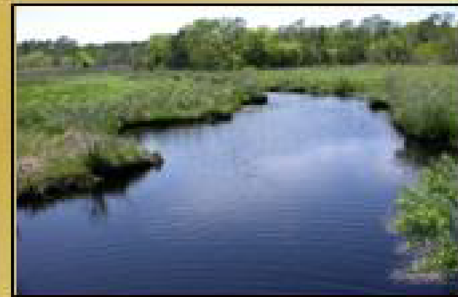
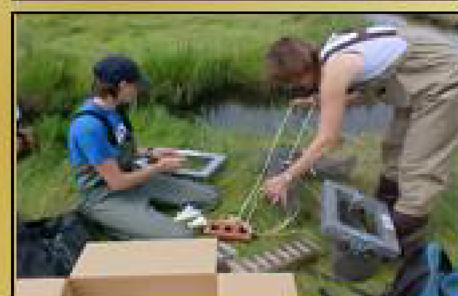
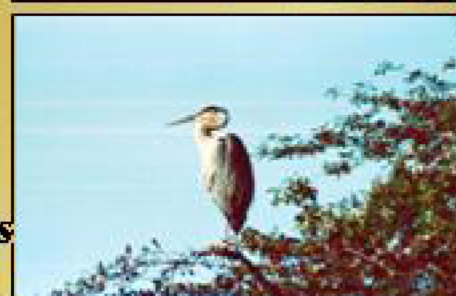
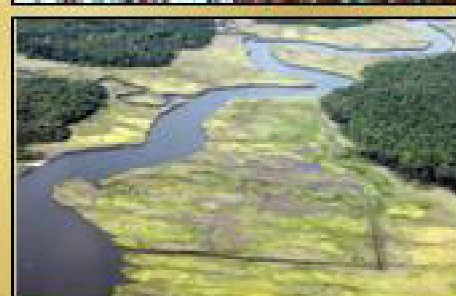
Suffolk County Vector Control & Wetlands Management Long Term Plan & Environmental Impact Statement









Draft Generic Environmental Impact Statement

Steve Levy, County Executive

Appendix C: BMP Manual

Prepared for:

Suffolk County Department of Environment and Energy
Suffolk County Department of Health Services
Suffolk County Department of Public Works
Suffolk County, New York

Prepared by:

CASHIN ASSOCIATES, P.C.
1200 Veterans Memorial Highway, Hauppauge, NY

May 3, 2006

SUFFOLK COUNTY VECTOR CONTROL AND WETLANDS MANAGEMENT LONG - TERM PLAN AND ENVIRONMENTAL IMPACT STATEMENT

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Suffolk County Executive

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Suffolk County Vector Control & Wetlands Management Long Term Plan & Environmental Impact Statement

Management Plan
Salt Marsh Management
Draft Best Management Practices Manual

Submitted to:

Suffolk County Department of Environment and Energy
Suffolk County Department of Health Services
Suffolk County Department of Public Works
Suffolk County, New York

Submitted by:

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Revised May 3, 2006

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TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

BMP	Best Management Practices
EEE	Eastern Equine Encephalitis
EPF	Environmental Protection Fund
EQBA	Environmental Quality Bond Act
GEIS	Generic Environmental Impact Statement
GIS	Geographic Information Systems
IMA	Interim Management/Ongoing Maintenance Action
IPM	Integrated Pest Management
LGP	Low-ground Pressure
MOU	Memorandum of Understanding
NGO	Non-Governmental Organization
NPS	National Park Service
NWR	National Wildlife Refuge
NYSDEC	New York State Department of Environmental Conservation
OMWM	Open Marsh Water Management
SCDEE	Suffolk County Department of Environment and Energy
SCDHS	Suffolk County Department of Health Services
SCVC	Suffolk County Department of Public Works Division of Vector Control
SEQRA	State Environmental Quality Review Act
USACOE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	Unites States Fish and Wildlife Services
WNV	West Nile virus

EXECUTIVE SUMMARY

Suffolk County Department of Public Works Division of Vector Control (SCVC) has the task of controlling mosquitoes so as to minimize impacts to human health and public welfare. One means recognized as being effective for mosquito control is to manage larval populations through water management. Water management can be conducted so as to minimize habitat for mosquito breeding and/or to maximize habitat values for predation on mosquito larvae.

Water management in wetlands implies affecting the hydrology of the wetlands. This could have environmental consequences for the marshes. Some traditional means of conducting water management in Suffolk County's wetlands, specifically, constructing ditches and then maintaining the ditch system, are thought to have had negative environmental impacts, although it is clear not all ditched marshes were similarly affected. In other jurisdictions, more progressive means of water management have been adopted. These progressive methodologies, which are sometimes grouped under the broad title of Open Marsh Water Management (OMWM), are intended to be effective means of mosquito control, and to also enhance other natural resource values where they are applied.

New York State regulations make almost all water management actions in fresh water environments impermissible. The focus of water management in Suffolk County will be on salt marshes. Therefore, most salt marsh systems need to be carefully considered prior to selecting a management technique to address mosquito breeding, since each salt marsh has unique attributes.

SCVC, as the County agency most involved in water management, has also become the responsible party for a variety of other water management structures, and for the maintenance and replacement of such structures, such as culverts, dikes and weirs. The maintenance and replacement of these structures can also affect mosquito breeding, and also the ecological conditions in the areas affected by the water flows associated with the structures. Therefore, work associated with culvert, dikes and weir maintenance and repair similarly should be carefully analyzed before it is conducted.

This Best Management Practices (BMP) Manual is intended to identify preferred means to conduct work in Suffolk County wetlands. The conditions that are suitable for the implementation of each BMP are identified as well as the benefits and impacts that could occur following the work. The kinds of equipment needed for the work, the regulatory status of the action, funding sources, and personnel requirements are all described. This enables SCVC to establish its marsh management program properly, in the context of any comprehensive County marsh management program, and then to make appropriate decisions regarding each mosquito breeding area it evaluates.

The BMPs are collected in four categories. Three categories relate to permanent actions and the fourth category relates to interim actions. The first category contains three BMPs that are described as having little to no impacts on the existing marsh conditions. The second category contains six BMPs that are described as having minimal impacts to the existing conditions, and the third category relating to permanent actions has six BMPs that may have major impacts on the existing condition of the marsh. The fourth category contains the four interim management actions. The BMPs are thus organized in a loose hierarchy.

The hierarchy of BMPs is not simply to be followed, or used as a process diagram that cannot be deviated from. Rather, it is a list of actions which, if applied under appropriate conditions to address specific problems, should have positive outcomes.

The BMPs are as follows:

Class I: Minimal Impacts:

- BMP 1. Natural Processes (no action/reversion)

  Reversion is to be the presumptive interim action for County wetlands, pending identification of a preferred active restoration plan for each wetland.

- BMP 2. Maintain/repair existing culverts, weirs, bridges

- BMP 3. Maintain/reconstruct existing upland/fresh water ditches

Class II: Minor Impacts:

- BMP 4. Selective maintenance/reconstruction of existing salt marsh ditches

Maintenance of ditches will only occur under well-defined conditions, subject to local concerns and input.

- BMP 5. Upgrade or install culverts, weirs, bridges
- BMP 6. Naturalize existing ditches
- BMP 7. Install shallow spur ditches
- BMP 8. Back-blading and/or sidecasting material into depressions
- BMP 9. Create small fish reservoirs in mosquito breeding areas

Class III: Major Impacts:

- BMP 10. Break internal berms
- BMP 11. Install tidal channels
- BMP 12. Plug existing ditches
- BMP 13. Construct large ponds
- BMP 14. Fill existing ditches
- BMP 15. Remove dredge spoils

In some instances, it will not be possible to immediately implement preferred long-term management programs at particular sites. In those cases, Interim Management Practices can be used until more permanent approaches are undertaken. The four Interim Management/Ongoing Maintenance Actions (IMAs) are:

- IMA 1. Natural Process (No action reversion)
- IMA 2. Selective ditch maintenance
- IMA 3. Culvert repair/maintenance when tidal restrictions are apparent
- IMA 4. Stop-gap ditch plug maintenance

Reversion is the presumptive interim action. All marshes undergoing reversion will be monitored to ensure that no catastrophic changes in vegetation patterns result from having no active management. The ditch maintenance activities identified here will also be limited in scope at any particular site. It is intended that the sum of interim and BMP ditch maintenance be less than the 50 acres of tidal wetlands a year.

1 INTRODUCTION

As an element of the Suffolk County Wetlands Management Plan, this Salt Marsh Best Management Plan (BMP) manual will serve as a guide for restoration and enhancement activities on salt marshes in Suffolk County, with a focus on mosquito management. The BMPs recommended in this manual are designed to modify larval habitats in the salt marsh so that they are no longer suitable for mosquito production, thereby controlling the insects in their immature mosquito stages, before they can emerge as adults. These techniques, known as "source control," reduce the need for widespread pesticide applications. Integrated Pest Management (IPM), the philosophy espoused in government directives and guidances regarding insect control, stresses that source control is preferred over pesticide use.

Salt marshes are highly productive ecosystems that perform many functions, including but not limited to:

- nutrient and organic matter production, alteration, and transport;
- nutrient and contaminant sequestration;
- buffering of wave energy;
- flood water storage; and
- sediment trapping.

Salt marshes and their near vicinities provide critical habitat for the larval and juvenile stages of many fish and invertebrate species, and are used for spawning by many species. In addition, salt marshes serve as important feeding and nesting grounds for many birds, especially migratory species, and also are habitat for other terrestrial vertebrates. Long Island salt marshes are described as a key element of the North Atlantic Flyway, the East Coast pathway followed by migratory birds, especially water fowl.

Salt marsh vegetation forms distinct zones in response to a combination of factors. In the northeast US, low marsh vegetation, which is inundated on every tide, is typically covered by one grass, *Spartina alterniflora*. The high marsh is that area that is irregularly flooded by tides, and typically supports *S. patens*. Other salt-tolerant plant species are found in the high marsh, and also grow from the high marsh zone up into the beginning of the uplands, which is where more typical terrestrial plants are found. Factors other than the frequency of tidal inundation that affect vegetation patterns include soil and groundwater salinity, the availability of nutrients, and the quality of the underlying sediments.

Long Island salt marshes are on the southern border of what is known as the New England type of marsh. New England marshes tend to be small in comparison to the very large expanses of marshes found in southern states. They are found on the glaciated coastal plain, and are marked by sediments composed both of inorganic marine materials and marsh peat. Typically, sediments contain little material from the surrounding uplands. Salt marshes in Suffolk County are present in North Shore embayments, all throughout the Peconic estuary, and on the barrier island, bay islands, and along mainland tidal creek and river shores in the South Shore estuary system. Tidal ranges vary greatly among these areas, ranging from microtidal (0.2 meters in the South Shore Estuary at Bay Shore), to more mesotidal ranges, especially along the North Shore (0.7 meters at Montauk Point and Plum Gut and into the Peconic Estuary, and 2.0 meters near Port Jefferson).

Several species of mosquitoes breed in salt marshes, with the dominant species being *Ochlerotatus sollicitans*, the salt marsh mosquito. Mosquitoes need standing water for larval development, and so slight depressions where water accumulates, and neglected ditches or other still waters, can breed millions of mosquitoes during the course of a summer. The timing and quantity of mosquitoes produced is a function of time of the year, and the timing and amount of standing water generated by precipitation, storms, and tides. Salt marsh mosquitoes, for example, lay eggs on moist mud within shallow depressions in areas of high marsh, typically dominated by *S. patens*. Very small potholes can be formed in this area due to the typical growth pattern of *S. patens*. It grows in small clumps that trap sediments, and these patches of vegetation become elevated above the more general marsh surface. Intermittent pools or pannes are also preferred mosquito breeding areas. These areas form because of vegetation smothering by wrack, ice rafting of vegetation, hypersaline conditions, and other marsh processes. Salt marshes typically have hundreds to thousands of these pothole areas and pannes. They lie above the reach of daily tides, but precipitation and/or lunar high tides can fill them with water. The water serves as a cue for the mosquito eggs to hatch. After hatching, salt marsh mosquito larvae develop quickly and reach the pupal stage in about one week. Increased temperatures accelerate the process which allows the mosquitoes to emerge as adults before the temporary pools dry down. Adult mosquitoes fly inland for a blood meal and return to the marsh to lay their eggs on the moist mud left in the pothole depressions. The next lunar tide repeats the cycle producing the next brood.

Historically, source control in salt water habitats was addressed in three ways that are no longer viewed favorably, due to environmental considerations. These were filling marshes, constructing impoundments that flooded mosquito habitat, and the construction and maintenance of a system of grid ditches. Filling salt marshes, and grid ditching what then remained, was the preferred means of managing salt marshes in the northeast US. Approximately 95 percent of Suffolk County's salt marshes were grid ditched in the 1920s and 1930s. Grid ditches were constructed as a system of straight, parallel ditches set a fixed distance apart. This fixed pattern was relatively easy to lay out and construct, but generally was not related to natural features in the marsh, such as vegetation type or mosquito breeding sites. Grid ditches were believed to disrupt the hydrological processes that resulted in optimal mosquito breeding conditions by draining water from the surface of the marsh. However, it is also clear that ditches allowed more access to the interior of the marsh by insect-consuming fish (typically *Fundulus spp*. [killifish]). Especially where tide ranges are low, as on the south shore of Suffolk County, the predation by fishes is likely to have been much more effective for mosquito control than any effects from draining. Over the years, the grid ditch pattern was sometimes augmented by additional ditches intended to address specific breeding sites. The current ditch network consists of the original, 1930s grid plus additional ditches added over the decades.

Recent research at two South Shore marshes, Wertheim National Wildlife Refuge and Seatuck National Wildlife Refuge, indicates that grid ditching of marshes appears to coincide with vegetation changes. The changes were not exactly the same at both, probably because of other alterations to the marshes' general surroundings occurring at the same time. At Wertheim National Wildlife Refuge (NWR), there was a general change from fresher vegetation to more salt tolerant and low marsh species. At Seatuck NWR, salt tolerant high marsh plants replaced both low marsh and fresh water species. These data might be interpreted as resulting from the marshes becoming saltier, but not apparently much drier. Drier marshes might have supported vegetation associated with the upland fringe. This research suggests ditches may have enabled salt water to penetrate further into the marsh, and, in some places, to be more persistent. This would have allowed fish greater residence time in areas where mosquitoes breed. Thus, if these interpretations are correct, insofar as ditching was effective in terms of mosquito control in lower tidal amplitude environments, it appears to be due to predation rather than drying of breeding locations.

The most obvious impact from grid ditching is the linear construction of the ditches, which are obviously anthropogenic in nature and foreign to a natural marsh setting. Other impacts appear to be marsh or setting specific. They include draining of surface water features, loss of water fowl and muskrat habitat, loss of seaside sparrow, habitat, encroachment by *Phragmites australis* into the tidally-inundated areas, expansion of woody plants into the marsh, and other alterations of marsh vegetation regimes.

Ditches tend to be persistent features in a marsh. Some ditches do fill in or otherwise transmit water poorly. This has been addressed by periodically maintaining the ditch system by reconstructing them back to original dimensions. This kind of ditch maintenance is sometimes called standard water management. This is because the intended benefit of a maintained ditched marsh is fewer adult mosquitoes. Evidence that maintaining a ditch system is beneficial is, however, mostly anecdotal. These reports compare the initial conditions following ditching to times on Long Island when the ditches were not well maintained. Modern records indicate that complaints decrease in areas near marshes that have been recently maintained. New Jersey light trap data, although these traps are monitored regularly, and are set at fixed locations as a rule, may not generate quantitative data to support this finding, however, because most traps measure area production of mosquitoes. They generally do not reflect the mosquito production of a particular marsh. Ditch maintenance is usually conducted at specific marshes, rather than at all the marshes in a particular area. In addition, such comparisons are hampered by ditch maintenance recordkeeping, which has focused on machine and staff effort, and tended not to document work done in specific locations or in specific marshes. However, in areas or times where ditches are not maintained, mosquitoes appear to proliferate. Therefore, although quantitative assessments of the effectiveness of ditch maintenance are essentially non-existent, mosquito professionals on and off Long Island are convinced it is a means of reducing mosquito numbers. This, coupled with regulatory limitations on other forms of water management, accounts for the persistence of ditch maintenance as a means of water management on Long Island. Other northeast US mosquito control agencies tend to use other water management techniques now, mostly because alternatives are allowed, and even promoted, elsewhere.

Other benefits cited for ditches include increases in potential fish habitat within a marsh, increases in ecologically valued edge habitat, and increases in the level of connectivity between the marshland and the estuary.

In salt marshes, there does not appear to be any effective predators of adult mosquitoes. Dragonflies are said to consume large numbers of mosquitoes, but there is only one species of salt marsh dragonfly in New York State. Some bats and birds are sometimes said to prey on mosquitoes, but studies indicate larger insects generally suit these predators better, as mosquitoes are very small and somewhat difficult to capture on the wing. Some researchers have found bats will prey on mosquitoes as they swarm, but most do not hunt dispersed individuals. Mosquito larvae are consumed by a number of predacious aquatic insects, a wide variety of predatory fishes, and few species of predacious mosquito larvae (although none occur in salt marshes). Fish are probably the most efficient predators of mosquito larvae if given ample opportunities. Particular larval habitats can regulate the scope of predators that prey on the immature stages of individual mosquito species. In salt water habitats, for example, insects (e.g., dragonflies) are negligible predators on mosquito larvae, and less important for adult predation. Certain fish, on the other hand, can thrive in the shallow water environments that favor larval development, and also are very tolerant of the poor water quality that is often found in these areas. Water in ditches and marsh creeks can be warm, brackish, contaminated by noxious chemicals such as hydrogen sulfide, and low in dissolved oxygen. Altering a marsh enough so as to create the minimal water quality needed by killifish has been found to be extremely effective at controlling mosquito problems.

Due to regulations established through the Clean Water Act (1972), and increased awareness of benefits associated with marshes, coastal zone management plans have sought to balance mosquito control and the restoration-preservation of one or more marsh features, such as fish or bird habitat, plant communities, or estuarine water quality. Water management, as source reduction, is intended to reduce the need for pesticide applications, and has been found to be effective in other jurisdictions. There are many water management implementation choices, however, and so it is necessary to determine which forms of water management, under what conditions, have the least amount of environmental impact, and are most appropriate for the identified problem.

The Long-Term Plan planning project has identified 15 BMPs as means of salt marsh source reduction. These management activities range from allowing natural processes to control marsh features to techniques that involve major physical alterations to a marsh. It is an axiom of this manual that the management technique selected should be the most ecologically benign technique or combination of techniques for the conditions at a particular site. This can be achieved by establishing a goal to preserve, or even increase, acreage of coastal wetlands, including vegetated tidal wetlands, and to foster marine and estuarine biodiversity and a mosaic of ecological communities.

The management activities are categorized into three classes according to the amount of impact associated to a marsh:

- no or minimal impact
- minor impact
- major impact

Reversion is to be the presumptive interim action for County Wetlands, pending identification of a preferred active restoration plan for each wetland.

Class I activities are those that have no or minimal impact. They are:

- Natural processes (reversion/no action)
- Maintain/repair existing culverts
- Selectively maintain/reconstruct existing upland/freshwater ditches

Class II activities are intended to have minor impacts. They are:

- Selectively maintain/reconstruct existing salt marsh ditches
- Upgrade or install culverts, weirs, bridges
- Naturalize existing ditches
- Install shallow spur ditches
- Back-blading and/or sidecasting material into depressions
- Create small (500-1000 sq. ft.) fish reservoirs in mosquito breeding areas

Although ditch maintenance is the first technique listed under the minimal action list, it is not expected to be a primary means of water management for the County (estimates of ditching maintenance activity under the Long Term Plan are in the range of 50 acres or so a year). Maintenance of ditches will only occur under well-defined conditions, subject to local concerns and input, and review processes established in the Wetlands Management Plan. However, because of the ubiquitous nature of ditched marshes in the County, selectively maintaining ditches, primarily to promote better fish habitat where mosquito breeding is occurring, is a highly conservative action that maintains the status quo in the treated marsh. This means it generally represents little change from existing conditions, and so presents very little in the way of environmental impacts. It also might be suggested that opportunities for environmental benefits are similarly limited, however.

Any proposed ditching maintenance will only be conducted of the conditions in the marsh represent a public health risk by fostering excessive mosquito breeding, or if reducing the mosquito breeding will result in pesticide application reductions, and in consultation with the SCDHS Office of Ecology and the Suffolk County Department of Environment and Energy (SCDEE).

Class III activities require large-scale alterations of the marsh or will greatly impact existing hydrology, and therefore have the potential to result in major impacts:

- Break internal berms such as those created by roads and paths across the marsh
- Install tidal channels
- Plug existing ditches
- Construct ponds greater than 1000 sq. ft. (largely for wildlife value)
- Fill existing ditches
- Remove dredge spoils

Every salt marsh is unique. They can be dynamic settings, and each varies in significant ways from archetypes or exemplars. These differences are the result of hydrology, morphology, water chemistry, physical settings and surroundings, and substrate properties. Hydrology involves the presence/absence and cycling of water, in terms of quantity, form, frequency and duration. Water sources include precipitation, groundwater, rivers and streams, tides, tidal creeks, and terrestrial runoff. Salt marsh morphology is determined by elevation, slope, micro- and macro-topography, and the presence/absence of channels. Vegetation and wildlife habitat are influenced greatly by the water chemistry of a salt marsh, including salinity, temperature, nutrient content, and the presence or absence of key chemicals such as iron and hydrogen sulfide. The physical setting of the marsh can control storm impacts, overall water quality, and its overall ecological connection to its surroundings. Surrounding environments control the absence or presence of particular species, and determine the type and degree of anthropogenic impacts to the marsh. Substrate properties influence the interaction between the hydrology and morphology of a salt marsh. The size and type of sediment particles influences water drainage and the location of the water table, and the accumulation of sediment (or lack thereof) determines whether the marsh can maintain itself in the face of relative sea level rise. These controlling factors need to be considered prior to the selection of BMP techniques.

The management activities described in this BMP manual can be considered in the hierarchical manner they are presented in. The emphasis is on mosquito control, but control that is achieved by the means that results in the least amount of change to the marsh. It may be that in many cases greater amounts of alteration will be selected as the preferred management means for a marsh, because of the possibility for greater ranges of benefits associated with the alterations. Nonetheless, the techniques are presented in this manual from the least impact to the existing marsh, to those that represent greater changes.

Thus, the initial step prior to consideration of any management activity is to identify exactly what kind of problem is associated with the salt marsh. This manual focuses on mosquito breeding, but other problems can require salt marsh restoration, including tidal restrictions, *Phragmites australis* invasion, a need for habitat enhancement, removal of fills or spoils, or even improvements required for aesthetic purposes. However, in most cases, it seems that the more needs that are to be addressed, generally the greater the degree of alteration required.

For those proposed management actions that involve major impacts (as determined here) or include areas more than 15 acres of tidal wetlands (a size determined cooperatively with the Wetlands Subcommittee of the Long-Term Plan Technical Advisory Committee), a formal evaluation process must be undertaken. The process is simpler for smaller projects without major impacts. SCVC will coordinate with New York State Department of Environmental Conservation (NYSDEC), the local Town, and other identified interested parties on the project. Under no circumstances will SCVC undertake marsh management projects without some form of coordination with local interested parties, SCDHS Office of Ecology, and SCDEE. Once agreement regarding project scope has been reached, and necessary permits have been acquired, SCVC will undertake the work. Post-project monitoring should be addressable between SCVC and Town resources.

The process for major projects is more involved. Once a mosquito problem has been identified, informal consultations among the land manager, SCVC, permitting agencies and other interested parties will be undertaken to create an initial scope of the project. This scope will be intended to address the mosquito breeding problem, but may also, at the behest of others involved in the project, expand to address other marsh management concerns for the site such as improving biodiversity, enhancing specific wildlife values, or reducing *Phragmites* infestations. The project sponsor (generally, the land owner) will be required to submit to the Screening Committee a preliminary project approach. Once Screening Committee clearance is obtained, SCVC will assist in final design of the selected project. Permits would need to be acquired, and any environmental requirement under the State Environmental Quality Review Act (SEQRA) addressed. SEQRA compliance is generally the responsibility of the land owner, although County participation and assistance may be offered. Inherent in SCVC involvement is a project goal to control any mosquito problems at the site, but the presence of mosquitoes does not in and of itself represent a mosquito "problem," in all cases. Not all projects considered through this process will be driven by mosquito control issues. Marsh restorations may be initiated for ecological reasons. Participation by SCVC in the project implies that any mosquito control issues have been recognized and addressed by the proposed project. In fact, it is understood that projects addressed through this process will likely include sites where no mosquito issues need to be addressed, but other restoration needs must be addressed.

Management activity considerations will vary with individual site conditions. Site-specific characteristics of each restoration locale must be evaluated as part of the restoration planning. Although the impact to and the generic characteristics of salt marshes are often similar, restoration of these resources must be planned and evaluated on a case-by-case basis. A given set of designs will not be applicable to every wetland type, nor to every landowner's needs. This approach rejects any cookie-cutter approach to marsh management, and requires adoption of nuanced, site-specific actions. With a detailed understanding of site conditions, this BMP manual posits that effective management tools can be applied.

2 ESTABLISHING THE NEED AND TYPE OF ALTERATION

Establishing the need for action is the first determination in assessing Suffolk County salt marshes. Following the assessment of whether or not action is required, site-specific characteristics of the marsh must be collected to the degree necessary to determine which BMP is most appropriate for the situation.

The Wetlands Subcommittee of the Technical Advisory Committee has identified a set of goals as general management objectives for the coastal wetlands of Suffolk County. These goals and objectives have been modified slightly for the purposes of the Long-Term Plan. When establishing the need and type of alteration required for a particular wetland the following overlapping and yet hierarchical set of goals should be considered:

1. reduce mosquito populations;

2. preserve or increase acreage of coastal wetlands, including vegetated; (tidal) wetlands, and to foster marine and estuarine biodiversity and a mosaic of ecological communities; and

3. control *Phragmites* and other invasive plant and animal species.

2.1 Establish a Need for the Action

Two prima facie conditions immediately establish a need for action. One is repeated or extraordinary flooding associated with water management structures under the purview of SCVC. SCVC has responsibility for mosquito control ditches installed in various salt and fresh water settings. In addition, SCVC has become the de facto maintenance organization for a variety of culverts, bridges, and other roadway water management structures. Maintenance of these structures, or problem-solving for flooding associated with them, is now the responsibility of SCVC.

Secondly, marshes that receive aerial applications of larvicides are in need of expanded water management. SCVC selects marshes for aerial larviciding when surveillance has demonstrated that large areas consistently produce mosquito larvae. Many other jurisdictions have reduced or eliminated larvicides following progressive water management. Their success in curtailing pesticide use, and many demonstrations of environmental benefits accruing from more progressive water management, are the primary reasons that the County has selected progressive water management as its preferred means for addressing mosquito problems.

Other situations will require more nuanced determinations of mosquito problems. Areas that experience elevated trap counts due to brood development, where virus isolations have been made, even if in species other than *Oc. sollicitans*, and where surveillance of mosquito breeding sites show the presence of larvae, are all potential locations for water management projects. Salt marshes in the vicinity of populated areas that generate many complaints about biting mosquitoes are also candidates for source reduction steps.

Low population density in the general vicinity of a breeding marsh, recognition that existing conditions are ecologically sensitive or sound, or prohibition on management by a permitting agency, will eliminate the need for mosquito control.

2.2 Pre-project Initial Data Collection

The more intensive the data collection effort is at earliest stages of a project, the more likely it is that an early determination of the scope of the project can be made. The setting of the marsh, its general physical and biological features, and the scope of the mosquito problem at the site should be documented as well as can be. Understanding the present condition of the marsh will allow the most appropriate choice of water management to be used, resulting in the least impacts.

A key element in the determination for any action is the perception of the marsh owner/manager as to the present-day condition of the marsh, and what, if any restoration plans may have been considered for the marsh. Those marsh managers who are generally satisfied with the present condition of the marsh, and who do not perceive a need for changes to the marsh, will be more receptive to plans that call for fewer changes. Those that are concerned about some aspect of the present-day condition of the marsh, or who have identified restoration needs for the site, may be more interested in more intensive approaches to any mosquito problem.

Basic environmental variables should be documented to support the scope of the project. Salt marshes in Suffolk County vary with regard to several ecological characteristics such as tidal amplitude, plant species present, salinity, and distribution of open water. Surrounding land use and overall marsh morphology can also be key features. Off-shore water quality can also be an important determinant in deciding on the kind of water management approach for a particular marsh. Information on these variables should be collected, with the scope of the effort being appropriate to the most likely BMP to be selected. Construction of a major OMWM project should require more pre-project planning than the replacement-in-kind of a culvert.

It is important that the overall health of the marsh be described. There are many ways this can be determined, including a monitoring scheme described as part of the Marsh Health report in the Long-Term Plan literature search (Book 9, Part 1) (see Table 1). The Natural Heritage Program has identified reference salt marshes across Long Island, to which proposed sites can be compared. The Long Island Wetlands Initiative has identified candidate sites for restoration, with justifications for the proposed action. The Long Island Sound Study and the Peconic Estuary Program have both set up guidelines identifying the kinds of projects that these planning efforts would likely support, and in some instances have identified specific locations for restoration projects. The Towns, the US Fish and Wildlife Service (USFWS), the National Park Service (NPS), and other major landowners of marshes have all generally considered the existing quality of their marshes, and have often considered how they might like to manage these settings if the opportunity arose. Therefore, it is clear that early consultations with interested parties will deliver benefits in terms of developing the soundest site-specific plan for a particular marsh project.

Table 1. Proposed first-order indices for marsh health in Suffolk County.

Health Indicator	**Good Condition**	**Alert Status**
Marsh stability	Net loss of vegetated wetland <1% per year	Net loss of vegetated wetland >3% per year
Plant health (for *S. alterniflora* only – health of the high marsh presumably threatened by *Phragmites* invasion rather than vegetation loss as in the low marsh)	<5% of vegetated marsh with stem densities below 100/m^2 or total below-ground biomass from 0-20 cm >3000 g/m^2	>10% of vegetated marsh with stem densities below 100/m^2 or total below-ground biomass from 0-20 cm <1500 g/m^2
Invasive species	<30% *Phragmites* sp.	>50% *Phragmites* sp.
Resident finfish	Killifish group represented in most or all suitable habitats	Killifish group absent from >30% of suitable habitats
Species of Interest (e.g., marsh sparrows, terrapins, forb plants, others)	Stable population or consistent use of marsh by species of special State or Federal status	No species of concern present or viable
Temporal trends	Selected indicator does not trend negatively in 3 or more consecutive years	Selected indicator trends negatively in 3 or more consecutive years
Note: marsh characteristics between Good and Alert condition should be considered to be Of Concern and monitored closely		

One means of determining the health of various kinds of salt marshes is to determine their long-term history. This can be done by examining aerial photographs and historical descriptions. It can also be addressed by looking at long-term vegetation patterns across the marsh, and determining when and how these patterns have changed. Research supported by the Long-Term Plan has developed a novel means of analyzing photographs of Dutch corings across marsh transects to generate such information. This can be done very rigorously, using radiometric dating techniques on a few selected cores to establish marsh specific sediment accumulation rates, or more informally by assuming that, as with apparently all Long Island marshes, sediment is accumulating at or close to sea level rise rates. The determination of stable or changeable vegetation regimes does not rely on the absolute dating of changes, in any case. It should be noted that developing an accurate history for a marsh is not always simple or easy.

Minimal data collections include:

- the need for mosquito abatement, and the means by which this was determined (from complaint logs, anecdotes and experience, larval sampling, trap records);
- ownership of the marsh and adjacent land;
- flow of salt water into the marsh (can include levels of inundation, determinations of tidal restrictions, surveying the salt water table, fresh water source determinations); and
- health of the marsh (see above)

Further efforts can include:

- water quality of major bodies of water and tidal creeks/mosquito ditches;
- distribution of vegetation on the marsh and along the upland edge of the marsh; and
- wildlife surveys

2.3 Permits

One of the most essential parts of the planning process is determining what, if any, permissions from regulating agencies must be obtained prior to the project. Jurisdictions with interest in salt marshes range from local villages, towns, and town trustees, to branches of County government other than SCVC, to State agencies, especially NYSDEC and New York State Department of State. Depending on the landowner, Federal organizations such as NPS, US Environmental Protection Agency (USEPA), US Geological Survey (USGS), and USFWS may be involved. The United States Army Corps of Engineers (USACOE) also has jurisdiction over any activities involving "waters of the United States," and USACOE may bring in other agencies such as National Marine

Fisheries to help in the process. For this reason, the permitting requires understanding the length of time necessary to receive approvals of proposed plans.

The landowner, nominally, has the responsibility for obtaining all permits. However, involvement of SCVC in the project implies County interest. Therefore, in many situations the County may be a participant in the permitting of the project. The assistance may range from technical guidance regarding filings to taking a lead role in preparing any applications that are necessary.

The Long-Term Plan planning project is intended to address many of the issues related to permitting of projects. The production of a Generic Environmental Impact Statement (GEIS), which is intended to meet SEQRA requirements that relate to the generation of a Management Plan for Suffolk County's vector control program, is likely to be sufficient for many aspects of permitting for water management projects.

As discussed in the Generic Environmental Impact Statement, on a project by project basis, the following criteria need to be considered to determine if additional environmental reviews are warranted:

- the techniques to be employed have been classified as having the potential for major environmental impacts;
- the total area of the wetlands that may be affected by the project exceeds 15 acres of tidal wetlands with hydrology being the primary consideration;
- the project requires physical alteration of more than 15 acres of wetlands;
- consultation with local authorities or review by the Screening Committee finds there is a potential for major impacts under the proposed course of action

However, exactly what releases will still be required following the adoption of the Long-Term Plan by the County Legislature will be largely determined by the practical processes associated with the first few projects in conjunction with the approved Wetlands Management Plan.

The sponsor of a potential project will be encouraged to contact interested parties as soon as is possible. This can allow for several mutually beneficial exchanges between the proposer and any potential regulator. For one, the regulator may possess or be aware of information that will reduce the need for independent evaluation of marsh conditions. Secondly, the scope of the investigation of marsh conditions can be agreed to early in the process, avoiding excess expenditures of effort, or the frustrations of delays associated with data collection that could have been accomplished at earlier stages had the need been clearly identified. Third, interactions between project sponsors and regulators can lead to incorporation of design elements that may not have been considered without discussions of goals and objectives of the action. Finally, early interaction ensures that all interested stakeholders are involved in project design and development.

2.4 Salt Marsh Screening Committee

In order for SCVC to be involved in major projects, approval from the County-sponsored Salt Marsh Screening Committee will be required. This committee will have a membership comprised of County Executive and Legislature representatives, New York State permitting agencies, Estuary Program managers, local government (on a rotating basis, as determined by project locations), and other interested parties with standing, such as certain non-governmental organizations. The Screening Committee will assess concordance of the preliminary project description with the goals and objectives of the Wetlands Management Plan and any overarching marsh management strategies that may be applicable. If it determines that the project meets with these goals and objectives, the applicant may then proceed onto final project design, and to apply for necessary permitting.

Certain projects, such as major alterations of significant salt marshes, may require several iterations of the initial project description in order to receive approval by the committee. One aspect that the Screening Committee will pay great attention to is the proposed scope of post-project monitoring (see below). This is an extremely important element of any project, and one that is often given short shrift.

Although the County intends to have several permitting organizations participate on the Screening Committee, initial approval of a project by the Screening Committee does not indicate that the applicant should assume future permit success with these participating agencies. These organizations are being requested to participate because of their degree of wetlands expertise, or, in the case of local municipalities, their local knowledge and awareness which may exceed County capabilities. Review and approval of a project by the Screening Committee in no way implies regulatory approval or review; they are distinct processes.

2.5 Project Design

Any project with SCVC construction involvement will also require SCVC involvement in the design of the project. SCVC completely understands the capabilities of its equipment and workforce, and is inherently suited to determine the impact of a project on mosquito breeding. For those reasons, SCVC must have a major role in designing any project where it will be requested to provide construction assistance.

Additionally, SCVC has perhaps the most experienced wetlands construction personnel in Suffolk County, and, with each additional project addressed under the Long-Term Plan, will add to that professional expertise.

SCVC's expertise will be augmented by a committee of salt marsh experts – the Wetlands Subcommittee. This committee is intended to provide a role for local government, non-government, academic, and other salt marsh experts in crafting the more complex management proposals so that they are able to meet the goals of reducing mosquitoes, fostering salt marsh ecologies, and discouraging invasive species. The committee will also report to the Screening Committee, as necessary, as information is developed through the execution of projects, so that the Screening Committee can adjust its objectives in light of practical experience.

2.6 Monitoring

All projects will require some degree of follow-up monitoring. Monitoring is intended to determine if the marsh alteration met its overall goals as a project, and especially to ensure that the action did not cause harm to the health of the marsh. In most cases, determining the former ensures that the latter will be accomplished. In some cases, regulatory agencies will require specific monitoring over a certain length of time. Often, for many of the less ambitious projects, it may be the role of applicant to determine the level of appropriate monitoring. Monitoring is clearly one of the elements of project design that will benefit from early and prolonged discussions with regulators and their associated interested natural resource agencies or branches. This will ensure that an appropriate level of scrutiny to determine post-project impacts is selected, and that this level of monitoring is project-specific, and manageable for the party responsible for conducting the work.

Almost always, monitoring will be the responsibility of the landowner. Where SCVC or other elements of the County or other local government have overriding interests in the particular project, assistance may be available for monitoring efforts. There have also been expressions of interest in providing monitoring support from some of the local resource agencies, as the kinds of measurements needed to monitor the project may be part of their local environmental stewardship activities. Suffolk County will take responsibility for monitoring marshes where reversion has been adopted as the preferred interim action. This monitoring, assumed to be conducted using remote sensing, will focus on ensuring major changes in the extent and composition of existing marsh reaction does not occur in the absence of active marsh management.

The County intends to formally present its proposed monitoring scope following the completion of the fourth year of monitoring at the Wertheim Demonstration project (early 2007).

3 BEST MANAGEMENT PRACTICES

3.1 Class I: No or Minimal Impact

There are three management activities that result in no or minimal impacts to a salt marsh. These actions are classified as either "No Permit Needed" or "Generally Compatible Use – Permit Needed" in the Tidal Wetlands Regulations (6 NYCRR 661). These actions may be taken in the absence of mosquito breeding on a prophylactic basis, or because no residents are in the immediate vicinity, meaning that any mosquito breeding will not constitute a mosquito problem (assuming there are no virus isolations), or the proposed action will result in little or no impact to the existing environment. In addition, reversion, allowing natural processes to manage the marsh, is the presumptive interim action in the absence of a recognized, accepted restoration management plan for a marsh. Management strategies may require alteration, however, if future development leads to greater numbers of nearby residents, or if the existing environment is otherwise found to require different management.

BMP 1. Natural Processes (reversion/no action)

This is the presumption management means in the absence of another identified accepted restoration management plan. Natural processes can generate a return to pre-ditch hydrology and vegetation by passively allowing the marsh to return to its natural state. This should minimize impacts of ditching on the marsh, both positive and negative. Negative impacts associated with ditching include the aesthetic impacts of linear structures across the marsh and potential changes in marsh hydrology, including associated impacts to vegetation, wildlife, and marsh functions. Proponents of reversion note that ditches are obvious alterations of the marsh, and so allowing natural processes to occur may lead to a return to a natural state. Others note that allowing ditches to fill through natural processes does not mean the new condition is as natural as pre-alterations conditions were. This can be difficult to assess without knowledge of pre-ditch conditions. Skeptics also suggest natural marshes were effective at breeding mosquitoes.

The success of reversion as a restoration technique is dependent on the pace and kinds of natural processes at work in the particular marsh. More active means to achieve the general end of grid ditch removal include ditch naturalizing and filling. In some settings, ditches seem to maintain themselves. In other settings, the ditches tend to infill. This infilling process may result in the disappearance of functioning ditches within years in some instances, or it may require decades in others. Partially filled ditches may lead to more favorable habitats for mosquito breeding, and so reversion may create a mosquito problem where there once was none. Another potential issue that may arise for a partially-filled ditch system is the potential for water to not drain off the marsh surface. Some have implicated this process in the sudden die-backs of salt marshes in Jamaica Bay. Others see this as a mechanism for *Phragmites* expansion, if the water accumulating on the marsh is fresher than ambient surface waters. The County intends to carefully monitor all marshes undergoing reversion. The preferred methodology involves analyzing satellite photographs to determine if the total area of vegetated marsh is changing, and to look for gross changes in the composition of marsh vegetation, relative extents of low marsh, high marsh, mixed vegetation communities, and *Phragmites*. If the analysis finds a trend over three years of monitoring, a site investigation will be conducted to determine if the reversion is causing adverse impacts to the marsh. If so, more active management means will be relocated.

Reversion is the presumptive interim management policy for all marshes, until a more site-specific restoration management plan is adopted at each one. This is to advance a position that non-intervention in natural systems will provide benefits that exceed those associated with more active ecological management. Sites best suited for reversion as a permanent management process are those that are actively infilling and currently do not create mosquito problems. Reversion should be fostered where generally unmaintained systems have created stable systems that include important ecotones. For example, at Crab Meadow, the upland ends of ditches are actively infilling and vegetating, while the ditch mouths are widening and settling, creating habitat areas that are likely to support a diversity of plants and animals. Reversion is often considered at sites where the owner has a philosophical predilection for allowing natural processes to proceed unimpeded. Reversion may not be appropriate at sites where intervals between ditch maintenance have led to the development of mosquito problems, especially where frequent larviciding has been required.

Since no action is being taken under reversion, no regulatory input is needed.

BMP 2. Maintain/Repair Existing Culverts

Culvert maintenance includes clearing blockages, replacing damaged pipes, and controlling erosion around the structure. This action is classified as "Generally Compatible Use – Permit Needed" under the Tidal Wetlands regulations, which has usually been addressed by means of a general permit issued to the County. The need for maintenance is determined when unexpected flooding occurs and is reported, or by inspection. Maintaining or repairing existing culverts allows tidal flow to be maintained to the marsh, while preventing flooding. Repairing culverts perpetuates existing conditions, and so should only be considered where the existing marsh has been evaluated as being healthy.

At the time of maintenance, a determination needs to be made regarding whether the culvert is adequate for its purpose. Signs that it is not adequate include tidal lags, vegetation differences between marshes upstream and downstream of the culvert, differences in key water quality parameters between the upstream and downstream marshes, flooding history, and constrictions, indicated by excessive flow velocities in the pipe. If these factors are present, decisions need to be made as to whether upgrades to the culvert system will be sufficient to alleviate them.

Sometimes the repairs can be accomplished using hand tools, but often culvert repair will involve extensive use of heavy equipment. Culverts often pass under roadways. Repair of the culvert may necessitate road work, and so all activities may need to be coordinated with the appropriate highway department. Impacts to the marsh from culvert repair are generally minimal if restricted to the marsh periphery. More involved projects, especially where road work is involved, require planning and inter-agency coordination to ensure impacts to the marsh – and residents – are minimized.

BMP 3. Maintain/Reconstruct Existing Upland/Freshwater Ditches

Ditches were installed in freshwater wetlands generally to increase drainage and to provide a degree of mosquito control. These systems are found in some areas that are now extensively developed, such as Mastic-Shirley and Oakdale, in agricultural areas, especially in Riverhead and on the North Fork, and in areas that have very little development, such as Manorville. The primary reason for SCVC to maintain such ditches today would be to continue historical water management for flood control reasons. Secondarily, this reduces standing water, which is the habitat of the flood water mosquito. Standing water may occur should flooding continue unabated. The focus of efforts will be in the areas where flooding affects residents' use of property and local streets, although some systems are also maintained in order that existing agricultural uses can continue. The end result is that the scope of the BMP is very limited. This BMP does not foresee maintenance of upland ditches in areas where residential property is not affected by flooding. An exception to this may be made if it is determined that maintained fresh water ditches are essential for spotted turtle habitat and so provides a natural resource benefit. Such maintenance would be carefully conducted in order to ensure that minimal impacts occur to the turtles or their habitat.

It should be emphasized that maintenance of existing ditches is not the same as installing new ditches. The County will not install new ditches under this Long-Term Plan. Proposing to maintain ditches in a particular marsh does not mean that the County has any intentions to install more grid ditches at that location.

Prior to any maintenance activities, the ditch system needs to be inspected and evaluated in order to determine the cause of the failure. For example, if bank erosion is occurring, then reconfiguration or re-engineering of the affected area should be considered to minimize the need for continuing maintenance. Where these structures exist in backyards, options may be limited in terms of new configurations. Many problems associated with these systems may be reduced if homeowners can be educated so as to avoid activities that lead to flow failures, such as dumping yard waste or other debris into the system, or creating excessive amounts of impermeable surfaces that promote run-off. It should be an operating principle that maintenance activities need to be conducted so as to reduce the potential for repeated actions in the future.

Most upland systems can be maintained by hand tools. Very often the only work that is required is the removal of debris, usually anthropogenic in nature. Where systemic problems exist, the situation is often linked to culvert maintenance or upgrades. Such maintenance situations should be carefully considered in order to develop optimal approaches to what may be persistent problems.

These ditched drainage systems may channel run-off into estuarine systems without much natural retention, thereby increasing loadings of nutrients, chemicals, metals, and pathogens into the estuary. Where possible, treatment of stormwater flows into these systems should be sought ,as part of comprehensive stormwater management steps under USEPA Phase II Stormwater guidelines,. Many of these systems are the legacy of early, less well-informed development and land-use practices, and probably would not be permitted today. However, they cannot be abandoned without significant impacts to the property of many residents, and without increasing mosquito threats to these homeowners. Fresh water mosquitoes are essential for Eastern equine encephalitis (EEE) transmission, and are believed to be the main vector for West Nile virus (WNV). Therefore, these maintenance activities, when selectively applied, are important to the maintenance of public health and the quality of life of those who live near them.

This BMP has been classified as having minimal impact because the maintenance activities are generally limited in scope, in terms of the amount of work expended on the ditches, and often in the geographical extent of the projects. These kinds of activities also are intended to maintain existing conditions. Maintenance of upland ditches is exempt from permit requirements under the Freshwater Wetlands Permit Requirement Regulations (6 NYCRR Part 663).

Table 2. Management Activities for Minimal or No Action

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

NPN - Uses not requiring a permit I – Incompatible Use GCp – Generally Compatible Use – Permit Required P – Permit Required Pip – Presumptively Incompatible Use – Permit Required NA – Not Applicable

* local regulations may or may not be more stringent than these State regulations

3.2 Class II: Minor Impact

There are six management activities that result in minor impacts to a salt marsh. Permits are usually required from NYSDEC for these actions, although nearly all are considered to be Generally Compatible Uses – Permit Needed, and might be addressed through a general permit of some kind. Factors determining whether these activities should be implemented at a marsh include marsh size, geographical setting, and the areal extent of mosquito breeding. Geographically restricted marshes or marshes with a small number of mosquito problems are good candidates for these kinds of restoration. The property owner will often determine if these generally limited efforts will be acceptable in meeting any predetermined restoration goals. Prior to undertaking any of the following actions, all federal, state, and local municipality regulations must be addressed. Because these actions should have minor natural resource impacts, they represent opportunities to make rapid progress in implementing progressive water management to relatively large portions of the County's marshlands as an alternative to the use of pesticides.

Although ditch maintenance is the first technique listed under the minimal action list, it is not expected to be a primary means of water management for the County. Ditch maintenance will only be carried out under well-defined conditions, subject to local concerns and input.

Ditch maintenance is found at this point in the BMP manual because this form of water management requires little change from existing conditions. Inherently, this means the maintenance of the existing ditches, especially when limited in scope, causes little to no impact to the existing system. If that system as been judged to have adequate ecological functions and to provide appropriate ecological values, then there will be little overall environmental impact from the project. This does not mean that ditching is the optimal water management tool for that system, however. More progressive actions may have greater environmental benefits, through resource enhancement, for example. However, in some situations, limited actions may be determined to be the preferred marsh management approach.

Existing water management systems, such as ditches, culverts, and other structures, will normally be either left alone, if not needed for mosquito control, or upgraded to BMPs as outlined in the Wetlands Management Plan. In some cases, implementation of BMPs is not immediately feasible due to lack of pre-project information or institutional factors such as landowner policies. Implementation of BMPs may also not be immediately feasible due to lack of resources. For instance, if major tidal flow restoration is desirable but is currently too expensive because it involves major road work, interim measures should be taken while these resources are sought.

Assuming Long-Term Plan water management policies are implemented, especially OMWM, the general presumption will be against maintenance of ditch systems. However, in limited circumstances, existing structures may be maintained on an interim basis, when the following conditions are met:

- Deterioration of or damage to structures is resulting in a significant mosquito problem, as evidenced by larval and/or adult surveillance, serious enough to require control. An example would be a collapsed pipe that restricts tidal flow and results in a need to larvicide an area. Or:

- Failure to maintain the structures would result in the loss of resource values, such as fish passage or tidal flow, or loss of vegetation due to freshwater impoundment. Or:

- Failure to maintain the structures would result in a hazard or loss of property as a result of flooding.

Benefits to be expected from the work include:

- Maintaining or reconstructing the existing structures will improve water circulation or provide fish habitat sufficient to reduce the need for pesticide application.

- Maintaining the structures is compatible with habitat values that existed prior to the failure or deterioration of the structures.

- Maintaining the structure will prevent flooding or other hazards.

Constraints on any maintenance of a pre-existing ditch system include:

- The structures will be maintained essentially in-place and in-kind.
- Disruption of wildlife habitat due to construction will be minimized by limiting work areas and/or by using seasonal constraints.
- Listed species will not be adversely impacted.
- Interim maintenance will not lead to excessive drainage that would result in a loss of wetlands values.
- The action will not lead to increased or more direct conveyance of inputs from storm drains or other structures.
- The action will not preclude the implementation of BMPs when resources and/or institutional considerations allow.

BMP 4. Selective Maintenance/Reconstruction of Existing Salt Marsh Ditches (Standard Water Management)

In the 1920s and 1930s, nearly all of Suffolk County's salt marshes had a grid of linear ditches constructed across them. Although intended for mosquito control purposes, these ditches were not targeted at the specific areas of marshes that bred mosquitoes. Nonetheless, it was found that these structures reduced mosquito populations appreciably, usually by providing access for insect-consuming fish to breeding sites, but also, in instances, by draining standing water and so reducing habitat availability. Many of the ditches tended to become clogged with debris and to infill with sediments, some more quickly than others. This meant that in order for them to continue to reduce mosquito populations, maintenance was required. It became habitual to maintain the ditch system on marsh-wide basis, rather than to target the specific ditches where maintenance was needed and that were needed in order to control existing mosquito populations. New

York State Tidal Wetlands Regulations deem this to be an action that does not require a permit.

The installation and subsequent maintenance of the grid ditched system is believed by many to have caused damage to the salt marshes. Ditches, where they have altered marsh hydrology, certainly did affect the marshes. These impacts may have included an overall impact on the water regime of the marsh, the loss of habitat for certain species, and changes in the general distribution of marsh vegetation, including contributing to the spread of *Phragmites*. In many instances, however, marshes that are grid ditched appear to be in very good health. In fact, one complaint about grid ditching is that it leads to such vigorous marsh grass growth that it makes the marsh appear like a monoculture lawn.

Maintenance of the grid ditched system has been called "standard water management." The name indicates the role it can play in an Integrated Mosquito Management program, as the control of mosquitoes by water management means less reliance on pesticides to address mosquito problems. Ditch maintenance has been identified as a BMP because it offers the opportunity to address certain mosquito problems through source reduction, with the least disturbance to the existing environment. This is sometimes the best alternative as it can be impossible to determine exactly how natural systems will react upon manipulation. However, more progressive marsh management actions have been extremely successful as mosquito and salt marsh management tools, all across the Middle Atlantic States up into New England.

This proposed BMP is not to continue past measures of cleaning every ditch in a treated marsh. Ditch maintenance, as intended in the BMP, is:

- the selective cleaning of some existing ditches;
- deepening of the upstream portion of clogged ditches so as to provide adequate fish refuges from predatory birds;
- re-grading berms to allow water to access the marsh during flood tides; or

- removal of other obstacles to allow tidal flow of water over the marsh to areas of mosquito breeding.

It is to be a designed process, as the causes of ditch clogging will be investigated, and steps taken to limit repeated maintenance efforts. This may require widening stretches of selected ditches, establishing baffles to prevent erosion, through installing small curvatures in the ditch pathway, for example, and other steps necessary to make the tidal hydrology work to maintain the ditches rather than to fill them. In a few instances, the clogs will not be removed, but alterations to the upland stretches of ditch will be undertaken in order that killifish can flourish and control any mosquito breeding. The precept of this adjusted approach is to assume that not all ditches in a particular marsh will require maintenance. It may be that some ditches in the low marsh should be allowed to revert, and discretion is needed in high marsh areas that show no signs of mosquito breeding. Another key step prior to the initiation of work is the identification of important breeding locations throughout the marsh, and assessment of the quality of the ditches that may allow fish access to these areas.

In general, at most sites it will be a goal to reconstruct the ditches so as to maintain tidal flows into areas that show excessive mosquito breeding activities. Good tidal flow will ensure that water quality is maintained for killifish to allow them to persist in the marsh, and reach shallow water environments where mosquitoes breed. Berms, whether naturally formed or the result of previous maintenance activity, should be breached to ensure access for fish onto the marsh, and to prevent water pooling behind these berms. Ditch maintenance should only be conducted outside of nesting times, and when fish use of the marsh is minimal, which is during the winter, late fall, and early spring.

Some ditch maintenance can be done by hand; nearly all, however, is best addressed by heavy machinery, such as self-propelled, low ground pressure, rotary ditching machines. A side-benefit of their use is that spoils can be sidecast into potholed areas, further minimizing mosquito breeding.

This kind of modified standard water management, where the maintenance activities are carefully planned, and targeted to achieve maximal results, is best suited for wetlands where existing conditions already meet the long-term expectations of the landowner and other involved parties. This is where marsh functionalities meet all identified basic requirements and the marsh is deemed to be in reasonably good health. The maintenance activities must also be approved by SCDHS Office of Ecology and SCDEE, and address concerns and issues that may be raised by local officials and other involved parties. However, the marsh also must have a localized mosquito breeding problem, one that is associated with failures of the ditch system.

As mentioned above, this is the most conservative means of large-scale water management, and will perpetuate existing conditions. Ditch maintenance is not appropriate for salt marshes with a history of continuing maintenance and ongoing aerial larviciding. The need to larvicide in the face of existing maintenance of the ditch system shows that some element of the remediation is not functioning properly. Either the existing grid system does not reach all of the areas where mosquitoes breed, or water quality cannot be maintained consistently, even for hardy killifish. This signals the need to take more intensive steps to address the mosquito problem.

BMP 5. Upgrade or Install Culverts, Weirs, or Bridges

The purpose of upgrading or installing culverts, weirs, or bridges is to increase tidal flow onto the marsh. This will result in mosquito control benefits, as it should improve water quality for predacious fish, and the increased tidal flow may lead to greater fish access to breeding areas. Poor water quality and reduced tidal flows are hallmarks of marshes where standard water management is often ineffective. In addition, increasing tidal flow will improve exchange between the marsh and the estuary. This, in turn, will improve access by marine species, increase salinity to favor native salt marsh vegetation, and potentially reduce *Phragmites* extent, and increase the areas of marsh covered by each tide. Because this is a major change to the hydrology of the system, it requires a permit under NYSDEC regulations.

There are many potential negative impacts to this action. Increasing flow through the water control structures could drain adjacent uplands, lead to flooding of upland areas during storm tides, and short-circuit drainage from the uplands out into the estuary.

Alterations in the tidal regime will affect vegetative communities present in the marsh. Salt-tolerant vegetation could be replaced by other species in areas that are no longer inundated. Pre-construction monitoring can determine the likelihood of any of these negative impacts, and other mitigations, such as self-regulating tidal gates, can be used to minimize hydrological changes while maximizing flow increases.

The need for augmenting flow through such structures can be signaled by the following problems:

- tidal lags;
- vegetation differences between marshes upstream and downstream of the structure;
- differences in key water quality parameters between the upstream and downstream marshes;
- flooding history; and
- constrictions (indicated by excessive flow velocities in the pipe).

Tidal restriction is widely recognized as the greatest problem for many remaining Long Island salt marshes, and has been a driver of remedial designs. SCVC involvement in this work stems from its responsibilities for "legacy" installations, and the knowledge that better water quality invariably means more fish, which tends to restrict mosquito breeding.

As with culvert maintenance (BMP 2), heavy equipment is almost always required. If roadways are involved, coordination with highway departments will be necessary. The greatest single impediment to these remedial projects is the coordination of resources if road reconstruction will be required or desired. Materials besides old structures may need to be disposed, due to the increase in size of the aperture(s) of the structure. Incidental impacts to the nearby marsh will need to be addressed, as well. Therefore, project planning needs to account for issues such as:

- the location for a suitable staging area for equipment and machinery during the project;
- the exact placement of the new culvert, weir, or bridge to obtain desired results;
- the management of machinery while construction is being performed in order to minimize impact;
- the removal and proper disposal of spoil generated; and
- the pre and post project sampling protocol to assess potential impacts.

To limit impacts to wildlife, this type of maintenance and reconstruction should be seasonally restricted to cold weather months.

BMP 6. Naturalize Existing Ditches

Part of the common, visceral reaction to grid ditched wetlands is the unnatural appearance of the geometric precision of the ditch layout. In addition, ditches tend to have berms along their edges. These berms can develop through natural accretion, as water welling out of the ditches as the tide rises will slow as it spreads over the greater marsh surface, and the loss in velocity induces sediment deposition, as slower-moving water cannot carry larger grain sizes. Berms may also be a remnant of construction or maintenance activities, as hand-operations or mechanical equipment often deposited spoils in piles near the edges of the ditch. Berms block some flows from the ditches, serve as barriers for killifish seeking access to the marsh under lowest flow conditions, and may capture water on the panel-side of the berm where it will create good mosquito breeding environments. Naturalizing existing ditches generally consists of incising meanders to create sinuosity across the straight-line existing plan. These meanders will break through the berms, establish a less linear environment, and may change the hydrology of the existing ditches by altering the rate of flow. Naturalizing the ditches is the use of techniques of deepening, shoaling, widening, narrowing, and creating meanders in the otherwise regular ditch network, in conscious mimicry of a natural stream path.

Naturalization of ditches will generally have small effects on mosquito breeding, and so is a technique best used to augment other means of controlling breeding. It also can be a choice made in the service of other marsh issues, such as aesthetics, while not ignoring concerns regarding mosquito breeding.

One potential technique could impact mosquito breeding directly. That is the incision of deeper, or deeper and wider areas, in a grid ditch layout, to provide additional refuges for killifish from wading bird predators. This may allow for the killifish to remain on the marsh longer and more successfully, which should increase their predation on any mosquito larvae in the general area.

Changing the hydrology of the ditches has benefits and risks. Meandering streams often have erosive patterns where the inside bank accretes and the outside bank erodes because of the velocity differential in the path lengths. The peat of the marsh is likely to be resistant to these impacts – as is demonstrated by the persistence of natural marsh channels and many ditches. Greater sinuosity can lead to more diverse micro-habitats, and create small areas of cover, which can lead to greater wildlife use of the channel. Meanders will increase streambed length, which should lower overall velocities of the tidal prism. This may encourage infilling, or may result in more natural dissipation of tidal energies. Net effects of naturalization will be difficult to determine a priori. This restoration approach needs close monitoring to ensure it does not devolve into unintended impacts.

Minimalist naturalizations involve only breaching berms. Creating small breaches in an existing berm may be done with hand tools, and only mildly affects the appearance and functioning of the existing ditch. The taper of the ditch can be softened, in another less intrusive form of naturalization. Although many natural marsh ditches have vertical banks, some find the appearance of the straight-sided, flat-bottomed grid ditches to be offensive. In addition, studies have shown steep sides impede fish access to the marsh surface. Therefore, tapering the edge of the ditch can be undertaken, using a low ground pressure ditching machine with side casting capabilities, preferably one with the ditcher mounted on a moveable arm to minimize movement and impact to wetland. Full-blown installation of meanders requires a low ground pressure ditching machine, and this work is most practical with a moveable arm ditcher. The use of heavy machinery would restrict these actions to cold weather months, when impacts on wildlife should be less.

If this action can be classified as a modification of existing ditches than it would not require a permit under the New York State Tidal Wetlands Regulations. If it were deemed as the construction of new mosquito control ditches, it would be classified as Generally Compatible Use – Permit Needed.

BMP 7. Shallow Spur Ditches

Spur ditches are an effective means of extending the impact of water management structures into the heart of mosquito breeding areas. This is a lesser impact means of attacking persistent mosquito breeding, where standard water management has not succeeded in reducing larvae presence to avoid larvicide applications. Spur ditches are shallow, narrow waterways that connect ponds, channels, or ditches to areas of known breeding. The intent is to allow more frequent access by killifish to the areas where mosquitoes are known to hatch, without all of the impacts associated with a full-depth ditch. Spur ditches can also be used as means of connecting ponds and pools to channels and ditches, and yet the shallowness of construction ensures that water will remain in the pools and ponds even at low tide. This enables these bodies of water to be hydraulically connected to the estuary without drying during tidal cycles. This means they can continue to serve as fish habitat throughout the tidal cycle, and so support more robust fish populations within the marsh. The connection to the estuary may result in better water quality in what might otherwise be an isolated water body with a potential for stagnated water quality.

Construction of spur ditches can be accomplished by either hand or with the use of machinery, dependent on several factors (i.e., site accessibility, length of ditches to be constructed, disposal of spoil, and the presence of a substantial vegetation to prevent erosion of existing marsh surface). The use of hand tools is practical for small spurs and creates minimal impact to the wetland; hand work is not usually seasonally restricted. Longer spur ditches should be constructed by machine. The cutter head should be as small as possible, as that minimizes the chances the operator will cut too deeply.

It may be possible to classify the construction of spur ditches as the maintenance of existing water management structures, which would not require a permit under the New York State regulations. However, it is more likely that spur ditch construction will be classified as new ditch construction, and so a permit may be required, although it should be considered a Generally Compatible Use – Permit Needed.

BMP 8. Back-blading and/or Sidecasting Material into Depressions

Spartina patens tends to grow in groups of plants, so that it forms raised areas above the general elevation of the marsh. This creates small potholes, "ankle-busters or –breakers," familiar to all who have walked across a South Shore marsh. These small potholes are very effective mosquito habitat, because the area where *S. patens* thrives is not regularly flooded, but rather only is covered by water on the higher monthly tides. Salt marsh mosquitoes need this kind of irregularly flooded terrain for eggs to mature and require standing water for the larvae to grow. The potholes, especially in dense vegetation where evaporation may be limited, serve this function well.

Larviciding can have limited effectiveness in such areas. The small potholes tend not to be hydrologically connected at all times, so the pesticide needs to reach each little area to attack the larvae. Vegetation cover may hinder this. The limited fish habitat provided in the ditches may mean that fish may not be as adventurous in seeking out the farthest potential sources of food, if they must also retreat with receding tides. Ponds and spur ditches may provide either more secure high marsh fish habitat, or better access to these potholed areas. However, it is not clear that all potential breeding habitats can be accessed, no matter how dense the network of ponds, channels, and spur ditches.

Elimination of the potholed areas does provide a clear solution to breeding in these areas. Spreading material out to smooth the micro-topography is successful when wet marsh sediments are used for this task, as their plasticity makes them good at filling nooks and crannies under the plants. The application of several inches of sediments rarely has any deleterious effect on existing vegetation, as the plants are limber and rapidly spring back or sprout through the surficial application, depending on the time of year. Other jurisdictions have noted that these kinds of applications of sediment often encourage spreading of *S. patens*, thereby reducing the clumping effect that was responsible for the development of the pothole terrain in the first place. The depth of material for rapid plant regrowth is on the order of several inches. Where sediments are spread more thickly, as is common in some New Jersey applications, for example, it may take several growing seasons for full recovery of vegetation to be realized. However, it has been generally found that even smothered marshes will revegetate with the applicable plants associated with the hydrology, meaning *S. alterniflora* dominated communities for regularly flooded areas, and *S. patens* communities where irregular flooding is maintained. These projects can sometimes cause changes in overall flooding patterns due to hydrological modifications, but typically, at several inches in depth, the amount of material spread on the marsh is far too little to cause changes in tidal flooding patterns in and of itself. The process is slowest when asexual propagation via runners, rather than resprouting or seed dispersal, is the predominate means of pioneering the sedimented areas.

The source of the material can be ditch maintenance or the construction of channels, spur ditches, or ponds. The material can be applied either directly via sidecasting from a ditching machine, or through various blading techniques by low ground pressure equipment.

There are some concerns regarding this habitat elimination technique. Application of excessive amounts of material could elevate the marsh surface, creating drier conditions which could encourage undesired vegetation changes such as encroachment by *Phragmites* or shrubby upland vegetation. The depth of material across the marsh surface must be limited to a depth where it can be "absorbed" without an overall change in the elevation of the marsh surface, as seemingly minor changes in the elevation can enhance competitive exclusion, especially by *Phragmites*. Damage to roots can occur through too frequent tracking across the area being treated, and ruts are always a concern, even with low ground pressure equipment. Seeding is one approach when pannes are filled. In

New Jersey, without seeding, pannes have been found to vegetate, but it often requires years for appropriate vegetation to seed or spread to the area by runner. Filling potholes or pannes with sediment from areas where *Phragmites* has colonized has the risk of spreading *Phragmites* by sidecasting seeds or rhizome pieces. Thus, not all sediment may be suitable for redistribution.

Either technique, sidecasting or back-blading, requires the use of heavy equipment and therefore is time sensitive. Impacts to flora and fauna must be evaluated prior to commencement of either of these actions. Low ground pressure, side casting ditching machines with a back blade apparatus attached would be the preferred machine for these actions. The back-blade attachment would allow for "touch-up" of the side-cast material.

The technique that generates this material will determine its regulatory status. If generated from ditch maintenance activities, no permit is required. If the material is generated by construction of channels, spur ditches, or ponds, the regulatory status of each of those actions will apply to the management of sediment generated by them.

BMP 9. Small (500-1000 sq. ft) Fish Reservoirs in Breeding Areas

It is believed by many that the construction of grid ditching fundamentally altered marsh hydrologies, with the main impact being the loss of surface waters from the marshes. There are many examples where this is the case. There may also be approximately as many examples where the loss did not happen, according to contemporary accounts, or where modern grid ditched marshes support an array of surface water features. Research in New England generally found that grid ditched marshes had fewer ponds than marshes that were not ditched.

One relatively consistent intent of OMWM techniques is to establish ponds and pools on the marsh surface. These are intended to be fish refugia. When breeding problems are intractable under standard water management, provisions to ensure fish presence on the high marsh need to be implemented. This may be the least intrusive and most natural appearance of the potential means for achieving better fish habitat. New Jersey has had great success in reducing larviciding over large areas of high marsh by installing series of ponds in mosquito breeding areas. Ponds are optimally placed where mosquito breeding is most intense. This can lead to conflicts with vegetation specialists, or with marsh managers where wetlands are measured in terms of vegetated acreage, as is the case in New York. Replacing vegetated wetlands, almost always high marsh, and very often *S. patens*-vegetated marsh, with open water features, leads to an overall loss of wetland acreage, according to the New York State definition of wetlands as the area of vegetated wetlands. That is a violation of many policies and precepts, and New York State law. The construction of very small ponds ameliorates this impact, as the loss of vegetated wetlands associated with any one pond is negligible. Based on data collected in New Jersey and throughout New England, it can also be shown that Long Island marshes nearly all have much less open water than is usual for natural marshes Open water should be 20 to 25 percent of the entire surface area according to the New Jersey study, and approximately 10 percent of the marsh according to the New England data. Thus, arguments can be made that small ponds have no discernable impact on overall marsh acreage, and merely make a small dent in the overall open water deficit found for most County marshes.

Small fish reservoirs make for major habitat improvements for insect consuming fish that voraciously feed on mosquito larvae. These reservoirs should be constructed in areas where potholes or breeding pannes occur. It is best if the sites can be selected in areas that have little or undesirable vegetative cover. The pond should have a cross-section in the shape of a saucer or spoon, with a maximum depth of 30 to 36 inches. Reservoirs should have gentle slopes and offer shorebird foraging areas, ranging in depth from six to 24 inches. A sump should be located within the reservoir, with a maximum depth of 30 to 36 inches deep to provide a refuge for fish.

The excavated material can be used to either fill ditches, or to fill potholes and other breeding areas. If ditches are to be filled, then an excavator must be used in conjunction with a dump-body hauler. The top layer of vegetative matter should be stockpiled, and set in the ditch last, in order to jumpstart the revegetation process. If ditches are not to be filled, the material can be spread across mosquito breeding habitat. This habitat is characterized by the presence of potholes and pannes. Thin layers of material can be spread to fill these areas where water collects. The physical material prevents water from accumulating and it may also encourage the spread of root mat material from typical clumpy *S. patens* patches. The material can either be spread, if an excavator is used for the pond, by back-blading with grading boxes, or using bulldozer blades. Alternately, the pond can be dug using a ditcher with a swivel head. Fixed arm ditchers can also be used, but care needs to be taken that multiple track swaths do not lead to excessive ruts on the surface of the marsh.

It is very important that pond construction be carefully planned. Pond locations should be located in areas of demonstrated mosquito breeding. The pond boundaries should be indicated clearly, using wooden stakes, and the overall design plan adhered to. There should be design consultation with resource specialists to optimize ancillary benefits such as water fowl use and/or creation of wading bird habitat.

Certain studies of marsh loss and overall marsh quality deterioration have implicated increasing surface water, especially in the interior of the marsh, as the cause. It is clear that increasing amounts of surface water correlate with ongoing marsh losses in many settings. Whether growing amounts of interior surface water causes the problem, or is merely symptomatic of some other underlying root cause is the subject of ongoing scientific research. By and large, most studies of the individual marshes with increased surface water and marsh deterioration have found other causes besides increasing amounts of interior surface water as the most probable reason for vegetated marsh losses.

The County believes it is too conservative to avoid interior marsh surface waters because of the correlation to ongoing vegetated marsh losses. In most settings where OMWM ponds have been installed, such as New Jersey and Connecticut, reports on resulting marsh health show no such impacts. Most pond creation in nearby jurisdictions results in uniformly good reports on ecological and other environmental effects, and also report consistent, persistent mosquito breeding control.

It is clear that pond construction requires heavy machinery, and will need associated restrictions regarding seasonal construction windows and site accessibility. Although New Jersey has had good success with year-round construction, frozen marshes limit tracking impacts. In addition, unless ditches are to be filled, it is preferable to use low ground pressure rotary ditching machines with side casting capabilities. The rotary ditcher should be attached to a moveable arm in order for the action to be completed with minimal amount of movement, reducing the impact on the wetland.

One interpretation of the New York State Tidal Wetlands Regulations is that this kind of BMP is an extension of standard water management techniques. Therefore, it could be viewed as akin to the construction of new mosquito control ditches, and so would be treated as Generally Compatible Use — Permit Needed.

Table 3. Management Activities for Minor Impacts

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

NPN - Uses not requiring a permit
GCp – Generally Compatible Use – Permit Required
Pip – Presumptively Incompatible Use – Permit Required
I – Incompatible Use
P – Permit Required
NA – Not Applicable
* local regulations may or may not be more stringent than these State regulations

3.3 Class III: Major Impact

There are six water management activities that result in major impacts to a salt marsh. Application of these techniques requires a clear understanding of the marsh being treated and careful consideration of potential impacts. Because the potential for major impacts exists, these techniques should only be employed when a serious mosquito problem exists, or in the service of other overriding concerns of the landowner or other involved parties. In many instances, these BMPs offer the opportunity for significant natural resources enhancement.

The potential for impact increases the scrutiny of these kinds of projects. It is likely that the permitting process will be more complex and involve more parties than the less impactful measures discussed previously. Interested parties in such actions include NYSDEC, USACOE, local agencies such as towns and town trustees, and others involved in marsh management. While the County may have an interest in assisting in the permit process, as mentioned earlier, it is the responsibility of the landowner to collect approvals as required.

BMP 10. Break Internal Berms

In some instances, substantial levees, berms, roadways, or dikes have been constructed that hydraulically isolate part or all of the salt marsh from part or all of tidal flow. This impacts water quality, making it difficult for insect-consuming fish to maintain themselves. This also may result in shifts in vegetation patterns. It is especially supportive of *Phragmites* invasions, as *Phragmites* does best when water conditions are less saline.

The considerations associated with improving culverts apply in this condition. However, because the modification of exiting hydrology is much greater (in most instances), and often affects larger areas of marshland, these decisions must be made carefully with much planning. Breaking internal berms, such as those along ditches or those created by roads and paths across the marsh, will improve fish access to mosquito breeding sites as well as prevent stagnant water where mosquitoes are likely to breed. By implementing this technique, estuarine species may gain better access to the marsh. In addition, waterlogging of soil and loss of high marsh vegetation may also be prevented by this action. Conversely, excessive drainage of pannes and pools and the introduction of tidal water into areas where it is not desired are potential negative effects of this technique. There may be additional impacts in terms of removal of flood protection, vehicle access, or whatever other original goals were associated with the installation of the berm.

In order to limit any potential negative effects of breaking berms, the depth of cut through the berm should be limited to that necessary to restore the desired degree of tidal connection. The same series of problems associated with culverts should be avoided in this work, including:

- tidal lags;
- conditions that support vegetation differences between marshes upstream and downstream of the structure;
- differences in key water quality parameters between the upstream and downstream marshes;
- creation or support of conditions likely to result in flooding of adjacent property; and
- constrictions (indicated by excessive flow velocities in the pipe).

Tidal restriction is widely recognized as one of the more serious problems facing many of the remaining Long Island salt marshes. Because it is a visible problem where solutions appear to be easily determined, tidal restrictions have been the subject of many remedial designs. It is possible that restorations to tidal restrictions can have negative impacts, such as draining of adjacent wetland uplands, flooding of upland areas during storm tides, and potential short-circuit drainage from the uplands out into the estuary. Alterations in the tidal regime will affect vegetative communities that are present in the marsh, which may or may not be desired. Mitigations, especially such as self-regulating tidal gates

,although these have been rarely implemented on Long Island, can be used to minimize hydrological changes while maximizing flow increases.

This technique would require the use of heavy machinery and the associated restrictions such as a seasonal timeframe for construction windows and site accessibility. Coordination with other parties associated with the berm will be required. Also, a determination of the type of equipment to be used depends on what will be done with the spoils generated from this action. If the spoil can be disposed of on site by either back blading or side casting, then a low ground pressure, side casting ditching machine with a back blade attachment will suffice. If the material needs to be removed from site, a low ground pressure backhoe and dump body truck may be required to remove the spoil from the marsh. In addition, if the spoil must be removed from the site, an upland disposal area must be located prior to commencement of this action.

A permit for this action is required under the New York State Tidal Wetlands regulations.

BMP 11. Tidal Channels

Tidal channels or salt marsh creeks are integral features in most salt marshes. A striking feature of some South Shore marshes is the absence, or relative paucity, of such features. Tidal creeks can also be important to conduct salt water to areas of the marsh that appear to suffer from an excess of fresh water, as where *Phragmites* is expanding. In some instances, it appears that fresh groundwater discharges into the upland fringe area of the marsh, creating fresher conditions there. These channels have the potential to convey this seeping fresh water away. Tidal channels can serve as excellent fish habitat, and also can conduct good quality estuarine water into the interior of the marsh.

A tidal channel is a water body engineered to have natural features that should allow it to maintain itself, and to mimic the functions of natural marsh creeks. This means that these features will taper from the estuary to the back of the marsh, and will contain meanders, wider portions of channel, and potentially have narrower stretches. The depth of the channel can vary, as well. The intent is to facilitate the transport of estuarine water into back marsh areas and improve habitat for fish to enhance mosquito control efforts. This is accomplished by improving exchange between the marsh and the estuary. This should lead to improved access to the marsh by estuarine species, increases in marsh water table salinity to favor native salt marsh vegetation, and a greater extent of tidal inundation. These features can result in major changes to the hydrology of the marsh, and should be considered carefully. Tidal channels have the potential to cause excessive drainage of adjacent uplands or flooding of adjacent areas during storm tides. They may also result in short circuiting of any overland flows from adjacent uplands. In order to limit these adverse effects, installed tidal channels should be limited to tidal areas (thus the denoted "tidal channels"). A buffer between the channel and upland should be provided. A sill connector to the estuary could limit drainage from the creek during low tide. In addition, sill ditch connectors between the tidal creek and any other marsh surface waters could also promote the intentional retention of water on the marsh during lower tides.

Tidal channels are used as a supplement to other efforts to control mosquitoes. In and of themselves they are unlikely to have major impacts on breeding. Tidal channels can be a useful component of a larger project if they meet the overarching design needs for the project. Tidal channels are expected to be extremely useful in restoring overall tidal circulation to control *Phragmites* and will often be helpful in promoting better water quality to ensure fish presence in the high marsh. Tidal channels are likely to be important for certain wildlife habitat focused projects, especially those seeking to improve estuarine fish use of the marsh. Tidal channels may be an essential ingredient of a marsh restoration that focuses on aesthetic improvements, such as ditch removal, or to adjust what otherwise is a "marsh reversion" project (see BMP 1).

Tidal channels will be dug using heavy equipment, and so seasonal and access-related restrictions will apply to these efforts. Low ground pressure ditching machines can be used for construction. Fixed arm machines will be less useful than those that have more flexibility. Machines with flexible arms are better at constructing curved waterways. Spoils, especially if generated in *Phragmites* areas, need to be managed carefully. One possibility is to sidecast *Phragmites*-laden spoils away from *Spartina* areas, potentially directing the material into existing *Phragmites* stands. If the material needs to be removed from site or will be used to fill existing ditches on the marsh, a low ground pressure backhoe and dump body truck is required to redistribute or remove the spoil from the marsh. Also, if the spoil must be removed from the site, an upland disposal area must be located prior to commencement of this action.

These projects need to be carefully planned, with the proposed channel designed not only to determine where it should go, but also for selection of the appropriate widths and depths for the various stretches of the channel. A potential tool is the wetting-drying model developed for the South Shore Estuary Reserve by the Marine Sciences Research Center, Stony Brook University. This model can be extended into adjacent salt marshes, if appropriate survey information is available, for nominal costs. Then various channel scenarios can be modeled under realistic projections of water flows even as the tidal waters rise out the creeks, and later retreat into the estuary.

It may be possible to treat such channels as new mosquito control ditches, which is classified as Generally Compatible Use – Permit Needed under the State regulations. However, it is also possible this will be classified as an essentially unclassified action, requiring a permit process absent the assumption of compatibility with the regulations.

BMP 12. Ditch Plugs

A common implementation of OMWM is to construct ditch plugs to retain water in existing mosquito ditches. In fact, until the Long-Term Plan OMWM Demonstration Project at Wertheim NWR, ditch plugging had been the only kind of OMWM conducted in Suffolk County. The first effort was at Seatuck NWR in the mid-1980s. Other notable efforts with County involvement included earlier efforts at Wertheim NWR, Fireplace Neck, William Floyd Estate, and Goose Creek. The Town of East Hampton has also conducted some ditch plugging, in concert with Cornell Cooperative Extension and The Nature Conservancy, notably at Napeague. The plugging of ditches, as a mosquito control technique, is intended to enhance fish environments by providing refuges from predators. Ditch plugs also create tide cycle-proof habitat for fish, allowing them to remain in proximity of breeding locations, whether or not the ditches would have drained at low tide absent the plug. Some have also asserted that creating higher water tables, as may result from plugging, will reduce potential mosquito habitat through oviposition disturbance, as salt marsh mosquitoes require damp but not inundated soil to lay eggs. As a salt marsh restoration action, it is intended to restore pre-ditching water regimes, by elevating water tables that may have been drained by the ditches. It may assist in *Phragmites* control because it potentially keeps salt water within the marsh. This is based on the concept that the water in the ditches will tend to be saltier, as salt water is denser than fresh. If there is any density separation between salty estuarine water and fresher inputs, the fresh water will be more buoyant and drain over the top of the plug first. Ditch plugging can enhance natural resource values by creating more surface water; as noted, Suffolk County marshes appear to be generally deficient in surface water percentages compared to other area salt marshes. Plugs are also expected to increase water retention time in the ditches. This could enhance any polishing impacts that occur within the marsh. This is the main impetus for the East Hampton projects, which are said to have been successful in reducing coliform loads to the harbor.

Plugs generally consist of standard size (four foot by eight foot) sheets of plywood driven into the peat to the level of the marsh surface, with the addition of marsh spoil. Plugs are intended to be installed to the marsh surface, with final elevations attained with adequate compaction of the emplaced materials resulting in quicker revegetation. Plug widths in Suffolk County historically have been on the order of three feet. This is generally considered to be inadequate by others employing this technique. A more progressive approach, as is generally espoused in Connecticut, would require 50 to 100 feet of plug, to reduce chances of blow outs or undermining by muskrats. Most plugs installed in the County have failed for these two reasons. The spoil required for plugging are generally obtained by deepening and widening the ditch behind the plug. Besides generating the materials required to create the necessary plug, deepening and widening the ditch enhances refuges for fish from wading bird predation by providing adequate protective depths. Plugs should extend laterally onto the marsh to prevent erosion around the edge of the plug. Plugs are likely to settle with time and be impacted by water flow prior to revegetation and stabilization, and so in many cases they are often initially installed to an elevation above that of the surrounding marsh. This may not be optimal, as such steps can lead to impacts to sheet flow patterns. Vigorous tamping can reduce the need to build above the marsh surface. Backhoes mounted on low ground pressure platforms are generally used for plug installation; smaller plugs can be created by hand, with much effort.

Potential negative impacts of ditch plugs on natural resources include a reduction in tidal exchange, a reduction of fish diversity in ditches, and impoundment of freshwater. The latter can lead to freshening of the marsh and potential *Phragmites* expansion. Most experiences have indicated that the reverse, an increase in overall salinity, is more likely to occur behind the plug. Drowning of vegetation is also possible if excessive water is held on the marsh. Maintaining salty water in the marsh often leads to changes in vegetation, as *S. alterniflora* will be promoted in the areas experiencing greater inundation.

A mitigation of some of these effects is to construct sill plugs, rather than plugs installed to the top of the marsh. Sill plugs terminate some distance between the surface of the marsh and the low tide level, usually on the order of six to 12 inches below the general marsh surface. This means that tidal exchange is not dependent on over-marsh flows, but will occur on every tidal cycle, or nearly so. Sill ditches need to be designed so that the volume of water released during lower tides is not so great as to cause continuing erosion of the sill. Sill plugs may be a sounder choice for where lower tidal ranges predominate, in order to ensure there is adequate water quality within the ditches, given the smaller tidal prism and therefore overall smaller exchange rates on each tidal cycle.

Open (no plugs), semi-open (sill), and closed (full plugs) OMWM efforts have generally been shown to be effective mosquito control techniques in all environments. Jurisdictions from Maine to Maryland have installed varying OMWMs. Of the jurisdictions most avidly pursuing these ventures, plug techniques have been favored most in Connecticut and Maine. Delaware has tended to use a variety of approaches. New Jersey has focused mostly on open systems, albeit also creating many isolated ponds. The only jurisdiction expressing great concern regarding this technique is Maryland, where endangered species habitat loss appears to have become a paramount salt marsh management issue, and research has indicated a strong correlation between increases in surface water within marshes and on-going marsh losses. However, there have been few if any OMWM installations under the kind of micro-tidal regimes found on the South Shore of Suffolk County.

Broadly speaking, closed systems seem to be best suited for higher tidal regimes where surface water losses may be a grave concern, and open systems best in the lowest tidal ranges where marsh interior water quality is a primary issue. However, a major determinant of OMWM suitability for a particular marsh is the refinement of "ancillary" concerns. Closed systems may not be appropriate where managers wish to encourage interchange between the marsh and the estuary, especially for finfish. If excessive water levels are a concern, open or sill systems will be better choices. Where more open water is desired, the use of ponds or closed ditches will help achieve that goal.

Clear delineation of the location and extent of plugs needs to be made. Modeling, as with the wetting-drying model, may be of some use in selecting the most appropriate kind of OMWM.

OMWM installations require permits from NYSDEC under current interpretations of the Tidal Wetlands Regulations.

BMP 13. Ponds above 1,000 sq. ft for Wildlife Value

BMP 9 discussed the myriad virtues associated with ponds constructed in the high marsh. It may be that the landowner/marsh manager has an overriding need for larger ponds, as was the case with the USFWS for the Wertheim OMWM Demonstration Project, to enhance water fowl habitat, but other reasons could be set forth. These might include a need to mimic the general pattern in New England salt marshes of a mosaic of pond sizes. Research shows that there is a general distribution for natural ponds of various sizes across unditched salt marshes in New England. Larger ponds need to be designed so that they maximize the intended use. Water fowl specialists study how pond shape and the size of "bays" and other nooks influence water fowl numbers on a particular water body, for example. Larger ponds may receive greater scrutiny from regulators, however, as they may be in conflict with no-net loss policies and regulations.

Larger ponds geometrically increase the effort of construction. As with smaller ponds, spoil from pond excavation may be side-cast or back bladed into depressions or used to raise ditch depths and plug man-made ditches. However, it is unlikely all the spoils can be side-cast efficiently from a larger pond, and back-blading or other forms of touch-up work will almost certainly need to be conducted. Repeated equipment passages over the same areas of marsh can lead to rutting and damage to the plant root structures. This kind of impact is much more likely for larger ponds due to the many more vehicle trips associated with excavation and spoil management. Bottom topography should be based on mimicking that associated with a series of smaller ponds, to create more micro-habitats. That is to say, uniform bottom depths are generally to be avoided, as the creation of too much deeper or shallower habitat will not benefit all of the needed or desired communities. The use of sills to encourage water exchanges is another key design determination. A sill will result in varying water levels in the pond, which is often an important element for certain wildlife use, while preventing the pond from completely emptying during low tide stages. Other species may not welcome such variations.

This action requires the use of low ground pressure machinery and the management of the spoil dictates the type of equipment required to incorporate this technique. If the spoil is to be distributed in the immediate area of the pond, the use of a rotary ditching machine with the ditching apparatus attached to a moveable arm is recommended. This type of machinery will perform the operation with fewer tracking movements and therefore less impact to the marsh surface. It is unlikely that the side-casting will be completed properly by this machine, and some remedial back-blading is probable.

If the material needs to be removed from site or will be used to fill existing ditches on the marsh, a low ground pressure backhoe and dump body truck may be required to redistribute or remove the spoil from the marsh. If the spoil must be removed from the site, an upland disposal area must be located prior to commencement of this action.

Large ponds will almost certainly require a permit under the Tidal Wetlands Regulations. They need to be carefully engineered, with the exact perimeter staked and plotted in advance of construction. The distribution of shallow and deeper areas within the pond needs to be communicated clearly with the operators performing the work and the monitors overseeing construction. Attention to wear and tear to the immediate surroundings is an important construction element. This is often a function of vegetation type as well as the underlying substrate, as hardier vegetation may withstand traffic that more delicate vegetation cannot. Construction under frozen conditions may be optimal for larger ponds. Coordination with permitting agencies and concurrence of the land manager and other interested parties with clear project goals are essential to achieve optimal results.

BMP 14. Filling ditches

The ultimate restoration of salt marshes for many planners is to undo the grid ditch system. This can be done by filling the ditches. Such an operation is difficult to conduct without other remediation activities. since the spoil for the ditch filling needs a source The best material for this purpose would be salt marsh sediments. Removing the mosquito ditches eliminates the water management tool currently in use. Therefore, ditch filling is unlikely to be done without constructing an alternative water management system – one such as tidal creeks and/or ponds, as these can generate the large quantities of fill needed. Ditch filling may be a mitigation to meet requirements of no net loss of vegetated wetlands when surface water features are proposed.

The intent of ditch filling is to remove the visually intrusive grid ditch system, and to restore the marsh to earlier, pre-ditching conditions. This assumes that earlier hydrological and vegetation conditions will return – an assumption shared with Natural Processes, BMP 1. It is clear that this action must be a goal of the landowner/land manager and other involved parties. If ditch-filling is proposed for an area with an existing mosquito problem, the need for alternate water management is clear. The needs where mosquito control problems are not as difficult are unclear. Then the project becomes much more of a restoration project than a mosquito control project.

The filling of ditches can deny mosquito breeding habitat if the ditches themselves were habitats made through blockages that created stagnant water in them. Potential negative effects of filling ditches may be the loss of ditch habitat for fish and other estuary species, and the loss of habitat for other wildlife using the ditches. If fresh water is retained on the marsh because the ditches were successful in draining standing water resulting from precipitation, *Phragmites* may invade the area. Vegetation drowning may occur if excessive water remains on the marsh surface. Tidal circulation may also be lost as a result of ditch filling. There is the possibility of creating new mosquito breeding habitats if ditches are not properly filled, or if filling leads to the creation of new habitats by making the marsh wetter, or by restricting fish access to breeding locations. A mitigation of some of these impacts can be to conduct selective ditch filling as part of an overall project. Ditches that do not provide circulation or other benefits could be selected to be filled. A tidal channel or features such as ponds or sill ditches can be implemented to replace functions lost by filling ditches.

Obtaining material for ditch filling is the governing factor for the type of machinery necessary to perform this operation. If the material used to fill ditches is generated from the construction of new tidal creeks, then low ground pressure backhoes and dump body machinery will be needed. In addition, the depth of fill in the ditches should not raise the marsh surface above the level flooded by spring tides. Importing material, from either upland sources or perhaps from a dredging project, may not be well-received by regulators and other interested and involved parties. This factor is one which suggests ditch filling is most likely to occur in projects where other activities on the marsh generate excess spoils.

Project planning is extremely important for this major change to the marsh. Modeling would be useful to explore impacts of altered hydrology. Careful pre-project surveys of ditch conditions and water quality will enable good choices to be made. Resource and permitting agency involvement at an early stage is essential, as is good communication of the landowner's needs to these involved agencies. All involved parties must understand exactly what will constitute a successful execution of a project like this, and determine exactly how these ends will be measured.

BMP 15. Dredge Material Removal

Dredge material disposal sites often impinge upon salt marshes. This can create uneven topography that supports mosquitoes, often those associated with the upland fringe, such as *Aedes vexans*, the flood water mosquito, or *Culex salinarius*, the unbanded salt marsh mosquito, rather than *Oc. sollicitans*, the classic salt marsh mosquito. More importantly these sites constitute a blight on the salt marsh and often impede water flows in some fashion. Thus, they are frequent targets for classic restoration actions. Therefore, SCVC will assist in removing dredge spoils from marshes, and restoring the habitat to more standard salt marsh vegetation regimes. However, as these sites are almost never in the intertidal wetlands but rather are in the irregularly flooded high marsh, and the classic restoration would be plantings of *S. patens*, SCVC interests also include precautions to avoid the development of mosquito breeding habitat.

To limit potential adverse effects, grading should be supervised to ensure even and appropriate elevations are achieved. Consideration for the provision of fish access from good fish habitats should be included in the design. Many alternatives to achieve this have been previously discussed. Good tidal exchange to help create better water quality will be important. Plantings need to be monitored to ensure that unwanted pannes do not develop and that *Phragmites* does not take advantage of this pioneer situation to advance further. Monitoring should also include a concern for the development of slow draining puddles and pools at microtopographical lows.

The removal of dredge spoils will almost certainly be a major earth-moving operation. This kind of alteration will require permitting by interested and involved agencies, not the least of which is NYSDEC (under the Tidal Wetlands Regulations). However, a well-designed and –considered project should garner approval, given the damage done to marshes historically by filling operations, and the benefits to be reaped by undoing this kind of damage.

Different types of machinery may be needed depending on the location of the spoils and the scope of the project. The disposal of the spoils is likely to be a key issue. Beneficial reuse opportunities for such materials are generally limited and that is usually why upland disposal was originally called for. Now that the spoils are almost certainly dewatered, they may have applications as general fills. Landfill disposal is certainly much more feasible as a thoroughly dewatered material, although it may not be the least expensive option. It may be that conventional earthmoving equipment will be appropriate for much of the work. When near-to-final grade is reached, then marsh-suitable equipment may be needed for the final stages. These kinds of decisions need to be made based on site-specific conditions.

Table 4. Management Activities for Major Impacts

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

NPN - Uses not requiring a permit
GCp – Generally Compatible Use – Permit Required
Pip – Presumptively Incompatible Use – Permit Required
P – Permit Required
I – Incompatible Use
NA – Not Applicable

* local regulations may or may not be more stringent than these State regulations

3.4 Interim Actions/On-going Maintenance Activities

It will not be possible, following initial evaluations of the conditions at various salt marshes in the County, to ensure that the BMP most appropriate for each particular marsh can be installed immediately. In fact, in some cases a rather long time period may be required before the BMP can be undertaken. Fiscal realities and equipment scheduling may lead to some delays (although it is anticipated these will be relatively short-term under most conditions). Other factors that may affect the ability to conduct a BMP would be landowner unwillingness or uncertainty regarding the proposed project, and, in some instances, failures to conduct necessary public planning processes. This is an issue for the many New York State Tidal Wetlands in the County. Prior to undertaking major restoration activities there, Unit Management Plans need to be adopted by NYSDEC. It is unclear if each wetland is required to be assessed separately, or if the holdings can undergo a single unified review. It is clear that this public process generally requires a year or more to complete when full attention is given to the process. Given staffing realities and program priorities, it is unlikely that the State wetlands will undergo this planning process in the very near future.

Therefore, four IMAs have been identified. These are generally not to be the optimal BMPs for the wetland to which they are applied. Nonetheless, the IMAs provide SCVC with a means of providing a degree of progressive water management on an interim basis until the necessary steps can be taken to conduct more appropriate BMPs at the salt marshes.

The presumptive preferred interim action is to be reversion of the marsh. It is understood that reversion may not be optimal for many of the County's marshes. Therefore, careful monitoring of all reversion sites will be undertaken. Reversion will be the adopted management action until a preferred, long-term restoration management plan is adopted for the site in question.

Selective ditch maintenance has been identified as an IMA. This is for two reasons. One, ditch maintenance, when conducted carefully and thoughtfully, has the potential to reduce mosquito populations, primarily by providing fish access to mosquito breeding areas. Implementation of this IMA will focus on enhancing water quality in the areas where mosquito breeding is occurring, and in improving overall fish habitat values to encourage killifish populations. Secondly, as an interim action, it has the advantage of being a minimal change to existing marsh conditions. Although opportunities for greater enhancements are not being immediately realized, neither are most other BMPs that might be implemented at the site being eliminated from consideration. Ditch maintenance, in this view, will constitute a holding action until a better alternative can be selected and designed. Ditch maintenance is not expected to be widely practiced and is expected to be applied to 50 acres or less for every year of the Long-Term Plan.

IMA 1. Natural Processes (No action/reversion)

The presumptive policy of the County for interim actions is to allow natural processes to occur. This is to advance a position that non-intervention in natural systems will provide benefits that exceed those associated with ecological management. However, it is also acknowledged that reversion may not be optimal for all marshes. To ensure this policy does not result in negative impacts to County's marshes, monitoring will be conducted. It is assumed that remote sensing capabilities will allow for the determination of gains and losses of vegetated wetlands at each marsh, and will be able to distinguish between low marsh, high marsh, mixed vegetation-type areas, and *Phragmites*-dominated areas. These measurements will be analyzed for trends, and if potential impacts are noted for a marsh, a site investigation will be made to determine if reversion is the cause of the problem.

Reversion, as an interim activity, is intended to serve as a bridge between past practices and a selected, long-term marsh restoration management plan. It may very well be that reversion is selected as the long-term management technique.

IMA 2. Selective Ditch Maintenance (Standard Water Management)

Ditch maintenance has been applied to the grid ditched system, with various degrees of enthusiasm, skill, and forethought, for approximately 70 years. When maintenance activities have been most frequent or intensive, anecdotal evidence would indicate that mosquito populations were reduced effectively. When applied indifferently, ditch maintenance has had a more spotty record regarding mosquito control. It should be emphasized that maintenance of existing ditches is not the same as installing new ditches. Ditch maintenance is successful when it either helps drain mosquito breeding habitats, or provides good access for mosquito consuming, hardy marsh fish to the breeding habitats. It is most likely that fish predation is the more effective means of mosquito control on the South Shore. In two marsh systems with equally unclogged ditch systems, the one with better tidal circulation and associated better water quality will generally produce many fewer mosquitoes, most probably because fish are more able to withstand the rigors of the marsh and conduct effective predation. Therefore, prerequisites for action include the identification of a mosquito problem, with continuing aerial larviciding being the number one signal of an ongoing problem, together with an inability to apply a preferred optimal BMP at the site at this time. In addition, observations need to be made supporting the need for selected maintenance to stretches of key ditches.

The technique will have five goals:

- improve tidal circulation within the marsh by removing blockages to water flow to the high marsh;
- potentially deepen areas behind clogs as a means of enhancing fish habitats;
- clean ditches that are essential for fish to reach areas where mosquito breeding is documented;
- naturalize the ditches, where appropriate, (see BMP 6) so as to minimize impacts of ditching on the marsh, especially in terms of aesthetics; and,
- determine if simple modifications to the existing ditch system, such as widening the mouth of a particular ditch, or blocking flow from one area of the marsh to another, could prevent the need for future ditch maintenance.

Selected, key parts of the ditch system will receive appropriate maintenance so that the biota of the marsh can combat the existing mosquito problem.

The preferred means of conducting ditch maintenance have been discussed in BMP 4. Those precepts hold for this Interim Maintenance Activity (IMA). The County anticipates conducting selective ditch maintenance at a rate of perhaps 50 treatment acres of tidal wetlands per year over the ten year implementation period. This suggests that at most approximately 500 of the 17,000 acres of salt marsh in Suffolk County might receive this interim action over the course of the Long-Term Plan. Any ditch maintenance activity, even as an interim action, must undergo review by SCDHS Office of Ecology and SCDEE, and be subject to cooperative resolution of the concerns and issues of local agencies and interested parties.

IMA 3. Culvert Repair/Maintenance when Tidal Restrictions are Apparent

Alteration of an existing culvert system when tidal restrictions or other flow problems are apparent is the preferred BMP (see Upgrade or Install Culverts, Weirs, or Bridges, BMP 5). However, these kinds of actions often require close coordination with highway departments, and may involve funding issues should major roadway reconstructions be involved. These can lead to delays of several years until the preferred action can be undertaken.

Therefore, as an interim action, SCVC will clean and maintain undersized or incorrect existing water control structures in order to alleviate the immediate problem. This IMA would follow all of the concerns and issues associated with BMP 2 (see Maintain/repair Existing Culverts, BMP 2) except it is understood that the action will be made even though conditions indicate a better action should be selected. When the necessary processes have been completed, then BMP 5, or something similar, will be applied.

IMA 4. *Stop-gap Ditch Plug Maintenance*

Currently, many of the ditch plugs installed in County salt marshes since 1986 are failing or have failed.

There are three options for these situations. One is to re-evaluate the project area, and select a BMP that will be successful. This is the preferred option. However, logistics or other impediments may make it impossible to immediately conduct the BMP at the area in question. If this is the case, then one of the following two interim actions could be undertaken.

One interim action would be to selectively maintain the ditches so as to improve water quality (IMA 2, above). A second choice as an interim action, where information exists that the ditch plugs appeared to be achieving the goals associated with the restoration project, would be to reconstruct the plugs, similarly to their original construction. For example, anecdotal information associated with most of the OMWM projects conducted in the County indicates that they achieved notable natural resource improvements, including greater water bird use of project marshes, and apparent increased nekton use in the altered ditch environments. Although three-foot ditch plugs are rarely identified as an optimal OMWM technique, these kinds of plugs could be re-installed as an interim measure until a more appropriate BMP can be installed. The typical installation methodology would be followed, with plywood sheets used to stabilize the plug, and a small reservoir established to provide the necessary spoil material. This is only acceptable in that these plugs are not intended to be permanent, but rather are temporary actions that appear to be justified in terms of past marsh responses to the original plugs.

The County will seek to have this accepted by NYSDEC as a variant form of ditch maintenance, which would obviate the need for a permit. It may be that the regulations will be interpreted that these kinds of actions, although a Generally Compatible Use, will require a Permit.

Table 5. Interim Management/Ongoing Maintenance Actions

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

NPN - Uses not requiring a permit GCp – Generally Compatible Use – Permit Required Pip – Presumptively Incompatible Use – Permit Required
I – Incompatible Use P – Permit Required NA – Not Applicable
* local regulations may or may not be more stringent than these State regulations

4 FUNDING SOURCES

These proposed BMPs require resources beyond those immediately available to SCVC through its operating budget. Some equipment purchases may be possible under the County capital budget. However, grant funds such as the State Environmental Protection Fund (EPF) and Environmental Quality Bond Act (EQBA) generally look favorably on assisting in the purchase of machinery that will be used directly on restoration projects.

Environmental restoration funds for active projects are more plentiful than funds for planning such projects. As SCVC and the County develop a list of potential projects, which is likely to require some substantial expenditures, it may be possible to reach out to funding sources such as USACOE restoration funds, USEPA initiatives, State bond funds, and the County Quarter-cent Fund. All of these support projects that result in actual restoration actions. Towns and certain Non-Governmental Organizations (NGOs) may be able to provide resources to assist with project planning NGO involvement may be greater if these same organizations can recoup fixed personnel costs by assisting in project implementations. Certain towns have also indicated a willingness to assist in pre- and post-project monitoring, especially those aspects of monitoring that may coincide with existing town environmental data collection efforts. Monitoring costs could prove to be a barrier to multiple project implementations, given current regulatory perspectives regarding the scope and duration of such efforts.

5 EQUIPMENT AND PERSONNEL NEEDS

Suffolk County has probably undertaken as large and complex a water management project as will ever be considered under the Long-Term Plan, in the OMWM Demonstration Project at Wertheim NWR. The experiences there were used to guide the determinations made in this section.

5.1 Equipment

The type of machinery best suited for the operation depends on the BMPs required to complete the project. The following section will discuss the type of machinery best suited for each task.

The use of heavy equipment machinery for restoration activities is required for many of the BMPs. A primary concern is compaction of substrate. Compacted substrate can greatly affect the survival, development, and rate of plant propagation. Compacted substrates could result in restoration failure. All machinery used in marsh construction should be special, low-ground pressure (LGP) equipment, generating less than two pounds per square inch of ground pressure. Machinery that does not conform to this specification should only have limited use.

5.1.1 Types of Equipment

Rotary Ditching Machinery – This type of machinery is indispensable in construction or maintenance projects where sediments are to be removed, and where spoil is not required for ditch filling or does not need to be removed from site. Fixed arm rotary ditchers have been used to create straight-line grid ditches and to maintain the ditch system. These machines do well at that application. However, in the creation of ponds and tidal channels requiring curved features, fixed arm types of ditching equipment are less appropriate. This is because, to reach all areas of a pond or create curves in a tidal channel with a fixed arm, multiple track swaths may be required. This excessive back and forth maneuvering can lead to unnecessary ruts and tracks carved into the nearby marsh.

Alternately, ponds and tidal channels should be constructed using a ditcher with a swivel head attached to the movable arm of an excavator. This type of ditcher will require a minimal amount of movement, reducing the impact on the wetland.

Three sizes of round-profile (Quality Industries –type) rotary ditchers are available:

16-inch Rotary Arms – ideal for small ponds, sills channels, small tidal creeks.

24-inch Rotary Arm – ideal for small to medium ponds, sill channels, tidal creeks

36-inch Rotary Arm – ideal for large ponds, tidal creeks and ditch maintenance.

In addition, Vector Control has a Dondi ditcher attached to a swinging mount behind its Pisten Bully. The Dondi head digs a trapezoidal profile ditch approximately 24 inches wide at the top, 10 inches wide at the bottom, and about 21 inches deep. The swinging mount allows curved ditches to be easily constructed.

Excavators – This type of machine is ideal when spoil is needed to fill in existing mosquito ditches, used to fill known mosquito breeding areas such as potholes or pannes, or requires removal from site. Buckets should have removable teeth, and should be a swivel bucket. Buckets with a straight edge are advantageous in constructing ponds, because they create a smooth contour to the ponds bottom.

Standard Body with LGP Tracks – A LGP excavator is a standard machine where the steel tracks have been lengthened and widened to reduce their ground pressure. It can be a very useful tool in constructing ponds, but spoil has to be removed by dump body or back-blading. The back-blading may be accomplished by attaching a movable blade to the front of the excavating machine; however, when back-blading is to be accomplished in concert with excavating, it may be preferable that the blade be attached to a separate machine, so the excavator does not have to interrupt pond construction to back-blade. A LGP excavator is more maneuverable than an amphibious excavator, and can travel faster. However, its tracks are not long enough to span the wider tidal creeks or ditches, and it does not float, limiting its ability to reach some wetland areas.

Amphibious Excavator – An amphibious excavator is a standard machine where the steel tracks have been replaced with pontoon track that exert a very low ground pressure, even allowing the machine to float. It is a very useful tool in constructing ponds but spoil has to be removed by dump body or back-blading, both requiring an additional machine. This machine is useful when the marsh becomes soft from construction activities. An amphibious machine can cross wide ditches and creeks or float across water bodies, but is less maneuverable than a LGP machine. It is extremely slow.

Dump-body trucks – These vehicles are extremely useful when movement of material across the marsh is needed. These machines have proved to be invaluable to fill ditches with pond spoil. Multiple trips along the same path may impact the marsh, and so monitoring is necessary. Only tracked machines should be used for this task in wetlands, but wheeled vehicles could be used in uplands, such as dredge spoil areas or at culvert sites.

Back–blading Equipment – This type of equipment can be fitted to many types of machines. Efficiency may require that the machine not be needed for other, simultaneous tasks. This equipment is very important when filling in areas of active mosquito breeding because it can take material from pond or ditch cleaning and spread out the spoils over immediate area to fill in voids that may harbor mosquito larvae.

Personnel Transporters – Small vehicles suitable for transporting personnel and small amounts of equipment about the marsh are extremely useful. These machines remove the need for larger equipment to leave work sites at break times, thus minimizing heavy equipment trips across the marsh, and can save time because many of the larger machines move very slowly, requiring more time to traverse the marsh than smaller pieces of equipment. Personnel transporters allow inspectors to move about the marsh when conditions are not favorable for movement on foot, such as after heavy rain, during high tide flooding, or across areas that have been extensively reworked.

5.1.2 List of Equipment

A major project such as the Wertheim NWR OMWM Demonstration project almost certainly would require more equipment than could be expected to be available through County resources. In such cases, items not owned may be available through loans, rentals, and informal arrangements with area agencies and NGOs. USFWS, Nassau County, and Ducks Unlimited all own appropriate low ground pressure equipment that may be suitable for some or all projects, and may be available for local projects.

The following equipment is presently owned by SCVC:

Pisten Bully – The piston bully is the most versatile of all equipment owned by SCVC. It has the ability to back-blade, dump, and ditch, including the construction of curved ditches. It also is one of the faster moving machines and is very valuable when being used as a dump body machine for filling ditches. Its low ground pressure is important, leaving few ruts on the marsh surface except for the softer areas.

Large (200 hp) Quality Amphibious Ditcher – This machine has the least versatility in SCVC's fleet. It is good for cutting straight runs in ditches, and its 36 inch cutter head can move a lot of material quickly. The fixed position of the cutter, behind the machine, limits its ability to cut curved ditches in its current configuration. Options to improve its ability to follow curves are being explored, such as reversing the mount so that the cutter is ahead of the machine. It may be possible to dig small fish reservoirs with this machine, provided it can be done without excessive tracking over the area.

Small (150 hp) Quality Amphibious Ditcher — This machine was retrofitted during the course of the Wertheim project to greatly increase its versatility. It was originally fitted with a 22 inch round rotary ditcher, which can cut straight or curved shallow spur ditches. It also mounts a grader box that allows it to spread and back-blade material into a thin layer, though not with the finesse and precision of the Pisten Bully with its 12-way blade. In addition, the rear attachments can be removed to allow the machine to mount a dump body for transporting material. This machine can operate on softer ground than the

Pisten Bully and cross wider bodies of water than a non-amphibious machine. It is thus nearly as versatile as the Pisten Bully, with the advantage of amphibious tracks.

Kobelco SR-70 LGP Excavator – This is a very useful tool in constructing ponds, but spoil has to be removed by dump body or back-blading, both requiring an additional machine. When the site becomes soft, the machine has a tendency to sink into marsh surface, and to potentially damage root mass of marsh vegetation.

Kobelco SR-70 Amphibious Excavator – This is a useful machine for pond construction. Other equipment is needed in tandem with this excavator to remove the spoils, or to back-blade them. Because this machine can float it can be used under a wide variety of conditions and terrains. It is also easier to transport to the site, capable of being towed over water to the marsh.

It is recommended that SCVC acquire the following machinery:

16-inch Rotary-arm Ditcher – SCVC needs a rotary-arm ditcher. A larger rotary-arm ditcher would be more efficient for larger projects. However, the rotary-arm ditcher is essential for many smaller projects, and this size is probably the most versatile choice. If NYSDEC's Unit Management Plans allow for pond construction to improve fish habitat in its South Shore marshes, then the purchase of a larger cutting head would be in order.

A rotary cutter could be retrofitted onto either one of the SR-70 excavators. Cutters larger than 16 inches require an auxiliary engine and a very large excavator, an expensive and probably not very practical option for Suffolk County marsh conditions.

Amphibious, Long Reach Excavator – The current excavators have standard arm that limit the radius that can be reached without repositioning the machine. Frequently repositioning the machine, particularly when excavating a pond, lowers productivity, and can damage vegetation if not done with great care. A long-reach excavator could excavate a larger area from a single position, and could also load a dump body machine without having that vehicle come immediately alongside the pond. Also, a long reach excavator can, in some cases, place excavated material directly into a receiving area, such as a ditch adjacent to a pond being dug. A long reach excavator can also work over and around obstacles such as fences and trees more easily than a conventional excavator. It may be possible to retrofit the existing amphibious excavator with a longer arm, but issues such as machine balance may require that an entirely new machine be acquired.

Personnel Transporter – one is needed; two might be preferable.

5.2 Personnel

Marshes are complicated environments, as they exist at the interface of land and water. Manipulation and restoration of a marsh therefore requires skills and knowledge of both land and sea. This means most projects will require the involvement of different fields of expertise, and different kinds of personnel to execute the plans. Prior to the commencement of any restoration project the identification of site-specific goals, objectives and limitations, and the difficulties that may be encountered, must be taken into consideration as part of the planning process. Considerations in planning a restoration project may involve outlining the habitat zones associated with particular tidal wetlands, their vegetation, common fish and wildlife species, habitat functions, and generic impacts to these habitats. Therefore, it may be necessary to consult several different specialists.

5.2.1 Professional Staff

These lists are intended to identify the scope of expertise required by SCVC, and/or other groups proposing projects for SCVC to conduct. It should be understood that many of these staffers do not need to be full-time employees; staffing needs may be met by "borrowing" expertise from other government agencies, through advisory groups, by academic contacts or consulting arrangements, or contracting for environmental consultants. It may be that the functions of several titles can be addressed by a single, suitable person.

Natural Resource Manager

The person in this position will be required to oversee the four major phases involved in the process and considerations for restoration projects:

- Planning and Design Phase
- Construction Phase
- Assessment Phase
- Documentation and Communication Phase.

Planning and Design Phase – Overseeing and defining project goals and objectives, the development of specific and quantifiable performance criteria, research of the restoration site, refinement of objectives based on site research, and specific project planning of the project leading to engineering designs and development of a contingency plan for unexpected outcomes. It also should include permit preparation and acquisition.

Construction Phase – involvement in the considerations of effects on natural resources at the site, and adjacent areas; determination of construction staging and timing, so that there is the least impact to existing flora and fauna, and the greatest likelihood of success for any changes in habitat – such as determining the best time to replant; supervision of construction activities and work plan compliance monitors.

Assessment Phase – development of appropriate monitoring plan to meet and test site goals and objectives; implementation of the plan; and identifying needed adjustments to correct the plan during the course of the project, and in the post-project monitoring window.

Documentation and Communication Phase – develop appropriate record-keeping processes and technologies for engineering, construction, and monitoring data, and cost information; turn data into information through accessibility – designate a contact person, and develop a database or central file system; oversee the sharing of results through internet availability, conferences, workshops, public outreach, and other means.

Natural Resource Specialists

The role of a resource specialist is to provide senior technical support to the natural resource manager. The work could in involve:

- inventorying, data collection, and/or resource analysis;
- developing sampling protocol based on technical/scientific principles and practices;
- prescribing solutions to construction and monitoring problems;
- developing narratives and/or statistical reports.

The input from natural resource specialists is extremely important in selecting appropriate goals and objectives for the project, and during design and implementation of monitoring techniques.

Entomologist – An entomologist would be responsible, not only for evaluating mosquito breeding and the effects of projects on mosquito production, but also for the effects of projects on non-target insects, especially aquatic insects. There are a variety of aquatic and other insects that use salt marsh habitats, and it is likely that they would be affected by management measures. It may not be possible to quantitatively measure these effects, but the use of the marsh habitat should at least be documented.

Salt Marsh Ecologist – Salt marsh ecology focuses on the physical dynamics of salt marshes including; sediments, erosion, chemical composition, vegetation structure, ecology of individual organisms, and management and conservation. Therefore, a salt marsh ecologist should be a professional experienced in wetland delineations, have a working knowledge of vegetation identification, soils, and hydrological processes. In addition, the ecologist should have competence in the USACOE 1987 Wetlands Delineation Manual, state delineation requirements, and experience in permit filing procedures.

Hydrologist – the formation, size, and function of wetlands are controlled by its hydrologic processes. The hydrologic and water quality functions of wetlands, the way wetlands change the quantity or quality of water moving through the marsh, are related to the wetland's physical setting. Hydrologic processes or the hydrologic cycle of wetlands are controlled by tides, storms, precipitation, surface water flow, ground water flow, and evapotranspiration. The relative importance of each of these components differs from wetland to wetland and therefore must be evaluated at each marsh.

A hydrologist will assist the project by performing moderately complex to advanced ecological analysis of surface water resources of the designated restoration site, leading to the planning, execution and summary of scientific and engineering field studies. Also, the hydrologist will be able to manage data resources; apply statistical methods and computer programs for the determination of environmental flow needs; and communicate analyses and findings with general and technical audiences.

Complex reworking of the hydrology of a marsh may require advanced computer simulation capabilities. Modern wetting-drying models hold the promise of being able to accurately simulate the effects of changes in existing waterways. These models are only as accurate as the information used to drive them; therefore, any modeling exercise will require intensive collection of appropriate data, including but not limited to hydrographic and other surveys, and local tide and other water flow information. Modeling expertise may be available from Stony Brook University.

Benthic Ecologist – Wetland benthic ecology involves the study of organisms living in and on the marsh substrate, the interactions between them, and impacts on the surrounding environment. The benthos, comprised of the organisms and the substrates together, is an extremely valuable component of the wetland environment. Benthic systems are important to recycling of nutrients, and the burial and storage of organic matter.

The benthic ecologist primarily studies functional relationships among keystone biota in aquatic ecosystems. This research is used to clarify the fundamental trophic linkages between primary producers and consumer, and assesses the role of these trophic interactions in the regulation of energy and biogeochemical nutrient cycles. This is especially important in monitoring the effects that restoration will have on the benthic community. A benthic ecologist must be able to sample, recognize, and analyze benthic communities in a meaningful way that will provide information to other members of the natural resource team.

Botanist – Salt marshes constitute one of the most productive habitats on earth. Typically, salt marshes are broken into three zones, low marsh, high marsh, and open water areas that are generally further defined in terms of salinity gradients and duration of inundation. Each of these zones is extremely critical to ensuring a properly functioning marsh ecosystem; characterizing the existing vegetation patterns and anticipating the impacts of a restoration project is extremely important.

The botanist can assist in the characterization of a marsh; the botanist should be qualified to conduct field studies including but not limited to habitat mapping, rare plant surveys, wetland assessments and delineations, and to prepare related quantitative sampling and statistical analysis. Habitat mapping is an important technique in order to compare pre and post alteration vegetative comparisons in order to evaluate the success of desired results.

Marine Biologist – Tidal wetlands are considered marine resources in New York State, and evaluating and ensuring that management actions sustain and enhance marine biota is a critical aspect of these actions. Certain fish species reside in salt marsh waters for most of their life cycle, such as the mummichog (*Fundulus heteroclitus*), striped killifish (*F. majalis*), and sheepshead minnow (*Cyprinojon variegates*). Other species of fish depend on the salt marsh habitat, associated tide creeks, and adjacent mudflats for nursery areas, such as winter flounder (*Pleuronectes americanus*), Atlantic silverside (*Menidia menidia*), sand lance

(*Ammodytes americanus*), and striped bass (*Morone saxatilis*). Several diadromous fish inhabit wetlands, such as American eel (*Anguilla rostrata*), alewife (*Alosa pseudoharengus*) and menhaden (*Brevoortia tyrannus*). Invertebrate macrofauna, such as ribbed mussels (*Geukensia demissa*), fiddler crabs (*Uca spp*.), salt marsh snails (*Melampus didentatus)*, and blue crabs (*Callinectes sapidus*), may be important to document. Therefore, prior to proceeding with any restoration project, the effects of the project on the marine community must be determined.

Knowledge of the different habitats needed throughout different life stages of fish and key invertebrates will help in deciding where ponds and tidal creeks should be placed in order to enhance a desirable marine habitat.

<u>*Ornithologist*</u> – Many bird guilds utilize salt marshes throughout all or part of their life history. Many species rely on the marsh for nesting and rearing their young, such as the marsh wren (*Cistothorus palustris*), sharp-tailed sparrow (*Ammodramus caudacutus*), black-crowned night heron (*Nycticorax nycticorax*), Canada goose (*Branta canadensis*), American black duck (*Anas rubripes*), red-winged blackbird (*Agelaius phoeniceus*), and sometimes clapper rail (*Rallus longirostris*), and willet (*Catoprophorus semipalmatus*). Others depend on the marsh for food, feeding on small fish, invertebrates, insects, and vegetation, such as the green heron (*Butorides striatus*), great egret (*Casmerodius albus*), snowy egret (*Egretta thula*), glossy ibis (*Plegadis falcinellus*), tree swallow (*Tachycineta bicolor*), and terns (*Sterna spp*.). Also the northern harrier (or marsh hawk) (*Circus cyaneus*) and short-eared owl (*Asio flammeus*) are known to hunt for rodents on the marsh. Immature bald eagles (*Haliaeetus leucocephalus*) sometimes overwinter on Long Island marshes, and ospreys (*Pandion haliaetus carolinensis*) build impressive nests overlooking salt marshes, often on poles provided for this very reason. Therefore, it is extremely critical that any impact to the marsh be analyzed for the effect it will have on its avian community.

The ornithologist will help identify the bird species at risk and the limiting factors involved with restoration activities. This expertise is critical to help evaluate management approaches and documenting recovery.

Other Technical Staff

GIS Programmer/Analyst – Geographic Information Systems (GIS) is a technology used to analyze data from a geographic perspective. A GIS interactive map can provide geographic information for analysis, advanced data compilation, and field data collection. This is extremely useful in the design and implementation phase of a restoration project. In addition, through the use of historical aerial photography and satellite imagery it is possible to perform a long-term analysis of changes in wetland areas and evaluate any patterns or trends that may be observed.

GIS programmer/analyst responsibilities may include writing, testing, and debugging customized GIS applications for maintaining and accessing site data, conducting spatial analyses, and developing GIS applications and map products for various users to support implementation of site restoration. Other duties may include coordinating habitat mapping applications and effectively communicating with colleagues, staff, other agencies, organizations, and the public.

Engineers (Environmental) – An engineer is a valuable asset to develop a plan for the restoration project. An engineer can assist in determining the level of physical effort needed, technological requirements, cost estimates, and construction scheduling, such as amount of laborers, machine operators, and equipment requirements.

The environmental engineer uses the principles of biology and chemistry to develop solutions to environmental situations. An engineer should be consulted on many of the purposed actions in this BMP (i.e., culvert replacement, pond construction, tidal creek design). The engineer can assist in the design; implementation, analysis of the scientific data collected, and quality control checks. An important engineering determination is an estimate of the amount of spoil that may be generated by any given action, which will assist in the decision of spoil control.

Surveyors – Delineating wetland boundaries is an important part of any restoration project and may be necessary when applying for federal and state permits. In this case a surveyor, preferably one who is a Certified Wetland Delineator, will be needed to accurately map the wetland boundaries. In addition, accurate post-construction mapping may be required in many instances.

5.2.2 Project Implementation Staff

This staff is likely to be agency or other full-time staff. Although BMP implementation is not likely to be a full-time, year-round job, actual construction is often intensive and will require greater commitments of time than most of the other positions described above.

Site Supervisors – These personnel are responsible for overseeing and coordination of site specific work. They are also responsible for monitoring for impacts to the marsh and ensuring that heavy equipment does not do irreversible damage to vegetation. Biological training is useful and important.

Construction Foreman – The construction foreman is responsible for coordinating with Site Supervisors as to where and what work should be performed. The Foreman determines the division of labor among operators and laborers, and maintains good working conditions at the site.

Machine Operators – Several of the machines require a driver and an equipment operator, such as the Pisten Bully and the Quality Ditcher. All operators should be experienced in operation machinery for marsh restoration/maintenance. A trainee program for junior staff would be useful.

Laborers – Construction laborers perform a wide range of physically demanding tasks involving loading equipment onto machinery, performing minor excavating tasks on the marsh, digging small sill channels, and removing clogs from ditches or tidal channels by hand.