximately 24 m along transect W-A and core WA-B was taken at about 72 m along the transect. Core WA-A had densely matted roots of *S. patens* from 0-25 cm; 25-50 cm consisted of a mix of *S. patens* and *S. robustus*. Core WA-B consisted of *S. patens* from 0-20 cm; from 20-50 cm the core was muddy, with *S. robustus* throughout.

Along transect WB, core WB-A was taken just landward of the ditch (75 m along the transect) and core WB-B was taken further upland at 114 m, in an expanse of *S. patens*. Core WB-A had dark brown to black soil, with dense roots of *S. alterniflora* from 0 to 25 cm; preserved roots and rhizomes shifted to primarily *S. patens* for the second half of the core (25 to 50 cm) in a muddy, light brown soil. Farther inland, core WB-B had light brown to brown colored soil and contained dense roots of *S. patens* from 0 to 30 cm; fom 30 to 50 cm the core became muddier and contained mainly *S. patens*, mixed amongst some *S. robustus*.

At Seatuck, core SA-A was taken at approximately 48 m and core SA-B was taken on the far side of the *I. frutescens* border and just beyond the ditch, at about 99 m. Core SA-A had several distinct transitional zones. Between 0 and 20 cm there was a mix of *S. patens* and *S. alterniflora*, with *Phragmites* rhizomes between 20 to 30 cm; 30 to 45 cm consisted of *S. alterniflora*, and the last five cm of the core (45 to 50 cm) was a freshwater peat layer, characterized by black peat and fine, freshwater plant roots and rhizomes. In addition, some sand was detected at depths of

15 to 16 cm and near the bottom of the core at 48 to 50 cm. Core SA-B proved somewhat of a surprise, as its lower half consisted mainly of sand. Cores had not been taken directly next to ditches due to the possibility that dredge spoils were deposited there; although core SA-B was taken some distance from the nearby ditch, it may have intersected spoils nonetheless. Conversely, there may be other explanations for the sand. The top 20 cm of core SA-B consisted mainly of *S. patens*, with a small amount of sand detected in intervals 10 to 11 cm and 15 to 16 cm. Sand dominated from 20 to 38 cm and at 38 to 40 cm was a thick clay layer.

Large Cores – Organic and Water Content

Organic and water content data for large-diameter cores are similar to those values obtained for their respective transects, if the sand intervals are disregarded.

Large Cores – Mineral Fraction versus Organic Flux

The fluxes of organic and mineral fraction in $g/cm^2/y$, for specific depth intervals for each core, were calculated, generating an organic matter to mineral ratio for the sediments. Because the calculation required a time computation, they were only calculated to the depths where dates were determined. A ratio less than one meant the marsh accreted primarily by mineral fraction input, and one greater than one indicated that the marsh accreted predominantly by organic matter. Cores WA-A, WA-B, SA-A, and SA-B generally show accretion primarily by organic matter for the latter half of the 20th century, although earlier than that the mineral fraction dominates. Cores WB-A and WB-B had accretion via mineral deposition throughout.

Large Cores – Radioisotope Dating

Core sediment age, determined by the constant flux model, plotted against depth showed a linear increase in age with depth for approximately the top 15 cm of each core, after which this linearity becomes less defined and ages trail off. A calendar year was assigned to each depth interval for the depths up to 80 to 100 years, and used to calculate short-term accretion rates, according to the constant flux model. The constant flux model resulted in relatively low accretion rates lower in the core (less than two mm/yr), with the calculated accretion rates increasing starting at approximately 12 cm (between two and 4.5 mm/yr). The increased rates held throughout the remainder of the cores to the surface, which roughly corresponds to the later half of the 20th century. Specifically, cores show short-term accretion rates generally being less than 0.20 cm/y for the first part of the 20th century and between 0.20 and 0.45 cm/y for the latter half of the century.

Long-term accretion rates, calculated by dividing the length of accumulated core by the length of time from the last reliable calculated date, were fairly constant (except for WB-A) (Table 6-10). Note that the long-term record for sea level rise at The Battery (Manhattan, New York) shows increases of approximately 3.0 mm/yr.

^{137}Cs measurements were made for five cores (excluding WA-A). After finding the depth interval (cm) peak of cesium activity, it was divided by 41 (the number of years from 1963 to 2004 – 1963 was the peak of nuclear-weapons testing) to determine a long-term accretion rate (Table 6-10). A comparison of the two dating methods (at the 1963 depth as determined by the cesium peaks) is shown in Table 6-11; the two methods correspond extremely well at three of the cores.

Table 6-10. Average Long-Term Accretion Rates Derived from Radioisotope Dating

Core	^{210}Pb (mm/yr)	^{137}Cs (cm/yr)
WA-A	2.3	n/a
WA-B	2.7	2.9
WB-A	4.1	3.2
WB-B	2.4	2.0
SA-A	2.0	2.4
SA-B	2.5	1.7

Table 6-11. Comparison of Calendar Dates Derived by ^{137}Cs and ^{210}Pb Radioisotopes

Core	*^{210}Pb Constant Flux Date for 1963 ^{137}Cs Peak*
WA-B	1962
WB-A	1962
WB-B	1969
SA-A	1962
SA-B	1955

Large Cores – Grain Size Analysis

Grain size analysis showed no consistent differences within or between sites. The cores consisted primarily of silt and clay, with the exception of core SA-B, where there were significant amounts of sand from 18 cm to the base of the core. Other detectable sand deposits (i.e., the analyst could feel sand grains while sieving the sample) were found only in core SA-A at intervals of 15 to 16 cm and near the bottom of the core at 48 to 50 cm. With the exception of core SA-A, which shows nearly 100 percent clay at 39 cm depth, no significant grain size pattern was discernible.

6.5.4. Analysis

Vegetation Changes

The present day surface vegetation at Wertheim indicates that the marsh transitions from a wetter *S. alterniflora* dominated marsh in the lower intertidal zone to a higher and drier marsh characterized by *S. patens* and its associated high marsh plant communities. Area 1 of Wertheim has a diversity of brackish high-marsh vegetation co-existing with *S. patens* whereas Area 2 transitions from a classic intertidal low marsh (indicated by pure stands of *S. alterniflora*) to an expansive area of *S. patens*. That *Phragmites* is restricted to the margins of the marsh and near ditches (as opposed to the interior of the marsh) suggests that there may have been some disturbance to the marsh in recent years, but that the marsh is still appropriately functioning (Niering and Warren, 1980).

Cores from these two areas show a shift in plant community at 20 to 30 cm, corresponding to the early 1900s, based on radioisotope dating. In general, the marsh has transitioned from a wet and brackish marsh, as indicated by abundant *S. robustus* found in the bottom half of the cores, to a drier and more saline marsh, as indicated by the salt marsh plants *S. patens* and S. *alterniflora* found in the top half of the cores. Organic content data for transects and cores show increasing amounts of organic matter corresponding to the same interval where the shift in plant community structure occurred. Organic matter is typically greatest at the marsh surface, and then decreases or remains unchanged as it is buried, because of slow anaerobic decomposition processes in a marsh (Cochran et al., 1998

The surface vegetation at Seatuck consists mainly of a mix of *S. alterniflora* and *S. patens*, with a substantial amount of *Phragmites* invading the marsh. The abundance of *Phragmites* at Seatuck might be attributable to a combination of suppressed tidal inundation, lack of drainage for fresh water after heavy rain storms, and upland development. Bertness et al. (2002) attribute *Phragmites* expansion to nitrogen eutrophication associated with shoreline development. Since Seatuck borders a town beach and a highly trafficked road lined with many houses, it is plausible that nitrogen eutrophication is one factor perpetuating the spread of *Phragmites*. However, Seatuck has a long history of large-scale human disturbances, dating back to the 1800s. The most severe disturbance is the fragmentation of what once used to be a large uninterrupted marsh, extending from Champlin Creek west to Orowoc Creek, which was once on the far west side of the town beach. Filling in Orowoc Creek and subsequent development cut off tidal exchange to the west side of the marsh. Following this event, in the late 1800s three major roads were built through the marsh (St. Marks Lane, South Bay Avenue, and Old Corduroy Road), further fragmenting the marsh (Cowan et al., 1986). These major disturbances have altered the hydrodynamics of Seatuck and these changes are evidenced in the shifts in plant community structure during the past 200 years.

Examination of core SA-A allows for the history of Seatuck marsh development during the past 100 years to be reconstructed. The bottom of the core consists of a freshwater peat layer over which is a layer of *S. alterniflora*. This implies an abrupt transition from a freshwater marsh system to a tidal marsh. Extrapolation of dates determined from radioisotope dating places the freshwater peat layer in the early 1800s. Just prior to the 1900s is evidence of *Phragmites*, possibly due to a disturbance event of some kind, for example the creation of South Bay Avenue and Old Corduroy Road which divided the marsh from north to south (Cowan et al., 1986). The top 20 cm of the core, which represents the majority of the 20th century, reveals a mixture of *S. patens* and *S. alterniflora*. The potential for transition from *Phragmites* to *Spartina* species occurred during the early years of the 20th century. Records indicate that Seatuck was first ditched in the summer of 1914 (Havemeyer, 1996), thus suggesting this transition to *Spartina* corresponds to the ditching practices.

The mix of surface vegetation indicates that the marsh is not functioning as a true high or true low marsh, but rather has adapted its plant communities to survive in this altered marsh system. Alternatively, the marsh could be in a transition state, moving from one *Spartina* species to the other. Redfield (1972) notes that the boundary between *S. patens* and *S. alterniflora* is often not defined and it is not uncommon for these two species to coexist in the high and/or low marsh.

However, he also notes that a true high marsh that is well drained will be dominated by *S. patens* and its low marsh will consist of pure stands of *S. alterniflora*. Thus the present surface vegetation mixture of *S. patens* and *S. alterniflora* at Seatuck further suggests this is not a well drained marsh system.

A methodological complication associated with the stands of *Phragmites* on the marsh at Seatuck is that this plant often propagates by rhizome. Therefore, it is not clear if the *Phragmites* matter found at depth at Seatuck represents an early stand of the plant, or if the matter is due to horizontal propagation efforts.

Core SA-B did not provide as substantial information due to the fact that the bottom portion consisted of sand. However, it is important to note that the sand is related to mixing with underlying outwash and is not a function of marsh processes.

There was no evidence in the core that OMWM modifications made to Seatuck during the mid-1980s potentially altered marsh functioning. This finding is mitigated since there has been no more than three to five cm of marsh accretion during the past 20 years, and that thin a layer of material is difficult to analyze well, especially when it occurs right at the surface.

Radioisotope Dating

The accretion rates calculated as part of this study for Wertheim are similar to others published for Long Island (Cochran et al., 1998), Long Island Sound (Bricker-Urso et al., 1989), and Massachusetts (Roman et al., 1997), using similar techniques. The comparatively higher accretion rate for WB-A may be due to the tides delivering sediments to this part of the marsh and the subsequent effectiveness of *S. alterniflora* in trapping delivered sediment (Reed, 1995), which is supported by the finding that this area of the marsh has been accreting predominantly by mineral input for the past century.

Long-term accretion rates at Seatuck are lower, and tend to be below the rates found in the other studies. It is not clear if this signifies a problem for the marsh in maintaining itself against sea level rise.

6.5.5. Summary

One intent of this retrospective study was to determine if the disturbances from parallel grid-ditching triggered changes at these marshes. There is a suggestion that a shift in vegetation was concurrent with the onset of ditching. The issue is exactly what the shift might have been. The shift may have been from *S. alterniflora* to a *S. alterniflora-S. patens* mix (assuming the evidence of *Phragmites* to be recent and indicating invasion via rhizomes) at Seatuck. If so, that is a classic ditching impact, suggesting that the marsh became drier (from regular, twice daily tidal inundations to irregular tidal inundations), due to the ditches draining the marsh (although how greater draining of the marsh diminishes inundation periodicity is not clear). The shift may have been from *Phragmites* to the *Spartina* mix. This is similar to the shift observed at Wertheim. There, concurrent with ditching, vegetation shifted from *Scirpus* to *Spartina*, or *S. patens* to *S. alterniflora*. These shifts seem to signal that ditching made the marsh saltier and may have increased inundations. This could have occurred if the ditches conveyed estuarine water further into the marsh on a regular basis.

For Seatuck, impacts associated with ditching may be overshadowed by upland development and in-marsh developments. The inability to isolate environmental changes such as ditch installation from other concurrent factors makes it near-to-impossible to be certain of the cause of any particular effect. Nonetheless, that major vegetation changes appear to be concurrent with the onset of ditching suggests that such activities did have implications for the vegetation regime at these marshes.

A full discussion of this experiment is found in Cashin Associates (2006b).

6.6. Mosquito Ditch Conveyance of Pollutants Experiment

The full report that this excerpt is based on will not be finalized when the GEIS is submitted, but the report will be posted on the project website early in the comment period. The work is thus being cited as (Cashin Associates (in prep.).

6.6.1. Introduction

It has been believed by some that mosquito ditches constructed on salt marshes directly transport stormwater from uplands to the estuary, thereby short circuiting any natural filtration that the marsh might provide for what has been identified as pollutant-laden water. The literature review found no information regarding this potential negative aspect for ditching in marshes.

CA therefore set out to make some measurements to potentially test whether ditched marshes negatively affect the estuary by conveying stormwater directly to the estuaries without first processing the stormwater through the marsh surface. This work was funded by the County legislature, and conducted by CA with assistance from the Bureau of Marine Resources and the PEHL (SCDHS), and two subcontracted laboratories – the Sanudo laboratory, Marine Sciences Research Center, Stony Brook University, and H2M Laboratories, Melville, NY.

The sampling included measurements made at the selected sites under both wet weather and dry weather conditions. Two pairs of marshes were selected. One set ("Gilgo" marshes) was composed of one area that was ditched ("ditched Gilgo"), and one area that was unditched ("unditched Gilgo"). This pair of marshes had identical upland land use, the most notable feature of (and expected major pollutant source) was Ocean Parkway. A second pair of ditched marshes ("Flanders" marshes) was selected, where each marsh had different upland land use. One was in parkland ("Hubbard") and the other had moderate density housing with residential streets in its drainage ("Goose"). If it is correct that ditches convey stormwater to the estuary and so short circuit pollutant removal processes that might occur through the marsh surface, the following results would be expected:

- Water quality under dry weather in the estuary off both Gilgo marshes should be the same. If water quality conditions for the estuary at ditched Gilgo is worse than at unditched Gilgo, and it would be positive if those impairments were traceable to the ditches. If dry weather conditions at unditched Gilgo are worse than those at ditched Gilgo, then meaningful comparisons can not be made.

- Under rainy conditions, water quality in the estuary at ditched Gilgo should be worse than at unditched Gilgo (or should deteriorate more than the difference found for dry conditions), and the impairments should be traceable to the ditches.

- Water quality in the estuary for the two Flanders sites could be similar. However, if the water quality is not similar, water quality at Goose should be worse than that at Hubbard, and it would be a verification of the hypothesis if the impairments were traceable to the ditches at Goose. It would also be somewhat of a validation if water quality in the ditches were similar at both sites. If water quality in the estuary at Hubbard is worse than that at Goose under dry conditions, then meaningful comparisons can not be made. If water quality in the ditches at Hubbard is worse than that at Goose under dry weather conditions, then it is most probable that meaningful comparisons can not be made.

The marsh pairs were chosen in close proximity to each other in order to reduce some of the inherent variability associated with salt marshes (such as tidal regime, substrates, approximate age, and general morphology) was reduced, and so that they shared regional general groundwater quality. Also, due to the wet weather portion of the study, the use of geographically close pairs of marshes for study reduced the chances that precipitation at the study sites would be very different in amounts, duration, or intensity. Furthermore, close sites allowed for easier concurrent sampling. Although in close proximity to each other, the pairs of marshes were separate enough from each other so that the estuarine water samples would not necessarily be similar.

6.6.2. Site Selection

Two pairs of marshes were selected. One pair consists of a ditched marsh and an unditched marsh with similar upland characteristics. The second pair consists of two ditched marshes with different upland characteristics (developed and undeveloped). The different upland characteristics of the pair of ditched marshes were chosen to test if the degree of development plays any role in different water quality impairments theoretically transmitted by the ditches.

Well over 95 percent of Suffolk County's salt marshes have been ditched as a past mosquito control practice. This reduced the chances of finding similar pairs of ditched and unditched salt marshes. In an effort to locate appropriate pairs of marshes, CA mapped the locations of all unditched salt marshes in the County. This was accomplished using USGS quadrangle maps and aerial photograph analysis. USGS quadrangle maps note the presence of most tidal wetlands. In many cases, ditches are also drawn on the marsh land. Therefore, for USGS-mapped wetlands, those with ditches drawn on the map were assumed to have been ditched. Those mapped wetlands without drawn ditches were examined using the 2001 County aerial photographs, which have a resolution of six inches. Those areas without visible ditches in the aerials were identified as unditched marshes. Thirty-two such marshes or marsh fragments were identified in this way (see Figure 6-9).

There are a number of unditched marshes on the North Shore in the Long Island Sound watershed. These were not considered, as the steep topography generally found there might promote run-off such as is not found in less steep terrain. Most salt marshes on Long Island are along the less steeply sloped south shore, or in the Peconic Estuary, and so the focus of the search fell there. In addition, marshes without an obvious source of polluted stormwater (such as those in the park settings or undeveloped land) were either eliminated or given a lower selection priority.

In the end, the only feasible site for this comparison appeared to be in Gilgo State Park. It was suboptimal in that it was a relatively pristine setting, and overall land use as a park was not likely to impact water quality. However, a major divided highway, Ocean Parkway, lies just south of the marsh. This roadway was identified as a potential source of contaminated run-off, especially if sampling could occur after an extended dry period when hydrocarbons and other automobile-petroleum product residues might accumulate on the road. A further complication is the estuary by the unditched portion of the marsh lies further from the road than it does by the ditched portion of the marsh. This is because the unditched marsh is somewhat wider than the ditched portion of the marsh. This is noted in particular as it may bias the sampling results towards finding impacts from the ditching, as it may be easier to convey pollutants through the ditched portion of the marsh from the road simply because it is narrower, and not because the ditches convey the pollutants.

In any case, the eastern portion of the marsh is unditched, and west of it is a ditched area. This pair of sites had been used by Audubon researchers in the 1970s to investigate the difference in bird use of ditched and unditched marshes, and so the site selection echoed earlier research choices (Post, 1970a; Post, 1970b; Post and Greenlaw, 1975; Merriam, 1983; Greenlaw, 1992).

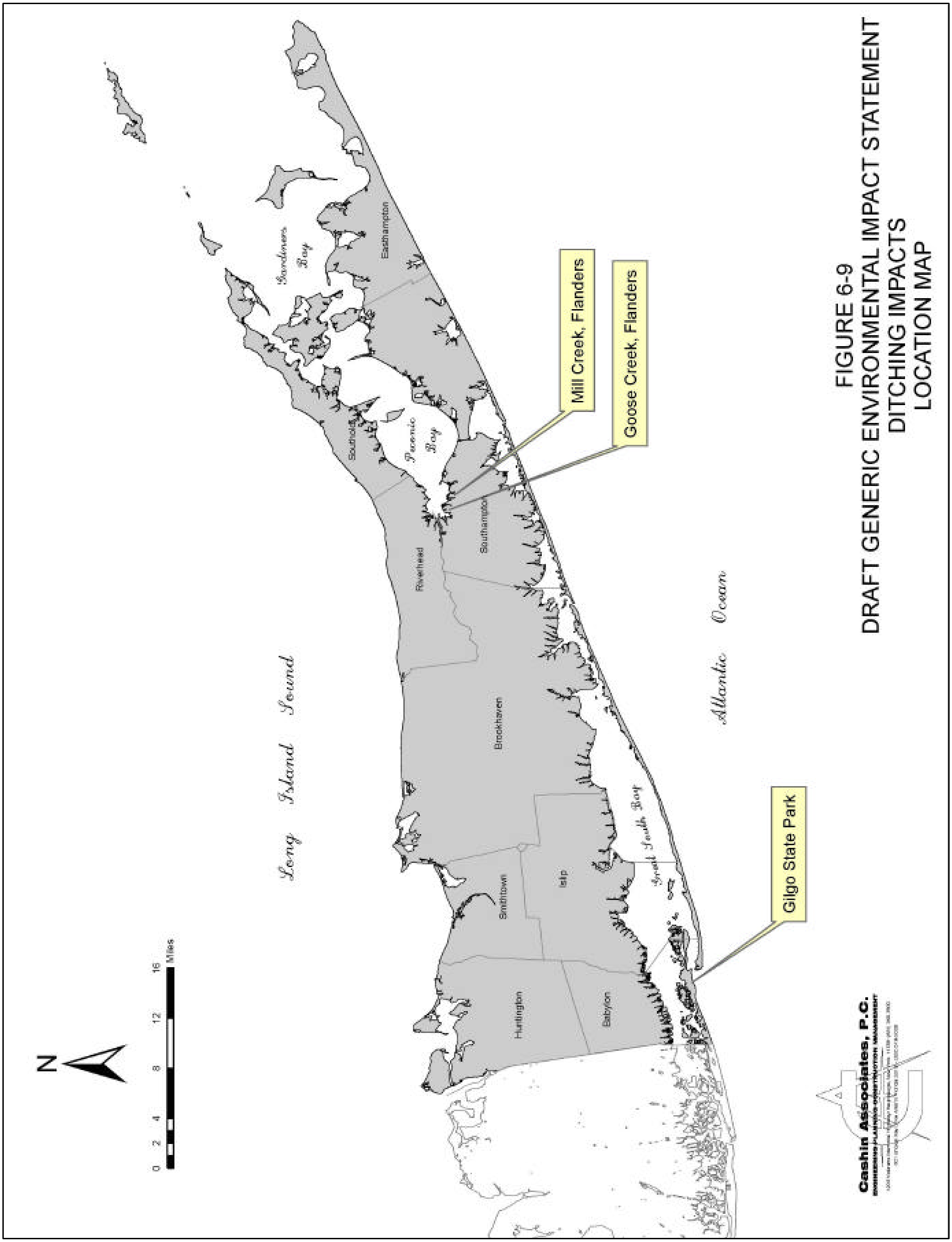

FIGURE 6-9
DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT
DITCHING IMPACTS
LOCATION MAP

It also proved more difficult than expected to select the second pair of marsh sites. General constraints included morphological similarity, so that if one marsh fronted on an enclosed embayment, so should the second. Because storms would play a role in the test, if enclosed embayments were to be used, it would be best if they had the same general orientation so that impacts from wind-driven water would be equivalent. The general size of the marshes and quality of ditches were to be similar. The marshes should be located close to one another, as discussed above, to limit storm, tide, and overall groundwater discharge quality differences, and yet should be located far enough from each other so as to enable two distinct estuarine samples to be collected.

Two marshes fringing the Peconic Bay in Flanders were eventually selected. The upland at the first marsh, located at Mill Creek, consists of undeveloped County parkland (Hubbard Creek Park). The second site, located on the west side of Goose Creek, has a one-house fringe of residential development around it, with the necessary street for access. The marsh at Goose Creek had previously been ditch plugged as part of an OMWM demonstration. However, site examination prior to sampling revealed that plugs in several ditches have noticeably failed. A ditch with a failed plug that did not retain water and had considerable flow during ebb tide was selected to be sampled.

6.6.3. Methods

All ditched marshes had three sampling stations. One was in the estuary, and two were in a selected ditch. At the unditched marsh, only an off-shore sample was collected. Two sets of samples were taken at each station, one for analysis by the SCDHS PEHL, and one for trace metals. The PEHL does not analyze for metals in seawater samples on a routine, as the salts in seawater would foul instrumentation dedicated to analyzing drinking water samples (one sample, the dry weather sample in Flanders, was analyzed for metals). Three of the trace metal sample sets were analyzed by the Sanudo laboratory, Marine Sciences Research Center, Stony Brook University. The fourth was analyzed by H2M Laboratories, Melville, NY.

The PEHL is a participating laboratory in the Environmental Laboratory Approval Program (ELAP) of NYSDOH. Sampling parameters analyzed for in the PEHL samples were:

- general water quality parameters (salinity, DO, pH),
- coliform and fecal coliform
- the standard estuarine nutrient suite analyzed for by the PEHL (various nitrogen and phosphorus species)
- volatile organic compounds (analyte list based on County regulations for groundwater quality)

The PEHL can sample for an extensive list of semi-volatile organic compounds, including pesticides and pesticides degradates, but it was assumed that these compounds would not be detectable due to stormwater runoff. Samples were collected by trained SCDHS personnel following standard SCDHS procedures for the collection of sweater samples.

The Sanudo laboratory analyzed samples for the following dissolved trace metals:

- cadmium
- cobalt
- copper
- iron
- lead
- nickel
- silver
- vanadium
- zinc

These nine metals were selected by Dr. Sanudo, with input from CA, because most have been identified in various marine investigations as land-derived. Clean metals techniques (Sanudo and Gill, 1999) were used, including collecting samples using a 15 foot stainless steel boom so that the hose end was at least ten feet from the boat and/or samplers, the use of acid washed Teflon-coated tubing, acid-washed pump tubing, and filtering through acid-washed 0.45 µm polysulfone cartridges into acid-washed polyethylene bottles (all acid-washing involved at least one month contact between quartz-distilled hydrochloric acid and the materials). The samples analyzed by the Sanudo laboratory were digested for at least a month using quartz-distilled hydrochloric acid, pre-concentrated using organic solvent extraction (as described in Buck et al., 2005), and quantified using a graphite furnace atomic absorption spectrophotometer in laboratory space under ultra-fine air filtration-clean room conditions. These techniques make it possible to have detections at the nanomolar (part per trillion/quadrillion) level for some metals. This means, for many samples, detectable quantities of metals in ambient conditions can be found, which is not always the case. Samples analyzed by H2M were digested for one month using nitric acid. They were analyzed using gas chromatography mass spectrometry, following an initial analysis by atomic adsorption to determine if instrument fouling would be an issue with these samples. Iron results were from the atomic adsorption analysis. Prior to sampling, CA personnel received instruction in the appropriate clean-metals sampling techniques.

Dry weather samples were collected on a falling tide when no rain had fallen for at least 48 hours. Freely-draining ditches were selected at the Flanders marshes, and the same ditch as was sampled under wet weather conditions was sampled at Gilgo. Off-shore samples were then taken, also under falling tide conditions, within 10 meters of the unditched marsh at Gilgo, and at the mouth of the ditches. Flanders was sampled January 3, 2005. The last previous rain event (according to the National Weather Service at http://www.erh.noaa.gov/box/dailystns.shtml was December 23, 2004. Gilgo was sampled May 6, 2005, and the previous rain event had been on May 1, 2005. A trace amount (0.01 inches) of precipitation was seen the day after, May 2.

On September 28, 2004, remnants of Hurricane Ivan were forecast to strike Long Island. Samplers were dispatched at 4 am to Gilgo. Rain began falling at 9:30. Sampling began at 10 am, when approximately 0.5 inches of rain had fallen, according to NEXRAD radar analysis. The previous rain event had been on September 18, 2004.

The wet weather sampling round was collected in the early morning of August 30, 2005 at the Flanders marshes. The weather system consisted of a series of thunderstorms. Samplers arrived at the marshes as a substantial storm, generating stormwater on local streets, was ending. The storm was quantified at Westhampton Beach as having generated 1.42 inches of precipitation, including the night before. Suffolk County was in the midst of an extended dry period at this time. Patchy rainfall occurred throughout the summer, but, by some accounts, the last island-wide storm system had been on July 8. Some substantial rainfalls (greater than 0.1 inches) were recorded for three days in total for August at Westhampton Beach (the last having occurred August 15). It is not known if local rainfall substantially impacted the Flanders marshes area over that time period.

Several factors prevented the opportunity to collect samples during an optimal wet weather event. These factors include inaccurate weather forecasts, slow-start rain storms, or storms that began during late night hours or off-work days.

The marshes at Gilgo State Park were collected by boat. The boat was positioned upstream, facing the wind with the engine turned off to prevent exhaust fumes from contaminating the sample.

Samples conducted by SCDHS were collected at a sub-surface depth of approximately six to 18 inches, using four-liter wide mouth Nalgene dipping bottles. Individual bottles were not filled in succession directly from the water column to prevent from encountering different water masses as the boat drifted. All information including the sampling date, the name of the bay being sampled, the area code, the names of the sampling crew, the vessel being used, the serial number(s) of any meters used, the general water color, the present and previous weather, the approximate wind speed and direction, and in the case of marine sites, the tidal stage, were all recorded on field data sheets prior to commencement of sampling. At each station, the samples collected were denoted by a check in the appropriate box. Any unusual conditions (water discoloration, odors, etc.) or problems encountered during sampling were noted in the "remarks" column.

Of utmost importance in maintaining the integrity of each sample, is the thorough rinsing of all collection and sample bottles where appropriate. The four-liter bottles were rinsed at least twice with sample water before being filled. As appropriate volumes are transferred to individual sample bottles or to a filtration apparatus, these containers were also thoroughly rinsed with sample water. After rinsing the entire apparatus with sample water (before fixing the filter pad), approximately the first 200 ml of filtrate was used to rinse the receiving flask. The sample bottles for the dissolved aliquots were also rinsed with a portion of the filtrate before being filled.

Trace metal samples were collected through Teflon tubing using a peristaltic pump with acid-washed C-Flex tubing in the pump head. The tubing was mounted to a 15-foot stainless steel pole extended from the bow of the boat to the sample location, upwind from boat exhaust. Samples were pumped through a 0.45 µm filter cartridge and into acid-washed polyethylene bottles. All sample containers without preservatives were rinsed with approximately 250 mL of sample water prior to collecting the sample.

Samples in Flanders were collected on foot. Estuarine samples were collected by extending the 15 foot stainless steel boom out from the marsh shoreline near the mouth of the ditch.

For nutrient samples, immediately after collection, sample water was placed into each of three new polyethylene bottles (after rinsing) that are color coded for specific analyses. A small air space is left at the top of each bottle to facilitate later mixing and all are placed on ice at less than four degrees Celsius. A portion of the sample water was filtered through a 0.45 µm Whatman GFC filter pad to remove particulates. While filtering, care was taken to limit the amount of vacuum applied (< 100 mm Hg) so that cells are not disrupted and contents forced through the filter pad. One aliquot, for the analysis of ammonium, nitrite, nitrate, and ortho-phosphate, was placed in a separate bottle unpreserved. These aliquots were frozen at the laboratory. A second aliquot, for total dissolved nitrogen (TDN) and total dissolved phosphorus (TDP), was placed another individual bottle. This aliquot was also preserved with sulfuric acid at the laboratory. All nutrient samples were kept on ice at less than 4 degrees Celsius.

Coliform bacteria samples were collected in pre-sterilized 125 ml wide-mouth plastic bottle. A small air space was left at the top to facilitate later mixing. Care was taken to avoid contaminating the sample during collection and storage (the top of the bottle was not be allowed to become immersed in melt water when placed in the cooler containing ice). During each sampling event, one additional sample (labeled TC) was collected to serve as a temperature control. Upon arrival at the laboratory, the temperature of that sample was measured and recorded. For the samples to be acceptable, the TC must be less than 4 degrees Celsius. Bacteriological samples were analyzed within 6-hours of collection.

For organic compound analyses, the various compounds sampled for are divided into analyte-groups, which include carbamate pesticides, dacthal metabolites, volatile organic compounds (VOCs), chlorinated pesticides and micro-extractables, semi-volatile organics, and herbicide metabolites. At each station, two VOC samples were collected in 40 ml vials that with a Teflon septum, to which 25 mg ascorbic acid had been pre-added by the lab. Five drops of 1:1 HCL were added in the field as an additional preservation. When collecting these samples, care was taken to avoid analyte loss by volatilization. To check for contamination during sample handling and transport to the lab, two trip blanks consisting of distilled water were also collected.

For each station, two chlorinated pesticides and micro-extractables samples were collected in 40 ml vials that have a Teflon septum, to which NaS_2O_3 has been pre-added by the lab. Five drops of 1:1 HCL were added in the field as an additional preservative. As with VOCs, two trip blanks (consisting of distilled water) were collected for each sampling event.

Two semi-volatile organics samples were collected in one liter brown glass bottles to which a preservative had already been added by the lab. The bottles were not rinsed or overfilled during collection. As a pH adjustment, 1:1 HCL is added in the field.

One herbicide metabolites sample was collected in a 125 ml wide-mouth brown glass bottle. No preservative was added.

One metal sample was collected during each event in a 250 ml polyethylene bottle that already contained a predetermined amount of nitric acid (added by lab). The sample was first filtered through a 0.45um Whatman GFC filter pad to remove particulates.

6.6.4. Results

Most of the analytes sampled for by the PEHL were not detected. The number of analytes varied from 225 for the first sampling run to 245 for the second Gilgo event, to 273 for the Flanders events. Flanders had the most analytes, as metals were tested for. The Gilgo wet weather event did not have certain pesticide break-down products analyzed for in the SVOCs fraction.

Table 6-12 lists the results for any analyte detected in the first three sampling events (excluding the Flanders wet weather event). The Flanders wet weather sampling is reported in Table 6-13.

Table 6-12. Sample Detections, Run-off experiment, first three sampling events

Sample ID:		**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**	**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**
Sample Location:		**Open ditch**	**Open ditch**	**Off shore**	**Unditched marsh**	**Open ditch**	**Open ditch**	**Off shore**	**Unditched marsh**
Sample Date:		**9/28/2004**	**9/28/2004**	**9/28/2004**	**9/28/2004**	**5/6/2005**	**5/6/2005**	**5/6/2005**	**5/6/2005**
Analyte	**Units**								
Field Parameters									
Conductivity	umho					**45600**	**45400**	**46900**	NA
pH	N/A					**7.68**	**7.86**	**7.88**	8.11
Sanitary Indicators									
Fecal Coliform	MPN/100 ml	< 20	< 20	< 20	< 20	< 20	< 20	< 20	< 20
Total Coliform	MPN/100 ml	**170**	**80**	**130**	**130**	< 20	< 20	< 20	< 20
Nutrients									
Ammonia	mg/L	**0.02**	**0.04**	**0.02**	**0.01**	**0.0187**	**0.0236**	**0.5876**	**0.0077**
Dissolved Nitrogen	mg/L	**0.11**	**0.14**	**0.22**	**0.13**	**0.28**	**0.3**	**0.25**	**0.29**
Total Nitrogen	mg/L	**0.23**	**0.15**	**0.24**	**0.17**	**0.36**	**0.37**	**0.28**	**0.29**
Nitrate & Nitrite	mg/L	**0.560**	**0.121**	**0.005**	< 0.005	**0.00597**	**0.00797**	**0.00521**	**0.00809**
Dissolved Phosphorous	mg/L	< 0.025	**0.03**	< 0.025	**0.04**	**0.0613**	< 0.025	**0.0259**	< 0.025
Total Phosphorous	mg/L	< 0.025	**0.026**	< 0.025	< 0.025	**0.0503**	**0.046**	**0.0354**	**0.028**
Ortho-Phosphate	mg/L	**0.05**	**0.06**	**0.04**	**0.04**	**0.0208**	**0.0167**	**0.0102**	**0.0165**
PEHL Metals									
Aluminum	ug/L								
Arsenic	ug/L								
Barium	ug/L								
Cadmium	ug/L								
Calcium	ug/L								
Cobalt	ug/L								
Copper	ug/L								
Iron	ug/L								
Lead	ug/L								

Sample ID:		**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**	**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**
Magnesium	ug/L								
Manganese	ug/L								
Molybdenum	ug/L								
Nickel	ug/L								
Potassium	ug/L								
Silver	ug/L								
Sodium	ug/L								
Titanium	ug/L								
Vanadium	ug/L								
Zinc	ug/L								
Trace Metals (Sanudo)									
Cadmium	ug/L	0.04344	0.04156	0.04145	0.04559	0.07486	0.0488	0.04899	0.04543
Cobalt	ug/L	0.02861	0.02876	0.03625	0.03611	0.03028	0.03868	0.03573	0.02985
Copper	ug/L	0.54	0.54	0.57	0.63	0.53	0.63	0.48	0.45
Iron	ug/L	10.17	10.43	9.65	14.49	54.01	43.35	25.71	15.9
Lead	ug/L	0.0337	0.02502	0.03997	0.04039	0.35359	0.10712	0.07908	0.03643
Nickel	ug/L	0.29	0.25	0.31	0.28	0.66	0.58	0.38	0.28
Silver	ug/L	0.00113	0.00132	0.00177	0.00193	0.00274	0.00273	0.00179	0.00156
Vanadium	ug/L	1.23	1.11	1.33	1.3	1.02	0.96	0.94	0.81
Zinc	ug/L	0.063	0.6	0.53	0.63	2.11	1.14	0.93	0.51
VOCs									
Carbon disulfide	ug/L	< 0.5	< 0.5	**1**	**1**	< 0.5	< 0.5	< 0.5	< 0.5
Methyl sulfide	ug/L	< 0.5	< 0.5	**0.8**	**0.6**	**1.3**	**1.1**	< 0.5	< 0.5
Toluene	ug/L	< 0.5	< 0.5	< 0.5	**1**	< 0.5	< 0.5	**1.6**	< 0.5
Total Xylene	ug/L	< 0.5	< 0.5	< 0.5	**1**	< 0.5	< 0.5	**0.9**	< 0.5
SVOCs									
Triclosan	ug/L	< 0.2	**0.5**	**0.4**	**0.6**	< 0.2	< 0.2	< 0.2	< 0.2
1,2,4-Trimethylbenzene	ug/L	< 0.5	< 0.5	< 0.2	< 0.5	< 0.5	< 0.5	**0.6**	< 0.5
Number of PEHL ANALYTES		225	225	225	225	245	245	245	245

Sample ID:		**MC-1**	**MC-2**	**MC-3**	**GC-1**	**GC-2**	**GC-3**	**detection limits (trace metals)**
Sample Location:		**Head of ditch**	**Mid ditch**	**Mouth of ditch**	**Mid ditch**	**Mouth of ditch**	**Head of ditch**	
Sample Date:		**01/03/05**	**01/03/05**	**01/03/05**	**01/03/05**	**01/03/05**	**01/03/05**	
Analyte	**Units**							
Field Parameters								
Conductivity	umho	**23300**	**23900**	**36200**	**40500**	**39500**	**38200**	
pH	N/A	**6.3**	**6.9**	**7.4**	**7.7**	**7**	**6.7**	
Sanitary Indicators								
Fecal Coliform	MPN/100 ml	< 20	< 20	< 20	< 20	< 20	**40**	
Total Coliform	MPN/100 ml	**20**	< 20	**20**	< 20	**20**	**40**	
Nutrients								
Ammonia	mg/L	**0.01**	< 0.005	**0.01**	**0.0095**	**0.05**	< 0.005	
Dissolved Nitrogen	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	**0.09**	
Total Nitrogen	mg/L	**0.07**	< 0.05	< 0.05	< 0.05	< 0.05	**0.07**	
Nitrate & Nitrite	mg/L	**0.008**	**0.007**	**0.007**	**0.00687**	**0.0136**	**0.018**	
Dissolved Phosphorous	mg/L	< 0.025	**0.04**	**0.11**	< 0.025	**0.0472**	**0.14**	
Total Phosphorous	mg/L	**0.03**	< 0.025	**0.133**	**0.0429**	**0.046**	**0.166**	
Ortho-Phosphate	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	**0.0207**	**0.02**	
PEHL Metals								
Aluminum	ug/L	**75.9**	**19.7**	**17**	**11.5**	**6.07**	**9.86**	
Arsenic	ug/L	< 10	< 10	**16.40**	< 10	< 10	< 10	
Barium	ug/L	**36.7**	**11.9**	**9.51**	**8.11**	**14.8**	**31.9**	
Cadmium	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Calcium	ug/L	**141000**	**144000**	**238000**	**262000**	**305000**	**280000**	
Cobalt	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Copper	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Iron	ug/L	**210**	<100	<100	<100	**108**	**280**	
Lead	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Magnesium	ug/L	**454000**	**460000**	**833000**	**933000**	**917000**	**857000**	

Sample ID:		**MC-1**	**MC-2**	**MC-3**	**GC-1**	**GC-2**	**GC-3**	**detection limits (trace metals)**
Manganese	ug/L	**34**	**99**	**22**	**12.4**	**110**	**333**	
Molybdenum	ug/L	< 5	< 5	**9.41**	**10.1**	**6.72**	< 5	
Nickel	ug/L	**8.84**	**9.5**	**16**	**17.7**	**17.6**	**16**	
Potassium	ug/L	**243000**	**249000**	**417000**	**461000**	**540000**	**493000**	
Silver	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Sodium	ug/L	**4170000**	**4250000**	**6780000**	**7670000**	**7530000**	**7030000**	
Titanium	ug/L	**28.1**	**27.3**	**41.7**	**46.4**	**44.1**	**41.6**	
Vanadium	ug/L	< 5	< 5	< 5	< 5	< 5	< 5	
Zinc	ug/L	< 50	< 50	< 50	< 50	< 50	< 50	
Trace Metals (Sanudo)								
Cadmium	ug/L	0.02161	0.05271	0.09052	107.45	0.06949	0.08376	0.0009
Cobalt	ug/L	0.04954	0.03795	0.06101	0.11193	0.06389	0.04191	0.00012
Copper	ug/L	0.33	0.76	0.86	0.47	0.47	0.69	0.064
Iron	ug/L	256.32	71.68	33.8	318.74	113.8	3.81	0.045
Lead	ug/L	0.15383	0.05369	0.16678	0.06718	0.04576	0.01585	0.00166
Nickel	ug/L	0.32	0.39	1.14	0.48	0.52	0.64	0.012
Silver	ug/L	0.00131	0.00191	0.00248	0.00156	0.00123	0.00097	0.00033
Vanadium	ug/L	0.77	0.32	0.83	1.05	0.87	0.68	0.028
Zinc	ug/L	3.07	2.64	4.14	3.6	1.93	1.36	0.026
VOCs								
Carbon disulfide	ug/L	**1**	< 0.5	< 0.5	< 0.5	**0.5**	**0.6**	
Methyl sulfide	ug/L	**0.6**	< 0.5	**2.0**	**0.6**	**1**	**1.0**	
Toluene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	
Total Xylene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	
SVOCs								
Triclosan	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
1,2,4-Trimethylbenzene	ug/L	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	
Number of PEHL ANALYTES		273	273	273	273	273	273	

Table 6-13. Sample Detections, Run-off experiment, Flanders wet weather samples

Sample ID:		**MC-1**	**MC-2**	**MC-3**	**GC-1**	**GC-2**	**GC-3**	**detection limits (trace metals)**
Sample Location:		**Head of ditch**	**Mid ditch**	**Mouth of ditch**	**Mid ditch**	**Mouth of ditch**	**Head of ditch**	
Sample Date:		**08/30/05**	**08/30/05**	**08/30/05**	**08/30/05**	**08/30/05**	**08/30/05**	
Analyte	**Units**							
Field Parameters								
Conductivity	umho	**31900**	**23300**	**29400**	**17600**	**38500**	**40400**	
pH	N/A	**6.5**	**6.9**	**7.2**	**7.1**	**7.5**	**7.7**	
Sanitary Indicators								
Fecal Coliform	MPN/100 ml	<200	**70**	**230**	**300**	**40**	**20**	
Total Coliform	MPN/100 ml	**14000**	**9000**	**5000**	**1400**	**110**	**230**	
Nutrients								
Ammonia	mg/L	**0.0341**	**0.0457**	**0.0603**	**0.2736**	**0.0781**	**0.019**	
Dissolved Nitrogen	mg/L	**0.7**	**0.96**	**0.5**	**0.82**	**0.35**	**0.24**	
Total Nitrogen	mg/L	**1.9**	**0.98**	**0.58**	**1.2**	**0.36**	**0.36**	
Nitrate & Nitrite	mg/L	**0.00966**	**0.0115**	**0.0141**	**0.0112**	**0.0149**	**0.0128**	
Dissolved Phosphorous	mg/L	**0.0265**	**0.121**	**0.0963**	**0.207**	**0.0604**	**0.0579**	
Total Phosphorous	mg/L	**0.168**	**0.114**	**0.128**	**0.316**	**0.0807**	**0.102**	
Ortho-Phosphate	mg/L	<0.005	**0.0704**	**0.1035**	**0.2073**	**0.1107**	**0.0868**	
PEHL Metals								
Aluminum	ug/L	**82.5**	**32.1**	**31**	**36.9**	**9.07**	**14.8**	
Arsenic	ug/L	<10	**11**	<10	<10	<10	<10	
Barium	ug/L	**29.8**	**42.1**	**50.6**	**88.4**	**21.7**	**16.9**	
Calcium	ug/L	**193000**	**139000**	**185000**	**75300**	**254000**	**266000**	
Chromium	ug/L	**5.31**	**4.53**	**3.95**	**3.62**	**4.06**	**3.8**	
Cobalt	ug/L	**1.54**	**1.18**	**1.34**	<1	**1.74**	**1.79**	
Copper	ug/L	**5.46**	**9.45**	**12**	**8.21**	**17.5**	**19.9**	
Iron	ug/L	**0.89**	**0.71**	**0.28**	**0.3**	<0.1	<0.1	
Lead	ug/L	<1	<1	<1	**1.57**	<1	<1	

Sample ID:		**MC-1**	**MC-2**	**MC-3**	**GC-1**	**GC-2**	**GC-3**	**detection limits (trace metals)**
Magnesium	ug/L	**634000**	**457000**	**611000**	**350000**	**833000**	**869000**	
Manganese	ug/L	**188**	**660**	**253**	**270**	**135**	**112**	
Molybdenum	ug/L	**4.02**	**5.08**	**5.64**	**4.24**	**7.48**	**7.67**	
Nickel	ug/L	**8.24**	**6.7**	**8.9**	**5.29**	**12.4**	**13.5**	
Potassium	ug/L	**292000**	**218000**	**284000**	**179000**	**396000**	**413000**	
Sodium	ug/L	**5470000**	**3950000**	**5250000**	**3110000**	**7200000**	**7310000**	
Titanium	ug/L	**21.4**	**16.3**	**19.8**	**14**	**23.1**	**24.3**	
Uranium	ug/L	**1.17**	<1	**1.97**	<1	**2.82**	**2.96**	
Vanadium	ug/L	<1	<1	<1	**1.18**	<1	<1	
Zinc	ug/L	<50	<50	**55.5**	**54.5**	<50	<50	
Trace Metals (H2M)								
Cadmium	ug/L	<0.26	<0.26	<0.26	<0.26	<0.26	<0.26	0.26
Cobalt	ug/L	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	1.3
Copper	ug/L	<1.3	<1.3	**2.4**	<1.3	**3.9**	<1.3	1.3
Iron	ug/L	**1440**	**1080**	**419**	**325**	**57.9**	**12.5**	4.3
Lead	ug/L	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	1.3
Nickel	ug/L	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	0.012
Silver	ug/L	**2.8**	**2.4**	**2.3**	**1.6**	**3.4**	**3.4**	0.6
Vanadium	ug/L	<1.3	<1.3	**1.4**	**2.3**	<1.3	<1.3	1.3
Zinc	ug/L	**5.8**	<4.0	**4.4**	<4.0	<4.0	<4.0	4.0
VOCs								
Ethylbenzene	ug/L	<2.5	<2.5	<0.5	<2.5	**0.8**	<0.5	
Methyl sulfide	ug/L	**44**	**2.5**	**33**	<2.5	**3.6**	**7.9**	
Number of PEHL ANALYTES		273	273	273	270	270	270	

6.6.5. Discussion

Field Data

Field data showed Gilgo was saltier than Flanders, which corresponds to their relative settings in the estuary. Gilgo is close by the Fire Island Inlet, while Flanders is near the head of the Peconic system. For the Flanders wet weather sampling, the Goose sample at the head of the ditch was notably fresher, which indicates that run-off input may have occurred.

Sanitary Indicators

Coliform (total and fecal) were elevated under wet weather conditions at Gilgo compared to dry weather conditions. The results were not indicative that the ditches were transporting these bacteria into the estuary, however. Coliform results under dry conditions at Flanders did not appear to follow any clear pattern. Coliform under wet weather were also elevated at Flanders. Fecal coliform were highest at the head of the ditch at Goose, but total coliform were highest in the Hubbard samples.

Nutrients

Under wet weather conditions, nitrogen compounds were elevated at the ditched system at Gilgo and Flanders. Phosphorous compounds tended to be higher at the unditched site at Gilgo under wet conditions. With the exception of ammonia (which was much higher at the ditched site), the situation seemed to be reversed for nitrogen compounds. At Flanders, the highest levels of nutrients were found at Goose at the head of the ditch. They did not appear to have been transmitted down the ditch to the estuary, however. During dry weather, nutrients at Goose were higher overall than Hubbard. For Goose, concentrations in the estuary were higher than in the ditches, although some minor trend towards increasing concentrations down ditch may be discernable. Most of the nutrients were not detectable in the ditch at Hubbard.

PEHL Metals

At Flanders, where the metals were sampled for, concentrations of the major ions (sodium, magnesium, potassium, calcium) generally tracked salinity (as is to be expected). Some of the other results appear to correlate with salinity as well, especially for the wet weather data where there was a sharp distinction between the head of the ditch sample at Goose and other samples. Metals that appeared to follow salinity levels included cobalt, copper, molybdenum, nickel, titanium, and uranium. Metals that were elevated at the head of the ditch at Goose were barium, lead, and vanadium, but none of these three metals were found at the mid-ditch or estuary stations under wet weather conditions. Under dry weather conditions, most of the metals do not show any trends, with the possible exception of manganese and iron. These redox-active metals, which tend to be enriched in anoxic sediments such as those found in marshes, are generally higher in the ditches than the estuary, suggesting the ditches may be conveying them to the estuary.

Trace Metals

H2M was unable to duplicate the analytical work of the Sanudo laboratory, and so the trace metal discussion is restricted to the three samples where the Sanudo laboratory reported results. There are few indications of any trends in the detections reported by H2M, except that silver appears to track salinity and vanadium may be enriched at the head of the ditch at Goose (although it was also detected in the estuary off Hubbard).

At Gilgo, it is notable that the dry weather concentrations for copper and vanadium were greater than wet weather samples in general (comparing the unditched estuarine samples), and that many of the ditched system metals sampling results were much greater for the dry weather samples as compared to wet weather samples. This suggests that precipitation does not wash contaminants from the marsh or marsh uplands into the estuary.

To simplify the metals analysis, the results were normalized to the “more pristine” estuarine samples (the Hubbard estuarine sample, or the Gilgo unditched sample) (Tables 6-14 to 6-16). They show that nearly all of the results for the wet weather event at Gilgo were within the method variability (as defined by correspondence to a standard seawater sample). There are even some suggestions that the ditched area concentrations are lower than the unditched estuarine sample results. Under dry weather conditions at Gilgo, it appears that metals are enriched in the ditches as compared to the unditched area concentrations, which results in slightly elevated concentrations in the estuary offshore from the ditched area. However, the opposite was determined for Flanders, where most metals had lower concentrations at Hubbard in the ditches compared to the estuary (although some metals were slightly enriched in ditches at Goose as compared to the estuary at Goose).

Table 6-14. Gilgo Wet Weather Sampling Trace Metals Results, Relative to the Unditched Marsh

Wet	**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**	Variability
Cadmium	95%	91%	91%	100%	0%
Cobalt	79%	80%	100%	100%	4%
Copper	86%	86%	90%	100%	5%
Iron	70%	72%	67%	100%	9%
Lead	83%	62%	99%	100%	9%
Nickel	104%	89%	111%	100%	9%
Silver	59%	68%	92%	100%	
Vanadium	95%	85%	102%	100%	
Zinc	10%	95%	84%	100%	19%

Table 6-15. Gilgo Dry Weather Sampling Trace Metals Results Relative to the Unditched Marsh

Dry	**GSP-1**	**GSP-2**	**GSP-3**	**GSP-4**	Variability
Cadmium	165%	107%	108%	100%	0%
Cobalt	101%	130%	120%	100%	4%
Copper	118%	140%	107%	100%	5%
Iron	340%	273%	162%	100%	9%
Lead	971%	294%	217%	100%	9%
Nickel	236%	207%	136%	100%	9%
Silver	176%	175%	115%	100%	
Vanadium	126%	119%	116%	100%	
Zinc	414%	224%	182%	100%	19%

Table 6-16. Flanders Dry Weather Sampling Trace metals Relative to Hubbard Marsh Offshore

Dry	**1a**	**2a**	**3a**	**4a**	**5a**	**6a**	Variability
Cadmium	24%	58%	100%	119%	77%	93%	0%
Cobalt	81%	62%	100%	183%	105%	69%	4%

Copper	38%	88%	100%	55%	55%	80%	5%
Iron	758%	212%	100%	943%	337%	11%	9%
Lead	92%	32%	100%	40%	27%	10%	9%
Nickel	28%	34%	100%	42%	46%	56%	9%
Silver	53%	77%	100%	63%	50%	39%	
Vanadium	93%	39%	100%	127%	105%	82%	
Zinc	74%	64%	100%	87%	47%	33%	19%

Organics

The detections of organic compounds showed no patterns.

6.6.6. Summary

Most of the data do not support the determination of any differences between water quality in the ditches and in the estuary, under wet conditions or dry. Wet weather samples at Goose did appear to have some elevated constituents at the head of the ditch, where a fresh water input may be described. The most sensitive analysis, for trace metals using clean metals techniques, found that some of the data did indicate higher concentrations within the ditches compared to concentrations in the estuary. However, there did not appear to be any indications that the ditches transmit contaminants to the estuary, as the data did not conform to any of the overall patterns described in the introduction (which were intended to describe clear evidence that ditches transmit contaminants to the estuary or serve as a source of contaminants of concern to the estuary).

6.7. Keystone Marsh Invertebrate Species and Larvicides Survey

The following is based on information presented in Cashin Associates (2005d.)

6.7.1. Introduction

Invertebrates are often used as a measure of overall habitat function and health. Melampus snails (family Melampodidae) serve as food for waterfowl. Amphipods (Order Amphipoda) are common inhabitants of tidal marsh vegetation. Fiddler crabs (*Uca spp*.) are not found in all Long Island salt marshes, but may be a keystone species where present (they are one of the most conspicuous inhabitants of the intertidal zone). Studies have suggested that the use of vector control larvicides can reduce the number and diversity of invertebrates.

CA therefore sampled five pairs of marshes for the presence of these invertebrates. This study was funded by the County Legislature.

Paired marshes were in close physical proximity, morphologically similar, and sampled on the same date, within two hours of the low tide. The intent of the pairing was that one marsh in each pair is treated with larvicides, while the other is not. Due to communication errors, it turned out that only three of the sampled marshes have been treated, and the other seven were not. Although this reduces the power of the sampling, it also allows for greater comparison of between marsh differences.

The marsh pairs were:

- Pair 1: Smith Point North-Hospital Point (South Shore)

Smith Point North has received larvicide treatments, and Hospital Point did not over the 2001 – 2004 period.

- Pair 2: Smith Point Park-William Floyd Estate (South Shore)

Smith Point County Park has received only a few larvicide treatments, and the William Floyd Estate was not treated at all over the 2001 – 2004 period.

- Pair 3: Sunken Meadow-Crab Meadow (North Shore)

Sunken Meadow has received treatments, and Crab Meadow did not over the 2001 – 2004 period.

- Pair 4: Hubbard Creek-Mill Creek (Peconic)

There was miscommunication that led the site selector to understand Mill Creek received larvicide treatments. Neither marsh has been treated over the 2001 – 2004 period.

- Pair 5: Mashomack-Little Northwest Creek (Peconic)

There was miscommunication that implied Mashomack and Little Northwest Creek had received some larvicide applications; it was anticipated that the amount of treatment for each would differ. A records search showed neither marsh has been treated over the 2001 – 2004 period.

All 10 marshes were grid ditched, presumably in the 1930s. The presence of ditches has been noted, by some, to impact invertebrate populations.

The locations of the marshes are shown in Figure 6-10. The treatment history of the three larvicided marshes is summarized in Table 6-17.

Table 6-17. Number of Larvicide Applications

	Smith Point North	Smith Point Park	Sunken Meadow
2001			
Bti	4	3	5
Methoprene	11	0	12
Duplex	3	0	4
2002			
Bti	3	0	3
Methoprene	4	0	9
Duplex	4	0	4
2003			
Bti	3	1	4
Methoprene	7	0	12
Duplex	2	0	2
2004			
Bti	1	0	1
Methoprene	7	0	5
Duplex	5	0	3
Total, 2001-2004	54	4	64

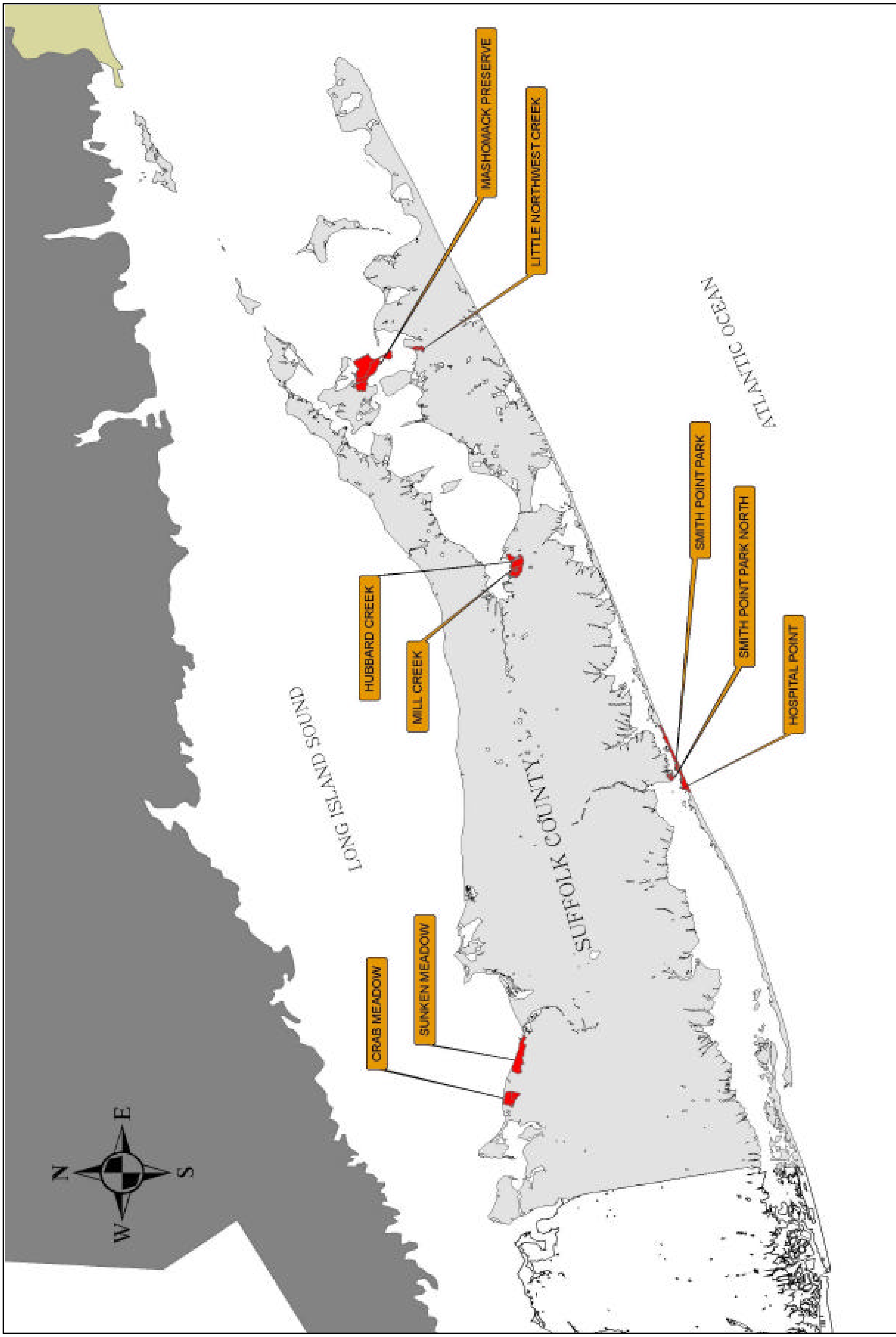

FIGURE 6-10
DRAFT GENERIC ENVIRONMENTAL
IMPACT STATEMENT
NON-TARGET INVERTEBRATE SAMPLED MARSHES

6.7.2. Sampling Procedures

Four marsh surface samples were taken on each marsh. Sites were selected by vegetation type and elevation, beginning near a major ditch or tidal creek (low marsh, *Spartina alterniflora*) and moving inland to include a high marsh (*S. patens*) sample and a marsh transition sample (*Iva*, *Phragmites*). If pools or panes were present, a sample was taken from its vegetated edge. If not, the fourth sample was taken at a mid marsh elevation containing a variety of species of vegetation.

A circular metal frame 16 cm in diameter was used to define the sampling area. The frame was inserted into the marsh surface to a depth of approximately 5 cm. The soil and root mass within the frame was excavated using a sharp knife, and the sample was collected in a labeled plastic bag. Each marsh sample was processed in a sorting tray. The sample mass was carefully examined for the presence of Melampus and Amphipods.

If *Uca spp*. were present, their abundance was measured by counting the number of burrows within a 30 cm ring. Sampling for *Uca spp*. was done parallel to a major ditch or tidal creek edge, by dropping the ring at three meter intervals.

6.7.3. Data

The sampling results are summarized in Tables 6-18 to 6-20 below.

Table 6-18. South Shore

	Smith Point North	Hospital Point	Smith Point Park	William Floyd Estate
Fiddler Crabs	**None**	**None**	**None**	**None**
Amphipods				
Low	4	41	8	25
Mix	4			
Panne		49	10	6
High	3	8	14	9
Transition	2	25	14	11
Total	**13**	**123**	**46**	**51**
Melampus				
Low	0	0	1	3
Mix	4			
Panne		0	1	2
High	0	15	4	5
Transition	9	0	1	4
Total	**13**	**15**	**7**	**14**

Table 6-19. North Shore

	Sunken Meadow	Crab Meadow
Fiddler Crabs	**13**	**5**
Amphipods		
Low	8	9
Mix	17	
Panne		5
High	5	3
Transition	5	3
Total	**35**	**20**
Melampus		
Low	0	0
Mix	0	
Panne		0
High	0	0
Transition	0	0
Total	**0**	**0**

Table 6-20. Peconic Bay

	Mill Creek	Hubbard Creek	Mashomack	Little Northwest Creek
Fiddler Crabs	**8**	**6**	**11**	**None**
Amphipods				
Low	0	18	0	10
Mix		4		
Panne	3		1	10
High	4	4	2	5
Transition	5	0	7	2
Total	**12**	**26**	**10**	**27**
Melampus				
Low	26	12	0	0
Mix		1		
Panne	68		6	0
High	12	5	3	0
Transition	1	0	2	1
Total	**107**	**18**	**11**	**1**

6.7.4. Discussion

Amphipod abundance was clearly greatest at Hospital Point, and snail abundance was greatest at Mill Creek. There were more fiddler crabs at Sunken Meadow than any other marsh, although the difference between this site and the other four marshes were crabs were detected was much smaller than the differences between the maximum amphipod and snail abundance sites.

Amphipods were detected at all ten marshes. A pattern of greatest abundance in the low marsh-mix-panne areas, with lesser abundances in the high marsh and transition zones can be discerned for all marshes except Smith Point Park, Mill Creek, and Mashomack. Abundance was high at Smith Point Park, despite this lack of conformance. Three sites had lower abundances: Smith Point North, Mill Creek, and Mashomack. Therefore, one of the treated sites had an "unusual" pattern of amphipod detections, and one had lower abundances.

Snails were not detected at the North Shore marshes, and only one was found at Little Northwest Creek. Abundances were very high at Mill Creek, and very low at Little Northwest Creek; otherwise, abundances were somewhat similar at the other six marshes where the snails were found. There were few coherent patterns in terms of ecological settings for the detections. One of the treated sites had lower abundances of snails; no conclusion should be drawn regarding the absence of snails at Sunken Meadow, as they were not found at the paired site, either. The variation in snail abundance was greater for the Peconic sites, which suggests environmental factors are a greater control on their overall abundance than treatments with larvicides.

Fiddler crabs were not detected on the south shore, due to a general lack of favored habitat – open beach along a waterway. The treated site had more crab burrows than the untreated sites. The difference between the two north shore sites seemed to be approximately the same as the differences found among the three marshes in the Peconics where crabs were detected. This suggests that larvicide applications do not influence crab abundances.

A more complete report on this experiment is available (Cashin Associates, 2005d).

6.8. Spotted Turtle Research in Napeague Marsh

The observations reported on here were presented in Cashin Associates (2006c), unless otherwise referenced.

6.8.1. Introduction

Spotted turtles are diurnal, semi-aquatic, primarily freshwater reptiles, which are active during the spring (Stewart and Springer-Rushia, 1998), specifically, between the months of March and May (NYSDEC, 2003a). Haxton and Berrill (2001) report that spotted turtles are active for a relatively short period of time per year as compared to most other North American turtles.

Their shells range from 3.5 to 5 inches in length (NYSDEC, 2003a). The upper shell (carapace) is black with a series of small, round, yellow spots or "polka-dots." Hatchlings have one dot per scute; however, mature turtles may have a hundred or more spots in total. The lower shell (plastron) is yellow and black and the head, legs, and tail of spotted turtles exhibit small yellow and orange spots. The male's jaws are dark in color and their eyes are brown. The female's jaws and eyes are both yellow (Stewart and Springer-Rushia, 1998).

Spotted turtles are carnivores. Their diet consists primarily of insects, snails, worms, and slugs (NYSDEC, 2003a). They commonly bask in the sun during the day and will enter the water slowly when startled. During evenings and nights, they dive to the bottom of a pond and stay there until the next day. Preferred habitats include marshes, swamps, bogs, fens, muddy streams, wet meadows, sedge meadows, ponds, and ditches that contain freshwater (Stewart and Springer-Rushia, 1998; Harding, 2004). Spotted turtles like shallow water bodies with soft bottoms that are supportive of emergent and submergent vegetation (Harding, 2004). They are known to hibernate within the water beneath mud and debris (Western New York Herpetological Society, 2004). Streams that are inhabited by spotted turtles are characteristically muddy and slow-flowing (Harding, 2004).

Spotted turtles are sexually mature between eight and 10 years of age and have life spans that range between 25 and 50 years. Breeding occurs between March and May, when the turtles are active. In May, females seek nesting areas to oviposit (lay her eggs). Nesting areas are often established in meadows, fields, or along roadsides. When a suitable nesting area is found, the female will dig a hole in the ground that is about two inches deep. She then lays three to four eggs in the hole and buries them. The eggs hatch in about 11 weeks (NYSDEC, 2003a).

Millam and Melvin (2001) found that a spotted turtle's habitat is generally 3.5 hectares (8.6 acres) with a home range length of 313 m (1,027 feet). Spotted turtle movement generally includes travel to and from vernal pools, and movement between aestivation, over-wintering, and nesting sites. They found that 25 of 26 turtles spent between 20 and 150 cumulative days per year (with a mean of 80 days) basking, foraging, and mating in seasonal pools.

Spotted turtles were once very common. However, the NYSDEC has now classified the spotted turtle as a "species of concern" in New York (NYSDEC, 2003a; NYSDEC, 2003b). Its status as a species of concern was established largely as a result of ongoing widespread disturbance to its habitat, which has adversely affected overall numbers. NYSDEC has reported occurrences of spotted turtles on eastern and east-central Long Island (NYSDEC, 2003c).

Decreases in the number of spotted turtles on Long Island can be attributed to a variety of other causes, including being killed by predators or automobile traffic. They are also vulnerable to polluted water, particularly toxic chemicals, and are sometimes taken from the wild to be kept as pets (NYSDEC, 2003a).

However, loss of habitat is cited as the major cause of its population decline throughout New York. Habitat includes a wide variety of shallow wetlands including marshes, meadows, fens, bogs, ditches, swamps, small ponds and slow-moving streams (NYSDEC, 2003at). Pet collecting is also responsible for the loss of significant spotted turtles from the wild.

A mark-recapture study of spotted turtles at Napeague State Park initiated by John Behler of the Wildlife Conservation Society (Bronx Zoo) in 1996 indirectly suggested that spotted turtles may be hibernating in the mosquito-control ditches found in that area. Since groundwater is a fairly uniform 10 to 12°C temperature throughout the year, if there is significant groundwater seepage into the ditches during the winter months the ditches may meet many physical requirements of spotted turtle hibernacula. Over the years 1996 to 1999, Behler compiled information on 59 individual spotted turtles in an approximately 30-acre study area. Since that time, an additional 45 spotted turtles have been caught and marked in the study area, for a total of 104 marked individuals at the site. During the winter of 1999-2000, SCVC conducted ditch maintenance operations in a portion of the study area using mechanical equipment to deepen and widen several mosquito control ditches to improve drainage and tidal flow. In the 2000 trapping season, a significant number of the marked turtles were not found. Behler speculated that the missing turtles may have been overwintering in the ditches where they were vulnerable to damage from ditch maintenance equipment.

Most turtle species, including spotted turtles, have high egg and juvenile mortality, low adult mortality, and are very long-lived. Most literature cites maximum ages of wild spotted turtles in the 35 to 50 years range, but recent research indicates that spotted turtles may live over 100 years

(J. Litzgus, Laurentian University, personal communication, 2005). Either figure implies that adults need to be protected, since population replacement is infrequent.

CA therefore arranged to subcontract with Michael Bottini, an independent turtle researcher from East Hampton. The study was funded by the County Legislator. CA served as project manager. Jacqueline Litzgus, PhD, University of Georgia, served as an unpaid consultant to the project.

This study focused on telemetry to provide information on how and when the turtles use the mosquito-control ditches. This information could prove valuable in refining ditch maintenance practices to ensure turtle protection. It might also be useful for designing spotted turtle surveys of other ditched marshes in Suffolk County, or provide preliminary information as regards the uniqueness of the Napeague marsh situation.

6.8.2. Study Goals

The following were the goals of the project:

- Describe the winter hibernacula of spotted turtles at Napeague State Park.
- Determine spotted turtle use of mosquito control ditches at Napeague State Park in spring, especially as congregation and mating sites.
- Determine if spotted turtles can be found in other ditched wetlands in Suffolk County outside of Napeague marsh.
- Determine spotted turtle use of mosquito control ditches at Napeague State Park in summer, as estivating sites.
- Describe environmental conditions (water levels, salinity, water temperature) that may impact turtle use of ditches.

6.8.3. Methods

The main research technique was to try to capture and fix radio transmitters onto 14 spotted turtles (seven males and seven females) at the Napeague site during the fall of 2004. This number was considered to be robust enough to allow for some equipment failure and loss, and still account for over 10 percent of the marked population at the study site. Radio transmitter units and a receiver were fabricated by L. L. Electronics of Mahomet, IL. Weights of transmitter units (including material used to attach them to turtles) varied from seven to 11 grams. Transmitters were selected so as to not exceed 10 percent of an animal's body weight. A Pesola scale (300 gram capacity, calibrated every 2 grams) was used for recording weights. Transmitter units were attached to the carapace and held in place using wraps of electrical tape over the unit and around the carapace and plastron (crossing at the bridge so as not to impede movement of legs). The flexible antennae trailed behind.

Turtles were captured using rectangular wire box traps having a 12-inch width and height, a length of 24 inches, and a 3.5 inch-square funnel entrance at one end. Several trap modifications were made:

- back doors were replaced with removable entrance funnels to enable turtles to enter from either end of the trap
- wire mesh wings were positioned between trap entrances and the sides of ditches to catch turtles who were moving through but not necessarily interested in the bait and feeding
- one-way gates were placed over entrances to prevent captured turtles from escaping when water levels fluctuated.

A total of fifteen traps were set and baited with canned fish on October 16, 2004.

Turtles fitted with transmitters were located twice a week or eight times per month during the fall until they settled into their hibernacula. During the winter months, turtle locations were determined a minimum of once every 10 days or three times per month to ensure that transmitters were working properly and to determine if turtles moved during this period. During the spring mating period (determined to be mid-March through April in 2005), they were located 22 times (an average of every other day). Spring turtle work also involved using traps to capture additional individuals for study; the data presented only uses telemetry relocations, however. Summer work (July 5 to September 2) involved a total of 17 turtles, with efforts to locate the turtles conducted at least weekly (turtles were relocated twice weekly on average).

Data collected in addition to turtle location included:

- plants in the immediate vicinity;
- water temperature; and
- distance moved since last location.

A majority of the radio-telemetry locations involved sighting or palpating the turtle positions in the water. This enabled additional useful information to be collected regarding the position and orientation of turtles in the ditches.

Three other ditched wetlands in Suffolk County outside of Napeague were surveyed for spotted turtles, using knowledge of their habits gained through the winter and spring. The additional survey sites were:

- a Nature Conservancy preserve adjacent to Accabonac Harbor in East Hampton (April 25 to 29)
- Northwest County Park adjacent to Northwest Creek in East Hampton (April 14 to 19)
- Smithers County Park in Flanders (May 1 to 5).

Interruption and baited traps were set in ditches at each site and checked daily for up to five days. These sites and Napeague Harbor are shown in Figure 6-11.

Six environmental characteristics monitoring stations were established in Napeague marsh to record changes in water levels (as measured from the top of a stake set in the ditches), salinities (using a refractometer), and water temperatures (by thermometer) over four tide cycles that included a spring tide, during summer. Water temperatures and air temperatures, when appropriate, were also recorded when turtles were located.

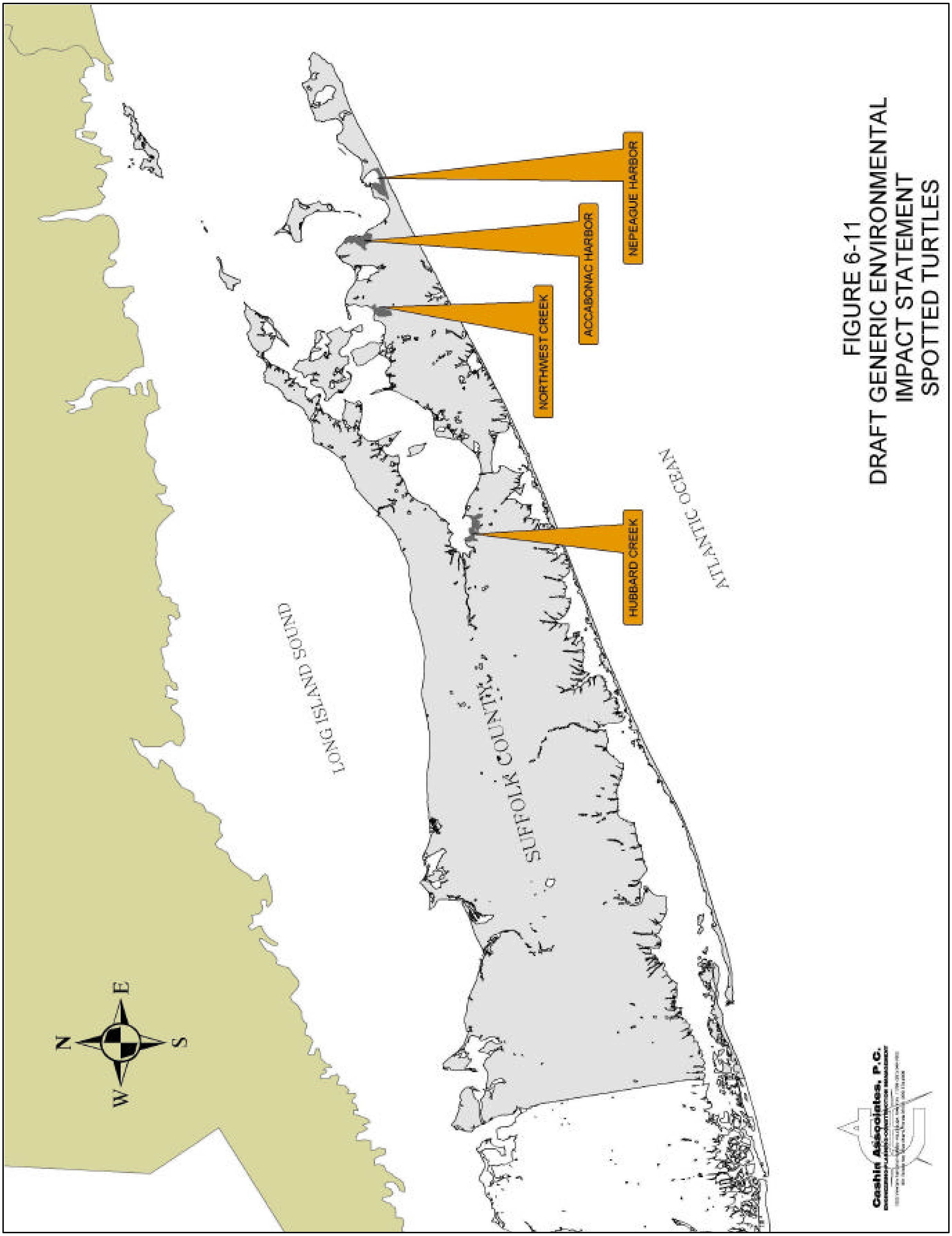
FIGURE 6-11
DRAFT GENERIC ENVIRONMENTAL
IMPACT STATEMENT
SPOTTED TURTLES
NEPEAGUE HARBOR
ACCABONAC HARBOR
NORTHWEST CREEK
HUBBARD CREEK
ATLANTIC OCEAN
LONG ISLAND SOUND
SUFFOLK COUNTY
N
S
E
W
Cashin Associates, P.C.

6.8.4. Results

Winter Hibernacula of Spotted Turtles at Napeague State Park

By the end of November, 2004, seven spotted turtles (three females and four males) had been captured and fitted with radio transmitters. Another was captured in December. Thirty eight telemetry relocations revealed strong preference among the turtles for ditches: thirty seven were found in mosquito control ditches and one on land moving through a thicket of Groundsel bush three meters from the nearest ditch (two days later this turtle was back in the ditch). 1180 meters of movement were noted during the month, for an average movement between relocations of 30 meters. These movements were not in one direction only, but generally back and forth within the linear ditches.

The meteorological station in Bridgehampton reported unusually mild weather through November, with temperatures averaging 3 to 5°F above normal. Water temperatures in the ditches were between 6°C and 8°C (43°F - 48°F). The mild fall weather continued into mid-December. In December, average daily temperatures dropped below freezing on eight days before significantly rewarming again at the end of the month. By the third week in December, skim ice had formed on most of the ditches in the study area. Water temperatures in the ditches during that time varied from 0°C near the surface to 4°C within 15 centimeters of the surface.

Most of the turtles continued to move in December, although not as much as the previous month. fifty relocations were recorded during the month. All relocations were in ditches. Two turtles settled into a debris-filled ditch; their movements for the month averaged five meters each, most of which was limited to changing position from one side of the ditch to the other. The other six turtles accounted for movements totalling 984 meters, for an average movement of 27 meters per relocation (very similar to the average for November).

Detailed notes were taken of each turtle's position on December 29, 2004. The exact location in the ditch was determined for seven of the turtles by feeling for them by hand in the water. One female could not be seen or felt to determine its exact position in the debris-filled ditch it had occupied since November 18, 2004. All other turtles were found hugging the bank of the ditch no deeper than 20 cm below the water surface. Two turtles were found aligned against the nearly vertical bank sides with heads and part of their shells out of the water. Most were beneath roots and mat-like masses of sedge, grass and rush leaves overhanging the sides of the ditch. Two were in debris-filled ditches (catbriar twigs, pine needles, and other leaf and twig debris). None were in burrows of any sort.

Telemetry relocations between January 7 and March 5, 2005 totaled 58. Visual sightings or palpatings for the turtles' exact position in the marsh occurred on 37 occasions (64 percent). All ditches containing radio-tagged turtles had a layer of surface ice January 27, 2005. Movements noted on that survey date were the least compared to all other survey dates. Total movements for the January 7 to March 5, 2005 period were significantly lower than the previous two months, totaling 460 meters -- eight meters per relocation. 52 of the 58 locations were in mosquito control ditches. Of the non-ditch locations, three were in burrows leading off ditches (two within one meter of the ditch edge, the other an unknown distance), and three were in the marsh under a thick mat of sedges and Canada rush in 10 cm of water adjacent to a ditch (within two meters of the ditch).

All turtles showed some movement during these two months, although the two turtles that chose to overwinter in a section of ditch characterized as being filled with leaf and twig debris showed no significant change in position over these months. Movements of these two females were less than one meter and often from one side of the ditch to the other. This ditch seems to have the least amount of groundwater movement and was covered with ice more than the other locations. These turtles were always found within 25 cm of the water surface, and usually within 10 to 15 cm. No turtles were found burrowed deep in the bottom sediments of any ditches.

The male turtle that chose a ditch with the warmest recorded water temperatures during this period (7°C) moved 43 meters over these months and was always found in a different location. This ditch did not have ice at any point during February's field surveys, and only had ice on one visit in January (when all the ditches had ice, January 27).

The study area had patches of ice and snow until mid-March. There was little movement noted on the March 5 and 14 field visits (the greatest change in position was four meters and nine of 14 relocations recorded on these dates had movements of one meter or less). That changed on March 18, when four turtles moved over 10 meters, and one moved 67 meters. Subsequent locations recorded for the month revealed increased movement activity. The largest changes in position recorded for the month were on March 31 when seven of eight turtles moved over 35 meters, and one moved 103 meters.

Habitat use during the period November 1, 2004 to March 5, 2005 is summarized in Table 6-21. Ditches were the preferred habitat in the study area during the late fall and winter months, with over 90 percent of spotted turtle locations during this time being in ditches. Among the various types of ditches, spotted turtles showed a preference for those characterized as supporting fresh water emergent vegetation (cattails and *Phragmites*).

Table 6-21. Winter Napeague Habitat Use

Habitat	**11/04 – 12/04**	**1/03-3/5/05**
Cattail/*Phragmites* ditch	71%	48%
Debris-filled ditch	22%	28%
Other ditch	6%	14%
Burrow linked to ditch	0%	5%
Non-ditch	1%	5%

Spotted Turtle Use of Mosquito Control Ditches at Napeague State Park in Spring

Winter conditions (ice-covered ditches, snow, sub-freezing temperatures) persisted until mid-March. The spring study commenced on March 14 when significant movements were noted; this corresponded with ditch water temperatures registering 10°C. Turtles fitted with radio transmitters were located in the field with telemetry equipment and wire box traps on 23 days between March14 and April 30 for a total of 174 mapped locations. It was possible to make a visual sighting or palpate the turtle's exact position in the marsh on 151 occasions (87 percent of locations). Notes were taken on each turtle's location, the adjacent vegetation, physical environment, and the distance moved since the last known position.

Total movements recorded for the March 14 to April 30 period amounted to over 7,000 meters, with the greatest single change in location recorded being 294 meters (a male between April 6 and 8). 10 of the 13 turtles tracked during this time period recorded at least one position change greater than 100 meters between relocations.

For the April turtle identifications involving telemetry equipment (excluding trap results, in other words), 30 percent resulted in finding another of the opposite sex in contact with the individual carrying a transmitter. The notch codes of these pairs were noted. This pairing behavior, which is thought to be associated with mating, continued through the month.

Of the 174 mapped locations during the mid-March through April period, 159 were in mosquito control ditches and 16 were not in ditches. Of the 16 instances where turtles were not found in a ditch, seven were basking (five of these were basking on the edge of the ditch and two were basking within 2.5 meters of a ditch), six were found in flooded sections of marsh adjacent to ditches, and one turtle traveled overland between ditches.

Ditches containing emergent vegetation (cattail and *Phragmites*) remained the most common habitat type used from mid-March through April. The ditch filled with leaf and twig debris that was used extensively by two radio-tagged turtles over the winter months continued to be used until March 30. However, as of July 1, it had not been used since the end of Marsh.

An interesting aspect of the spring radio telemetry and trapping study is the turtles' use of ditches as travel corridors to move throughout the study area. Ditches were used to reach other ditch habitat although the ditch routes are longer and less direct than travel overland. Turtles also preferred ditch routes to flooded marshes, although the flooded marshes appear to contain the same kind of habitat values as the ditches.

On June 2, a tagged turtle was reported to have been run over by an automobile, 485 meters northeast of its last known location. The turtle was treated by a veterinarian, released again June 3, but died on June 4. It was thought to be 11 years old.

Table 6-22. Spring Napeague Habitat Use

Habitat	**3/18 – 5/27**
Cattail/*Phragmites* ditch	66%
Debris-filled ditch	3%
Other ditch	23%
Basking <0.5 m from ditch	3%
Non-ditch	5%

Spotted Turtle Use of Mosquito Control Ditches at Napeague State Park in Summer

Turtles were also tracked from July 5 and September 2, 2005. July and August 2005 were noted to have been extremely warm (12 days of 90ºF or more) and dry (2.01 inches of rain compared to the Bridgehampton mean of 6.59 inches). 17 individual turtles were followed, and a total of 154 relocations were mapped.

Turtle use of the mosquito ditches decreased somewhat. The turtles expressed an interest in leaving the ditches to burrow benath surrounding marsh thatch (accumulated dead vegetation on the surface of the marsh. They also left ditches with emergent vegetation and were found in "open" waters that were characterized as having a thick, brownish-green material floating on them to provide cover for the turtles.

Table 6-23. Summer Napeague Habitat Use

Habitat	**3/18 – 5/27**
Cattail/*Phragmites* ditch	37%
"Open water" ditch	23%
Other ditch	1%
Burrow linked to ditch	<1%
Basking <0.5 m from ditch	1%
Non-ditch	37%

Water temperatures in the summer were between 22 and 28 degrees C; salinity varied from 0 ppt to 23 ppt. It is not known if turtles were in the ditches when salinities were highest. It seems likely that turtles tolerated salinities as high as 13 ppt. Water level variation was controlled by the tides, by the amplitude of overall water levels was controlled by groundwater levels, so that the highest water levels were associated with higher groundwater stands. Fresher waters had more constant water temperatures.

Presence of Spotted Turtles in Other Ditched Wetlands in Suffolk County

Northwest Creek County Park

The Northwest Creek County Park site is located between Swamp Road and the tidal waters of Northwest Creek. The study area is a closed canopy pitch pine (*Pinus rigida*) and white pine (*Pinus strobus*) forest with a sparse understory shrub layer. To the west, separating the creek and the forest is a large stand of *Phragmites* and a large expanse of salt marsh. To the east, the ditches run through a culvert under Swamp Road and into a mixed pine-deciduous swamp. The ditches in the fresh water swamp that were trapped had firm bottoms, significant currents (flowing westward toward the creek), and no emergent vegetation.

45 spotted turtle captures were recorded and a total of 20 individual spotted turtles were documented at this site over five trapping days. The 20 turtles consisted of 15 males and five females. Turtles were weighed, measured (carapace and plastron lengths) and marked with marginal notches.

Accabonac Harbor

The Accabonac site is a mixed hardwood swamp owned by The Nature Conservancy. It extends north from the intersection of Old Stone Highway, Neck Path, and Accabonac Road. A large stand of *Phragmites* separates the fresh water swamp from a large expanse of salt marsh called the Great Meadow that borders Accabonac Harbor. The fresh water swamp has a canopy dominated by red maple (*Acer rubrum*) and tupelo (*Nyssa sylvatica*) and a dense shrub understory of sweet pepperbush (*Clethra alnifolia*). Several marsh areas dominated by tussock sedge (*Carex stricta*) are found where there is no closed canopy. Despite what appeared to be excellent habitat and a report of spotted turtles at this site, no spotted turtles were seen or trapped here.

Smithers County Park

This site was inspected with Norm Soule (Director, Cold Spring Harbor Fish Hatchery, Cold Spring Harbor, NY) in April and traps were set in early May. Soule has been doing telemetry and trapping work with Eastern mud turtles (*Kinosternon subrubrum subrubrum*) at this site for several years, and has kept note of spotted turtles trapped in the area as well. Traps were set in ditches that ran through three distinct habitats: tussock sedge and *Phragmites* marsh, red maple swamp, and a sedge (*Scirpus spp.*) and sphagnum moss (*Sphagnum spp.*) fen. Although spotted turtles have been documented in a small, shallow pond within 100 meters of the closest trap, none were observed or captured in traps set in the mosquito control ditches during this study.

6.8.5. Discussion

It is clear that spotted turtles will use mosquito ditches as habitat. They use ditches located in high marsh, but that use may be restricted to times when salinities are lower (although they can tolerate brackish and low salinity water). They prefer ditches with emergent vegetation located along the upland fringe of the marsh. Turtles clearly have fidelity to the ditches for travel corridors, preferring longer routes using ditches to shorter overland trips. This may have implications for mechanized ditch cleaning activities in upland fringes. It is unclear whether mosquito ditches have become essential spotted turtle habitat, and so if this kind of waterway needs to be maintained to preserve optimal habitat for the species where it occurs in Suffolk County (and if so, how such maintenance can be conducted without risk to the turtle population).

More information on this study is available (Cashin Associates, 2006c).

6.9. Catchbasins Mosquito Breeding Survey

The information presented here is based on CA-CE (2005a).

6.9.1. Introduction

Mosquitoes, especially *Culex pipiens* (the house mosquito), are known to breed in places where stagnant water collects. *Cx. Pipiens* are thought to be the primary vector for WNV. Therefore, elimination of such breeding habitats, or treatment of them when elimination is not possible, would reduce disease risks where their habitats were found. In order to eliminate or treat these habitats, however, they must be located.

SCVC has recognized, as have other mosquito control agencies around the nation, that stormwater devices can serve as breeding locations for *Culex spp*. This is because they are often designed to retain and detain stormwater to reduce potential pollutant impacts. Stormwater devices not designed to retain water are often not effectively maintained, and may unintentionally hold water long enough to allow breeding. Often these structures are not designed with mosquito propagation control in mind, and so even if properly maintained, may robustly produce mosquitoes. SCVC, therefore, treats catch basins in areas of the County with high groundwater tables, with the assumption that such devices may drain more slowly than those far above the water table. Altosid time-release briquets are most commonly used. Recharge basins also are treated in response to biting complaints. *Gambusia* may be stocked in basins that do not generally dry out; Altosid briquets are used in basins that are irregularly flooded.

CA determined it would be prudent to investigate the potential of catch basins outside of the areas usually treated by SCVC to breed mosquitoes, and to see if it might be possible to predict the kinds of areas more likely to support any such breeding. Sampling was undertaken in August and early September 2004, to survey such devices. The work was funded by the County Legislature. SCVC provided some technical assistance for this project.

6.9.2. Study Areas

Four residential areas were selected for evaluation. These sites were North Lindenhurst, East Northport, Smithtown, and Wading River.

A neighborhood in North Lindenhurst was selected because it is an older, dense development with small lots. An area in East Northport was chosen because there were known mosquito biting complaints, although no natural wetlands are present in the surrounding area. The East Northport-Greenlawn area has also been an area of concern for SCVC regarding potential WNV outbreaks. The Pines in Smithtown is an area of large residential lots with extensive landscaping. It is assumed that the well-maintained landscaping typical of the area requires use of sprinkler systems, adding runoff to the surrounding basins, thus creating the potential for additional mosquito breeding opportunities. A Wading River area was selected because it is a fairly new development, with large lots with extensive landscaping, and a recently installed stormwater control system.

Figure 6-12 shows the locations of the study areas.

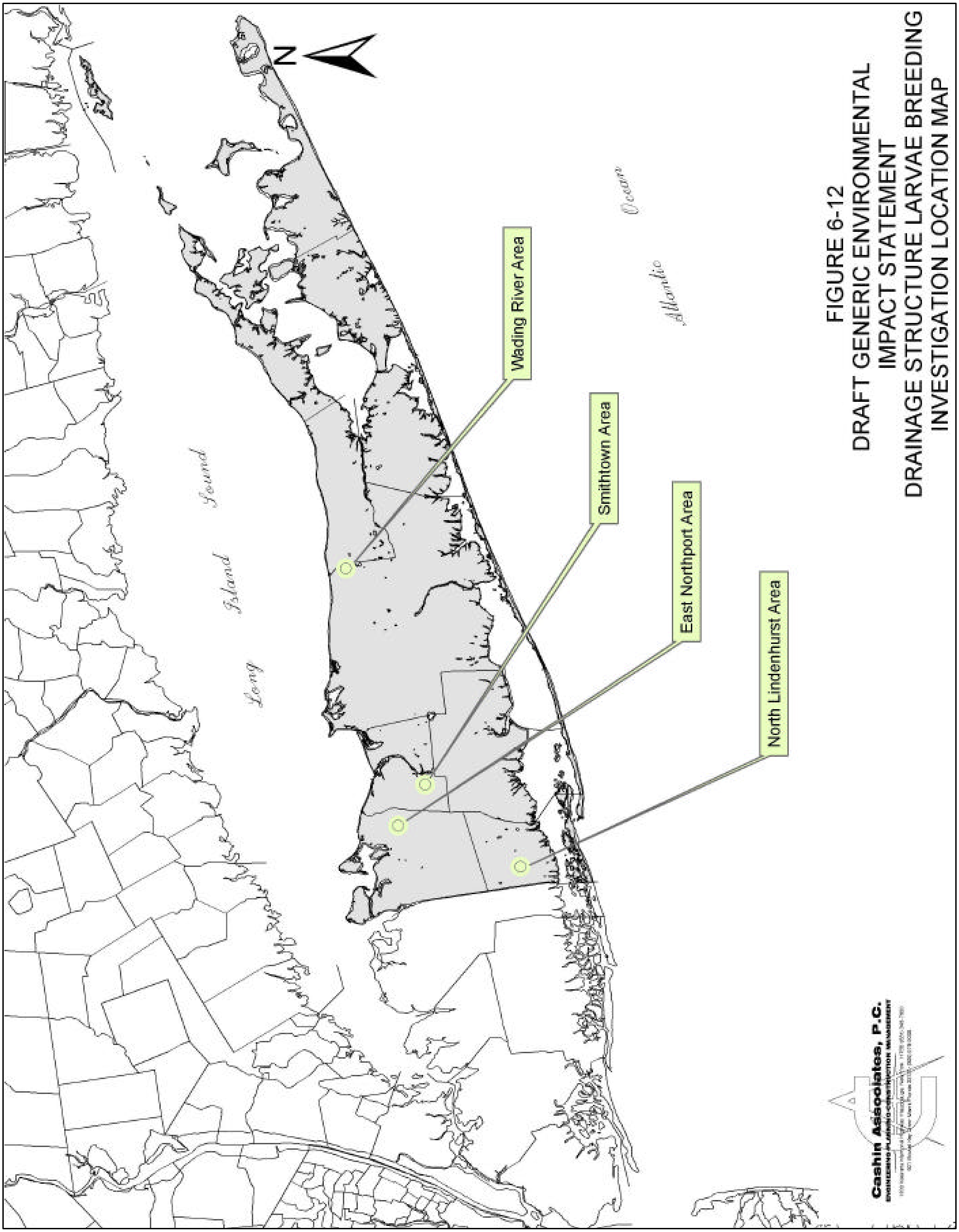

FIGURE 6-12
DRAFT GENERIC ENVIRONMENTAL IMPACT STATEMENT
DRAINAGE STRUCTURE LARVAE BREEDING INVESTIGATION LOCATION MAP

6.9.3. Methodology

Each site was inspected for the presence of catch basins and leaching basins. Samples were to be collected during a dry period (last rainfall more than five days previously) and approximately two to three days following a significant rainfall. At each station, the cover was removed and the type of structure was identified as either a "leaching basin" or "catch basin." Leaching basins are designed to drain through the bottom of the structure, and are common on Long Island due to the extremely pervious soils. Catch basins are designed to collect stormwater and eventually convey the water to another structure where it will drain into the subsurface (either a recharge basin or a leaching basin). The nearest house address was recorded to identify the sample location.

If the structure was holding water, a mosquito dipper was lowered into the basin gently, as to not cause any potential larvae to scatter. A full dipper was collected and analyzed for the presence of larvae. The basin was resampled if no larva was detected. If larvae were present, the sample was placed in a labeled sample jar (with adequate head space) and was stored on ice for preservation.

The depth of water in all sampled structures was measured and recorded subsequent to collecting the sample. All samples were delivered to SCVC for larval identification analysis.

6.9.4. Results

Thirty-three structures were sampled in East Northport and North Lindenhurst following a rain event. Samples were not collected at either site during dry weather due to end of the breeding season. Eight samples in East Northport contained larvae, ranging from one larva per sample to over 100 larvae per sample. *Cx. pipiens* were reported in all of the samples, and *Cx. restuans* were reported in two samples. Nine samples collected in North Lindenhurst contained *Cx. pipiens*, ranging from seven larvae to over 100 larvae per sample.

Sixteen structures were sampled in Smithtown during a dry period, and four were sampled following a rain event. The samples following the rain event were limited to four specific structures located in a low lying area that collects runoff from several adjacent roads. *Cx.*

pipiens were detected in three dry weather samples, ranging from one larva per sample to more than 30 larvae per sample. Four *Cx. pipiens* larvae were detected in the only structure that was holding water after the rain event.

Forty-one structures were sampled in Wading River during a dry period and following a rain event. The amount of structures sampled was higher due to the large number of dry structures encountered. No larvae were detected in any structure during either sampling period.

Leaching basins tended not to hold water; not surprisingly, they also, therefore, tended not to breed mosquitoes. However, in Smithtown, the only structures that had breeding under dry conditions were leaching basins that retained water.

Catch basins were more likely to retain water, and so were more likely to support breeding. This was not the case in Wading River, however, as the recent installation of the structures allowed them to drain well under both dry and wet conditions.

6.9.5. Conclusions

Some areas of the County where SCVC does not routinely monitor catch basins, and then treat those that may serve as breeding sites, have the potential to serve as breeding locations for potential disease vectors. For example, approximately one-quarter of the structures sampled in East Northport and North Lindenhurst were found to breed *Culex spp*. mosquitoes. Vector control for the house mosquito has long focused on the removal of potential breeding sites in the vicinity of residences, due to the short flight range of these pests. However, it seems that some kinds of stormwater control structures may serve as significant breeding loci for a mosquito that now has disease transmission importance.

This initial study was unable to determine whether the structures actually lead to more disease-bearing mosquitoes in a particular neighborhood; however, areas with older, less well-maintained catch basins may deserve greater monitoring by SCVC. In addition, as Phase II stormwater control improvements are made to decrease the pollutant potential of stormwater run-off, SCVC should be involved in the selection of technologies, as it is clear that these basins can support substantial numbers of mosquitoes under certain conditions.

6.10. Recharge Basin Breeding Survey

The results presented here are based on CA-CE (2005b).

6.10.1. Introduction

Recharge basins have a reputation as mosquito breeding areas. That reputation may not be deserved for all basins under all conditions. Basins that hold water for periods long enough for mosquitoes to successfully breed may not necessarily support them.

Therefore, Cameron Engineering, under subcontract to CA, conducted a survey of a selection of County recharge basins. SCVC provided technical assistance. The County Legislature funded the project.

6.10.2. Study Sites

SCVC complaint records were cross-referenced with recharge basin locations to identify basins that might support mosquito breeding. Six identified recharge basins were then sampled for mosquito larvae (see Figure 6-13 for the site locations). The basins were all owned by the Town of Huntington: Basins # 36, 88, 336, 338, 339, and 450.

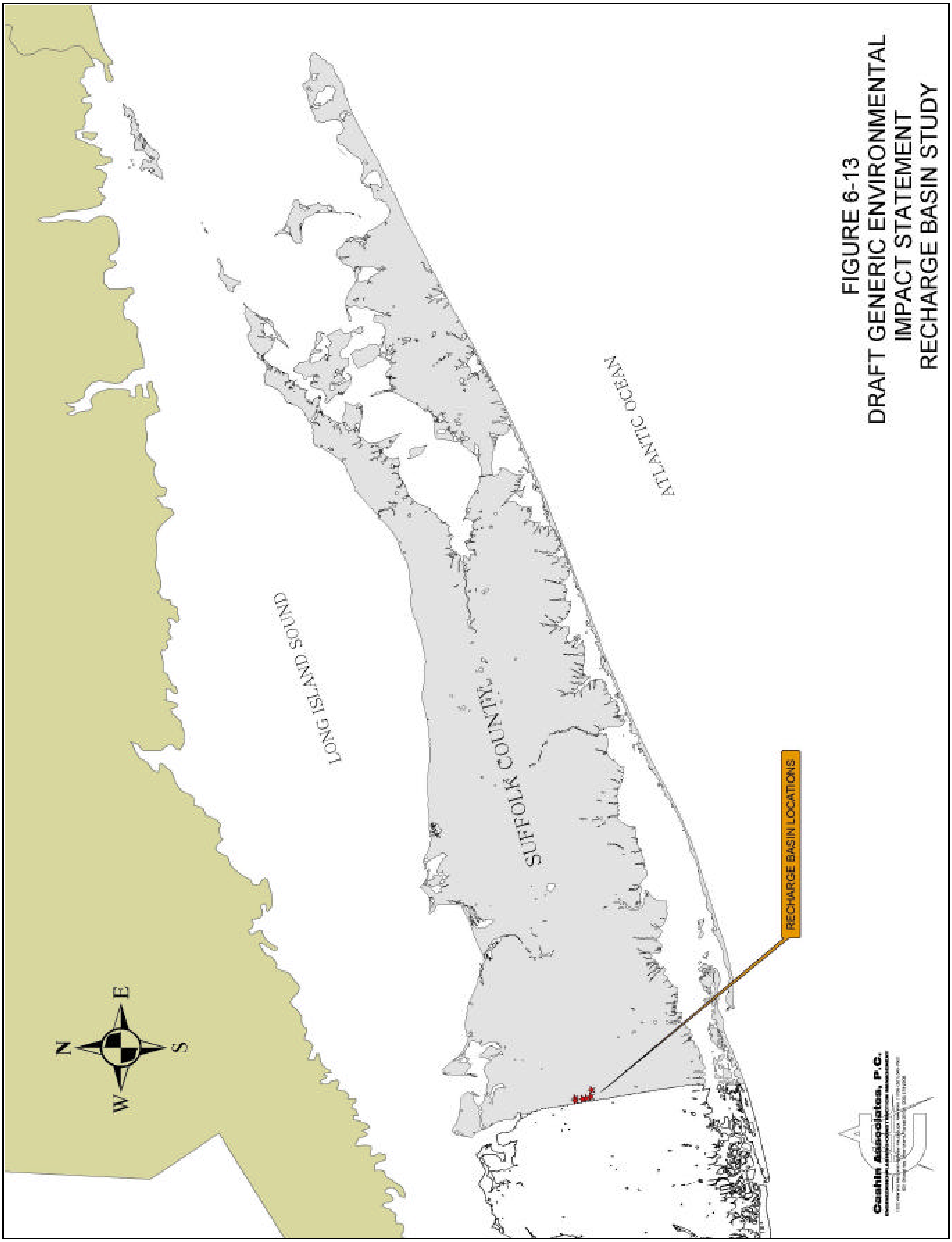
FIGURE 6-13
DRAFT GENERIC ENVIRONMENTAL
IMPACT STATEMENT
RECHARGE BASIN STUDY
ATLANTIC OCEAN
LONG ISLAND SOUND
SUFFOLK COUNTY
RECHARGE BASIN LOCATIONS
N
E
S
W
Cashin Associates, P.C.

6.10.3. Methods

Larvae samples were collected three times a week over a three week period in all basins. The larvae samples were collected with a standard larval dipper in the shallower areas where mosquitoes would most likely breed. Six dips were taken in each basin. Samples were placed into jars if larvae or pupae were present. The jars were transported at room temperature to the SCVC laboratory for species identification. Basin conditions were also recorded each sampling day.

6.10.4. Results

Basin Number 36

Basin 36 was covered with duckweed (*Lemna* sp.), which made observations of its depth or turbidity impossible. Amphibians, dragonflies, water striders, and swimmers were observed in the basin. Few or no larvae were observed in this basin except when the water level had dropped sufficiently to create shallower areas. On those two occasions *Culex pipiens* larvae were sampled.

Basin Number 88

Basin 88 holds a relatively large quantity of water. The water was clear, and very light brown with two to three inch visibility. Frogs, dragonflies, and fish were observed in the pond. The basin has steep, sandy sides with aquatic vegetation visible at the bottom. No shallow areas were present in the basin. No larvae were found, nor were adult mosquitoes observed.

Basin Number 336

The water level in Basin 336 changed substantially with rain events. At its shallowest, the basin separated into two pools of brown water with eight to twelve inch visibility. Dragonflies and fish were observed, but no amphibians. Mosquito larvae (*Cx. pipiens*) were present on the two sampling days when the water was shallowest.

Basin Number 338

Basin 338 contained clear, light brown water with two to three inch visibility. Amphibians, dragonflies, water striders, and other small aquatic organisms were observed. The basin has steep sides and vegetation that consisted of trees and shrubs, with no grasses. There were no shallow areas. No larvae were found, nor were adult mosquitoes observed.

Basin Number 339

Basin 339 contains brown water with two-inch visibility. Amphibians, dragonflies, water striders, and other aquatic organisms were observed in the basin. This basin has steep sides with no shallow areas. No larvae were found, nor were adult mosquitoes observed.

Basin Number 450

Basin 450 changed the most with precipitation. During dry weather, small puddles or no water was present. The basin did fill to the vegetation level (about six inches deep) after a rain event. No amphibians, water striders, or fish were observed in the basin. Dragonflies did appear when the basin had filled. *Cx. pipiens* and *Cx. restuans* larvae were found on seven of the nine sampling days. Many adult mosquitoes were observed.

6.10.5. Discussion

The recharge basins chosen differed in the amount of water they held over time and in the presence of mosquito larvae. Mosquito larvae were present in only three of the basins:

- basin 36 on two occasions. On both occasions, water levels in the basin were low and the area where samples were taken was shallow. Adult mosquitoes were never seen. Amphibians and dragonflies were observed in this basin.

- basin 336 on two occasions. On both days, basin water levels were such that shallow areas were present. This basin had dragonflies and fish in it. Adult mosquitoes were never found.

- basin 450 supported the most mosquito breeding. It filled and emptied with the weather. During dry weather no water was present or, at most, there were stagnant shallow puddles. At its wettest it held about six inches of water with many especially shallow areas. A number of larvae were present when water levels were low, and adult mosquitoes abounded. No amphibians, dragonflies, or fish were present in this basin.

Results demonstrate that mosquitoes will breed in shallow, stagnant areas, and will survive when there are few or no predators. Basins with steep sides and no shallow areas that retain water are unlikely to support mosquito breeding. Those that drain completely in a short time will support mosquito breeding only if shallow waters are present for a sufficient period of time. Basins that support fish, amphibians, and dragonflies, which are all mosquito larvae predators, are generally deeper with permanent water and do not support much mosquito breeding.

More information on this study can be found in CA-CE (2005b).

6.11. Non-standard Control Measures Efficacy Tests

These experimental results are excerpted from CA-CE (2005b).

6.11.1. Introduction

These demonstration projects were designed to evaluate the efficacy of two commercially available liquid repellants, and propane-powered traps to examine their effectiveness when used as a barrier. Mosquito Solution is a rosemary oil solution and Mosquito Barrier is a garlic oil solution. Mosquito populations in treated areas were compared to populations in untreated control areas for a three-week test period. Mosquitoes trapped in control and treatment areas were identified to species and counted. The repellants would be considered effective if test area traps contained, on average, fewer mosquitoes than control area traps. The traps have been demonstrated in academic studies to be effective tools for trapping mosquitoes in large quantities under certain circumstances. If the units were effective in intercepting mosquitoes that would have otherwise traveled from breeding areas to residential areas, they might reduce the need for aerial spraying.

Cameron Engineering, as a subcontractor to CA, undertook these tests in the summer of 2005. SCVC provided technical assistance. Mosquito Magnet and Rutgers University provided Mosquito Magnets for use. The County Legislature provided the necessary funding.

Mosquito Solution contains rosemary oil to repel mosquitoes and guar gum to smother larvae. Rosemary (*Rosmarinus officinalis*) is an herb that has been used for medicinal purposes throughout history and is commonly used as a food seasoning. Gardeners routinely plant rosemary alongside cabbage, beans and carrots to deter cabbage moths, bean beetles and carrot flies (GardenGuides, 2004). Rosemary oil is typically obtained from the stem and leaves, before bloom development (Botanical.com, 2005). The manufacturer lists the product ingredients in its concentrated product as found in Table 6-24.

Table 6-24. Rosemary Oil Solution Ingredients

Ingredient	**Concentration**
Active	2.82%
Rosemary Oil	1.62%
Table Salt	1.20%
Inert	97.18%
Vinegar	
Water	
Guar Gum	
Casein	

Once diluted with water, the product is applied to plants. After a 60-minute drying period, the solution reportedly repels mosquitoes for up to two weeks (Florida Sportsman, 2004). The manufacturer recommends it for low-lying water areas, ponds, rainwater collection areas and stagnant or standing water. Mosquito Solution ingredients are exempt from USEPA pesticide regulation.

SCVC applied the product according to the manufacturer's directions. The product was diluted 1:10 with water and loaded into a SCVC backpack mounted sprayer. As the manufacturer asserts that one gallon of the diluted product will cover 4,000 square feet, approximately 2.5 gallons were applied per 100 x 100 foot test area. The product was sprayed on lower tree limbs and all grasses and shrubs in the test areas. The product was reapplied after two weeks, per the manufacturer's directions.

Concentrated garlic oil has been reported to provide protection from biting mosquitoes for two to four weeks (Fiteni, 2002). Mosquito Barrier is a commercially available repellant that contains liquid garlic concentrate, which is diluted with water and mixed with canola oil or liquid soap.

The product is sprayed on outdoor plants. According to the manufacturer, plants absorb the oil through pores in their leaves, which open during early morning and evening hours for gas exchange. The oil travels throughout the plant, but does not alter the taste or smell of any part of the plant to humans. The solution reportedly repels mosquitoes for up to two weeks, but becomes odorless to humans within minutes (Extremely Green Gardening, 2005).

SCVC applied the product according to the manufacturer's directions. The product was diluted 1:100 with water and three tablespoons of canola oil added per gallon of diluted product to aid in product adherence to foliage. The diluted product was applied by SCVC from a backpack-mounted sprayer. As the manufacturer asserts that one gallon of the diluted product will cover five acres, less than one gallon was used to cover the three 100 x 100 foot test areas. The product was sprayed on lower tree limbs and all grasses and shrubs in the test areas. It was reapplied after two weeks, per the manufacturer's directions. The manufacturer lists the ingredients in the concentrated product in Table 6-25.

Table 6-25. Garlic Oil Solution Ingredients (all are active)

Ingredient	**Concentration**
Garlic Juice	99.3%
Citric Acid	0.5%
Potassium Sorbate	0.2%

Propane powered mosquito traps such as the Mosquito Magnet Liberty Plus (MMLP) and the Mosquito Magnet Pro (MMP) rely on the use of heat and carbon dioxide (CO_2) to attract mosquitoes. A small fan located in the center of the unit emits an exhaust of carbon dioxide and the attractant octenol, while a large fan at the top of the unit pulls air and mosquitoes into the trap. A thermoelectric generator uses the excess heat from the propane combustion process to generate electricity to run the trap's fan. Therefore, the device operates without the need for batteries or external power. Carbon dioxide is catalytically produced by converting propane to CO_2, water vapor, and heat. Mosquitoes, attracted to the CO_2, heat, and octenol attractant, fly into a tube where they are sucked into a collection bag.

Testing of these units has demonstrated their effectiveness in capturing mosquitoes (Smith, 2001; Kline, 2002). The capture rates and efficacy of several trap models were tested by Florida A&M University, in Panama City, Florida. Results revealed that American Biophysics Corporation's MMLP captured the greatest number of species and three times more mosquitoes than several other manufacturers' units tested, but did not significantly reduce mosquito populations in residential settings (Smith, 2003; Smith et al., 2004). The tests conducted here were designed to determine if multiple units could be effectively operated as a barrier.

The MMLP and MMP traps operated continuously according to the manufacturers recommendations. The MMLP is designed for one-acre sites and the MMP for one and a quarter acre sites. The American Biophysics Corporation provided four MMLP units for use in the project. Three MMP units were provided by the Rutgers University Department of Entomology.

6.11.2. Test Sites

Figure 6-14 shows the study site locations.

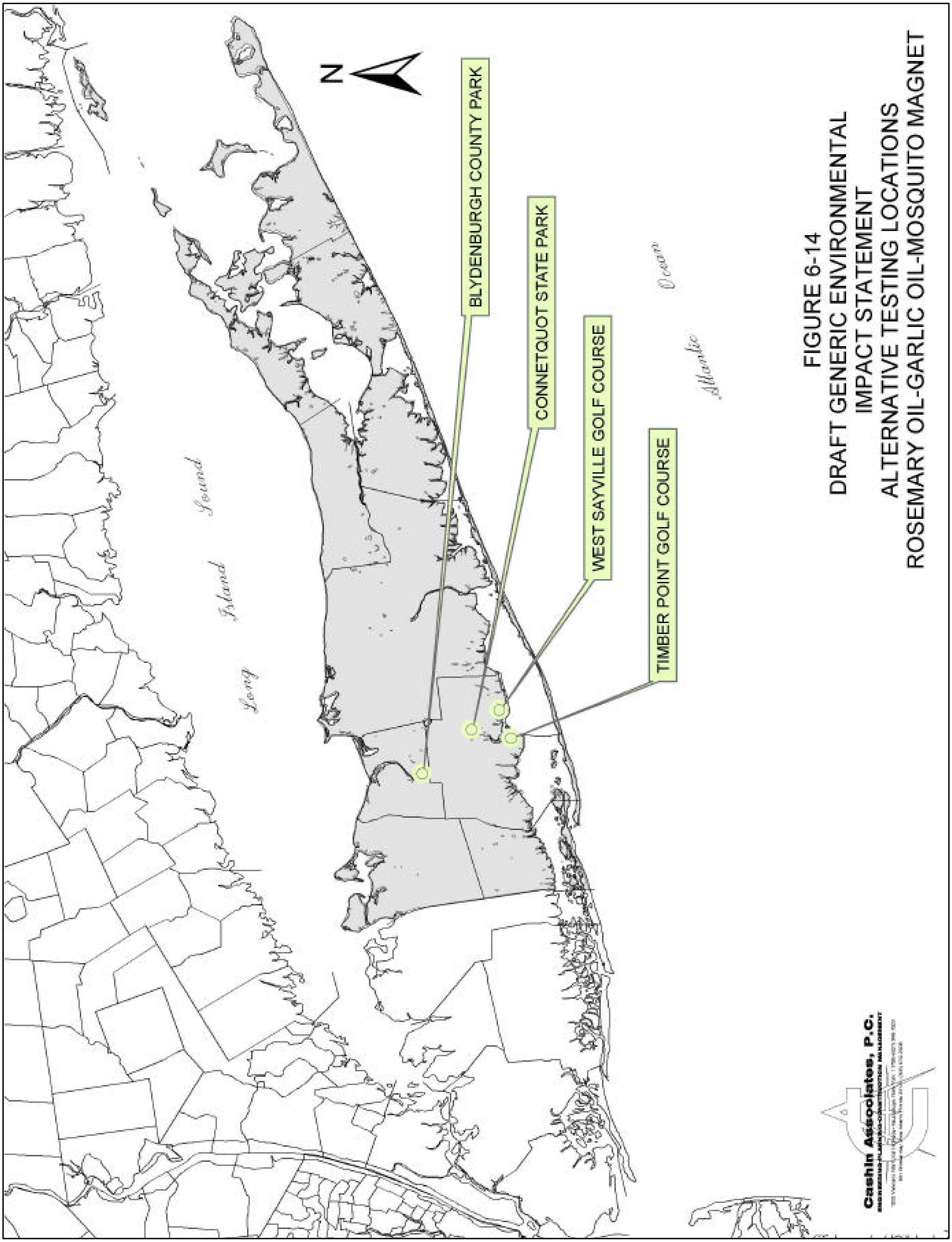
FIGURE 6-14
DRAFT GENERIC ENVIRONMENTAL
IMPACT STATEMENT
ALTERNATIVE TESTING LOCATIONS
ROSEMARY OIL-GARLIC OIL-MOSQUITO MAGNET
N
BLYDENBURGH COUNTY PARK
CONNETQUOT STATE PARK
WEST SAYVILLE GOLF COURSE
TIMBER POINT GOLF COURSE
Long Island Sound
Atlantic Ocean
Cashin Associates, P.C.

Timber Point Golf Course – Garlic Oil

The Timber Point Golf Course is owned by Suffolk County and is located on the south shore in West Sayville, adjacent to the Great South Bay. This site is surrounded on two sides by salt marsh and on another side by forest. The golf course is adjacent to salt marshes and regularly experiences problems with mosquitoes. To test the garlic oil repellant solution, three test and three control plots were located in one area on the course. The area is wooded, adjacent to a residential area and alongside the #4 fairway. Test and control sites were staked and measured 100 x 100 feet. All control sites were positioned upwind of the test sites. The six plots were aligned in a row with 50 feet of untreated space between each of the test and control sites. Six light traps were utilized to assess mosquito populations, one in each of the control and test areas. Plots 1 to 3 were upwind and untreated. Plots 4 to 6 were sprayed with garlic oil solution.

West Sayville Golf Course – Rosemary Oil

The West Sayville Golf Course is owned by Suffolk County and is located on the south shore in West Sayville, adjacent to the Great South Bay. There are ponds and a marsh within the golf course. The golf course tends to have standing water and regularly experiences problems with mosquitoes. To test the repellant solutions, three test and three control plots were located in different areas on the golf course. Test and control sites were staked and measured 100 x 100 feet. All the control spots were upwind of the test sites. The test sites were sprayed with the rosemary solution. Six light traps were utilized to assess mosquito populations, one in each of the control and test areas. The first area had a control area and a test area located on opposite sides of a mosquito ditch. The control area was located on fairway #1 and the test area was located on fairway #14. The second test area was located in between fairway #4 and fairway #13. The second and third control areas were located adjacent to each other with fifty feet between the two plots. They were located between fairway #11 and fairway #7. The last test area was parallel to the two controls, between fairway #7 and fairway #6. All test and control areas were in similar surroundings, located in the rough with some tree cover.

Blydenburgh County Park - Garlic Oil and Rosemary Oil

Blydenburgh County Park is located in Smithtown. The park contains the headwaters of the Nissequogue River in Stump Pond. The park has been closed several times in the past several years, including in 2005, due to the presence of WNV in mosquitoes.

Two areas in the park were selected to test the repellant solutions. One is a large open field surrounded by a forest with a considerable shrub understory. Three 100 x 100 foot test sites were located along the northern edge of the field and three control sites were located along the southern edge of the field. Each site was separated from the adjacent one by 50 feet. One half of each of the sites was in the forested area and one half in the field. This area was used for the garlic oil test.

The second Blydenburgh location was in the Historic Trust Area just north of Stump Pond. Grassed fields surrounded by forest with dense shrub cover characterize this area of the park. Three 100 x 100 foot test and three control areas were located in the grassed areas and separated by at least 50 feet. This area was used for the rosemary oil test.

Six light traps were utilized to assess mosquito populations, one in each of the control and test areas.

Connetquot State Park – Propane-Powered Traps

The propane-powered traps were deployed at Connetquot State Park in grassed fields surrounded by forest. Three MMP units were set up in a triangular arrangement 111, 118, and 126 feet apart from one another and chained to trees. A light trap was placed in the center. A control area of equal size and type was selected upwind of the test area and a light trap placed in its center. The control light trap was 250 feet upwind of the test light trap.

A second test area was established in a nearby, grassed field surrounded by forest. Four MMLP units were set up in a square with a light trap placed in the center of the square. The square was 150 feet on a side. Two of the MMLP units were chained to trees at the edge of the field and the other two were chained to trees in the field. A control area of equal size and type was selected upwind of the test area and a light trap placed in its center, 275 feet upwind of the test light trap.

6.11.3. Methods

Table 6-26 shows the sampling schedule for 2005.

Table 6-26. Project Schedule

Location	Product/Study	Test Traps	Control Traps	Start Date	Finish Date
Timber Point	Garlic Oil	3	3	6/13/2005	7/8/2005
West Sayville	Rosemary Oil	3	3	6/13/2005	7/8/2005
Blydenburgh	Garlic Oil	3	3	7/11/2005	7/29/2005
Blydenburgh	Rosemary Oil	3	3	7/11/2005	7/29/2005
Connetquot	Propane Powered Trap	3	3	8/1/2005	8/19/2005

CDC miniature light traps were used to recover adult mosquitoes to assess mosquito populations in the test and the control areas. The traps were baited with carbon dioxide supplied by dry ice. Traps were set to operate from dusk to dawn and were hung five to six feet off the ground from shepard's hooks (McNelly, 1989) in the center of each of the treatment and control areas.

For the repellents, traps were deployed Monday through Thursday evenings with newly charged batteries and new dry ice. Traps were collected within 14 hours of deployment as trap batteries and dry ice become depleted in that time. Mosquito samples from the traps were emptied into sample bottles labeled with the location, trap identification number, and sampling date. Sample bottles were transported in coolers with dry ice to the ABDL in Yaphank for identification and counts. Seven layers of newspaper separated the mosquito containers and dry ice, per ABDL procedures. This created a temperature in the coolers that sedated the mosquitoes, but did not kill them.

Traps associated with the Mosquito Magnets were emptied daily from Monday through Friday mornings and stored in a cooler with ice. The Mosquito Magnets and trap carbon dioxide delivery were checked along with Mosquito Magnet fan operation and trap function. Here also, weather conditions were recorded daily. Mosquito sample bottles were labeled with the location, trap identification number, and sampling date. Samples were stored in the cooler and transported the same day to the ABDL for species identification and counts.

6.11.4. Results

Garlic Oil

The Timber Point testing was done at the beginning of the summer, and fewer mosquitoes were present. An average of 23 mosquitoes was present in the control traps and an average of 27 mosquitoes was caught in the test traps. No species had substantially lower counts in the treatment area than in the control areas. Table 6-27 presents the results of the sampling.

Table 6-27. Garlic Oil Repellant Test Results from Timber Point Golf Course

TIMBER POINT	GARLIC OIL							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Oc. canadensis (CAN)	0.2	0	0	***0.1***	0.3	0.1	0	***0.1***
Oc. cantator (CTT)	10	6	16.9	***11.0***	8.1	4	11.4	***7.8***
Oc. japonicus (JAP)	0.5	0.2	0.2	***0.3***	0.5	0.1	0.4	***0.3***
Oc. sollicitans (SOL)	3.3	0.1	15.1	***6.2***	3.2	0.2	12.6	***5.3***
Oc. taeniorhynchus (TAE)	0.3	0	3.2	***1.2***	1.7	0.2	4.4	***2.1***
Oc. triseriatus (TRI)	0	0	0.2	***0.1***	0	0.2	0.1	***0.1***
Oc. trivittatus (TVT)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
Ae. vexans (VEX)	4.5	0.3	4	***2.9***	3.2	0.9	3.7	***2.6***
An. punctipennis (PUN)	0.2	0.4	0	***0.2***				
An. quadrimaculatus (QUA)	0	0	0.2	***0.1***	0	0	0.1	***0.0***
Coquillettidia perturbans (PER)	1.5	1	0.9	***1.1***	1.5	0.8	0	***0.8***
Cs. melanura (MEL)	0.2	0.1	1	***0.4***	0	0	0.3	***0.1***
Culex pipiens-restuans (PRE)	5.2	1.7	3.7	***3.5***	6.3	0.9	2.1	***3.1***
Or. alba (OAL)	0	0	0.2	***0.1***				
Total Mosquitoes:	25.9	9.8	45.7	***27.1***	24.8	7.4	35.2	***22.5***

Many mosquitoes were trapped in Blydenburgh County Park each night (Table 6-28). The average number of mosquitoes in the control traps was 158, whereas 72 mosquitoes were present in the test traps. Trap count reductions for certain species, especially for *Ochlerotatus/Aedes* species, exceeded 50 percent:

- *Ochlerotatus canadensis*
- *Ochlerotatus japonicus*
- *Ochlerotatus triseriatus*

- *Ochleorotatus trivattatus*
- *Anopheles quadrimaculatus*

Two other species had large reductions in trap counts in the treatment areas, although the reductions were less than 50 percent compared to control areas:

- *Aedes vexans*
- *Coquillettidia perturbans*

Other species did not have lower counts in the treatment areas, including *Cx. pipiens/Cx. restuans*.

Table 6-28. Garlic Oil Repellant Test Results from Blydenburgh County Park

BLYDENBURGH	**GARLIC**							
	Weeks							
	Test Traps				**Control Traps**			
Species	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***	**1st Avg**	**2nd Avg**	**3rd Avg**	***Tot. Avg***
Oc. canadensis (CAN)	1.3	2.2	1.2	***1.6***	6.5	6.3	7.1	***6.6***
Oc. cantator (CTT)	0.5	0.2	0.2	***0.3***	0.2	0.3	0.6	***0.4***
Oc. japonicus (JAP)	1.5	5	0.9	***2.5***	4.2	9.8	12.3	***8.8***
Oc. taeniorhynchus (TAE)	0	0.2	0	***0.1***				
Oc. triseriatus (TRI)	0.2	0.8	0.3	***0.4***	0.2	1.2	3.4	***1.6***
Oc. trivittatus (TVT)	2.5	0.7	0.3	***1.2***	4.7	1.8	1.3	***2.6***
Ae. vexans (VEX)	38	15	5.4	***19.5***	58.3	15.8	16.4	***30.2***
An. crucians (CRU)	0.2	0	0	***0.1***				
An. punctipennis (PUN)	1.2	1.2	1.9	***1.4***	0	2	2	***1.3***
An. quadrimaculatus (QUA)	8.7	12.5	22.8	***14.7***	44.8	28	127	***66.6***
Coquillettidia perturbans (PER)	32.3	17.2	7.8	***19.1***	49	25.3	12.9	***29.1***
Cs. melanura (MEL)	1.5	2.3	1.2	***1.7***	2	0.8	0.8	***1.2***
Culex pipiens-restuans (PRE)	6.8	12.7	9.9	***9.8***	10.7	6.7	9.7	***9.0***
Ps. ferox (PFR)	0	0.2	0		0.2	0.3	0.4	***0.3***
Total Mosquitoes:	**94.7**	**70.2**	**51.9**	***72.2***	**180.8**	**98.3**	**194**	***157.7***

The rosemary oil solution was tested on the West Sayville Golf Course (Table 6-29). The average number of mosquitoes in the control traps was 25, while the test traps had an average of 30 mosquitoes. For each of the three study weeks, the traps in the treated areas had more mosquitoes then those in the untreated areas, even after re-spraying. No species was preferentially reduced in numbers.

Table 6-29. Rosemary Oil Repellant Test Results from West Sayville Golf Course

WEST SAYVILLE	ROSEMARY OIL							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Ochlerotatus abserratus (ABS)					0	0.1	0	***0.0***
Oc. canadensis (CAN)	0.3	0.1	0	***0.1***				
Oc. cantator (CTT)	18.7	6.9	11.1	***12.2***	16	1.9	15.2	***11.0***
Oc. japonicus (JAP)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
Oc. sollicitans (SOL)	3	3	14.8	***6.9***	7.7	1.1	10	***6.3***
Oc. taeniorhynchus (TAE)	0	0.1	0.1	***0.1***	0.3	0	0.2	***0.2***
Oc. trivittatus (TVT)	0	0	0.1	***0.0***				
Aedes cinereus (CIN)	0	0.1	0	***0.0***	0	0.1	0	***0.0***
Ae. vexans (VEX)	7.7	0.8	4	***4.2***	3	0.3	4.7	***2.7***
An. punctipennis (PUN)					0	0.1	0	***0.0***
An. quadrimaculatus (QUA)	0	0	0.1	***0.0***	0	0	0.1	***0.0***
Coquillettidia perturbans (PER)	0	0.3	0.7	***0.3***	0	0	0.3	***0.1***
Cs. melanura (MEL)	0	1.2	0	***0.4***	0	0.6	0.1	***0.2***
Culex pipiens-restuans (PRE)	6.3	3.2	8.2	***5.9***	5.3	1.7	6.6	***4.5***
Total Mosquitoes:	36	15.7	39.2	***30.3***	32.3	5.9	37.3	***25.2***

The rosemary oil solution was tested in the historic section of Blydenburgh County Park (Table 6-30). The average number of mosquitoes in the control traps was 60, while the test traps had an average of 69 mosquitoes. For each of the three study weeks, the traps in the treated areas had more mosquitoes then those in the untreated areas, even after re-spraying. 10 percent trap count reductions were found only for *Ae. vexans* and *Cx. pipiens/Cx. restuans*.

Table 6-30. Rosemary Oil Repellant Test Results from Blydenburgh County Park

BLYDENBURGH	ROSEMARY							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Oc. canadensis (CAN)	2.7	0.5	0.5	***1.2***	1.3	0.5	1.3	***1.0***
Oc. cantator (CTT)	1	0.3	0.2	***0.5***	0	0	0.2	***0.1***
Oc. japonicus (JAP)	1.3	0	0.2	***0.5***	0.3	0.2	0.7	***0.4***
Oc. triseriatus (TRI)	0.7	0	0	***0.2***				
Oc. trivittatus (TVT)	2	0.83	1	***1.3***	1.7	0.8	1.7	***1.4***
Ae. vexans (VEX)	29.3	14.7	19	***21.0***	39.3	13.7	16.3	***23.1***
An. punctipennis (PUN)	2.3	1.5	1.7	***1.8***	0.3	1.7	0.5	***0.8***
An. quadrimaculatus (QUA)	3.3	22.3	14.8	***13.5***	0.7	5	15.5	***7.1***
Coquillettidia perturbans (PER)	25	8.5	5.3	***12.9***	16.7	7	6.2	***10.0***
Cs. melanura (MEL)	4.7	1.7	0	***2.1***	2	0.2	0.5	***0.9***
Culex pipiens-restuans (PRE)	17	9.7	13.7	***13.5***	17.3	13.2	14.9	***15.1***
Ps. ferox (PFR)	0.3	0	0	***0.1***				
Total Mosquitoes:	**89.6**	**60.0**	**56.4**	***68.7***	**79.6**	**42.3**	**58.3**	***60.1***

The propane-powered traps (Mosquito Magnets) were tested in Connetquot State Park (Table 6-31). The results for the two test sites were similar. In one site, the light trap within the mosquito magnet array collected an average of 150 mosquitoes, whereas the control trap collected 138 mosquitoes. In the other location, the light trap within the mosquito magnet array collected an average of 101 mosquitoes, whereas the control trap collected 83 mosquitoes. During the first and third weeks, many more mosquitoes were collected inside the mosquito magnet array than outside of it each week. For the second week, there was a slight reduction of on the order of 10 percent. *Cx. pipiens/Cx. restuans* were the only mosquitoes with overall lower trap counts in the treatment areas (approximately 230 percent less).

The mosquitoes trapped by the propane-powered traps themselves were collected and counted halfway thru the experiment and at the end of the experiment. The propane powered traps captured fewer mosquitoes. The light traps were set up at night, while the propane-powered traps ran all day, but one CDC trap caught more then six times the number of mosquitoes than were caught at the least effective propane-powered trap.

Table 6-31. Mosquito Magnet Test Results from Connetquot State Park

CONNETQUOT	MOSQUITO MAGNETS							
	Weeks							
	Test Traps				Control Traps			
Species	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*	1st Avg	2nd Avg	3rd Avg	*Tot. Avg*
Oc. cantator (CTT)	97.25	33.2	14.8	***48.4***	57.1	33.3	7	***32.5***
Oc. japonicus (JAP)	0	0.5	0	***0.2***	0.3	0	0	***0.1***
Oc. sollicitans (SOL)	21.2	2.5	0.3	***8.0***	18.6	4.5	0	***7.7***
Oc. taeniorhynchus (TAE)	0.5	0	0	***0.2***	0.4	0	0	***0.1***
Oc. trivittatus (TVT)	0.1	0	0	***0.0***				
Aedes cinereus (CIN)	0.1	0	0	***0.0***	0	0.2	0.3	***0.2***
Ae. vexans (VEX)	7.9	5.2	0.3	***4.5***	7.1	3.2	0.8	***3.7***
An. punctipennis (PUN)	33.5	30.8	40.3	***34.9***	29	30	31	***30.0***
An. quadrimaculatus (QUA)	1	0.2	4	***1.7***	0.5	0.7	3.5	***1.6***
Coquillettidia perturbans (PER)	1.9	0.8	0.5	***1.1***	2	0.7	0.3	***1.0***
Cs. melanura (MEL)	0.5	1.3	1	***0.9***	0.8	1.7	1.5	***1.3***
Culex pipiens-restuans (PRE)	54.3	14.8	8.5	***25.9***	65.1	24	7.8	***32.3***
Total Mosquitoes:	**218.3**	**89.3**	**69.7**	***125.8***	**180.9**	**98.3**	**52.2**	***110.5***

6.11.5. Discussion

The alternative controls did not prove to be as effective as progressive water management (up to 100 percent larval control, according to practitioners in the north-east US), larval control with

Bti, Bs, and methoprene (SCVC records indicate 90 percent or more population reductions), or adulticiding with modern pesticides (usual efficacy is between 90 and 95 percent). In fact, except for garlic oil in a fresh water habitat, none of the three alternatives (tested in a total of five scenarios) showed any effectiveness at all.

Garlic oil did reduce overall mosquito populations by approximately half in an upland setting. Some species in fact were controlled more completely than the overall rate. Yet, there was no evidence of control of *Cx. pipiens/Cx. restuans* in this setting. *Cx. pipiens* is arguably the most important mosquito vector to control in sites such as Blydenburgh Park, if theories regarding WNV transmission in uplands are correct in identifying it as the primary vector.

Therefore, it is difficult to support the use of these alternatives. Garlic oil did not show any barrier effects on salt marsh mosquitoes (it has been tried to control quality of life impacts for picnickers and campers at Smith Point County Park), and although there was a positive result in Blydenburgh Park, the reduction in mosquitoes was only 50 percent, and at least one key species was not deterred.

Although garlic oil may be of some use as a repellant in certain applications, with population counts in some settings reduced by 50 percent, greater efficiencies may be available to control mosquito populations. Source reduction, especially where breeding habitats are completely eliminated (such as stagnant water in household containers), remains the best method for controlling mosquitoes before they become a problem. Progressive water management provides up to 100 percent larval control, according to most practitioners in the northeast US. County records indicate that reductions of 90 percent or more in larval mosquito populations can be achieved with Bti, Bs, and methoprene. Immediate mosquito population densities can be reduced by 90 to 95 percent by adulticiding with modern pesticides. This, together with the apparent lack of control of key species in the appropriate habitats, means the County should not use garlic oil as a replacement for any of its existing or proposed control measures.

More information on these experiments can be found in CA-CE (2005b).

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