Salt Marsh Restoration Design Guidelines

NYC Parks

City of New York Parks & Recreation
Forestry, Horticulture, and Natural Resources
Bill de Blasio, Mayor
Mitchell J. Silver, Commissioner

EXECUTIVE SUMMARY

Background

Salt marshes are some of the most ecologically productive, historically significant, and culturally valuable ecosystems we have in New York City (NYC). They enable New Yorkers to experience beauty and nature, while helping to protect the City's shoreline. Today, salt marsh ecosystems are at risk from development, erosion, poor water quality, and drowning under rising seas. It is now more important than ever that we protect and restore them.

In the 1990s, New York City Department of Parks & Recreation (NYC Parks) and partners pioneered some of the first salt marsh restoration projects in the country. Since that time, over 35 salt marsh restoration projects have been constructed on parkland totaling over 150 acres across all five boroughs. These projects have largely followed restoration design approaches outlined in the New York State Salt Marsh Restoration and Monitoring Guidelines (2000 Guidelines). In 2015, NYC Parks assessed the condition of 22 of those 41 projects and found that the majority of salt marsh restoration projects met expectations. We determined, however, that lessons learned over the last decades, including a better understanding of the threats to salt marshes from climate change, warrant an update of the salt marsh restoration design guidelines for NYC.

Purpose

In this document, we build upon the 2000 Guidelines and provide updated restoration guidance for all levels of restoration practitioners. These 2018 guidelines are intended to serve as a reference for natural resource managers, landscape architects, and practitioners who plan to restore or re-establish salt marsh, augment or enhance existing salt marsh, or incorporate salt marsh vegetation into a larger shoreline project. Our update is informed by the review of the 22 past salt marsh restoration projects, which included field assessments and interviews with designers and project managers. The update also incorporates lessons learned during post-construction maintenance, and more closely considers the potential design impacts of sea-level rise, wave action, and other long-term management. We offer directions on how to conduct site analyses to inform restoration design, including biological benchmarks and tidal hydrology analysis to help identify target design elevations. Finally, we discuss updated restoration and enhancement techniques including marine debris removal and addressing marsh loss through sediment enhancement or shoreline restoration.

How to Use The Guidelines

This document is written as a guide to the planning, design, construction, and maintenance of constructed and restored salt marshes. For readers with little or no experience in salt marsh restoration, these guidelines can serve as step-by-step instructions for restoring a salt marsh—from project conceptualization to post-construction maintenance. For more experienced designers and restoration practitioners who would like more information on one approach or another, these guidelines can serve as a reference.

Each section is broken up into individual project steps. Some of these steps may be completed concurrently depending on the project complexity, flexibility, and timeline. Site analyses, design considerations, and the restoration approach vary with the unique conditions at each site. However, the information provided here addresses a typical process for the salt marsh restoration in an urban environment. Appendices are included at the end of the document to provide references, as well as more detailed information for various steps in the restoration project process. Appendices include protocols for site analyses, permitting resources, sample project schedules, specifications, and methods for invasive species management.

Chapters

This document has six sections that encompass a broad range of project components and tasks associated with restoration design and post-construction management. Some of the individual steps in each section may not be suited to or necessary for every project depending on its scope and scale.

1. Salt Marsh Restoration Goals
2. Project Planning
3. Site Analysis
4. Design Considerations
5. Summary of Restoration and Enhancement Approaches
6. Site Maintenance and Management

1: Salt Marsh Restoration Goals

Setting realistic and appropriate goals for the site context, budget, and timeframe in the scoping phase of a project is critical to align stakeholder objectives at a site. Goals can refer to the acreage the project aims to restore or enhance, or describe ecological objectives. The latter could include restoring high marsh for obligate nesting birds or building habitat structure to support ribbed mussels, fiddler crabs, and other benthic macro-invertebrates.

2: Project Planning

Proper planning, from project conceptualization and funding to planting and post-construction maintenance, will help ensure the project achieves its goals and is completed on time and on budget. Some of the specific steps in this section may occur concurrently with those in other sections. Critical planning tasks that apply to every project include forming a project team, defining roles and responsibilities, developing a schedule, setting a budget, identifying partners, identifying opportunities and constraints, securing permits, and considering maintenance needs post-restoration.

3: Site Analysis

A detailed analysis of existing site conditions must occur at the beginning of each project. This analysis should guide the restoration approach and scope and, potentially, modify project objectives. A site analysis includes an investigation of historic and current uses and conditions and an identification of the likely causes of salt marsh degradation or loss. Basic information needed to inform restoration design includes current topographical elevations, the elevation and extent of existing wetland or rare plant and animal species at the site, physical and chemical soil characteristics, local tidal ranges, fetch, wave energy, and sediment transport conditions.

4: Design Considerations

A salt marsh restoration design is most immediately informed by the project objectives, as well as any constraints or opportunities uncovered during project planning and site analysis. In addition, each site design should consider physical and ecological factors that could affect the cost and benefits, longevity and resiliency of a project. Factors to consider include planned or potential public uses of the site, sea-level rise impacts on the design conditions, sediment availability and erosion, wave conditions caused by fetch or boat wakes, existing vegetation and habitat, condition of the existing planting substrate, appropriate design slope to promote drainage and minimize erosion, and the sustainability of construction practices. The importance of these factors may vary, depending on the project location, size, site conditions, and goals.

5: Summary of Restoration and Enhancement Approaches

The approach taken to restore or improve ecological conditions should be a direct response to the impacts or stressors that have caused degradation or loss of that salt marsh. Approaches vary widely in level of cost and effort and improve conditions to varying degrees. Restoration approaches that can improve or enhance the condition of a marsh with relatively minimal site disturbance and low cost include debris removal and invasive species management. More intensive interventions, such as berm removal, culvert expansion, or installation of shoreline erosion control features may be needed to address hydrologic or hydraulic stressors. The most intensive and costly restoration approaches, such as excavation and removal of urban fill soil or placement of clean sand, are needed when a salt marsh site has been completely degraded or lost.

6: Site Maintenance and Management

Following construction, a restored salt marsh in an urban setting may need to be managed intensively in the short-term (1-5 years following project completion) to ensure vegetation successfully establishes. This is especially true where site conditions may include high wave energy, herbivory, frequent deposition of floatable debris, and high public use. Once vegetation is established, little if any maintenance and management is usually needed over the long-term. However episodic events or disturbances might require intervention, such as removing marine debris pushed in from high tides or storms. Setting clear maintenance goals and responsibilities with stakeholders and identifying maintenance issues through post-project monitoring can improve the outcome of salt marsh restoration projects.

Cover Photo: Soundview Marsh, Bronx, October 2012

Table of Contents

Figures

List of Tables

INTRODUCTION

Coastal salt marshes provide essential habitat for birds, fish, and other organisms, sustain biodiversity, and offer unique natural experiences in our highly developed urban environment. Salt marsh ecosystems help improve water quality by filtering pollutants and excess nutrients. They help protect our communities from storm impacts by detaining floodwaters and dampening wind and wave energy. Salt marshes can also help to mitigate climate change in the long term by capturing and storing carbon.

Over the past 100 years, much of New York City's (NYC) 520 miles of shoreline have been armored, filled, and developed, leading to the loss of thousands of acres of salt marsh. Today, less than 10% of the historic extent of NYC's salt marsh remains—about 4,000 acres.[1] Protection of existing salt marshes, and other natural shoreline habitats that might convert to tidal wetlands as sea levels rise, is the best strategy for ensuring that New Yorkers benefit from salt marsh ecosystems in the long run. With ongoing salt marsh loss, due to sea-level rise and continuing development pressures, salt marsh restoration remains an important tool for conserving this valuable ecosystem.

Background and Intent

The salt marsh restoration program in NYC began in 1991 in response to the spilling of over 5,000 gallons of heating oil into the Arthur Kill in 1990, a tidal strait between New Jersey and Staten Island.[2] A decade later, in 2000, the New York State (NYS) Department of State (DOS), and the Department of Environmental Conservation (DEC), with significant input from NYC Department of Parks & Recreation (NYC Parks), released the *New York State Salt Marsh Restoration and Monitoring Guidelines*.[1,3] Since 2000, these guidelines and protocols have been used by NYC Parks, as well as other restoration practioners in non-profits and city, state, and federal agencies, to inform restoration and mitigation projects.

Over the past 30 years, more than 35 salt marsh restoration projects totaling over 150 acres have been implemented on NYC Parks property alone (Figure 1). In 2015, NYC Parks began a review of these projects to evaluate their condition and restoration design strategies in our urban context under a changing climate. These restoration design guidelines are a direct result of that effort. They reflect findings from field monitoring, as well as interviews with project managers about the design and construction process for individual projects.

Specifically, our assessment confirmed that it takes time for restored salt marshes to attain ecosystem structure and functions comparable to reference existing salt marshes. In addition, our study results suggested the following restoration design approaches:

- Planting into existing natural substrate (e.g. sand or peat), following fill removal, can increase belowground biomass, which can improve marsh stability;
- Planting into existing substrate may require grading or other augmentations (i.e., clean sand placement) to ensure desired tidal elevations are attained to support marsh;
- Restoring salt marshes in protected sites (i.e., areas with existing fringe or fronted by a berm or other structure) can increase plant survival and productivity;

---

[1] New York / New Jersey Harbor Estuary Program. 2001. Status Report: A Regional Model for Estuary and Multiple Watershed Management. Habitat Workgroup.
[2] Bergen. A. C. Alderson, R. Bergfors, C. Aquila, M.A. Matsil. 2000. Restoration of a Spartina alterniflora salt marsh following a fuel oil spill, New York City, NY. Wetlands Ecology and Management 8(2-3):185-195.
[3] Niedowski, N.L. 2000. New York State Salt Marsh Restoration and Monitoring Guidelines. NYSDOS and NYSDEC. Canadian Journal of Fisheries and Aquatic Sciences 69:1420-1432.

- Minimizing the width of designed tidal creeks may help to maximize vegetated marsh area and reduce the risk of bank erosion over time; and
- Higher design elevations can result in higher vegetative cover and plant survival.[4]

This document is meant to expand upon and complement the 2000 Guidelines, include state of the art techniques, and consider the importance of sea-level rise and construction management in improving restoration outcomes. Our objective is to provide an overview of steps that are easy to follow, from project initiation through implementation and maintenance.

Finally, these design guidelines provide methods and approaches for planning, designing, and implementing salt marsh restoration projects in an urban setting. Our intended audience includes natural resources managers, restoration practitioners, ecologists, and landscape architects who are focused on re-establishing salt marsh, augmenting or enhancing existing salt marsh, or incorporating salt marsh vegetation into a larger project. While the restoration approaches described in this document are geared towards an urban environment, most are applicable to other coastal settings. For a broader overview and guidance for developing and renovating coastally resilient waterfront parks, see Design and Planning for Flood Resiliency: Guidelines for NYC Parks.[5]

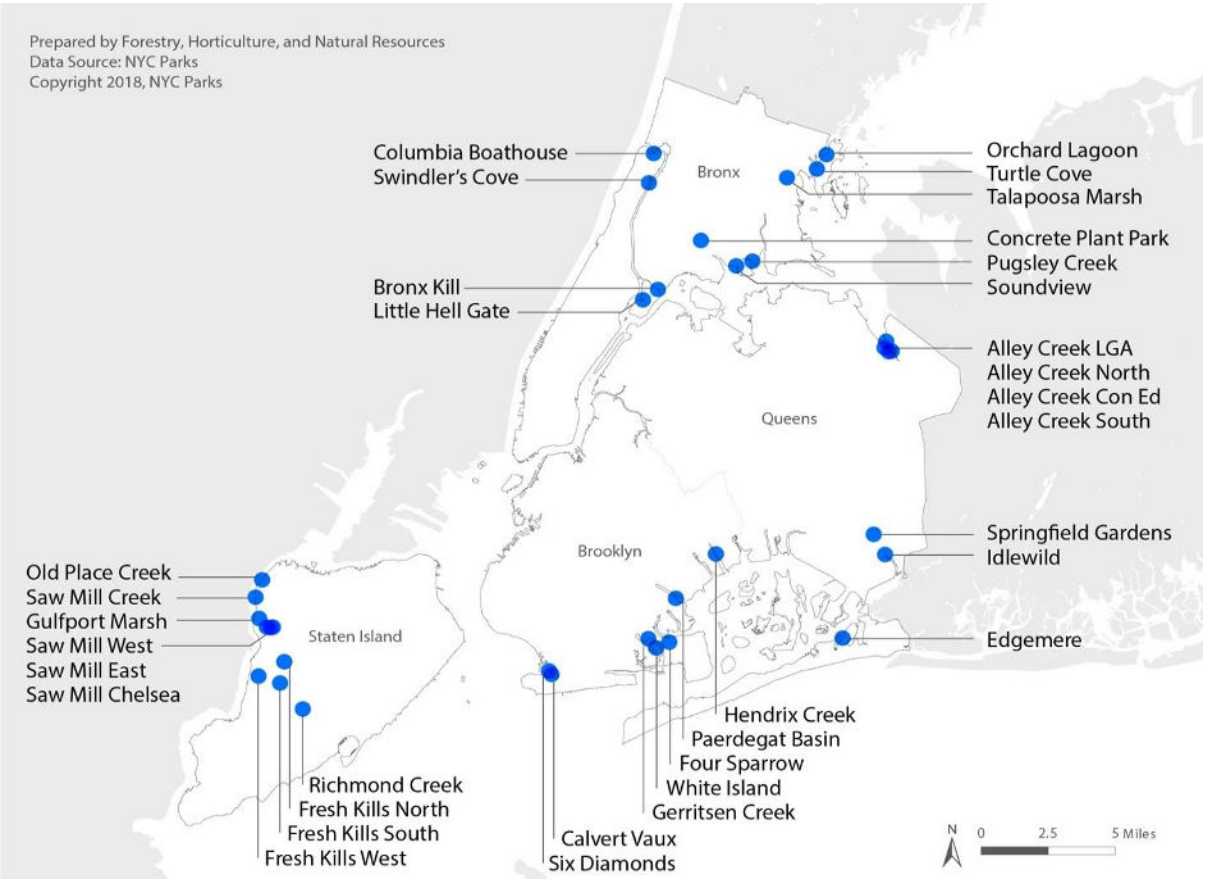


Figure 1. Salt marsh restoration projects on NYC Parks property from 1993 - 2015. See the final monitoring and assessment report for project information, Park name, and locations.[6]

[4] NYC Parks. 2018a. Salt Marsh Restoration in NYC: Assessment of Condition and Recommendations for Future Design and Monitoring. Report to Environmental Protection Agency Wetland Program Development Grant.
[5] NYC Parks. 2017. Design and Planning for Flood Resiliency: Guidelines for NYC Parks
[6] New York City Department of Parks & Recreation (NYC Parks). 2018a.

Structure of the Salt Marsh

Salt marsh ecosystems occupy a unique ecological niche in the landscape in the intertidal zone along the shoreline of our bays and estuaries. Each plant species found growing in salt marshes is adapted to flooding with saline water at a certain depth, duration and frequency, and thus inhabits a specific elevation range relative to mean tide level. Throughout the northeast, salt marsh is characterized by distinct plant communities at the lower and higher end of the tidal range: the low marsh and high marsh (Figure 2).

The low marsh is dominated by *Spartina alterniflora* (salt marsh cordgrass). Low marsh species typically thrive at elevations between the mean tide level (MTL) and mean high water level (MHW) and are flooded by the tides twice daily. The high marsh is generally dominated by *Distichlis spicata* (salt grass), *Juncus gerardii* (black grass), and/or *Spartina patens* (salt meadow cordgrass or salt hay). High marsh floods twice per month during the full and new moons and will typically establish between MHW and mean higher high water (MHHW). Transitional salt marsh communities are found above MHHW and are adapted to irregular flooding from storm events or spring tides and some level of salt spray. Transitional zones are generally dominated by *Baccharis halimifolia* (groundsel bush), *Morella pensylvanica* (bayberry), *Schizachyrium littorale* (coastal little bluestem), and *Solidago sempervirens* (seaside goldenrod), among others (Table 1). Transitional zones lead to upland maritime grassland, shrub land, and/or forest at higher elevations.

The role of salt marsh structure and functions in setting restoration objectives is discussed below in Section 2.4 “Establish Site-specific Objectives and Restoration Targets.”

Table 1. Salt marsh habitat types, tidal ranges and common plant species found within those ranges. Species in **bold** are those typically planted in salt marsh restoration projects in NYC.

Habitat Type	Tidal Range	Common Plant Species		Growth Habit
		Scientific Name	Common Name	
Mudflat	Mean Low Water (MLW) to Mean Tide Level (MTL)	*Ulva lactuca*	sea lettuce	Green algae
Low Marsh	Mean Tide Level (MTL) to Mean High Water (MHW)	***Spartina alterniflora***	**saltmarsh cordgrass**	**Graminoid**
High Marsh	Mean High Water (MHW) to Mean Higher High Water (MHHW)	***Distichlis spicata***	**salt grass**	**Graminoid**
		Iva frutescens	**marsh elder**	**Shrub**
		Juncus gerardii	**saltmeadow rush**	**Graminoid**
		Limonium carolinianum	sea lavender	Forb
		Salicornia spp.	glasswort	Forb
		Spartina patens	**saltmeadow cordgrass**	**Graminoid**
Coastal or Transitional Uplands	Above Mean Higher High Water (+MHHW)	***Baccharis halimifolia***	**groundsel bush**	**Shrub**
		Iva frutescens	**marsh elder**	**Shrub**
		Morella pensylvanica	**bayberry**	**Shrub**
		Panicum virgatum	**switchgrass**	**Graminoid**
		Schizachyrium littorale	**dune bluestem**	**Graminoid**
		Solidago sempervirens	**seaside goldenrod**	**Forb**

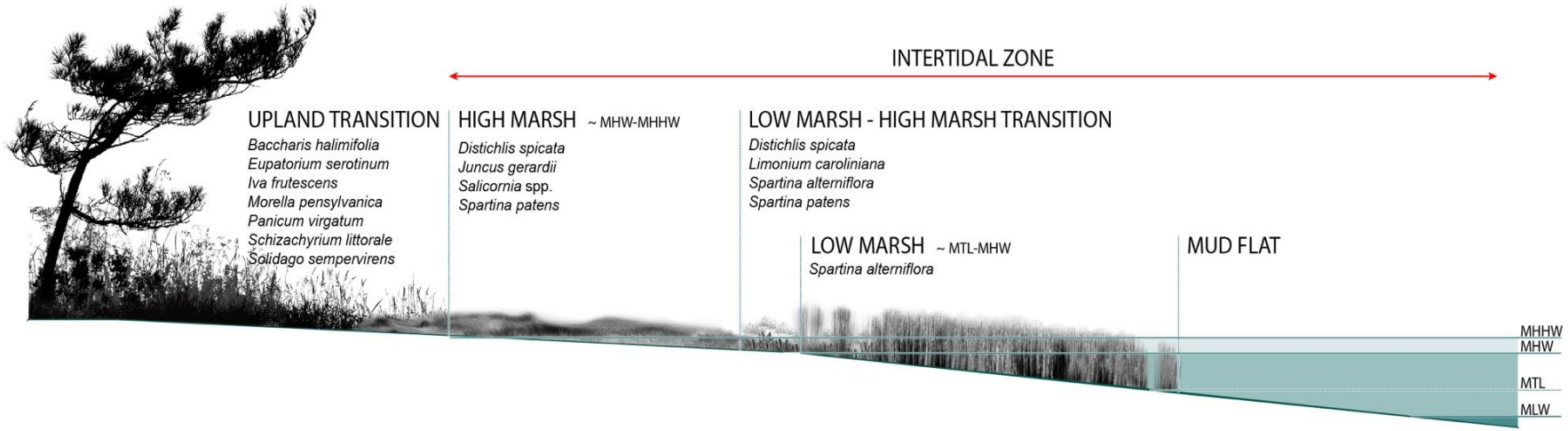


Figure 2. Typical profile of a natural salt marsh and maritime upland zone. Coastal plant communities are defined relative to tidal inundation levels.

DESIGN GUIDELINES

1. SALT MARSH RESTORATION GOALS

The fundamental goal of any salt marsh restoration or enhancement project is to recreate or enhance ecosystem functions, including increasing biodiversity and providing habitat; however, it takes decades for a restored salt marsh to provide functions comparable to a naturally-occurring marsh.[7,8] The goal of a restoration project, for our purposes, is to reconstruct, create or reestablish the vegetation structure of a salt marsh along a coastal edge where it does not currently exist because it has been completely degraded, destroyed, or hydrologically disconnected. Restoration actions can include restoring vegetation and tidal hydrology through regrading or removal of landfill, or removing barriers to tidal flow. The goal of an enhancement project, for our purposes, is to help an existing salt marsh recover or thrive, through low-impact actions such as invasive plant species removal, surficial erosion control and planting, or marine debris removal.

Salt marsh restoration projects may mention other goals beyond biodiversity and habitat that refer to the broader ecosystem services salt marshes can provide. Other goals for a salt marsh can include helping to clean water by absorbing and filtering excess nutrients and pollutants, buffering impacts of coastal storms through attenuation of wave action energy, or providing open space for recreation or education.[9,10]

While a small urban fringe marsh will not protect homes from flooding or storm surges on its own, salt marsh restoration can be one component of a larger project with a coastal resiliency goal.[11] For example, design features associated with a salt marsh restoration, such as reuse of excavated fill from the newly restored wetland to construct a berm for wave attenuation or flood risk reduction, may provide some resiliency benefits to local communities. In that way, and due to the fact that tidal wetlands are flood adapted ecosystems, salt marsh restoration projects or components of them may be considered coastal resiliency strategies.

1.1 Restoration Goals in the New York City Context

Conserving, protecting, enhancing and restoring salt marsh in a dense urban environment is challenging due to land development pressures, pollution, and poor water quality. Sea-level rise, due to global warming and geologic subsidence in the New York City region, places additional uncertainties on the longevity of existing and newly constructed salt marsh. Salt marsh restoration approaches, in some locations, can also involve high costs of construction and include temporary environmental impacts. Despite these risks, salt marsh restoration within our highly urban context is still an important way to help retain a diminishing and valuable ecological community for the benefit of fish and wildlife, as well as humans.

---

[7] Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology & Evolution 15(10):402-407. http://www.umanitoba.ca/institutes/natural_resources/pdf/Zedler_restoration.pdf

[8] Moreno-Mateos D., M.E. Power, F.A. Comı´n, R. Yockteng. 2012. Structural and Functional Loss in Restored Wetland Ecosystems. PLoS Biol 10(1): e1001247.

[9] Tiner, R.W., 2000. Wetlands of Staten Island, New York, Valuable and Vanishing Urban Wetlands. US Fish and Wildlife Service, Cooperative National Wetlands Inventory Publication. Hadley, Massachusetts. https://www.fws.gov/wetlands/Documents/Wetlands-of-Staten-Island-New-York-Valuable-Vanishing-Urban-Wildlands.pdf

[10] Moller, I., M. Kudella, F. Rupprecht, T. Spencer, M. Paul, B.K. van Wesenbeeck, G. Wolters, K. Jensen., T.J. Bouma, M. Miranda-Lange, S. Schimmels. 2014. Wave attenuation over coastal salt marshes under storm surge conditions. Nature Geoscience. 7: 727-731.

[11] Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology & Evolution 15(10):402-407. http://www.umanitoba.ca/institutes/natural_resources/pdf/Zedler_restoration.pdf

2. PROJECT PLANNING

Project planning should include the following steps, some of which may happen concurrently:

- Form a restoration project team
- Identify causes of degradation
- Identify opportunities and constraints
- Establish site-specific objectives and restoration targets
- Identify a reference site
- Choose restoration approach
- Establish project timeline and budget
- Identify project partners and conduct community outreach
- Develop the design and construction documents
- Plan for procurement and propagation of plant material
- Consider needs for maintenance and adaptive management
- Identify monitoring objectives and methods
- Secure project permits

2.1 Form a Restoration Project Team

A restoration team is made up of professionals from a number of disciplines. Depending on the scope and complexity of the project, the team may include biologists and/or ecologists, landscape architects, coastal engineers, land surveyors, GIS experts, and legal and permitting experts familiar with applicable regulatory requirements. At minimum, each project requires a wetland ecologist and a project manager. Assigning a project manager and agreeing on clear roles and responsibilities will help ensure the project runs smoothly, on-time, and on-budget.

2.2 Identify Causes of Degradation

The first step in planning and designing a restoration project is to identify the causes of degradation or salt marsh loss at a site. Different stressors can impact the restoration site in different ways, all of which can limit the ability of the marsh to function optimally or for marsh species to thrive. Some causes of degradation may be easy to discern. Others can be difficult to determine and may be a result of multiple factors at a broad scale and over long time periods. In either case, planning must include identifying which causes of degradation can be controlled or mitigated, such as sources of pollution directly on the site, and which factors cannot be controlled in the short term, such as off-shore sources of pollution, boat wakes, or storm waves.

Discrete or other localized causes may be relatively simple to address, whereas diffuse long-term impacts may be nearly impossible to address completely within the scope of one project. Discrete causes of degradation include:

- marine debris or other large items that float in with high or storm tides;
- landfilling or shoreline alterations;
- restricted tidal flow from a dike or culvert, or other changes to local hydrodynamics;
- invasive species;

- trampling, clearing, installation of structures such as piers, or other direct human activity;
- an oil spill (Figure 3);
- increased freshwater inputs from stormwater outfalls; or
- erosion from repeated boat wakes.

Other causes of degradation may be diffuse or long-term and result in loss of wetland function over time. Causes of this type of degradation include, for example:

- high nutrient loads from leaking septic tanks, waste water treatment plants, or combined sewer outfalls (CSOs);
- increased wave action from more frequent and higher intensity storms due to climate change;
- longer daily tidal inundation from sea-level rise;
- reduction in accretion of sediment on the marsh plain due to reduced sediment supply;
- repeated off-shore oil spills, or other diffuse pollution sources; or
- historic illegal dumping of waste or contaminants (Figure 3).

Figure 3: Examples of impacts to salt marsh: an oil spill in Calvert Vaux Park, Brooklyn (left) and illegal dumping (tires, drums, etc.) at Isle of Meadows, Staten Island (right).

The impact of historic fill, for example, is relatively easy to identify. Prior to regulation under the Clean Water Act in the 1970s, historic fill was commonly placed on wetlands and included household or factory waste, construction excavate or debris, or dredged material (Figure 4). This fill was often capped with compacted soil, gravel, pavement or another hard surface material.

Illegal filling of or dumping in wetlands after the 1970s is not uncommon, but less extensive than historic fill. This type of fill material varies widely from construction rubble to household garbage or abandoned boats and other vehicles. In some cases, property owners have illegally filled in marshland in order to stabilize an eroding shoreline or expand their property further into the water. Although illegal fill may be difficult to identify in the project scoping stages, as it may be buried or not obviously visible, it can usually be remediated in the scope of the project. See Section 3.1 “Site History” for more guidance and Appendix A for recommended data sources for project planning.

Even in situations where local causes of degradation can be quickly identified, the extent of impact from each cause may not be as easily defined. For example, a CSO with frequent contaminated discharge is clearly a source of degradation to a nearby marsh, but the contribution of this one source of pollution to overall decline in water quality and ecological function can be difficult to quantify and isolate from other factors. Another example may be site contamination. While a spill or dumping may occur at a discrete location, the extent of the impacts and spread of contaminants through the soil or water may be broad and more difficult to mitigate.

The cause of degradation will help determine the methods necessary to restore salt marsh. Specific approaches will be discussed below and in Section 5.0 “Overview of Restoration and Enhancement Approaches.”

Figure 4. Examples of construction (left) and demolition fill, sanitation fill (middle), and dredge fill (right).

2.3 Identify Opportunities and Constraints

Identifying opportunities and constraints early in the design process will help solidify the project scope, inform the restoration approach, determine accurate project costs, reduce risks, and, ultimately, improve the likelihood of long-term success.

Typical site conditions or contexts that may provide better or easier opportunities for salt marsh restoration projects include:

- clean fill material or clean natural substrate at desired elevations;
- shallow, or low-lying fill material between three and seven feet of elevation relative to mean tide level;
- existing natural shorelines or fringe wetlands along the shoreline or nearby;
- wide sites allowing for greater than 100 feet of salt marsh restoration inland from the shoreline;
- adjacent upland that allows for marsh migration inland over time;
- unobstructed access from the road, or water (depending on the project scope) that does not impact adjacent habitat;
- publicly owned property;
- small invasive trees only (no mature / native trees);
- no archeological sensitivity; or
- supportive project partners and community members.

Many constraints will not be fully understood until the site analysis is complete, but any constraints that are initially apparent are still important to consider in early planning, as they can impact project objectives, schedule, and costs.

Typical constraints to salt marsh restoration projects include, but are not limited to:

- current site use;
- contaminated or hazardous fill material existing on site;
- deep, high elevation fill material, e.g. greater than 10 feet of excavation required;
- structures, such as houses or utility lines;
- small or narrow sites with no connection to natural shoreline habitat;
- armored or heavily rip-raped shorelines;
- difficult or complex access through an intact forest or wetland;
- privately owned property;
- federally endangered species;
- large native trees;
- archeologically sensitive sites; or
- little community advocacy or project support.

A constraint at one site may be an opportunity at another. For example, in exposed sites with a high fetch, remnant shoreline armor such as rip rap could be an opportunity to continue to restore marsh behind the riprap, while continuing to protect the shoreline. Another example would be restoring a site with federally rare bird or plant species nearby. While rare species may be a general planning concern because of the regulatory requirements they trigger, providing habitat for a rare species may become a welcome project objective. In this instance, the constraint may be timing construction activities to occur outside of the breeding or growing season to minimize site disturbance.

As a general rule, any restoration project that requires importing or exporting soil (e.g. removal of fill material or utilizing dredge sediments) should assume soils may have some level of contamination given our densely urbanized and altered environment. As a result, the project manager should budget for sediment testing and disposal (see Section 2.7 “Establish Project Budget and Timeline”).

2.4 Establish Site-specific Objectives and Restoration Targets

After an initial site assessment to evaluate opportunities and constraints, identify specific restoration objectives and targets. Ideally, these objectives will have clear performance measures associated with them in order to guide post-restoration monitoring.

Choosing which habitat types to prioritize is one of the first steps. A typical salt marsh system will include low marsh, high marsh, transition zone, and coastal upland (including grassland, scrub shrub, or maritime forest), but the amount of each habitat may vary by site or project constraints (e.g. budget) and project objectives. When defining a restoration target area for each habitat type, it is important to consider any regional or site-specific factors that will affect the success of the restoration plantings in both the short and the long term. Long-term sea-level rise, coastal flooding, invasive species, and other pressures are important considerations at any coastal site.

Additional considerations for defining project objectives include:

- Identify local community priorities, including provisions for public access, such as a designated fishing area, small boat launch, or educational signage. This can increase the likelihood of long-term project success by limiting informal access and improving education to reduce the potential for long-term impacts from unintended uses.
- Explore possibilities for flood risk mitigation in adjacent at-risk neighborhoods, for example, by increasing buffer between the shoreline and homes through restoration, or potentially incorporating a vegetated berm into the project scope.
- Check for local regulatory constraints that may limit the project objectives. For example, even if a site hosted a former wetland, it may not be permissible to add substrate within the current water body in order to restore the wetland to its previous footprint as defined by the 1974 wetland boundaries or other historic extents. Seek guidance from the NYSDEC's (2017) Living Shoreline Guidelines for these types of projects.[12]
- Research any species of concern that could benefit from the project through improved foraging opportunities or nesting habitat. Salt marsh sparrow, for example, benefit from a specific proportion and configuration of low and high marsh habitat.
- Determine how restoration targets may impact funding opportunities. For example, maximizing the restoration area for low marsh may increase the potential for securing wetlands mitigation funding for the project, or for securing funds from an agency focused on fisheries habitat; however, focusing solely on low marsh may have long-term implications for site longevity under sea-level rise.
- Note any local or regional restoration targets and opportunities to restore habitat or increase habitat connectivity, such as those from estuary programs or watershed plans.

Initial restoration targets will be refined and adjusted during the detailed site assessment phase as new information is revealed. The overall scope of the project will also be constrained by the available budget and will necessarily be revised as plans and a detailed cost estimate are prepared. However, the objectives that are identified early in the planning phase should be reflected in the project scope, and these objectives should be used to clarify priorities and inform design decisions if costs need to be cut. These objectives will help guide the site analysis the project's initial design, and long-term management.

2.5 Identify a Reference Site

Each restoration project site should, ideally, have a nearby existing intact salt marsh or salt marsh vegetation that can provide a reference for the suitable elevations, vegetation species composition, soils, tidal channels, hydrologic conditions, and other characteristics relevant to a functioning ecosystem. In urban environments, an appropriate native reference marsh site may not be available directly nearby, or all relevant reference conditions may not be present on one site for comparison. In these cases, choose the closest possible site or multiple sites. The reference ecosystem helps to inform targets for the restoration site, and also serves as a benchmark to direct monitoring and adaptive management efforts post-restoration.

2.6 Choose Restoration Approach

Once the causes of degradation have been determined and the objectives for salt marsh restoration have been established, select the restoration approach.

[12] New York State Department of Environmental Conservation. 2017. Tidal Wetlands Guidance Document: Living Shoreline Techniques in the Marine District of New York State. http://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf

In an existing salt marsh, where the objective is to enhance ecosystem functions, simple interventions can have a large impact. Lower cost, minimal intervention approaches include:

- Removing marine debris, including floatables and smaller debris that can be collected by hand or boats, and large timbers that require machine removal with contractors.
- Removing other non-organic debris such as asphalt or concrete rubble that prevents plants from growing.
- Removing invasive species such as *Phragmites australis*, potentially with herbicide treatment. This is rarely an appropriate action by itself – because the conditions causing the establishment of *Phragmites* should be addressed – but may be appropriate where *Phragmites* is only just starting to invade a site.

On former wetland sites where the ecosystem has been severely degraded or altered so that little to no significant salt marsh remains, more complex and intensive restoration interventions are needed to manipulate the terrain and re-establish optimal elevations and plant communities. Many of these methods continue to evolve as new restoration projects are implemented and monitored, and lessons are learned from previous projects. Restoration approaches include:

- Re-establishing tidal connectivity by removing or modifying a barrier to tidal flow or installing or enlarging a culvert.
- Excavation to the optimal elevation for planting. This is appropriate when existing elevations on site are too high to support a desired marsh plant community, and the underlying substrate at the desired elevation is suitable for planting.
- Over-excavation and placement of clean sand. This is appropriate when existing elevations on site are too high to support a desired marsh plant community and the underlying substrate at the desired elevation is unsuitable for planting. In that instance, the site is over-excavated to allow for clean sand, which is then imported as a growing medium, and graded to design elevations.
- Construction of tidal channels to restore tidal flow to a site.
- Placement of clean sand on former marsh surface. This approach is utilized when a former salt marsh plain has subsided or eroded and is too low to support a marsh plant community, or where an existing wetland has experienced shoreline vegetation loss compared to its historical boundaries. This approach receives particular regulatory scrutiny since it technically involves filling in a wetland or converting one wetland habitat to another.

Both enhancement and restoration efforts require planting appropriate native plant species and may require erosion control methods to stabilize slopes or shorelines. These restoration and enhancement approaches are described in detail in Section 5.0 “Overview of Restoration and Enhancement Approaches.”

2.7 Establish Project Budget and Timeline

After determining causes of degradation and exploring possible restoration approaches, develop the project timeline and estimated costs.

In some cases, a project is funded through a grant or government budget allocation that covers the costs of design and construction. In this situation, the scope (project objectives) will be tailored from the outset to the available funding. The scope and budget may need continual refinement as the project progresses, and as the site analysis reveals additional opportunities and constraints. In other cases, initial funding may be available to develop a concept design

and/or construction drawings along with a detailed cost estimate. In these cases, the scope and estimated project costs are defined first, and the construction funding is sought.

Develop a preliminary estimate, or an itemized cost estimate containing a comprehensive list of expected tasks, contract items, and item quantities, to ensure the planned project fits within the available budget (or to identify additional funding needs). Ideally an existing conditions survey will be available early in the process to ensure accuracy of the preliminary cost estimate. Otherwise, base the estimate on a site inventory with general field measurements, or a cost multiplier derived from recent, nearby projects similar in scope and complexity, and then revise the estimate upon receipt and examination of the existing conditions survey.

Concurrently, prepare a schedule for the life of the project including the design, procurement, and construction phases, showing specific deadlines for key tasks and critical milestones. The schedule should identify responsible parties, note the length of time expected for each task, and determine which steps must happen sequentially and which can take place concurrently. See Appendix B for an example project schedule.

In preparing the schedule:

- Plan for design development with internal review and approvals.
- Plan for public outreach and design review.
- Include time for outreach to regulatory agencies about the project, as well as permit preparation and review, often from multiple regulatory agencies.
- Include time for legal review of the project and development of a construction contract.
- In cases where the project will be bid, include time for the procurement process to bid the project, review of bids and vetting of contractors, and award to a qualified contractor.
- Allow adequate time for treatment of invasive species prior to other work, including chemical or manual removal and planting and establishment of native species.
- Consider seasonal constraints (e.g. optimal time of year for site assessments, planting windows for different plant material, wildlife nesting and mating patterns, temperature or other seasonal limitations on construction activities, and public use of the site). See Figure 5 below for generally recommended seasons for various activities.
- Plan and include time for the preparation of planting stock or plant procurement. Work with a local native plant nursery when possible to assure local seed is collected, grown to specification, and available for project (see Section 2.10 “Plan for Procurement and Propagation of Plant Material” below).
- Plan for short- and long-term maintenance and adaptive management of the site.

Where available funding or capacity limits the immediate project scope, break the project into restoration phases. Develop a long-term site plan that reflects how the ultimate goals for the site can be achieved over time, outlining boundaries, objectives and targets for each phase to guide future restoration and funding goals.

Figure 5. Ideal seasons for site assessment and restoration methods, at most sites where adjacent or reference marsh conditions require on-going protection. Red arrows indicate extensions of the primary season if conditions are good. For example, planting may be able to occur in early summer if it's cool and wet and excavation and grading may be possible throughout the winter if ice does not prohibit equipment working in the area.

2.8 Identify Project Partners and Conduct Community Outreach

Early on in the planning process, it is critical to identify project partners. These include regulatory agencies, other local agencies, adjacent property owners, non-profit organizations, nearby businesses, other private organizations with mitigation needs, potential future park visitors, and potential project stewards. Identifying partners early on will help ensure all necessary stakeholders are aware of the project and agree on the objectives. Clear and regular communication can help identify potential problems early, such as construction constraints or funding gaps, and can help lead to faster resolution.

The most critical stakeholders are often the local community and property owners. Transparent communication with these stakeholders can help alleviate concerns and ensure support throughout the project. Successful engagement may even help encourage community members to help steward the site following construction by removing debris and invasive species and alerting park managers of illegal dumping or site uses.

2.9 Develop Design and Construction Documents

Design development for a salt marsh restoration project may differ from a standard landscape architecture or other design project given the focus on creating a habitat rather than structural amenities. For simple projects, with no structural elements such as boardwalks, multiple design steps may be condensed, and construction drawings may advance quickly from conceptual to final design. Permit application and review takes time and should begin early and continue concurrently with design development. In addition, construction and bid documents should include the requirement that both the contractor and the construction project manager has wetland restoration construction experience. If it is necessary to work with a contractor without prior experience, it is essential to assure there will be in-house or consultant oversight from a restoration specialist during construction.

Depending on project complexity and scope, a full standard set of plans is not always needed. Typical project sheets include:

- Notes sheet, describing:
    - Information on local tide levels with tide gauge and vertical datum references
    - Instructions to the contractor about limitations on when work can be performed, e.g. working during low tide / in the winter when ground is frozen, and plants are dormant / outside of nesting or breeding season for sensitive species etc.
    - Limitations on equipment (e.g. lighter weight, low ground pressure equipment with tracks in lieu of wheels or marsh mats to distribute the weight of equipment)
- Removals Plan (focused on debris removals and removals of invasive vegetation, plus unwanted pavements, piers, or other structures)
- Erosion Control Plan
- Staging and Access Plan
- Site Protection (needs for transplanting or protecting sensitive vegetation or habitats)
- Herbicide Plan
- Grading Plan
- Planting Plan (including the areas and elevations to plant, species for each zone, and quantities)

- Details, for example:
    - Cross sections for tidal channels and the water-to-upland gradient
    - Herbivory fencing
    - Raised berm for flood protection
    - Geotextile tubing
    - Shoreline protection features, including oyster castles or sills
    - Planting guidance

Project specifications (examples for typical specifications may be found in the appendices) are important in order to ensure that high quality workmanship and materials are used. Specifications may need to be customized for each project. Common specifications include:

- Clean fill (clean sand for salt marsh; loamy sand or sandy loam for upland zones)
- Marsh protection mats
- Herbivory fencing
- Marine debris removal and disposal
- Geotextiles appropriate for the marine environment
- Invasive plant removal and herbicide treatment (especially for *Phragmites australis*)
- Planting preparation and materials
- Extensive soil testing
- Excavation, handling and disposal of soil or other material with hazardous contamination

2.10 Plan for Procurement and Propagation of Plant Material

The use of genetically appropriate, source-identified plant material is critical for increasing the chances of planting success in NYC's highly urbanized conditions. As a result, it is important to identify the sources of plant material early in the restoration planning process. Alert nurseries ahead of time and work with a local native plant nursery, such as NYC Parks' Greenbelt Native Plant Center (GNPC), to ensure appropriate quantities of local seed are collected, grown to specification, and available for the project in time for planting.

These nurseries are also valuable sources of information regarding seed collection, should you conduct this activity on your own. Seed collection should follow best practices so that local plant populations are not impacted. This collection can be done on-site, at a nearby reference site, or within 100 miles from the restoration; however, the population must be from a stable wild population only to maintain genetic diversity and ideally as close as possible to the restoration site. No more than 20% of the available seed should be collected from any single population to ensure these populations are not negatively impacted.

It is important to note that not all seed can be stored and must therefore be propagated immediately. Alternatively, if seed has been stored, it likely requires dormancy breaking as part of the propagation process; therefore communicating changes in project timelines to nurseries is critical. The production of plants takes time; for example, trees and shrubs typically need to reach a 1- or 2-gallon container size before planting, which, grown from local ecotype (or wild-collected) seed, can take 2-4 years. Herbaceous material takes less time, but still requires 6 months to a year from the time of collection.

It is also important to consider the seasonal timeframe for seed collection and the optimal planting season. Most perennial species are collected in the late summer and fall; most trees and shrubs can be planted in either the spring or the fall; and herbaceous material is best planted in the spring (no later than mid-June) to reduce transplant shock.

2.11 Consider Needs for Maintenance and Adaptive Management

Early in the project planning and design phases, the project manager should work with ecologists and operations or land management and stewardship staff or partners to develop long-term site maintenance and adaptive management plans that consider what problems the site may face and who will be responsible for addressing them. This is discussed in detail in Section 6.0 "Site Maintenance and Management" post-restoration, and is a critical planning step. Considering post-restoration needs may help the project team evaluate and mitigate project risks and plan for future resource or budgetary needs to manage the site. Early planning and preparedness can help ensure resources are allocated, and that the need for adaptive management is less reactionary and does not come as a surprise.

2.12 Identify Monitoring Objectives and Methods

Identifying appropriate monitoring objectives and methods specific to the restoration goals is critical for determining if the project is successful and achieves restoration goals. Project and reference sites should be monitored pre- and post-restoration to evaluate short- and long-term response to restoration efforts. As a result, the project ecologist should plan for monitoring and develop protocols in the planning and design development stages of the project to allow plenty of time to monitor the site prior to construction and ensure that pre- and post-restoration monitoring may evaluate project success. Refer to NYC Parks (2018) Salt Marsh Restoration Monitoring Guidelines for guidance on developing an appropriate monitoring plan.

2.13 Secure Project Permits

A tidal wetland restoration project will overlap with jurisdictional wetlands or adjacent area (extending up to 150 feet from the wetland boundary in NYC, and 300 feet elsewhere in New York). Wetlands in New York State are regulated by the NYSDEC and the U.S. Army Corps of Engineers (USACE); therefore, permits must be submitted through a Joint Application to both agencies. Depending on the project scope, the type of permits required may differ. Thus the project team should discuss the project with regulatory agencies early in the planning stages to identify which environmental permits are needed. Check state and federal wetland maps first to evaluate the likelihood and location of mapped wetlands.[13,14,15] See Appendices A and C for a list of applicable data sources to permit applications and where to locate them.

Most restoration projects in or near wetlands will require a recent on-the-ground wetland delineation by a qualified professional and approval of that delineation by regulatory agencies. Following development of preliminary project designs and verification of the presence or absence of wetlands on site, submit City or State Environmental Quality Review (CEQR or SEQR) Environmental Assessment Forms (EAF) to determine the project type: a Type I, Type II or Unlisted activity. The EAF is used to determine if an Environmental Assessment Statement (EAS) is necessary, and if a more detailed Environmental Impact Statement (EIS) will be required. The EIS will help determine the extent of required submissions to regulatory agencies.

[13] U.S. Fish & Wildlife Service. 2017. National Wetland Inventory Maps. https://www.fws.gov/wetlands/data/mapper.html
[14] The Open Accessible Space Information System (OASIS). 2017. http://www.oasisnyc.net/
[15] New York State Department of Environmental Conservation. 2017. Environmental Resource Mapper. http://www.dec.ny.gov/gis/erm/

Once a schematic design has been developed or, at the latest, by the time grading plans have been developed and cut, fill, and removal quantities estimated, request a pre-application meeting with regulatory agencies. A pre-application meeting may occur earlier if the project is particularly complex or will require additional coordination with regulators. This meeting will help facilitate the application process, identify any additional submittals required, and determine if the project will be considered major or minor and if it should be covered under an individual or nationwide (general) permit. The type of permit will dictate the time needed to allow for permit issuance and the extent and type of public comment required—a public notice versus public hearings. In addition, federal permits from the Environmental Protection Agency (EPA) may be required when the site is found to be highly contaminated. The EPA permit type depends on which contaminants are present; contaminant removal should be guided by regulators.

Once restoration designs are complete, permits may be submitted through a joint application to USACE and NYSDEC. If the project site is outside of NYC (or outside of New York State), check with the state and local municipality for other permitting requirements. See Appendix C for checklists and resources for permitting in NYC.

3. SITE ANALYSIS

A detailed assessment of physical and biological conditions at the restoration site is needed to fully understand site impacts, constraints and restoration opportunities. This information will determine restoration design and approach. Information gathered during the site analysis phase may be seasonally restricted (Figure 5) and should include, at minimum:

- Site history
- Existing conditions and topographic survey and wetland delineation
- Vegetation characterization
- Biological benchmarks
- Salinity
- Hydrology and hydraulics, including tidal elevations, tidal prism, fetch, and wave height and frequency
- Geomorphology, such as tidal channel dimensions
- Soil conditions
- Photographic documentation
- Public use patterns

3.1 Site History

Conduct a desktop investigation into the development history of the site using archived tax maps, historic National Oceanic and Atmospheric Administration (NOAA) navigation charts, and historic aerial imagery (see Appendix A for recommended data sources), as well as historic site elevations to determine whether and how the site was altered. In addition, speak to park managers, community members, or others familiar with the site history.

Given the highly urbanized environment a Phase I Environmental Site Assessment, as per ASTM E1527 – 13 may be required to assess for potential contaminants and hazardous materials. These investigations may help determine if, when, and what type of fill material may have been placed on any part of the site (e.g. municipal garbage, construction debris, or dredged material). In GIS, use current aerial photos to compare the existing wetland extent and shoreline to historical extents, including the NYSDEC 1974 regulatory maps. The description and quantification of any changes that occurred between 1974 and current conditions may be important for design and permitting purposes.

3.2 Existing Conditions and Topographic Survey

Contract a professional NYS Licensed Land Surveyor to conduct a topographic survey, to determine elevations for all key features on the sites, confirm property boundary information (if necessary), location of streets, infrastructure, trees, and other information typically included in a standard survey. Depending on the project scope, this survey should extend from the upland project boundary or property line down to – or slightly beyond – the mean low water line. Typically, the survey should produce topographic contours with an interval of 0.5 feet across the site, based on spot elevations taken on a maximum 25 foot grid. Additional spot elevations sufficient to reflect more nuanced grade changes at key locations may be necessary. All topographic surveys should be in North American Vertical Datum, 1988 (NAVD88) in linear feet.

In addition, spot elevations should be provided at a 0.1 foot accuracy. These should be taken at various areas throughout the site and at specific areas that will help guide the design. Spot

elevations should occur at sensitive areas requiring protection such as existing wetlands or rare plants, or at the location of biobenchmark surveys (see Section 3.4 “Biological Benchmarks”); these areas must be marked in the field immediately before the survey with stakes, tape, or flags.

In New York State, delineation of existing wetlands is required by NYSDEC as part of the permit application (see Section 2.13 “Secure Project Permits” above). This delineation boundary should be flagged in the field and included as part of the survey. In addition, the top and toe of slopes, rock outcrops, ponded areas, and drainage channels or other fresh water inputs should be surveyed and depicted on the plan layout. In addition, all structures and drainage infrastructure (outfalls, headwalls, pipes, catch basins, manhole covers, etc.) should be included in the survey. Depending on the tasks and restoration approach, the survey may also identify areas of debris and major areas of erosion or deposition, all of which may affect the long-term viability of the restored marsh.

Typically, all trees greater than 6” DBH (diameter at breast height) and shrubs taller than six feet that are in or adjacent to areas of equipment access, staging, or grading should be included in the survey. However, where the site includes areas previously planted, tree surveys might need to include trees with a caliper as small as 1”. A certified arborist should conduct the tree survey and should record DBH and species for each tree, as well as its condition. In NYC, tree removals on NYC Parks property require restitution according to Title 56, Chapter 5 of the New York City Rules and Regulations, which stipulates the number and size of replacement trees that must be planted for each tree removed.[16] In this instance additional survey data such as species and condition of the tree will be required.

3.3 Vegetation Characterization

An assessment of the existing vegetation should be conducted during the growing season to identify native and invasive plant species or communities, especially rare native plants. Results will determine whether the project needs to incorporate specific techniques to remove exotic invasive plant species or protect or transplant native, rare, or sensitive plants. In addition, plant surveys may inform the plant palette for the restored wetland and any adjacent habitats or buffer zones. If a native species is currently thriving on the site, this is a good indication that conditions are suitable for its future survival (see Appendix D for vegetation characterization protocols and Appendix E for typical species naturally found in or adjacent to marshes, their community types, and salinity ranges). In addition to the wetland inventory as described above, the vegetation characteristics within the wetland and adjacent areas will be useful for permit documentation.

3.4 Biological Benchmarks

Biological benchmarks, or “biobenchmarks,” are elevation points surveyed where tidal wetland plants are growing, onsite or in a nearby reference, in order to glean site-specific data about the hydroperiod (depth and frequency of inundation) that a given species can tolerate. Since tidal range varies by location, the same plant species may be found at different elevations across different sites. Biobenchmark data is used, ideally together with tide gauge data, to predict the optimal elevation ranges at which individual species will establish and thrive in a restoration (see Appendix F for detailed protocols).

Biobenchmark data is collected at the restoration site or an adjacent naturally occurring salt marsh with a similar tidal regime and hydrologic position. Before selecting a site for a

[16] 2006 New York City Administrative Code § 18-107: Replacement of Trees Removed During Construction https://www.nycgovparks.org/rules/section-5 Rules Governing Tree Replacement https://law.justia.com/codes/new-york/2006/new-york-city-administrative-code-new/adc018-107_18-107.html

biobenchmark survey, verify that site conditions such as fetch, erosion, or presence of shoreline armor, such as concrete, do not constrict the natural extent of vegetation growth.

The objective of a biobenchmark survey is to document the low end, high end, and relative condition (e.g. percent cover) of vegetation within its full range within the tidal cycle. This data can be collected in a variety of ways. The example here uses transects:

- At relatively stable sites, flag the location of existing low and high marsh plants.
- Locate transects, perpendicular to the shoreline, that extend from the highest to the lowest elevation of these plant communities.
- Mark locations along the transect at:
    - lowest extent of native low marsh species;
    - densest location of dominant native low marsh species;
    - beginning of transition to native high marsh species (both low marsh plants and high marsh plants present);
    - densest location of dominant native high marsh species;
    - beginning of transition to native upland species; and
    - highest extent of native high marsh vegetation (Figure 6).
- Survey elevations and locations of flagged benchmarks or flag for subsequent topographic survey. Survey should be completed to the precision specified in Section 3.2 “Existing Conditions and Topographic Survey.”
- Confirm all site assessment data are in the same vertical datum (NAVD88).
- Compare biobenchmark elevations with local tidal elevation data (see “Tidal Elevations” below) to determine target elevations for new plant establishment and growth. Past nearby shoreline projects may include data that can serve as a reference.
- Where recorded tidal elevation data differs significantly from biobenchmarks, verify that both the tidal data and the vegetation data are accurate and precise.

3.5 Salinity

Salt marsh restoration projects may be located in estuaries, embayments, and tributaries with varied salinity levels. For example, water along the shoreline of a bay or estuary will be very saline (15 to 30 ppt). However, along tidal creeks or near stormwater outfalls, springs, or other freshwater inputs, the salinity may be much lower. Even within the same inundation regime, lower salinity can increase the number of plant species of plants that will thrive at site. This can potentially increase the plant species diversity on the site, but also increase the risks and challenges associated with controlling invasive plants, in particular *Phragmites australis.* For more information, see Sections 5.3 “Establishing Vegetation on Newly Restored Surface” and 5.1 “Methods for Salt Marsh Enhancement, Invasive Species Management.”

Salinity should be collected with a refractometer or similar instrument at high and low tide at various points throughout the site, including in tidal creeks and along the shoreline.

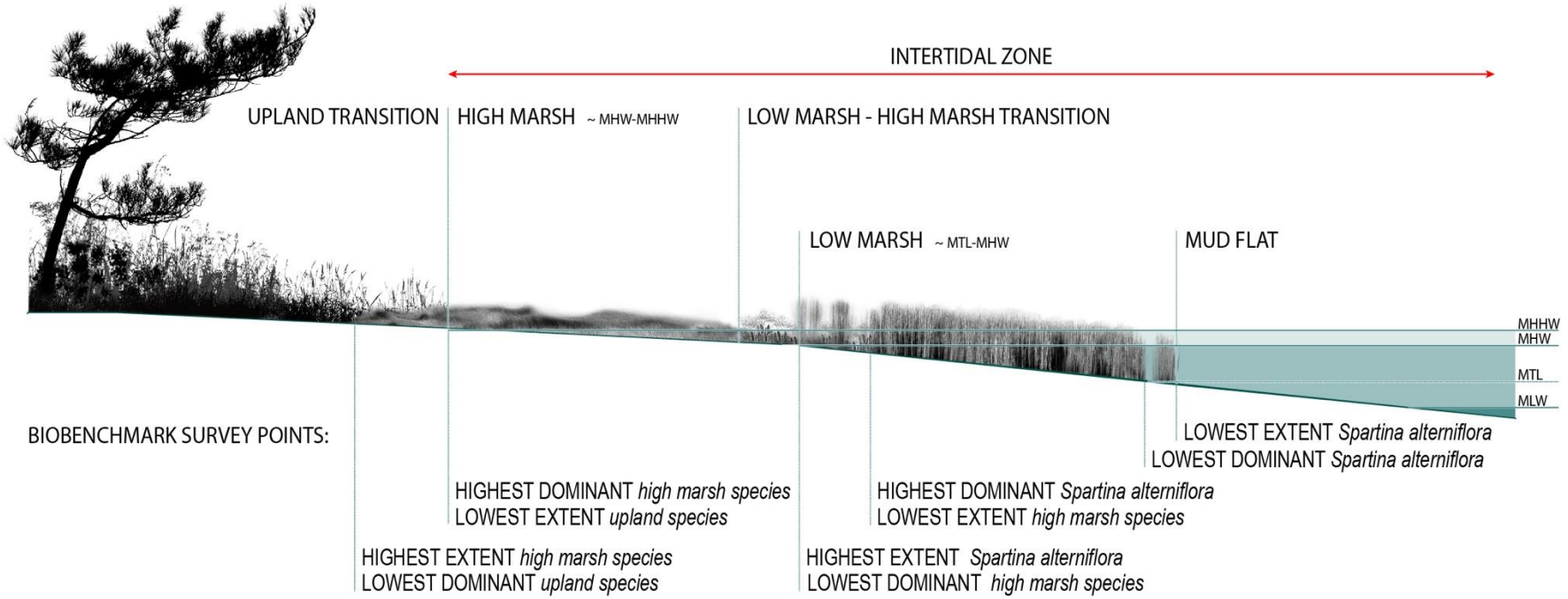


Figure 6. A typical salt marsh cross section. Callouts correspond to the suggested labels for biobenchmarks, including the lowest and highest extents of native vegetation along a transect, as well as dominance of each plant community. The extent of dominant low marsh should indicate mean tide level (MTL) to mean high water (MHW) and the dominant extent of high marsh should indicate mean high water (MHW) to mean higher high water (MHHW).

3.6 Hydrology - Tidal Elevations

The target design elevations for a salt marsh should be selected to establish a depth, duration, and frequency of flooding that supports low and high marsh vegetation. Data on water surface elevations can be taken from official tide stations and from on-site tide gauges. While precise official records of tidal elevation data are rarely available at the exact location of a restoration site, mean low water (MLW), mean tide level (MTL), mean high water (MHW), and mean higher high water (MHHW) can be estimated from records of tide elevation data from the closest tide station. Tide station data sources, including NOAA Tides & Currents website, and an explanation of how to determine tidal elevation values from the graph of datums found on this website are provided in Appendix A.

If a tide station is not in close proximity to the site, or if there is reason to believe that the site's tidal patterns will be significantly different from those of the nearest tide station (such as separation by a long, narrow channel or tidal restriction such as a berm or improperly sized culvert), a local tide gauge should be installed onsite to record the duration, elevation and frequency of tidal flooding. Establishing a local tide gauge typically requires a minimum of two to three months of data collection from a water level data logger placed in a secure location that will not easily be disturbed or vandalized (see Appendix G for specific protocols). Once location-specific elevations of MLW, MTL, MHW and MHHW are known, compare these to recorded biobenchmark elevations (see "Biobenchmarks" above) to determine target planting elevations. All tidal and land elevations must be relative to the same vertical datum, typically NAVD88.[17]

3.7 Fetch and Wave Impacts

If the site is exposed to large open water or is positioned along a channel that experiences frequent boat traffic, assess the typical height of waves at the shoreline. This can be done by observing and measuring waves using a staff gauge or by taking continuous measurements with a water level logger (see Appendix H for specific protocols). This data can help determine whether wave energy could threaten the survival of marsh plant species, and whether wave attenuation or shoreline stabilization techniques should be incorporated into the design.

In addition to field data collection, GIS models may be applied to evaluate fetch and wave impacts at an individual site, as well as the contribution to wave reduction from the location and orientation of specific design modifications.[18] Depending on the scope and scale of the project, coastal protection manuals may be consulted for additional guidance on designing shoreline protection features.[19] See Section 4.4 "Waves and Fetch" for additional considerations.

3.8 Tidal Channels

For larger salt marsh restoration projects, the design of tidal channel cross-sectional geometry and plan form becomes important. Tidal channels are essential to effectively convey water and sediment into and out of the vegetated marsh area. If existing tidal channels are present at an adjacent reference site, use the dimensions of that channel at a comparable location in the

[17] Zilkoski, D.B., J.H. Richards, and G.M. Young. 1992. Results of the General Adjustment of the North American Vertical Datum of 1988. American Congress on Surveying and Mapping, Surveying and Land Information Systems 32(3):133-149. https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

[18] United States Geological Survey. 2012. Waves Toolbox. https://www.umesc.usgs.gov/management/dss/wind_fetch_wave_models_2012update.html

[19] US Army Corps of Engineers. 2008. Coastal Engineering Manual.

drainage basin or within the marsh as the basis for the designed channel.[20, 21, 22] Estimate the freshwater drainage area if the tidal channel connects to a freshwater stream using geospatial data. Also determine the area of vegetated marsh plain that is inundated at MHHW to calculate the tidal prism. The tidal prism is the volume of water in the marsh exchanged over a complete tidal cycle, from mean low tide to mean high tide. The inter-tidal prism volume (P) can be expressed by the relationship: P=H A, where H is the average tidal range and A is the average surface area of the basin.

Determine the reference tidal channel geometry by measuring the top of channel width, vertical height from top of channel to bottom, and approximate the cross-sectional area of the creek. Take these measurements at a location along the creek where the upstream marsh area and upstream tidal prism will be similar to those planned for the designed salt marsh. Measure the radius of curvature and the amplitudes of the reference tidal channel from aerial photography.

3.9 Soil Analysis

Particularly in the urban environment, a soil analysis is needed to evaluate the suitability of substrate for planting, to determine whether excavated material is clean enough to be reused on site, or to inform appropriate disposal methods if contaminated. Soil sampling and testing should determine physical and chemical characteristics of existing soil both on the surface and at the target design elevation.

Soil tests for plant suitability should include pH, organic content, nutrients, texture, and heavy metal content. If planting into existing substrate, the sediment should be a relic sand or peat layer free of non-native plant rhizomes (e.g. *Phragmites australis*) and artificial debris, or a natural mineral substrate, preferably sand. The planting medium should be clean, ideally have an acidic pH of 4-6, and be free of any contaminants above levels safe for human health and safety limits appropriate to the projected human occupancy of the site (see Section 4.6 “Planting Substrate” below). This restriction typically pertains to Restricted-Residential levels, as defined by 6 NYCRR Part 375.

To test for contaminants, soil samples should be taken according to standard collection protocols and analyzed in a laboratory for heavy metals, volatile organic compounds (VOCs), semi-volatile organic compounds (sVOCs), pesticides, and polychlorinated biphenyls (PCBs). Chemical testing results will help determine whether any soil may be reused on site, if the site requires capping with a clean planting medium, or if specific disposal requirements are needed. At any location where that soil is proposed to be reused on site, the existing surface soils needs to be tested for the same parameters. Sampling should be conducted at representative locations throughout the site where excavation or beneficial reuse is anticipated (Figure 7). Where excavation is proposed, sampling should occur between 6 to 12 inches below ground surface (bgs) and at the estimated excavation depth. In locations where soil is proposed for reuse, sampling should occur between 0 to 6 inches bgs. NYSDEC should review and provide guidance on the proposed testing plan for soil contaminants if there are any questions. NYC Parks Environmental Remediation Unit and the Mayor’s Office of Environmental Remediation can also provide guidance on suitable soil sampling plans if environmental contaminants are suspected to be present at a site.

---

[20] Philip Williams & Associates, Ltd., and P. M. Faber. 2004. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay. The Bay Institute and California State Coastal Conservancy, Oakland, CA. 83 pp.
[21] Niedowski, N.L. 2000. New York State Salt Marsh Restoration and Monitoring Guidelines. New York State Department of State, and New York State Department of Environmental Conservation. Canadian Journal of Fisheries and Aquatic Sciences 69:1420-1432.
[22] Coats, R.N., P.B. Williams, C.K. Cuffe, J.B. Zedler, and D. Reed. 2003. Design Guidelines for Tidal Channels in Coastal Wetlands. The U.S. Army Corps of Engineers Waterways Experiment Station. 46 pp.

If the substrate at the target design elevation is determined to be contaminated fill, this fill may need to be excavated to a depth beyond the target design elevation (as determined by NYSDEC – typically at least one foot), and a clean substrate cap added for planting. If contaminated materials are reused onsite, they should be placed outside of the future tidal inundation zones to prevent transfer of contaminants to water under sea-level rise.

Because of the heterogeneity of contaminated soils, some debris or contaminants may only be exposed after excavation begins. Consequently, multiple soil samples may be needed throughout the course of the restoration process. For example, disposal facilities may require the contractor to test the soil again prior to disposal; this cost may be included in the estimates for excavation. Depending on the site, an allowance for this kind of work may be needed in the construction contract. Any contamination found onsite, especially hazardous contamination, may require special handling and worker protection protocols to be included in the project contract. It is important to gather as much information as possible about soil conditions early in the process. Depending on the amount and type of debris or contamination found onsite, the project budget can be impacted tremendously.

To avoid the costs and environmental impacts associated with transporting and disposing of contaminated materials elsewhere, work closely with regulatory agencies (NYSDEC) to determine whether materials can be reused on site. Depending on which contaminants are present, it may be possible to place the excavated material strategically elsewhere on site and, if necessary, cap with clean fill. For example, particularly in flood-prone areas, excavated material can be used to create an earthen berm at the perimeter of the property or where marsh migration would already otherwise be limited. The berm could then be capped if necessary, planted, and serve as both flood protection and an opportunity for visitors to view the site from an elevated position while keeping foot traffic out of sensitive marsh vegetation.

3.10 Photographic Documentation

Photographic documentation of pre-restoration, construction, and post-restoration conditions is essential. An organized photo record can help to:

- Illustrate restoration goals in the design phase;
- Make a clear post-restoration comparison to demonstrate change;
- Demonstrate impacts on the site, for example before and after a major storm event;
- Document construction processes and progress, which can be used to gauge success of different methods for future projects, or as evidence for legal and environmental regulation disputes depending on the type of contract and relationships between the property owner, designer / project manager, and the contractor;

Monitor and track specific concerns post-restoration, such as rates of herbivory on new plantings;

Photo documentation should be organized and systematic, and should include selecting, marking, and GPS-locating photo points for one of more of the following purposes:

- Before and after, or change over time photo point at the same season;
- Panoramic photos before, during, and after restoration;
- Documentation of vegetation along one or more transects perpendicular to the shoreline, extending from low marsh to upland vegetation; and/or
- Documentation of any unusual site concerns, features, plant species, or conditions.

3.11 Public Use Patterns

Observation of direct or indirect evidence of public use of the site in different seasons is essential to determine how access or human traffic will impact, or could benefit, the restoration project. For example, if it is apparent that a certain place along the shoreline is already used for small boat access, planning to include an access point in the project scope, or provide an alternate location, will help ensure that marsh is not restored in that location only to be trampled.

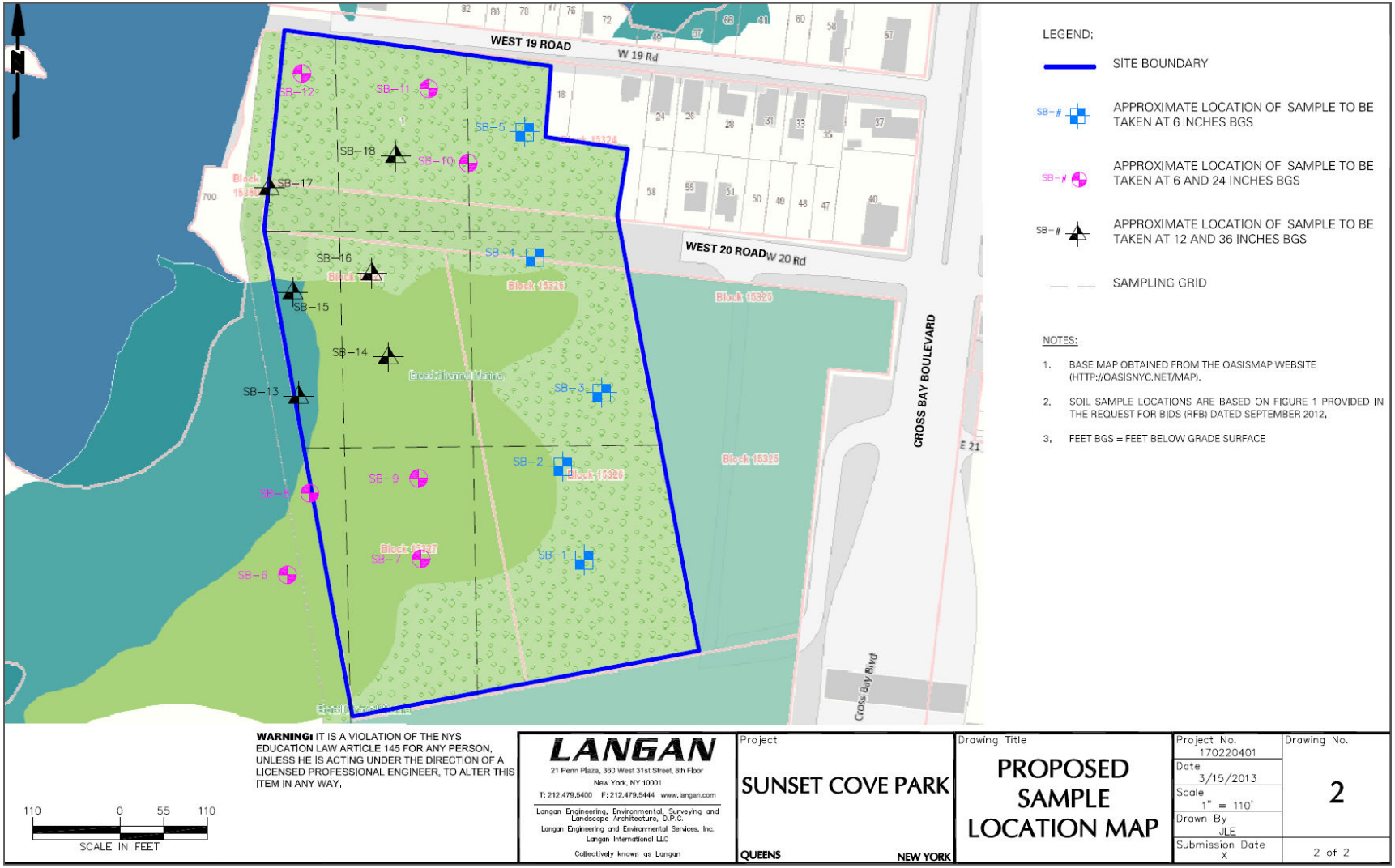


Figure 7: Example of chemical soil sampling locations grid design and map for Sunset Cove Park (Queens, NY). Locations with samples taken at 6 inches below ground surface (bgs) only were targeted as potential soil placement locations. Locations with multiple samples taken between 6 to 36 inches bgs were proposed for varying depths of excavation.

4. DESIGN CONSIDERATIONS

A salt marsh restoration design is most immediately informed by the project objectives, as well as any constraints or opportunities uncovered during project planning and site analysis. In addition each site design should consider factors that could affect the cost / benefit, longevity, and resiliency of a project. Factors to consider include:

- Planned site use and public access
- Sea-level rise, marsh accretion, and marsh migration
- Sediment deposition and erosion
- Waves and fetch
- Existing habitat preservation
- Planting substrate
- Design slope
- Sustainable construction
- Construction supervision

4.1 Planned Site Use and Public Access

Any potential public access at a site is an important consideration for restoration design. Need for access should be determined through soliciting community feedback and evaluating need through conversations with land managers, stewardship groups, and observations of site use (such as fishing or use of desire lines). If desire lines are prevalent, access points may require formalization or closure. Given the planned site features, access may be more appropriate on a berm, boardwalk, or through an upland trail with specific overlooks. Access through a marsh should not be planned without boardwalks or formal paths to avoid trampling of restored vegetation. In addition, site access may require regulatory considerations. For example, sites that include wetland mitigation or rare, threatened, endangered, or sensitive species will need to consider the impact of trails, boardwalks, or large structures requiring footings, and may require these access features to be approved by regulatory agencies.

4.2 Sea-Level Rise, Marsh Accretion, and Marsh Migration

Salt marshes naturally accrete, or increase in elevation, over time as sediment settles out with the ebb tide and vegetation dies in the winter, decays, and decomposes in place, adding layers of organic matter to the marsh plain. This accumulation of soil and organic matter increases the marsh elevation slightly each year.

In NYC, sea levels have risen an average of 1.2 inches per decade over the past century, and current models project accelerated sea-level rise on the east coast of the United States with a middle range probability approximating 3.3 feet (1 meter) of sea-level rise by 2100.[23]

Records and projections show marsh loss corresponds with accelerated sea-level rise, indicating that natural accretion is insufficient for many marshes to remain at the optimal elevation relative to the changing local tidal regime.[24] Over time, increased inundation results in waterlogging and a transition of plant communities from high marsh to low marsh, and low

[23] Horton, R., C. Little, V. Gornitz, D. Bader, and M. Oppenheimer. 2015. New York City Panel on Climate Change 2015 Report Chapter 2: Sea Level Rise and Coastal Storms. Annals of the New York Academy of Sciences, 1336:36-44.
[24] Warren Pinnacle Consulting Inc.. 2014. Application of Sea-Level Affecting Marshes Model (SLAMM) to Long Island, NY and New York City. Final Report (14-29).

marsh to open water or mudflat, due to marsh drowning. To address this stress from sea-level rise over time, we must consider adjustments to the design of our marshes.

Design for Sea-Level Rise and Marsh Migration

As a first step to mitigating the effect of long-term sea-level rise on our salt marshes, we recommend designing more and larger areas of high marsh. Most of our past successful salt marsh restoration projects consist of low marsh, predominantly because low marsh has been favored by regulatory agencies as mitigation for wetland filling, and because few invasive plants invade low marshes. Today, we must incorporate more high marsh to increase marsh longevity and reduce the chances that restored salt marshes convert to mudflat or open water.

Where space allows, shoreline marsh vegetation may be able to migrate upslope in order to keep up with rising sea levels. When planning a project, wherever possible preserve or create a gradual transition to the upland to allow the migration of marsh species over time with sea-level rise. Allowing space for mitigation can mean removing existing physical barriers inland of the marsh, such as bulkheads, pavement, or sudden changes in elevation due to fill. Wherever possible consider adjacent land use and potentially plan for long-term acquisition of adjacent properties. Where slopes are gradual, soils are native, and *Phragmites* exists, consider maintaining these areas for long-term marsh migration. See Section 5.1 “Methods for Salt Marsh Enhancement, Invasive Species Management” for more information.

In urban areas, however, marsh islands and most shoreline marshes often have no space to migrate, given intensive shoreline development. Instead, these marshes must be restored at the highest elevations possible within the inter-tidal hydrologic regime, to minimize the risk of excess inundation over time. Design elevations should err on the high side of the existing site conditions based on existing biobenchmarks and tidal elevations. An addition of approximately 6 inches in elevation throughout the site with the same slope is recommended above the target elevations to allow sufficient space for plant communities to transition under sea-level rise. This approach will allow low marsh species to migrate to high marsh elevations and high marsh species to migrate into transitions uplands over, potentially, the next 50 years, assuming continued sea-level rise at the current trend of approximately 3 mm per year (the sea-level rise rate at the low end of current projections).[25]

We will need to continue to monitor and evaluate how to most effectively design high marsh and transitional marsh migration pathways that withstand sea-level rise and facilitate marsh migration in the future.

4.3 Sediment Deposition and Erosion

NYC’s landscapes, streams and shorelines have been developed and modified extensively over hundreds of years, resulting in significant changes to natural sediment transport processes from the landscape to the estuary and along the shorelines. These alterations can result in less sediment conveyed from the landscape, stream systems, and long shore transport in our estuaries; thus, less sediment is available to deposit onto salt marsh systems.[26] As less sediment is available to settle on the marsh, the accretion rate of a salt marsh can be outpaced by sea-level rise, as discussed above. Where possible, consider the geomorphic processes of sediment availability at a site early in the design to help set target elevations and assess the longevity of a project. Augmenting natural marshes and restoration projects with additional sediment may be necessary to sustain these ecosystems long term. See Section 5.2 “Methods

[25] Kentula, M.E. 2002. Restoration, Creation, and Recovery of Wetlands; Wetland Restoration and Creation, EPA. https://water.usgs.gov/nwsum/WSP2425/restoration.html
[26] Tiner, R.W., 2000.

for Salt Marsh Restoration, Placement of Clean Sand to Restore Marsh Elevation" for more information.

In addition to considering sediment availability for vertical accretion, consider shoreline erosion. One way to evaluate localized erosion patterns is through examination of historic aerial imagery. Approximately 15 percent of NYC's marshes have been lost along the shoreline since 1974 (including in restored sites).[27] Therefore, selecting sites with an existing marsh edge or designing a constructed shoreline with careful attention to erosion stresses is critical to assuring that the vegetation at the edge will be sustainable and resilient.[28]

4.4 Waves and Fetch

It is important to consider whether the site is exposed to significant wave action from wind or boat wakes. Natural waves are dependent on numerous factors including, but not limited to, fetch (length of open water), prevailing wind direction, tidal range, shoreline bank angle (slope), bathymetry (depth of the ocean or tidal channel), and roughness (or friction of the adjacent channel bottom). Regardless of the natural hydrologic conditions at any site, boat wakes may exacerbate natural wave action.

Given the fetch and wave energy at a site, harder shoreline protection approaches compared to natural vegetation may be necessary. Regardless of wave energy, ecologically sensitive materials and opportunities for creating inter-tidal habitat should be considered in any design where erosion protection is needed. Rather than only using rock, for example, consider ways to maximize habitat complexities or interstitial spaces using a variety of materials, depending on the environment, such wood, coconut fiber rolls, bagged shell, and concrete shellfish substrate (e.g. reef balls or oyster castles).[29]

Shoreline protection may be implemented in coordination with an existing large-scale restoration project. See Sections 5.1 "Methods for Salt Marsh Enhancement, Shoreline Protection and Erosion Control" and 5.2 "Methods for Salt Marsh Restoration, Placement of Clean Sand to Restore Eroded Salt Marsh Shoreline" for more guidance.

Low Wave Energy

Low energy sites include sheltered sites with low or limited fetch. These are typically salt marshes flanking a river, tidal channel, or shallow estuary or bay. Wave heights are generally less than 2 feet.

Moderate Wave Energy

Moderate energy sites include those shallow waters that are partially sheltered or with a larger fetch. Wave heights are generally between 2 and 5 feet.

High Wave Energy

High energy sites are exposed to deep open water with a large fetch. These sites experience a wave height of greater than 5 feet.

In higher energy sites, the services of a licensed coastal engineer may be required to analyze conditions and determine stable dimensions and designs for edge structures.

---

[27] NYC Parks. 2017.
[28] NYC Parks. 2018a.
[29] New York State Department of Environmental Conservation. 2017. Tidal Wetlands Guidance Document: Living Shoreline Techniques in the Marine District of New York State. http://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf

4.5 Existing Habitat Preservation

Targeting sites for restoration that have an existing fringe of salt marsh or native vegetation can positively influence the outcome of the restoration (see Appendix E for list of common salt marsh plants).[30] The existing fringe vegetation can protect the restoration by reducing wave energy and water flow in and out of the restored site, slowing erosion and allowing for suspended sediment particles to deposit in the site.[31] Including existing habitat is also important because it preserves historical native vegetation and soils and provides an appropriate target elevation for the restored wetland. This existing habitat can also aid in the development of the vegetation and benthic community of the restored site by acting as a seed bank and providing benthic macroinvertebrate recruitment.

However, having invasive vegetation surround the site may negatively impact project success. If *Phragmites* or a seed source for another invasive species is nearby, the long-term success of the project may be limited.

4.6 Planting Substrate

Planting into existing substrate on the site is recommended wherever possible. If planting into existing substrate, the sediment should be, ideally, a relic peat layer free of *Phragmites australis* rhizomes and artificial debris. Alternatively, if no remnant peat remains, an existing natural mineral substrate, preferably sand, is suitable. Existing substrate should be tested for contaminants and not exceed thresholds selected for this site (these may be ecological thresholds or residential thresholds depending on the site and location). If clean substrate is not found at the target planting elevation, the contaminated soil or fill material may need to be over-excavated and replaced with clean sand, which becomes the new planting material. Planting into existing clean substrate may give plants only a slight growing advantage compared to planting into placed clean sand.[32] See Section 5.3 “Establishing Vegetation on Newly Restored Surface, Planting Substrate” for additional information about suitable planting mediums.

4.7 Design Slope

Positive drainage, through gradual slopes between 1% and 5%, towards tidal channels or the water’s edge, should be maintained in order to minimize standing water and deposition of marine debris when tides retreat. Ponding and extended inundation increase the risk of drowning the plants, and prolonged coverage by debris may smother them. Salt marsh plain slopes should ideally not be designed to exceed 3%, but may be as high as 10% in small, extremely constrained areas.[33] Gradual slopes will dissipate wave energy over a longer distance, thereby reducing erosion throughout the restoration site. Along the transition zones, the upland shoreline slopes should typically not exceed 33% (or 1V:3H)[34] to reduce wave scour and erosion concerns. If the planting medium is sand or predominantly sand, gradual slopes are critical to reduce risk of surface erosion that can lead to gullies and washouts.

4.8 Sustainable Construction

In any restoration project, the design and the construction should be as sustainable as possible, meaning it should not, to the extent possible, deplete resources or have enduring harmful impacts. If asphalt or other recyclable materials are removed from the site, they should be

[30] NYC Parks. 2018a.
[31] Gittman, R.K., A.M. Popowich, J.F. Bruno, C.H. Peterson. 2014. Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during Category 1 hurricane. Ocean & Coastal Management 102:94-102.
[32] NYC Parks. 2018a.
[33] National Oceanic and Atmospheric Administration, 2017. Mean Sea Level Trend; The Battery, New York https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8518750
[34] NYC Parks. 2018a.

recycled or reused. Sand, plant, seed, and other materials should be sourced locally to reduce the carbon footprint of transportation. In some instances, clean soil may be sourced from a nearby tidal creek in coordination with necessary dredging activities for navigation (see Section 5.2 “Methods for Salt Marsh Restoration”), or from excavation at a nearby construction site. In NYC, consult the Clean Soil Bank, managed by the City’s Office of Environmental Remediation, a couple of months before soil is needed, to determine if clean, local, pre-tested soil may be available for use.

Selecting restoration sites that are not contaminated or have soil that is appropriate for planting beneath fill are site selection considerations that can reduce the carbon footprint of transporting, or perhaps even quarrying sand to achieve tidal elevations and plant the site. Clean natural peat or plantable substrate should never be removed from a site. Removing natural peat or plantable substrate should only occur if required by regulators for remediation.

Selecting lower impact restoration approaches, such as thin-layer sediment placement or marine debris removal, to restore degraded existing wetlands may result in a lower carbon footprint than traditional fill removal methods to create new salt marsh. If excavation is necessary to restore the wetland, materials should be reused on site when possible. For example, excavated fill material resulting from a salt marsh restoration may be placed in a degraded upland around the site to construct a berm, or to restore upland habitat in conjunction with other remediation. The ability to reuse material may depend on the level of contamination and planned use of the site post-construction (see Section 3.9 “Soil Analysis”).

Trees removed in a design may also be reused as woody debris or mulch on site. However, there is a carbon storage cost to removing native or invasive trees from any area, so tree removals should be limited. In NYC, tree removals also incur a financial replacement cost per Title 56, Chapter 5 of the New York City Rules and Regulations.

Invasive plant control at restoration sites should also be carefully considered to limit the use of pesticides. Mechanical control or removal methods should be considered when possible (see Section 5.1 “Methods for Salt Marsh Enhancement, Invasive Species Management”).

4.9 Construction Supervision

An experienced wetlands restoration construction supervisor, with a expertise in wetland vegetation, soil, and hydrology, is essential for salt marsh restoration projects, as discussed in Sections 2.1 “Form A Restoration Project Team” and 2.9, “Develop Design and Construction Documents” above. Working in a dynamic coastal natural environment means conditions may change and design adjustments may be needed to assure best conditions for native plant success. The type of expertise that will be needed on site during construction needs to be considered even during the design process.

5. OVERVIEW OF RESTORATION AND ENHANCEMENT APPROACHES

The project planning, site analysis, and design considerations described above may result in or be conducted in service of a wide variety of restoration approaches. The wetlands restoration, or enhancement, approaches used most often in NYC are described below. We describe approaches used to enhance conditions and ecosystem function in existing marshes, which are aimed at minimizing intervention in the marsh systems as well as more intensive restoration methods needed to reconstruct severely degraded marshes or re-create salt marsh where it no longer exists.

Minimal Intervention Methods for Ecosystem Enhancement:

- Marine debris removal
- Other debris removal
- Invasive species management
- Erosion control

Intensive Restoration Methods for Establishing Optimal Elevations:

- Re-establishing tidal flow regimes
- Excavation of fill to optimal planting elevations
- Over-excavation and placement of clean sand to optimal planting elevation
- Tidal channel construction
- Placement of clean sand to restore marsh elevation
- Establishing vegetation on newly restored surface

5.1 Methods for Salt Marsh Enhancement

In an existing salt marsh where the objective is to enhance ecosystem functions, simple, lower-cost interventions are appropriate:

Marine Debris Removal

Anthropogenic marine debris is commonly found at wetland sites throughout New York City, and can smother vegetation and be a source of contamination in a marsh. Small and large floatable debris washes up and is deposited on the marsh at high tide or during a storm event.

Light debris such as small pieces of wood, tires, blocks of foam, and other floatable trash can often be removed by organized volunteers, provided the working conditions are deemed safe. Even small groups of volunteers can successfully remove significant amounts of debris from a marsh and have a significant impact (Figure 8). While debris can be removed year-round, collecting debris in the winter is ideal. In the winter, the marsh vegetation is dormant, making debris more visible and reducing impacts of trampling to existing plants. Ideally the ground is also frozen, minimizing compaction of marsh peat. Unfortunately, floatable plastics can be very small and difficult to extract from organic wrack (dead vegetation), which accumulates naturally in a marsh. Even foot traffic for hand removal of debris in a marsh must be closely controlled. As few people as possible should walk in the marsh, preferably single file and on boards (e.g. collected from debris on site), where possible, to minimize impact. Prior to any work in the marsh, sensitive species, such as salt marsh sparrow, should be identified, and there should be no activity in the marsh during nesting season.

Heavier debris such as large timbers, boats, oil drums, etc. should be removed by qualified contractors as part of the restoration. This must be factored into the project cost estimate.

Specifically, abandoned boats or other vehicles must be handled and disposed of carefully by a qualified contractor familiar with legal environmental stipulations for controlling release of fuel and other fluids, and vehicle owner notification procedures. Where water access is feasible, debris removal can be performed from a barge and crane to minimize damage to the existing marsh (Figure 9). Machine access through land may require pathways over existing marsh vegetation and specific protections to the marsh surface including marsh mats and low ground-pressure equipment. This type of work should be performed between approximately December 1st and April 30th to minimize marsh impacts and wildlife disturbance. Selection of contractor equipment has to be very closely monitored (see Appendix I).

Figure 8. Marine debris removal with volunteers at Alley Creek, Queens. Before (left) in June 2015, immediately following removal (middle) in June 2015, and one year after (right) in August 2016.

Figure 9. Example of accumulated marine debris at Four Sparrow Marsh, Brooklyn (left, ca. 2014) and marine debris removal of boats from a barge and crane in College Point, Queens (right, ca. 2014).

Other Debris Removal

Other large, non-organic debris such as asphalt or concrete rubble that prevents vegetation from growing where it otherwise might thrive is also common in urban marshes as a result of filling or dumping activities. This type of debris should be removed by a qualified contractor using small machines and must be included in the project cost estimate. Adequate provisions for minimizing negative impacts to the marsh must be in place, as described above. Areas impacted by debris, or by equipment used in debris removal, may require restoration. The substrate, elevation, and seed bank should be assessed after debris removal and fine grading, sediment placement, and re-vegetation planned as needed.

Invasive Species Management

Invasive species are commonly found in areas designated for restoration, particularly in urban environments. Before developing an invasive plant management strategy for a site, it is critical

to understand why existing site conditions are conducive towards that plant, whether the environmental cost of the intervention outweighs the outcome, and that it will be successful long-term. One of the most common invasive species found in urban wetlands is *Phragmites australis*, because it can tolerate inundation and has a competitive advantage over native salt marsh plants in brackish water. The dominance of *Phragmites* is usually indicative of elevations above the high marsh, land fill or disturbed soils, high nutrient water or soil, and freshwater inputs. Although elevation and soil type can be manipulated, water quality and freshwater inputs usually cannot be controlled. Consequently, *Phragmites* eradication can be nearly impossible without continued management under these latter conditions. *Phragmites* control should only be undertaken in conjunction with another intervention, such as removing fill and changing the elevation of the site or increasing tidal flushing with saline water. If coastal forest is planned for the site, shading out *Phragmites* may be an appropriate method for managing *Phragmites* in the buffer or upland, along with invasive species management. Despite location, the more stunted and sparse the *Phragmites* is at a site, the greater likelihood that treatment could be effective.

If invasive species are present at the project site prior to restoration in the intertidal or adjacent upland areas targeted for restoration, treat the plants using mechanical and/or chemical control methods. *Phragmites australis* has an extensive root system that requires excavation, repeated cutting, or use of chemical control to significantly reduce the population. While wetland safe chemicals should always be used for any chemical invasive species management, there are environmental pros and cons to use that should be considered. See Appendix J for detailed description of mechanical and chemical methods to remove and manage invasive plant species commonly found in marshes and adjacent upland plant communities in the New York City area.

If mechanical and chemical methods are not appropriate for the site, or have a low likelihood of success, consider excavating a tidal creek or ditch that is wide and deep enough to increase the tidal flow reaching the site and minimize the spread of *Phragmites* via rhizomes. If freshwater inputs are high, or the existing elevation of the site too high to support salt marsh, this approach may not be successful. One should also consider how sea-level rise will impact the site long-term. If the soils are native or unmodified and tidal elevations will be achieved within 50 to 100 years, *Phragmites*-dominated wetlands may naturally convert to native vegetation communities given increased flooding. In this case, excavating *Phragmites* or modifying the site hydrology through ditching may be unnecessary to restore native salt marsh in the long-term.

Shoreline Protection and Erosion Control

Assuming tidal channels and the marsh plane slope are appropriately designed, erosion control only needs to be considered at the marsh shoreline edge and in the adjacent upland.

Along the shoreline, where wave action or flow velocity is a concern, and there is no existing fringe marsh or armored edge that will be left in place, an erosion resistant shoreline toe or breakwater may be needed. Shoreline protection may be implemented in coordination with an existing large-scale restoration project (see Section 5.2 “Methods for Salt Marsh Restoration, Placement of Clean Sand to Restore Eroded Salt Marsh Shoreline”) or as an enhancement method independently to help protect an existing shoreline or reduce further shoreline loss. See Section 4.4. “Waves and Fetch” for additional guidance on incorporating these elements into projects.

Erosion resistant materials for shoreline protection should be sized according to the hydraulic or energy conditions at the sites. Bags of shell or coir logs may be suitable in very low energy environments until plants become established. Small rip rap sills of different sizes, or modulated blocks (e.g. oyster castles or reef balls), potentially of eco-concrete or other materials, may be required to reduce scour at highly exposed sites (Figure 10).

Figure 10. Green (nature-based) and gray (harder) shoreline protection methods for shoreline protection. Adapted from NOAA and USACE (2015) "Natural and Structural Measures for Shoreline Stabilization."

5.2 Methods for Salt Marsh Restoration

For sites that were formerly wetlands where the marsh ecosystem is non-existent or no longer functioning, more complex and intensive restoration methods to achieve elevations within in the intertidal range and reestablish tidal flow are appropriate. Data collected through site analyses should inform how the existing topography needs to be modified to support salt marsh.

Re-establishing Tidal Flow Regimes

Tidal flow at a formerly connected wetland may be reconnected by several means: berm removal, culvert expansion, or construction of tidal channels; however tidal channels may also be constructed in newly restored marshes as well. The goal of these methods is to re-introduce tidal flow where it had been suppressed or restricted to support salt marsh plant communities. Here we provide an overview of these methods but defer to Niedowski (2000) and Williams and Associates (2004) for specific guidance and design calculations.

Culvert expansion or removal

If tidal flow is restricted due to an undersized, broken, or blocked culvert, expanding or removing the culvert may be needed (Figure 11). The target culvert size should be based on local, naturally occurring reference tidal channel dimensions, or on tidal prism calculations for the target marsh to be restored.[35, 36] The invert at the landward side of the culvert must be higher than on the estuary side to assure adequate drainage as the tide retreats.

[35] Philip Williams & Associates, Ltd., and P. M. Faber. 2004.
[36] Niedowski, N.L. 2000.

Figure 11. Example of an undersized culvert (left) in 2013 into Eastchester Bay and following replacement (right) in 2016 at Turtle Cove in Pelham Bay Park, Bronx.

Berm removal

If a site is tidally restricted due to presence of a berm, and as long as the elevation of the formerly connected marsh has not been manipulated, natural tidal flow can be re-established by removing the entire berm or a section of the berm or constructing a culvert or tidal channel through the berm to provide adequate tidal flow to the formerly connected marsh (Figures 12 and 13). The size of the channel or culvert in the berm should be based on local naturally occurring reference salt marsh tidal channel dimensions.[37] If a channel is cut through the berm, depending on the stability of the berm material, the initial opening may scour and widen over time until tidal equilibrium is reached. Berm material and stability should be accounted for in the initial design.

Figure 12. Example of Saw Mill Creek East berm removal site before removal, ca. 2001 (left) and-post removal, ca. 2015 (right).

[37] Philip Williams & Associates, Ltd., and P. M. Faber. 2004.


Figure 13. Example of Saw Mill Creek East berm removal site post-removal, ca.1998 (left) and ca. 2015 (right).

Excavation to Optimal Planting Elevations

If the existing fill material on a historic wetland is not contaminated and is a clean mineral or organic soil suitable for planting, the site can be excavated and graded to the appropriate elevation and slope to support salt marsh vegetation (Figure 14).

In some cases, after fill material has been excavated, the underlying surface elevations will rise, or rebound, from having the weight of the fill removed. Contractors should complete excavation to target grades and resurvey several weeks later to verify that the target elevations have been achieved. In cases where the surface has rebounded above the target design elevations, additional excavation may be required. In other cases, where a site is over-excavated and clean sand is added to design grades, there may be compaction or settlement following sand placement. Surveys several weeks later are needed to determine if additional sand is needed to meet design grades.

Over-excavation and Placement of Clean Sand to Optimal Planting Elevation

If the existing substrate is found to be contaminated, the site must be over-excavated beyond the target grade, backfilled, or “capped” with clean substrate, and graded to the appropriate elevation and slope to support salt marsh vegetation (Figure 15).

In the event of site contamination, NYSDEC will provide guidance on required depth of over-excavation and capping with clean sand based on the type and levels of contamination found. Typically, clean fill placement is 18 inches, ranging from approximately 1 feet to 2 feet capping depths. Note that if contamination or hazardous material is found, safe excavation and disposal methods must be followed. This is very common in urban coastal areas due to oil spills and illegal filling and dumping activities and can significantly increase project costs. It is important to handle any contaminated materials using the most environmentally sensitive methods available, and to reuse these materials on site wherever possible.

Figure 14. Gerritsen Creek restoration during excavation ca. 2010 (left), immediately after planting ca. 2011 (middle), and immediately after Hurricane Sandy ca. 2012 (right). Clean soil existed under excavated fill, so no clean sand was placed.

Figure 15. Salt marsh restoration involving over-excavation of fill and placement of clean substrate at Pugsley Creek in The Bronx, NY Images show the site before, ca. 2008 (left), during, ca. March 2011 (middle), and after restoration, ca. September 2015 (right).

Tidal Channel Construction

Tidal channels can be constructed to restore tidal flow to a newly restored or enhanced marsh. If a site is large, with distances of more than 100 feet (30 meters) from the shoreline or an existing channel, channel construction can help increase tidal flushing, improve drainage, and allow for fish and other aquatic organisms to access the interior of the site. Channel dimensions, sinuosity, and density should be designed based on local, naturally occurring reference tidal channels.[38,39] Initial depth and width can be estimated from reference sites with similar drainage areas or tidal prisms. We recommend erring on the side of the smallest expected channel width to maximize planted marsh area and minimize erosion, as the channel cross-section and the bank slopes will often change and widen over time.[40] The slope of the restored marsh surface should be designed so positive drainage occurs towards tidal channels to ensure no standing water remains when the tide retreats.[41] See Section 4.7 “Design Slope.”

Tidal channels should only be constructed if they are required to provide tidal flushing throughout the restoration site. For example, if a restoration site is long and linear along the shoreline with an appropriate tidal prism, the ebb and flow of the tide may naturally provide adequate tidal flushing without the construction of a channel. In addition, tidal channels will form

[38] Coats, R.N., P.B. Williams, C.K. Cuffe, J.B. Zedler, and D. Reed. 2003. Design Guidelines for Tidal Channels in Coastal Wetlands. The U.S. Army Corps of Engineers Waterways Experiment Station. 46 pp.
[39] Philip Williams & Associates, Ltd., and P. M. Faber. 2004. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay. The Bay Institute and California State Coastal Conservancy, Oakland, CA. 83 pp.
[40] NYC Parks. 2018a.
[41] Niedowski, N.L. 2000.

naturally in a marsh through exposure to the natural tidal regime, so unless the hydrologic and topographic positions of the restoration site deem channel construction necessary, it may not be a cost-effective intervention.[42] While there are no detailed guidelines for the design of tidal channels for the east coast, one general rule of thumb can be used: no area within the marsh plain should be more than 100 feet (30 meters) from a tidal channel.[43] This guideline comes from a general recognition that the marsh plain needs to drain as the tide retreats; otherwise, continued inundation will create anoxic conditions that impair plant growth, resulting in marsh drowning.

Once construction begins, particularly at smaller sites, specific on-site conditions may require field directed changes during construction. For example, hydrodynamics at the site may require changes to the location of tidal channels due to the natural ebb and flow of tides, sediment movement, springs or seepage that may be exposed after fill is excavated, and overland stormwater runoff. As a result, projects are not always constructed as designed. In order for practioners to continue to learn from design and construction, as-built drawings and a complete record of field changes are critical to the project record.

Placement of Clean Sand to Restore Marsh Elevation

If the marsh has experienced significant erosion either along the shoreline or in the interior of the marsh, sediment may need to be added to the surface of the project site to re-achieve elevations that will sustain salt marsh. At this time, the following methods to increase marsh elevation are considered pilots by NYSDEC and their ecological benefits must be justified; however, they are actively used in other parts of the United States or region.

Thin-layer Sediment Application for Interior Marsh Enhancement

If an existing salt marsh appears to be subsiding, drowning, or converting to mudflat in the interior or edges, a thin layer of sediment placed on the marsh surface may serve to re-establish elevations that will support *Spartina*. Sediment placement has been piloted in Jamaica Bay, New York, on National Parks Service wetlands and salt marsh islands, as well as in the states of Louisiana, New Jersey, Rhode Island, and elsewhere in the Mid-Atlantic and Gulf Coast. Typically, 6 to 12 inches (15 to 30 cm) of clean mineral sediment are applied across the existing marsh surface to add elevation while not smothering the plants. This sediment, ranging from silt- to sand-sized particles, is combined with water and sprayed through a hose, or “rainbowed” over the existing marsh.[44] Depending on the project budget and available equipment, this sediment may be sourced from channels directly adjacent to the marsh restoration site and applied in a single step process. In other cases, a slurry may be prepared with dredged or excavated clean sediment from elsewhere and transported to the restoration site via barge, truck, or pipe. Beneficial re-use of nearby dredge material is the preferred application method when possible and may also save on construction costs. Thin-layer sediment application is an intervention that can help increase the longevity of a marsh and reduce conversion of salt marsh to mudflat with minimal disturbance to healthy vegetation in the marsh. Salt marsh grasses will recolonize the site when covered by 6 inches of sediment, but more may require re-planting.[45]

At a much smaller and more targeted scale, sand placement approaches can be modified to restore ditches or interior open water pools that have expanded over time. In these cases, depositing sediment as a slurry through a hose from land may be more appropriate than

[42] Simenstad, C.A. & R.M. Thom. 1996. Functional equivalency trajectories of the restored Gog-Le-Hi-Te estuarine wetland. Ecological Applications 6(1): 38-56.
[43] R. Thom, personal communication
[44] Messaros, R.C., Woolley, G.S., Morgan, M.J., Rafferty, P.S., 2012. Chapter 8. Tidal Wetlands Restoration, in: Ali, M. (Ed.), The Functioning of Ecosystems. InTech Europe, pp. 149-170. https://www.intechopen.com/books/the-functioning-of-ecosystems/tidal-wetlands-restoration
[45] Ray, G. L. 2007. Thin layer disposal of dredged material on marshes: A review of the technical and scientific literature. ERDC/EL Technical Notes Collection (ERDC/EL TN-07-1), Vicksburg, MS: U.S. Army Engineer Research and Development Center.

"rainbowing" (spraying sediment by hose). Sediment may also be hauled to a marsh and deposited by a bucket and spread using tracked low ground-pressure construction equipment and marsh mats to distribute weight and avoid impacts to the salt marsh. If the project area contains a large edge open to water (e.g. in a tidal pool) or is susceptible to wave action, coir logs may be necessary to stabilize the newly placed sediment until plants establish.

CASE STUDIES

Jamaica Bay Marsh Islands – Restoring Eroding Marshes

Sediment placement has been used in two different ways since the early 2000s in NYC on National Park Service (NPS) property in the Jamaica Bay following marsh loss observed on the islands in the late 1990s.[46, 47] At these sites, formerly vegetated salt marsh had converted to mudflat requiring the elevation of the island to be raised in order to support salt marsh.

First, in 2003 at Big Egg Marsh, Queens, NY, the NYSDEC approved placement of sand dredged from an adjacent tidal channel on to a marsh with increasingly sparse and fragmented low marsh vegetation.[48] The sand covered about 1 acre and was placed 6 inches to 2 feet deep depending on the existing terrain and inaccuracy in the application. NPS viewed the site as a success three years post-construction, based on the dense cover of smooth cordgrass.

Next, at a much larger scale, USACE, NYSDEC, New York City Department of Environmental Protection (NYCDEP), and NPS placed clean sand across 155 acres over five Jamaica Bay marsh islands from 2007 to 2013 (Figure 16).[49] This large-scale restoration effort was the result of analyses indicating that an estimated 220 acres of salt marsh were lost between 1994 and 1999 (approximately 47 acres per year), and as a result, were expected to cease to exist by 2025.

The sand used for these restorations was beneficially reused from USACE dredging projects to deepen and maintain shipping channels in the Ambrose Channel in New York Harbor. Sand was placed in varying depths of up to several feet deep across each island and contained through coir logs and other measures to keep it in place throughout construction. Various planting and seeding techniques were used to re-establish salt marsh vegetation after sand was placed, including transplanting, seeding, and both volunteer and contractor plug planting.

NPS monitored each site following each restoration. The marsh island project primarily met their restoration goals of 85% salt marsh vegetation cover within the project areas. The establishment of other functions, and the longevity of the marsh islands, given sea-level rise, reduced sediment supply and on-going eutrophication, will take decades to determine.[50]

---

[46] Gateway National Recreation Area, National Park Service, US Department of the Interior. 2007. An Update on the Disappearing Salt Marshes of Jamaica Bay, New York. Jamaica Bay Watershed Protection Plan Advisory Committee http://www.nytimes.com/packages/pdf/nyregion/city_room/20070802_FinalJamaicaBayReport.pdf

[47] Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, and D. Fallon. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:71-89.

[48] Frame G.W., M.K. Mellander, and D.A. Adamo. 2006. Big egg marsh experimental restoration in Jamaica Bay, New York. *In People, places and parks: proceedings of the 2005 George Wright Society conference on parks, protected areas, and cultural sites, ed. D. Harmon*, 123–130. Hancock: The George Wright Society

[49] Jamaica Bay Watershed Protection Plan Advisory Committee. 2007. Planning for Jamaica Bay's Future: Final Recommendations on the Jamaica Bay Watershed Protection Plan.

[50] Rafferty, P., J. Castanga, and D. Adamo. 2011. Building partnerships to restore an urban marsh ecosystem at Gateway National Recreation Area. Park Science 27(3):34-41.

Figure 16. Rulers Bar before restoration showing largely unvegetated mudflat (left) and Elders Point after restoration with transplanted salvaged marsh grasses (right). Photos courtesy of USACE.

Alley Pools – Targeted Restoration of Expanding Interior Pools

NYC Parks in collaboration with the Natural Areas Conservancy (NAC) conducted a sediment placement pilot project to restore recent areas of vegetation loss, here described as pools, in the interior of the Alley Creek salt marsh (Figure 17). These pools had increased by 40% in size since 1974, resulting in loss of contiguous marsh vegetation and risk that pools will continue to expand overtime unchecked further fragmenting the interior of the marsh. Testing this intervention is important, as the Alley Creek salt marsh is at risk of becoming increasingly fragmented as existing pools enlarge, new pools form, and more marsh converts to mudflat at a faster than historic rate. This effort tested an approach that could become a useful tool for addressing the ongoing loss of habitat from marsh pool expansion that has been documented in New York City over the last 40 years.

In April 2017, NYC Parks and NAC staff placed coir logs along the 1974 boundary of the largest pools in Alley Creek marsh. The entire pool area was not filled in, as pools have value as shorebird foraging habitat. The coir logs were staked and bound in place to stabilize newly applied sediment. Once sediment had settled and elevations were verified, volunteers helped plant *Spartina alterniflora* at the low marsh elevations and *Spartina patens* and *Distichlis spicata* at the higher elevations. Materials were transported onsite using marsh mats consisting of plywood or engineered plastic boards to protect vegetation and minimize soil compaction (Figure 17).

Figure 17. Salt marsh restoration at Alley Creek in Queens, NY, through placement of clean sediment where open water persists. Setting coir log along the flooded former marsh early April 2017 (left). Placing and and marsh mats to access the marsh with machinery mid- April 2017 (middle). Planting *Spartina alterniflora* with staff and volunteers, June 2017 (right).

Placement of Clean Sand to Restore Eroded Salt Marsh Shoreline

If an existing salt marsh has exhibited extensive shoreline erosion, consider reconstructing the shoreline by placing sediment along the eroded edge, usually together with a shoreline edge treatment to retain that sediment, protect new plantings, and prevent further erosion. In NYC, the placement of sediment may be permitted up to the extent of the recently lost vegetated marsh, or to the 1974 tidal wetland edge, a regulatory boundary established by NYSDEC (see Appendix A for recommended data sources for NYSDEC 1974 Tidal Wetlands Inventory). Place clean sediment (usually sand) on the mudflat at the target design elevations from the existing marsh edge waterward to the historic boundary (Figure 18). Depending on the slope, depth of sand, and erosional forces at the site, protect the edge with more resistant materials such as coir logs, oyster castles, reef balls, or an armored sill or breakwater to prevent erosion while plants become established. As shoreline erosion is likely exacerbated by boat wake, wave action, or localized currents, the level, type, and placement of edge protection should be determined based on site-specific criteria such as fetch and frequent boat wakes. Given these complexities, the site may require energy or structure analyses for rock placement typically conducted by a licensed coastal engineer.

Depending on the severity of erosion, the sediment transport and supply dynamics, and current flow patterns, shoreline protection materials can also be strategically placed to capture suspended sediment on the incoming tide and allow it to settle on the marsh. Ideally, such measures help the marsh accrete in place and keep up with sea-level rise. In this instance, placement of clean sediment behind the protective measure may not be required. On the marsh islands in Jamaica Bay, for example, no shoreline protection was used, due, in part, to the gradual slope of the sediment placement at the perimeter of the islands. Additional guidance for living shorelines in New York State may be sought from NYSDEC.[51]

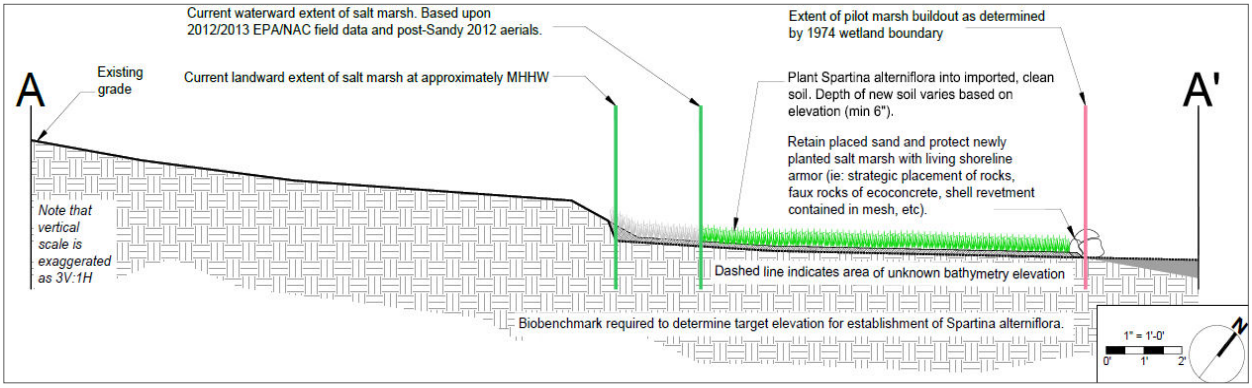


Figure 18. Example cross-section for restoring the marsh edge to the 1974 wetland edge.

5.3 Establishing Vegetation on Newly Restored Surface

Species Selection

For each project, it is important to note which native plant species currently exist on the site or on a nearby reference site, if any, and consider including those species in the restoration planting palette. Species already thriving on site or adapted to target site conditions are the most likely to survive, as they are adapted to persist within local conditions despite any

[51] NYSDEC. 2017. Living Shoreline Techniques in the Marine District of New York State. http://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf

stressors. For the most common and successful salt marsh restoration plant species in NYC see Table 1.

Plant palettes may need to be customized to salinity levels at the site, which may differ based on position further inland within the watershed or freshwater inputs such as springs or stormwater runoff from storm sewers or CSOs. In this instance, plant palettes should be modified to include species found in fresh or brackish water (0 to 15 ppt). Typical salt marsh and transition zone plant palettes include species that thrive in saline (15 to 35 ppt) environments. Depending on the location and goals of the restoration, it may also be important to consider species that are tolerant of salt spray in the upland zones.

Appendix E contains a list of common native plant species from tidal fresh to salt water that may be referenced for developing a restoration planting palette for salt marshes and adjacent areas. In salt marshes, the typical focus is on planting grasses, as the forbs typically colonize on their own in a few years, as is the case with annual species, not on this list (see "Native Species Planting Guide for New York City" for additional species).[52]

Native salt marsh vegetation communities can be established through planting of plugs, seeding, or transplanting vegetation as sod or individual plants from a nearby reference site.

Target Planting Elevations

As discussed above, low marsh plants typically thrive at elevations between Mean Tide Level (MTL) and Mean High Water (MHW), and high marsh plants thrive between MHW and Mean Higher High Water (MHHW), with some variation across different locations. If there is existing vegetation on site or at a nearby reference site, biobenchmarks should be used in combination with local tide gauge data and sea-level rise projections to determine the target elevations for each of the species in the restoration planting palette (see Sections 3.4 "Biological Benchmarks," 3.5 "Tidal Elevations," and 4.1 "Sea-Level Rise, Marsh Accretion, and Marsh Migration" above). In addition, to increase likelihood of plant survival and account for minor errors in elevation measurements, a generous transitional zone, or area where a mix of low and high marsh species are interplanted, should be incorporated.

Plant Sourcing

Wherever possible, it is best to use native plant material sourced from seed collected from diverse populations within a 100 mile radius of the project site, or a New York City property. This will help to ensure that seed stock or newly propagated plants are derived from local ecotypes, meaning plants will have the same traits as the local varieties which have evolved to thrive in highly urbanized conditions, increasing the chances of planting success (see Section 2.10 "Plan for Procurement and Propagation of Plant Material").

Planting Plugs or Stems

Plant herbs and grasses as two-inch plugs to maximize success, rapidly establish a root network, and reduce potential impacts from herbivory. Two inch plugs may also be "stepped-up" to quarts or larger containers; this is becoming a popular practice elsewhere in the Mid-Atlantic to maximize plant survival but may only be feasible at relatively small sites.[53] Recommended spacing for plugs in the initial restoration planting is 12 inches on center, in a triangular pattern. If the project budget does not allow for this density, spacing can be adjusted; however, spacing should not exceed 24 inches on center, especially in an urban context.

---

[52] NYC Parks. 2015. Native Species Planting Guide for New York City. https://www.nycgovparks.org/pagefiles/73/nrg-native-species-planting-guide-121213.pdf

[53] Delaware Department of Natural Resources and Environmental Control, personal communication.

Limited research indicates that cluster planting may be an alternative formation that potentially boosts plant survival at no cost to the project.[54] The original theory for spacing plants evenly in a triangular or grid pattern was based on the assumption that competition for light and nutrients would be reduced; however, this research indicates that plants may thrive in clusters by relying on each other to reduce erosion stress.

Salt marsh planting should occur after the last frost (generally mid-April) and before the end of June. High summer water temperatures can increase the risk of transplant shock and mortality. Following planting, plugs should be protected with Exclusion Fencing to protect new plugs from herbivory (see Section 6.1 "Short-Term Maintenance").

Trees and Shrubs

Woody material may be planted in spring (March to May) or fall (October to November) in one- or two-gallon containers. Spacing can be clustered or on-center spacing; however, trees and shrubs should be planted no closer than nine feet on center. All woody material should be appropriate for the tidal range and coastal environments, in that they should be adapted to survive occasional storm surge or tidal flooding as well as salt spray.

Seeding

In general, seeding is rarely recommended in small urban salt marsh restoration projects unless there is no other source of or budget for plant material. In low marsh zones, seed is likely to wash away with frequent flooding. Seeding is more suitable for larger sites, upland and transitional areas, or within the high marsh zone where the surface is inundated less frequently and less exposed to wave energy. Seeding is often used throughout the marsh when the revegetation area is very large (e.g. more than 10 acres) because pressure from herbivory may be less of a concern and cost of planting plugs is too high. Seeding should be considered as a low cost way of accelerating revegetation following debris removal.

There are several approaches to seeding, which are dependent upon available resources and site conditions. Seed can be broadcasted by hand across the site and left unsecured; however, it may be washed away with the ebb and flow of the tide. To try to keep seed in place, cover seed with wrack (organic dead marsh grass stems) found on site. In the upland, seed may be covered with coir webbing or jute mesh (see "Upland or Transitional Zone Erosion Control" below) to keep it in place. In general, to increase seeding success in the uplands, research points to increasing the seeding rate and diversity of mixes and including a roughly 1:1 ratio of grasses to forbs to give forbs a better chance for survival.[55,56]

Transplanting

Transplanting may be a viable option if a portion of the site will be impacted during restoration efforts or in an effort to transplant vegetation growing in fill material or undesirable substrate. Transplants should not be taken from an existing adjacent marsh, as no impacts should occur to native marshes.

Transplanting should occur in the dormant season and care should be taken to reduce damage to the root system while digging up plants. Grasses can be split easily by cutting and separating the root network; however herbaceous plants often have taproots that should not be damaged.

---

[54] Sillman. B.R, E. Schrack, Q. He, R. Cope, A. Santoni, T. van der Heide, R. Jacobi, M. Jacobi, and J. van de Koppel. 2015. Facilitation shifts paradigms and can amplify coastal restoration efforts. PNAS 112(46):14295–14300.
[55] Barr. S, J.L. Jonas, M.W. Paschke. 2017. Optimizing seed mixture diversity and seeding rates for grassland restoration. Restoration Ecology 25(3):396-404.
[56] Meissen. J. 2018. Cost-effective seed mix design and first-year management. Grant Report to the Iowa Nutrient Research Center 2016-07.

In the dormant season, plants dug up (by hand or machine) can be stored on site, but their root systems may need to be tightly covered so they do not dry out.

If transplants have to be held over the growing season, they can be brought to a greenhouse or placed in pots between harvest and planting. Transplants should be planted during the typical planting window (approximately mid-April to late June).

Prepare a detailed, custom specification for the contractor describing exactly what species will be transplanted in the restoration project, when this should take place, how the plants will be stored, where the plants will go, and how they will be dug and planted.

Planting Substrate

In some cases, existing soil on site can be used as planting substrate, while in other cases, clean sand must be added to the site for planting. Soil can be beneficially reused from uncontaminated dredge material or from clean material from a local construction site or obtained from quarries. Regardless of source, all soils remaining or placed on site must adhere to state and federal guidelines for human health and safety limits for heavy metals, persistent organic pollutants, and volatile organic compounds. NYSDEC will provide guidance on procedures for addressing or containing any soil contaminants and approval of materials. General parameters for soils appropriate for urban salt marsh restoration and planting are as follows, and a detailed table of material particle size and chemical properties can be found in Appendix K; however, plantable material generally consists of:

- Existing soil or peat layer free from contaminants, gravel, artificial materials or debris, refuse, and weed rhizomes, OR
- Clean sand, with particle sizes and chemical properties as shown in the tables below:
    - Dominant particle size (>70%) should be 0.05 mm to 0.25 mm in diameter, trapped by sieve size No. 60
    - Limited fines (<10%) silt or clay particles 0.05 mm to 0.0002 mm in diameter
    - Limited organic content (less than 3% loss on ignition)
    - pH of 4 to 8

Monitoring data from over 20 years of salt marsh restoration in NYC shows no significant difference in plant growth when plants are installed in peat, existing substrate, or clean sand.[57] This is likely the result of the high nutrient waters in NYC and the natural accumulation of organic matter over time. While many regions prefer to use finer sized material, sand is the preferred material in NYC due to its availability, affordability, and decreased risk of long-term compaction. Sand is less likely to experience water logging and is easier to handle and grade during construction, and thus is usually preferable to sandy material that has a significant fraction of fines (silt or clay).[58]

Soil Amendments and Fertilizer

Given the naturally low nutrient characteristics of sandy soils, soil amendments may be required for planting. In urbanized areas like NYC, the tidal waters inundating new plantings are typically high in nutrients, and there is no need for any amendments to the soil or plugs. Where there is some concern that tidal water is low in nutrients, the addition of fertilizer to plugs prior to planting may increase the likelihood of planting success—especially if planting in low nutrient

[57] NYC Parks. 2018a.
[58] Niedowski, N.L. 2000.

sandy soils. In NYC, the addition of organic matter to the substrate or fertilizer during planting may not be necessary and may only serve to add unnecessary nutrient loads to waterways.

Herbivory Exclusion Fencing

Installation of exclusion fencing is highly recommended to keep both herbivores and people out of the planted area and protect the restoration investment. Fencing should be installed and maintained by the contractors; however, it also may be installed and maintained by volunteers (see Section 6.1 “Short-Term Maintenance”). Fencing should remain in place and be maintained for at least two to three years after planting; however, it may require more maintenance if plants do experience herbivory damage due to fence damage or breaches, or if the fence is removed prior to plant establishment. The interior can be protected with 6- to 10-foot wooden stakes placed in a grid pattern approximately eight to ten feet apart across the site. Heavy nylon or mason line should be strung between the tops of the stakes and reflective flagging attached at two- to five-foot intervals along the length of the string (Figure 19). The flagging serves to deter waterfowl from landing in the planted area and grazing on and uprooting the new plants. Orange or black construction or deer exclusion fencing placed along the site boundaries will help prevent herbivores and people from walking into the planted area and help prevent floatable debris from washing in on high tide and crushing the new plants. If horseshoe crabs are prevalent near the site, it is imperative to inspect the site around their breeding timeframe (full and new moons from approximately late May to early August) to ensure horseshoe crabs do not get caught in the fencing. See Appendix L for herbivory fencing construction detail examples.

Figure 19: Goose fencing constructed surrounding newly planted salt marsh at Calver Vaux Park, Brooklyn.

Upland or Transitional Zone Erosion Control

In the uplands, install temporary erosion control materials such as jute mesh, coir webbing, coir logs, or erosion control blankets on steep slopes or edges vulnerable to storm wave splash, until plants become established. Inter-plant with native species where vegetation is sparse or where invasive plants have been removed (Figure 20).

Figure 20: Example of coir webbing installed on upland slope at Soundview Park, Bronx.

6. SITE MAINTENANCE AND MANAGEMENT

For any project, maintenance and planning for adaptive management are critical for long-term site sustainability. A maintenance plan should first be drafted during the planning phase (as discussed in Section 2.0 "Project Planning") and refined during and after design and construction. All post-construction maintenance and adaptive management should take place in coordination with post-construction monitoring. For guidance on monitoring see the "Salt Marsh Restoration Monitoring Guidelines.[59] This section will discuss the following:

- Short-term maintenance
- Long-term maintenance
- Adaptive management plan

6.1 Short-Term Maintenance

Project managers should develop a short-term maintenance plan for post-restoration and an associated implementation strategy. The plan should define the extent of the management area, management actions, those responsible for carrying out each action, and the timing for inspections and implementation. Maintenance instructions should be conveyed clearly, for example by providing an inspection form, an overview maintenance table, or "card," and a map (see Appendix M). Management or maintenance actions may include replacing plants or seed, maintaining herbivory fencing, maintaining erosion control features (fabric, fencing, coir logs, etc.), removing invasive species (mechanical or chemical methods), removing accumulated organic wrack, algae, and marine debris or floatable garbage. Those responsible for maintenance can include the contractor, project manager, operations staff, or volunteers.

Future potential problems and ways of solving them should be anticipated and described in the plan as well. For example, the success of the original planting palette should be reviewed and adapted as needed to reflect site conditions and plant performance post-restoration. See Appendix M for an example of site inspection forms and associated maintenance cards.

A short-term maintenance plan typically applies for one to five years following restoration, or longer as needed and resources allow. The following describe actions that project managers should plan for early in the planning and design process:

Exclusion Fencing

Exclusion fencing should be maintained throughout the year, but particularly in the winter months following ice that may shear across the site and dislodge stakes. Herbivory pressure from geese may be less intense during the winter months when the marsh is covered by ice and snow, but increases dramatically during early snow melt while lawns are still covered by snow—usually beginning in early March. It is critical to ensure fencing is maintained and secure during these months to protect establishing plants. Fencing may be maintained or constructed with volunteers to manage bare spots or localized herbivory (Figure 21). Details may be found in Appendix L.

[59] NYC Parks. 2018b. Salt Marsh Restoration Monitoring Guidelines.

Figure 21. Example photos of algae colonization (left) and goose fence installation at Soundview Park in the Bronx where plants were lost due to goose herbivory several years following restoration. Stakes with nylon string and attached bright flagging installed by volunteers (left). Algae on the marsh surface (right).

Algae Removal

Several species of algae may colonize the low marsh in newly planted areas or following disturbance. One common species is sea lettuce, *Ulva lactuca,* which can wash into the marsh at high tide and deposit on the ground, forming large sheets that smother young plants. Algae blooms are worst during the summer months when marsh grasses are just starting to grow. Algae is often caught by herbivory fencing in the first few years of restoration—it floats in and hangs on the fence. Algae can become more of a problem if there is a breach in the fencing or after fencing has been removed.

Following herbivory, algae will colonize in holes or small pools left from goose damage (Figure 21). In this instance, it is easiest to remove or rake algae at high tide either back into the tidal creek or upland onto the transitional slope where it can dry out and will not be reintroduced to the marsh. Algae can also be removed by hand at low tide and placed in buckets or garbage bags and left to dry. This method is more labor intensive and not recommended as soil is often removed with the algae.

Floatable Debris Removal

In some sites, especially near storm or sewer outfalls or near heavily recreated areas, floatable garbage may require routine clean-ups. This is a perfect activity to engage local stewards (Figure 22). Floatable clean-ups can occur any time of the year, and are especially great winter activities when plants are not obscuring debris and the ground is frozen; at these times, having groups of people in the wetland will be less impactful.

Replanting

If the initial planting event is not successful or if site disturbances result in plant mortality, additional planting may be necessary. Disturbances could be the result of goose herbivory, algae, or wrack or debris accumulation. Poor plant survival can also result from other issues during or immediately after construction, such as inadequately sized plant material, planting out of season, erosion, inappropriate elevations, or competition from invasive species, particularly in low salinity areas.

In the event bare areas are observed, try to determine the cause of the vegetation loss, if additional planting is needed, and if and how the planting palette should be modified to improve the likelihood of plant survival. Replanting is often best completed through partnerships through

local groups or stewardship events to promote long-term stewardship of the restored wetland. See Section 5.3 “Establishing Vegetation on Newly Restored Surface” for planting guidance.

Figure 22. Example of floatable debris collected by volunteers at a clean-up event in Four Sparrow Marsh, Brooklyn in 2017 before (left) and after (right).

Invasive Species Management

Invasive species, such as *Phragmites australis* (common reed), may need to be managed in the upland transitional area above the inter-tidal zone or where there are high freshwater inputs. Monitor the presence and migration or expansion during the first years of a project as installed native species become established. Maintenance can involve both mechanical and chemical removal. Staff or volunteers can perform mechanical cutting post-restoration, while chemical removal such as herbicide application should only be carried out using appropriate herbicides designed for use in or near water, with applicable permits, and by licensed individuals. Specific methods for invasive species removal and management are described in detail in Appendix J.

6.2 Long-Term Maintenance

Long-term maintenance should be considered beginning approximately five years following restoration. The following describe actions that land managers should consider in routine management plans.

Debris Removal

Marine debris is a constant issue in coastal urban environments. The ebb and flow of the tides in the restored salt marsh will inevitably result in the deposition of floatable debris over time, but debris may also accumulate rapidly during storm events. Debris accumulation should be monitored over time and when necessary, and/or feasible debris should be removed from the site by staff or with organized volunteers such as local community members or natural areas stewardship groups. If large marine debris such as boats or treated lumber wash into the site, removal may require licensed contractors, special disposal, and permits to remove.

Informal Pathways

Informal pathways may develop at wetland sites as people access for fishing, small boat launches, or viewpoints. These pathways should be monitored to determine if they greatly impact the habitat or sensitive species and to determine if they should be closed. Well-maintained educational signage and planned, formalized pathways outside of the marsh may reduce unwanted access.

6.3 Adaptive Management Plan

In the context of NYC Parks land management, we consider adaptive management at two levels, based on level of effort and timeframe. In the short term, one to five years following construction, routine maintenance, as described above, essentially functions as adaptive management, as long as the maintenance actions completed are documented, and land managers assess the issues that have arisen and the effectiveness of the response maintenance actions. Inspection reports provide recommendations and identify key parties responsible for taking specific actions to address site concerns. Lessons learned as a result of rapid site inspections and maintenance actions are observational and do not provide quantitative data to inform future design.

Another level of adaptive management should be considered that involves a higher level of resource investment and, usually, a longer timeframe. This more resource intensive adaptive management consists of establishing a specific field monitoring design aimed at evaluating the effect of specific management actions, often compared to a control site. Ecologists collect quantitative and statistically robust monitoring data that are analyzed to generate hypotheses geared towards learning about restoration or management methods. These hypotheses can then be tested in future projects, and thus systematically work towards improving long-term restoration outcomes. For guidance on monitoring for adaptive management, see the "Salt Marsh Restoration Monitoring Guidelines."[60]

[60] NYC Parks. 2018b.

REFERENCES

2006 New York City Administrative Code § 18-107: Replacement of Trees Removed During Construction. https://www.nycgovparks.org/rules/section-5. Rules Governing Tree Replacement https://law.justia.com/codes/new-york/2006/new-york-city-administrative-code-new/adc018-107_18-107.html

Barr. S, J.L. Jonas, M.W. Paschke. 2017. Optimizing seed mixture diversity and seeding rates for grassland restoration. Restoration Ecology 25(3):396-404.

Bergen. A. C. Alderson, R. Bergfors, C. Aquila, M.A. Matsil. 2000. Restoration of a Spartina alterniflora salt marsh following a fuel oil spill, New York City, NY. Wetlands Ecology and Management 8(2-3):185-195.

Browne, S., S. Crocoll, D. Goetke, N. Heaslip, T. Kerpez, K. Kogut, S. Sanford, D. Spada. 1995. New York State Freshwater Delineation Manual. New York State Department of Environmental Protection. 30pp. http://www.dec.ny.gov/docs/wildlife_pdf/wdelman.pdf

Coats, R.N., P.B. Williams, C.K. Cuffe, J.B. Zedler, D. Reed. 2003. Design Guidelines for Tidal Channels in Coastal Wetlands. The U.S. Army Corps of Engineers Waterways Experiment Station. 46pp.

Colon-Rivera, R.J., R.A. Feagin, J.B. West, K.M. Yeager. 2012. Salt marsh connectivity and freshwater versus saltwater inflow: multiple methods including tidal gauges, water isotopes, and LIDAR elevation models.

Frame G.W., M.K. Mellander, D.A. Adamo. 2006. Big egg marsh experimental restoration in Jamaica Bay, New York. In People, places and parks: proceedings of the 2005 George Wright Society conference on parks, protected areas, and cultural sites, ed. D. Harmon, 123–130. Hancock: The George Wright Society.

Gateway National Recreation Area, National Park Service, US Department of the Interior. 2007. An Update on the Disappearing Salt Marshes of Jamaica Bay, New York. Jamaica Bay Watershed Protection Plan Advisory Committee http://www.nytimes.com/packages/pdf/nyregion/city_room/20070802_FinalJamaicaBayReport.pdf

Gittman, R.K., A.M. Popowich, J.F. Bruno, C.H. Peterson. 2014. Marshes with and without sills protect estuarine shorelines from erosion better than bulkheads during Category 1 hurricane. Ocean & Coastal Management 102:94-102.

Hartig, E.K., V. Gornitz, A. Kolker, F. Mushacke, D. Fallon. 2002. Anthropogenic and climate-change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:71-89.

Horton, R., C. Little, V. Gornitz, D. Bader, M. Oppenheimer. 2015. New York City Panel on Climate Change 2015 Report Chapter 2: Sea Level Rise and Coastal Storms. Annals of the New York Academy of Sciences, 1336:36–44. http://onlinelibrary.wiley.com/doi/10.1111/nyas.12593/full

Jamaica Bay Watershed Protection Plan Advisory Committee. 2007. Planning for Jamaica Bay's Future: Final Recommendations on the Jamaica Bay Watershed Protection Plan.

Kentula, M.E. 2002. Restoration, Creation, and Recovery of Wetlands; Wetland Restoration and Creation, EPA. https://water.usgs.gov/nwsum/WSP2425/restoration.html

LaPann-Johannessen, C., J.K. Miller, A. Rella, E. Rodiquez. 2015. Hudson River Wake Study. The Hudson River Sustainable Shorelines Project NYSDEC HRNERR.

Meissen. J. 2018. Cost-effective seed mix design and first-year management. Grant Report to the Iowa Nutrient Research Center 2016-07.

Messaros, R.C., G.S. Woolley, M.J. Morgan, P.S. Rafferty. 2012. Chapter 8. Tidal Wetlands Restoration, in: Ali, M. (Ed.), The Functioning of Ecosystems. InTech Europe, pp. 149-170. https://www.intechopen.com/books/the-functioning-of-ecosystems/tidal-wetlands-restoration

Minello, T.J., L.P. Roza, S.P. Hillen, J.A. Salas. 2015. Variability in salt marsh flooding patterns in Galveston Bay, Texas. NOAA Technical Memorandum NMFS-SEFSC-678, 12p.

Moller, I., M. Kudella, F. Rupprecht, T. Spencer, M. Paul, B.K. van Wesenbeeck, G. Wolters, K. Jensen., T.J. Bouma, M. Miranda-Lange, S. Schimmels. 2014. Wave attenuation over coastal salt marshes under storm surge conditions. Nature Geoscience. 7:727-731.

Moreno-Mateos D., M.E. Power, F.A. Comı´n, R. Yockteng. 2012. Structural and Functional Loss in Restored Wetland Ecosystems. PLoS Biol 10(1): e1001247.

National Oceanic and Atmospheric Administration, 2017. Mean Sea Level Trend; The Battery, New York https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8518750

New York City Department of Parks & Recreation. 2013. Native Species Planting Guide. https://www.nycgovparks.org/pagefiles/73/nrg-native-species-planting-guide-121213.pdf

New York Department of Parks and Recreation (NYC City Parks). 2014. Guidelines for Urban Forest Restoration. https://www.nycgovparks.org/pagefiles/84/guidelines-to-urban-forest-restoration.pdf

New York City Department of Parks & Recreation (NYC Parks). 2017. Design and Planning for Flood Resiliency: Guidelines for NYC Parks.

New York City Department of Parks & Recreation (NYC Parks). 2018a. Salt Marsh Restoration in NYC: Assessment of Condition and Recommendations for Future Design and Monitoring. Report to Environmental Protection Agency Wetland Program Development Grant.

New York City Department of Parks & Recreation (NYC Parks). 2018b. Salt Marsh Restoration Monitoring Guidelines.

New York City Department of Parks & Recreation (NYC Parks). 2017. Toward a Salt Marsh Management Plan for NYC: Recommendations for Restoration and Protection. http://naturalareasnyc.org/content/3-in-print/3-partner-publications/nycparks_saltmarshstrategyreport_may_2017.pdf

New York City Tree Replacement guideline: https://www.nycgovparks.org/rules/section-5

New York/ New Jersey Harbor Estuary Program. 2001. Status Report: A Regional Model for Estuary and Multiple Watershed Management. Habitat Workgroup.

New York State Department of Environmental Conservation. 2017. Environmental Resource Mapper. http://www.dec.ny.gov/gis/erm/

New York State Department of Environmental Conservation. 2017. Tidal Wetlands Guidance Document: Living Shoreline Techniques in the Marine District of New York State. http://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf

Niedowski, N.L. 2000. New York State Salt Marsh Restoration and Monitoring Guidelines. New York State Department of State and New York State Department of Environmental Conservation. Canadian Journal of Fisheries and Aquatic Sciences 69:1420-1432.

NOAA Tides and Currents website: https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1407

O'Neil-Dunne, J.P.M., S.W. MacFaden, H.M. Forgione, J.W.T. Lu. 2014. Urban ecological land-cover mapping for New York City. Final report to the Natural Areas Conservancy. Spatial

Informatics Group, University of Vermont, Natural Areas Conservancy, and New York City Department of Parks & Recreation. 22 pp.

Onset HOBO U20 series website: http://www.onsetcomp.com/products/data-loggers/absolute-pressure

Onset HOBOware website: http://www.onsetcomp.com/products/software/hoboware

Philip Williams & Associates, Ltd., P. M. Faber. 2004. Design Guidelines for Tidal Wetland Restoration in San Francisco Bay. The Bay Institute and California State Coastal Conservancy, Oakland, CA. 83 pp.

Rafferty, P., J. Castanga, D. Adamo. 2011. Building partnerships to restore an urban marsh ecosystem at Gateway National Recreation Area. Park Science 27(3):34-41.

Ray, G. L. 2007. Thin layer disposal of dredged material on marshes: A review of the technical and scientific literature. ERDC/EL Technical Notes Collection (ERDC/EL TN-07-1), Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Rohweder, J., J.T. Rogala, B. L. Johnson, D. Anderson, S. Clark, F. Chamberlin, K. Runyon. 2008. Application of wind fetch and wave models for habitat rehabilitation and enhancement projects. U.S. Geological Survey Open-File Report 2008–1200, 43 p.

Russell, I. T. Kraaij. 2007. Effects of cutting Phragmites australis along an inundation gradient, with implications for managing reed encroachment in a South African estuarine lake system. Wetlands Ecology and Management. 16:383-393.

Sillman. B.R, E. Schrack, Q. He, R. Cope, A. Santoni, T. van der Heide, R. Jacobi, M. Jacobi, J. van de Koppel. 2015. Facilitation shifts paradigms and can amplify coastal restoration efforts. PNAS 112(46):14295–14300.

Simenstad, C.A., R.M. Thom. 1996. Functional equivalency trajectories of the restored Gog-Le-Hi-Te estuarine wetland. Ecological Applications 6(1):38-56.

The Open Accessible Space Information System (OASIS). 2017. http://www.oasisnyc.net/

Tiner, R.W. 2000. Wetlands of Staten Island, New York, Valuable and Vanishing Urban Wetlands. US Fish and Wildlife Service, Cooperative National Wetlands Inventory Publication. Hadley, Massachusetts. https://www.fws.gov/wetlands/Documents/Wetlands-of-Staten-Island-New-York-Valuable-Vanishing-Urban-Wildlands.pdf

U.S. Fish & Wildlife Service. 2017. National Wetland Inventory Maps. https://www.fws.gov/wetlands/data/mapper.html

Warren Pinnacle Consulting Inc.. 2014. Application of Sea-Level Affecting Marshes Model (SLAMM) to Long Island, NY and New York City. Final Report (14-29).

Zedler, J.B. 2000. Progress in wetland restoration ecology. Trends in Ecology & Evolution 15(10):402-407. http://www.umanitoba.ca/institutes/natural_resources/pdf/Zedler_restoration.pdf

ACKNOWLEDGEMENTS

These guidelines are based on decades of research, experience, and experimentation by NYC Parks staff, our colleagues from other state and local agencies and the private sector, and practitioners in a range of fields throughout the mid-Atlantic and New England coastal region. Many people contributed to this effort, and we greatly appreciate everyone who took time to make this document more complete, accurate, and useful to future restoration practitioners. We appreciate comments and notes provided by Alex Foumier, Victoria O'Neill, Ken Scarlatelli, and numerous others. At NYC Parks, Novem Auyeung, Jennifer Greenfeld, Ellen K. Hartig, Jamie Ong, Marcha Johnson, and Nancy Prince contributed valuable guidance, as did Helen Forgione from the Natural Areas Conservancy. This report was made possible through funding from the EPA, Region 2, Wetland Program Development Grant managed by Kathleen Drake.

AUTHOR'S CONTACT INFORMATION

City of New York Parks and Recreation
Forestry, Horticulture, & Natural Resources
Arsenal North
1234 Fifth Avenue
New York, NY 10029

Marit Larson
Chief, Natural Resources
Telephone: 212-360-1415
Email: marit.larson@parks.nyc.gov

Rebecca Swadek
Senior Wetlands Restoration Program Manager
Telephone: 212-360-1436
Email: rebecca.swadek@parks.nyc.gov

Elizabeth Jordan, RLA
Senior Project Manager, Landscape Architect
Telephone: 212-360-1453
Email: elizabeth.jordan@parks.nyc.gov

Kjirsten Alexander
Assistant Landscape Architect
Telephone: 212-360-1448
Email: kjirsten.alexander@parks.nyc.gov

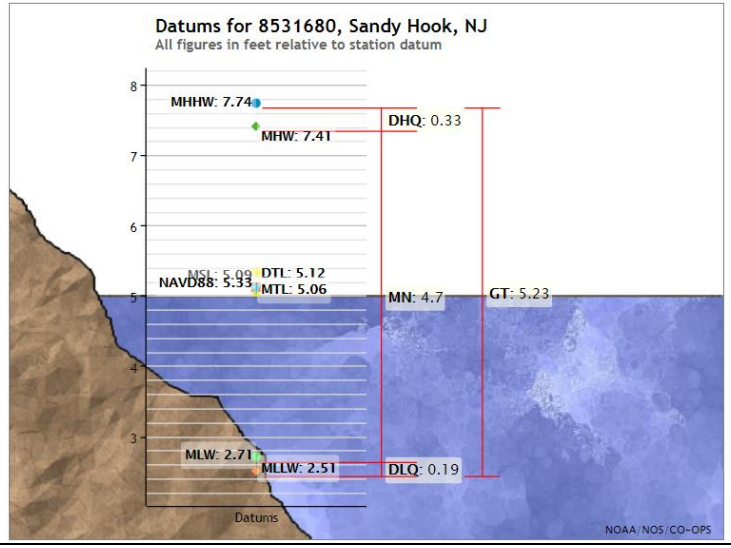
Chris Haight
Project Manager
Telephone: 212-360-1443
Email: christopher.haight@parks.nyc.gov

NYC Parks

APPENDICES

Appendix A: Public Data Sources for Planning, Permitting, and Design

Location	Source	Data Type	Website
New York City	NYC Open Data	Various data from the City of New York	https://opendata.cityofnewyork.us/
	NYC Dept. of City Planning Bytes of the Big Apple	Various data from NYC Dept. of City Planning	https://www1.nyc.gov/site/planning/data-maps/open-data.page
	NYC Dept. of Finance Tax Maps	Current tax maps	http://gis.nyc.gov/taxmap/map.htm
		Archived tax maps	http://gis.nyc.gov/taxmap/library.htm
	NYC Dept. of Information Technology and Telecommunications	Aerial imagery	https://maps.nyc.gov/then&now/
New York State	NYS Dept. of Environmental Conservation	1974 Tidal Wetlands Mapping Select a Tidal Wetlands Imagery grid cell and preview or download map image	http://opdgig.dos.ny.gov/#/map/0/2ABDDDD1-60BC-4E93-AACC-7D4E14046A1F/-74.755,40.188,-71.426,41.682/topo/8
		Tidal Wetlands Categories (explanation of letter codes used on the Inventory maps)	http://www.dec.ny.gov/lands/5120.html
		Environmental Resource Mapper	http://www.dec.ny.gov/gis/erm/
	NYS GIS Online	NYC Orthophotography	http://gis.ny.gov/gateway/mg/2016/new_york_city/
	NYS Orthos Online	Orthoimagery from the New York Statewide Digital Orthoimagery Program	https://orthos.dhses.ny.gov/
Federal	US Fish and Wildlife Service	National Wetlands Inventory	https://www.fws.gov/wetlands/data/data-download.html
	National Oceanic and Atmospheric Administration	Office of Coast Survey historic navigational chart archive	https://historicalcharts.noaa.gov/
		Office of Coast Survey historic current navigational charts	https://www.nauticalcharts.noaa.gov/

Location	Source	Data Type	Website
Federal	National Oceanic and Atmospheric Administration (NOAA)	Tidal charts: NOAA elevations on navigational charts are soundings in feet relative to mean lower low water (MLLW). To make them comparable to the elevations of a topographic survey, they must be converted to NAVD88, which is the vertical datum typically referenced as “0” in land surveys. On the webpage for the nearest tide station, below the option “Tides/Water Levels: Datums,” a chart demonstrates the differences between datums including MLLW and NAVD88. For example, at the Sandy Hook NJ tide gauge (Station 8531680), MLLW is defined as 2.51, and NAVD88 is defined as 5.33 (relative to the station datum). In order to redefine the sounding depths to be relative to NAVD88, SUBTRACT the difference between NAVD88 and MLLW (in this example, 2.81) from each of the sounding depths, i.e. a depth of -8 relative to MLLW will become a depth of -10.81 relative to NAVD88.	http://www.charts.noaa.gov/InteractiveCatalog
		NOAA tides and currents: On the webpage for each tide station, below the option “Tides/Water Levels: Datums,” a chart demonstrates the differences between the station datum, defined as 0, and other datums including MLLW, MTL, MHW, MHHW. For example, at the Sandy Hook NJ tide gauge (station 8531680), MLLW is defined as 2.51, MTL is defined as 5.06, MHW is defined as 7.41, and MHHW is defined as 7.74. At this location, the range where low marsh will thrive is the difference between MTL and MHW: 7.41-5.06, or if MTL is considered 0, from 0 to +2.35 feet. The difference between MHW and MHHW where high marsh will thrive is 7.74-7.41, or +2.35 feet to +2.68 feet, relative to MTL. 	https://tidesandcurrents.noaa.gov/stations.html
Other	Google Earth	Imagery from Google Earth	https://earth.google.com/web/

Appendix B: Sample Project Schedule

Project Name		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6-8	ROLES AND RESPONSIBILITIES			
[Date Updated]	**Scheduled Completion Date**	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	J F M A M J J A S O N D	R	A	C	I
TASKS											
Grant Title	**Dates**										
Grant Term	mm/dd/yyyy										
Grant Agreement Executed	mm/dd/yyyy										
Reporting Deadlines	mm/dd/yyyy										
Project Planning											
Determine Project Team	mm/dd/yyyy							PM	PM	LA, E, H	
Determine Goals, Opportunities, Constraints, and Approach	mm/dd/yyyy							PM	PM	LA, E, H	
Site Analysis											
Topographic Survey	mm/dd/yyyy							PM	PM	LA	E
Soil Borings (Chemical Analysis)	mm/dd/yyyy							PM	PM	LA	E
Wetland Delineation	mm/dd/yyyy							E	PM	LA	H
Biobenchmark Survey	10/31/yyyy							E	PM	LA	H
Vegetation Characterization and Tree Surveys	10/31/yyyy							E	PM	LA	H
Other Surveys (Tide Gage, Waves, Channels)	mm/dd/yyyy							H	PM	LA	E
Permitting											
CEQR Application Submittal	mm/dd/yyyy							PM	PM	LA, E, H	
DEC Permit Pre-Application Meeting (30% design)	mm/dd/yyyy							PM	PM	LA, E, H	
DEC/USACE Joint Permit Application Submittal	mm/dd/yyyy							PM	PM	LA, E, H	
Design											
Conceptual Design	mm/dd/yyyy							LA	PM	E, H	
Conceptual Design Review	mm/dd/yyyy							E, H	PM	LA	
Community Review (if applicable)	mm/dd/yyyy							PM	PM	LA, E, H	
Design Development - 30%	mm/dd/yyyy							LA	PM	E, H	
Design Review - 30%	mm/dd/yyyy							E, H	PM	LA	
Design Development - 60%	mm/dd/yyyy							LA	PM	E, H	
Design Review - 60%	mm/dd/yyyy							E, H	PM	LA	
Design Development - 90% (Construction Documents)	mm/dd/yyyy							LA	PM	E, H	
Design Review - 90%	mm/dd/yyyy							E, H	PM	LA	
Design Development - 100%	mm/dd/yyyy							LA	PM	E, H	
Design Review - 100%	mm/dd/yyyy							E, H	PM	LA	
Legal Review (**duration may differ by agency)	mm/dd/yyyy							PM	PM	LA, E, H	
Seed Sourcing											
Seed Collection	mm/dd/yyyy										
Propogation	mm/dd/yyyy	Woody Spp.	Herbaceous Spp.								
Solicitation											
Schedule for Bid Advertise	mm/dd/yyyy							PM	PM	LA, E, H	
Bid Submittal Date	mm/dd/yyyy							PM	PM	LA, E, H	
Award letter issued	mm/dd/yyyy							PM	PM	LA, E, H	
Order to Work (OTW)	mm/dd/yyyy							PM	PM	LA, E, H	
Construction											
Construction (**duration differs by size and complexity)	mm/dd/yyyy							ALL	PM		
Planting	6/30/yyyy							E	PM	LA, H	
Contractor Guarantee	mm/dd/yyyy							ALL	PM		
Close-Out	mm/dd/yyyy							PM			
Site Monitoring and Maintenance											
Develop a Maintenance and Monitoring Plan	mm/dd/yyyy							E, H	PM	LA	
Pre-Restoration Monitoring	mm/dd/yyyy							E, H	PM	LA	
Inspection	mm/dd/yyyy							E, H	PM	LA	
Replanting	6/30/yyyy							E, H	PM	LA	
Invasive Species Management	mm/dd/yyyy							E, H	PM	LA	
Fence Repair	mm/dd/yyyy							E, H	PM	LA	
Monitoring	10/15/yyyy							E, H	PM	LA	
Permit Reporting	12/31/yyyy							E, H	PM	LA	

R = Responsible; A = Accountable; C = Consulted; I = informed; PM= Project Manager; E = Ecologist; H = Hydrologist; L = Landscape Architect

Appendix C: Permitting Resources

Joint Application Form		
NYSDEC_2016_Joint Application Form Instructions	PDF	**Instructions to complete NYSDEC's Joint Application Form.** Use this application to **apply for Permits from all listed state and federal agencies: NYSDEC, USACE, NYS Office of General Services, and NYS Dept. of State. This form is for all projects that affect streams, waterways, waterbodies, wetlands, coastal areas, sources of water, and endangered and threatened species.**
NYSDEC_2016_Joint Application Form	PDF	**Application form** associated with "NYSDEC_2016_Joint Application Form Instructions" PDF.
NYSDEC_2017_Environmental Permits Application Checklist - Forms and Additional Materials Needed	Website	**NYSDEC permit types and associated required permit application forms and materials** for the following: Waterways, Coastlines, & Wetlands Permit Types Wastewater Permit Types - State Pollutant Discharge Elimination System (SPDES) Water Withdrawal Permit Types Mining of Mineral Resources Permit Types Air Permit Types Waste Management Permit Types Other Permit Types Also includes Joint Application Form information (NYSDEC Joint Application Form) and Supplements, Required Application Items, Application Fees info, and links to State Environmental Quality Review (SEQR) and Historic Preservation (Structural Archaeological Assessment) forms.
NYSDEC_2016_Permission to Inspect Property Form	PDF	NYSDEC **Permission to Inspect Property form** must be **submitted with the Joint Application Form**, per http://www.dec.ny.gov/permits/106121.html. By signing this permission form for submission with an application for a permit(s) to the Department of Environmental Conservation ("NYSDEC"), the signer consents to inspection by NYSDEC staff of the project site or facility for which a permit is sought and, to the extent necessary, areas adjacent to the project site or facility. Inspections may take place as part of the application review prior to a decision to grant or deny the permit(s) sought. By signing this consent form, the signer agrees that this consent remains in effect if the application is pending, and is effective regardless of whether the signer, applicant or an agent is present at the time of the inspection.
NYSDEC_nd_Freshwater Wetlands Sample Project Plans	PDF	NYSDEC **examples of project plan drawings for Joint Application Forms.** See pages 24 onward for Shoreline, Shoreline Stabilization, Wetland sample plans. Source: http://www.dec.ny.gov/permits/6277.html
NYSDEC_2017_Environmental Resource Mapper online tool	Website	The **Environmental Resource Mapper** is an **interactive mapping application** that can be used to identify some of New Yor State's natural resources and environmental features that are state or federally protected, or of conservation concern. **Project or activities occurring in or near any of these natural features may require permits from NYSDEC**. This tool includes: Freshwater wetlands regulated by the State of New York (outside the Adirondack Park). Federally regulated wetlands from the National Wetlands Inventory. New York's streams, rivers, lakes, and ponds; water quality classifications are also displayed. Animals and plants that are rare in New York, including those listed as Endangered or Threatened (generalized locations). Significant natural communities, such as rare or high-quality forests, wetlands, and other habitat types.

NYSDEC_2016_Structural Archaeological Assessment Form	PDF	To be completed as part of the **Joint Application Form package.** In accordance with the **State Historic Preservation Act (SHPA)**, the Joint Application Form application is not complete until a determination has been made concerning **the impact of the project on properties listed on or eligible for listing on the State or National Register of Historic Places**.
NYSDEC_nd_Applicant's Guide to State Historic Preservation Act SHPA	PDF	**Guide** that accompanies NYSDEC_2016_Structural Archaeological Assessment Form.
NYS Cultural Resource Information System (*repeated in CEQR section*)	Website	**Supporting EAS Short and Full Forms, Part II, section 6 - NY State Cultural Resource Information System (CRIS)** - **https://cris.parks.ny.gov/ -** Mapper allows applicants to determine if the proposed project site or an adjacent site contains an architectural and/or archaeological resource that is eligible for or has been designated (or is calendared for consideration) as a New York City Landmark, Interior Landmark or Scenic Landmark; that is listed or eligible for listing on the New York State or National Register of Historic Places; or that is within a designated or eligible New York City, New York State, or National Register Historic District. **(Note: The link in the Short and Full Forms is broken.)**
NYSDEC_nd_Coastal Erosion Management Permit Program	Website	The **Coastal Erosion Management Permit** is the written approval required by 6 NYCRR Part 505 to undertake any regulated activity within **Coastal Erosion Hazard Areas (CEHA)** as shown on the **official Coastal Erosion Hazard Area Maps issued by NYSDEC**. Coastal Erosion Hazard Areas are comprised of two different jurisdictions: **Natural Protective Feature Areas** and **Structural Hazard Areas**. Each jurisdiction has differing regulatory requirements. DEC staff review permit applications for construction and other activities within specified coastal areas. **You need a permit if you propose to undertake a regulated activity within a designated coastal erosion hazard area.** Information about how coastal erosion hazard areas are mapped, how to find out if your proposed work area is located within a coastal erosion hazard area, and how to appeal the a wetland designation may be found. **Regulated Activities** -Construction, modification, restoration, or placement of a structure or major addition to a structure -Any action or use of land that materially alters the condition of land, including but not limited to: **Grading, Excavating,** Dumping, Mining, **Dredging, Filling,** Or other disturbance of soil. **Coastal Erosion Management permits are included on the Joint Application Form; however, additional materials must be submitted to obtain this type of permit. See "NYSDEC_nd_Coastal Erosion Management Application Checklist"**
NYSDEC_nd_Coastal Erosion Management Permit Application Procedures	Website	Background information on Coastal Erosion Management Permit applications.
NYSDEC_nd_Coastal Erosion Management Application Checklist	PDF	The goal of this checklist is to assist applicants in the preparation of a complete **NYSDEC Coastal Erosion Management (CEM) Permit Application.** A Coastal Erosion Hazard Area (CEHA) permit is only required for work in CEHA areas. This checklist is designed to assist with CEHA permits only. Additional permits may be required from DEC, or other Federal, State, or Local agencies.

NYSDEC_nd_General Permit for Management of Invasive Species GP-0-15-005	Website	**NYSDEC General Permit GP-0-15-005 - Management of Invasive Species** The General Permit allows the **removal of invasive species using hand harvesting techniques, suction harvesting techniques, and/or benthic barriers**: -**within Freshwater Wetlands or their 100 foot wide adjacent areas**, and/or -within the bed or banks of Protected Streams, and/or **-within Navigable Waters,** and/or -in a designated Wild, Scenic and Recreational River area **Note:** -Hand harvesting of aquatic plants is not regulated under Article 15-0505 (implemented by 6 NYCRR Part 608.5) as an excavation in navigable waters. -In virtually all cases, hand harvesting of plants is not regulated under ECL Article15-0501 (implemented by 6 NYCRR Part 608.2) as a stream disturbance. -Department regional staff will determine if the hand harvesting of invasive aquatic and non-aquatic plants requires an Article 15/Part 608 permit. If a permit is required and the project is within the scope of this general permit, the general permit can be the mechanism for authorizing the activity. **If your project is included in the list of authorized activities, fill out the Joint Application Form.**
NYSDEC_2016_General Permit for Management of Invasive Species GP-0-15-005	PDF	**NYSDEC General Permit GP-0-15-005 - Management of Invasive Species** permit associated with "NYSDEC_nd_General Permit for Management of Invasive Species GP-0-15-005".
USACE_nd_Joint Application Form Submission Requirements	Website	**When applying for USACE permits using the Joint Application Form,** ensure the following materials are submitted (to NYSDEC and USACE): Joint Application for Permit - Joint Application Form August 2016 with Instructions **Environmental Questionnaire** Project Drawings **FCAF - Federal Consistency Assessment Form, to be used for projects that will occur within and/or directly affect the New York State Coastal Area - See "NYSDOS_nd_Coastal Management Program Federal Consistency Assessment Form"** **Note that USACE may have different requirements for submission than NYSDEC, so consult with USACE.**
USACE_nd_Environmental Questionnaire for Joint Application Form	PDF	USACE Environmental Questionnaire - **to be submitted with Joint Application Form when applying for USACE permits**.

City Environmental Quality Review (CEQR)		
NYC MOEC_City Environmental Quality Review backgrounder	Website	This site is a **Mayor's Office of Environmental Coordination (MOEC)** landing page for **City Environmental Quality Review (CEQR).**
NYC MOEC_CEQR Basics	Website	This site assists you with understanding **what CEQR is, when it applies, and how to go about conducting a review**.
NYC MOEC_2014_CEQR Technical Manual	PDF	The **CEQR Technical Manual provides guidance for city agencies,** project sponsors, the public, and other entities **in the procedures and substance of the City's Environmental Quality Review (CEQR) process**. CEQR requires city agencies to **assess, disclose, and mitigate to the greatest extent practicable the significant environmental consequences of their decisions to fund, directly undertake, or approve a project**. The environmental assessment analyzes the project that is facilitated by the action or actions. An action is a discretionary agency decision (approval, funding, or undertaking) needed in order to complete a project. The manual includes regulatory requirements of the CEQR process; types of documentation applicable during environmental review; approaches to determine the appropriate level of documentation; guidance in structuring the environmental analyses; technical analyses (including potential assessment methods); types of alternatives to be assessed; and contents of summary chapters included in an EIS (when required).
NYC MOEC_2010_CEQR EAS Short Form instructions	PDF	Instructions to complete NYC MOEC's **CEQR Environmental Assessment Statement (EAS) Short Form**, which is required for **Unlisted actions.** This form provides a detailed checklist to assist the project proponent and lead agency in determining whether further detailed assessment is needed and whether the potential exists for significant adverse impacts. If no further assessment is needed, the EAS Short Form incorporates a template for issuance of a Negative Declaration. Note that the lead agency may require supplementation of information requested in the EAS Short Form to make its determination of significance. **Unlisted actions** are those that are not specified as Type I or Type II actions in 6 NYCRR 617.4 and 617.5, respectively (https://goo.gl/2jJMw4); and do not exceed the Type I or Type II actions specified in 43 RCNY 6-15(A) (https://goo.gl/owu5ZU). Note: For some Unlisted actions, although they do not meet or exceed Type I thresholds, it may be appropriate to use the EAS Full Form. **Consult with the lead agency or MOEC if there is a question as to which form to use.**
NYC MOEC_2016_CEQR EAS Short Form	Word file	**CEQR EAS Short Form**, to be completed and submitted to the Lead Agency for review.
NYC MOEC_2016_CEQR EAS Full Form	Word file	**CEQR EAS Full Form**, to be completed and submitted to the Lead Agency for review.
NYC MOEC_2010_CEQR EAS Full Form instructions	PDF	Instructions to complete NYC MOEC's **CEQR Environmental Assessment Statement (EAS) Full Form**, which is required for **Type I and certain Unlisted** actions. **Consult with the lead agency or MOEC if there is a question as to which form to use**. **Type I actions** are defined in 6 NYCRR 617.4 (https://goo.gl/2jJMw4); and in 43 RCNY 6-15(A) (https://goo.gl/owu5ZU).

NYS Cultural Resource Information System (*repeated in Joint App Form section*)	Website	**Supporting EAS Short and Full Forms, Part II, section 6 - NY State Cultural Resource Information System (CRIS)** - https://cris.parks.ny.gov/ - Mapper allows applicants to determine if the proposed project site or an adjacent site contains an architectural and/or archaeological resource that is eligible for or has been designated (or is calendared for consideration) as a New York City Landmark, Interior Landmark or Scenic Landmark; that is listed or eligible for listing on the New York State or National Register of Historic Places; or that is within a designated or eligible New York City, New York State, or National Register Historic District. **(Note: The link in the Short and Full Forms is broken.)**
NYC MOEC_Jamaica Bay Watershed Protection Plan Project Tracking Form	PDF	The **Jamaica Bay Watershed Protection Plan**, developed pursuant to Local Law 71 of 2005, mandates that the NYC Department of Environmental Protection (DEP) work with the NYC MOEC to **review and track proposed development projects in the Jamaica Bay Watershed that are subject to CEQR** in order to monitor growth and trends. **If a project is located in the Jamaica Bay Watershed, the applicant should complete this form and submit it to DEP and MOEC.** This form must be updated with any project modifications and resubmitted to DEP and MOEC.
NYC MOEC_Jamaica Bay Watershed Map	JPEG	**Map of area included in Jamaica Bay Watershed**, for consideration with **CEQR** and **Jamaica Bay Watershed Protection Plan Project Tracking Form.** Also available: http://www.nyc.gov/html/oec/downloads/pdf/ceqr/Jamaica_Bay_Watershed_Map.jpg
NYC MOEC_Type II Prereq Screening Form	Word file	**Optional** for use in conjunction with actions classified as Type II. This form guides applicants completing what they believe is a Type II project to ensure they complete the correct CEQR form - EAS Short Form, EAS Full Form, full EIS, or no forms at all. This form is for use in conjunction with actions classified as Type II pursuant to the CEQR Rules of Procedure. However, **this form should not be submitted to the Department of City Planning.** Reference regulations here: http://www.nyc.gov/html/oec/downloads/pdf/ceqr/CEQR%20Rules-%2062%20RCNY%20Chapter%205.pdf
NYC DCP_2017_Waterfront Revitalization Program Overview	Website	This website provides an overview of the WRP; resources including a **User Manual**, **Guidance Document**, **Flood Elevation Worksheet**, **Flood Risk Mapper**, and links to relevant geographic boundaries for sensitive coastal/maritime areas; and, the **WRP Consistency Assessment Form**, **required by CEQR to be submitted** when **Unlisted or Type I actions** will directly affect an area within the City's Waterfront Revitalization Program boundaries.
NYC DCP_2016_Waterfront Revitalization Program Consistency Assessment Form	PDF	NYC Department of City Planning (DCP) Waterfront Revitalization Program (WRP) Consistency Assessment Form (CAF), **required by CEQR to be submitted when Unlisted or Type I actions will directly affect an area within the City's Waterfront Revitalization Program boundaries.**
NYC DCP_2017_Waterfront Revitalization Program Guidance for Applicants	PDF	Guidance for applicants using the NYC Department of City Planning (DCP) Waterfront Revitalization Program (WRP) Consistency Assessment Form (CAF). **Provides information about / instructions for completing each form section.**
NYC DCP_2016_Waterfront Revitalization Program Document	PDF	Document containing the NYC Department of City Planning (DCP) Waterfront Revitalization Program (WRP). **Provides details about the WRP policies and should be consulted when completing the WRP CAF.**
NYC DCP_2017_Waterfront Revitalization Program Flood Elevation Worksheet	Excel	**Complete and include with WRP CAF for projects that require the Detailed Methodology as described in "Waterfront Revitalization Program Policy 6.2 Climate Change Adaptation Guidance.pdf"**. Not required for **General Methodology** assessments.

NYC DCP_2017_Waterfront Revitalization Program Policy 6.2 Climate Change Adaptation Guidance	PDF	**Use this guide to assist in completing a WRP Consistency Assessment Form** for discretionary actions within New York City's Coastal Zone, including: • A local discretionary action, such as a City Planning Commission action or a City capital project, subject to City Environmental Quality Review. • State agency actions and programs subject to State Environmental Quality Review. • Federal agency permits/authorizations, funding, or direct actions. **This guide is not necessary if:** **• The discretionary action only includes maintenance activities or the in-kind, in-place replacement of existing structure or facilities.** **• The discretionary action only affects areas outside the 0.2% Annual Chance Floodplain.** The full text of Policy 6.2 as well as the other policies of the WRP are available at www.nyc.gov/wrp.

State Environmental Quality Review (SEQR)		
NOTE REGARDING SEQR (vs CEQR)	*Note*	**CEQR supersedes SEQR review for projects within New York City. CEQR is the process for local implementation of SEQR and can be no less stringent than its state counterpart. The SEQR EAF (and associated forms) does not need to be completed for projects where CEQR is completed.**
NYSDEC_nd_SEQR Environmental Assessment Form Mapper	Website	Online screening tool that **completes preliminary Short or Full Environmental Assessment Forms (EAFs) for SEQR applicants** based on geographic boundary of proposed project. Environmental assessments are standardized through use of the **Environmental Assessment Form (EAF)**. The Environmental Assessment Forms are in a pdf format that can be filled and saved. To assist applicants in preparing the Part 1 of either the Short or Full EAF, we have developed **EAF Workbooks** and a **GIS mapping program (the EAF Mapper)** that searches spatial data bases and provides answers to location-based questions which are automatically filled onto a pdf copy of an EAF and provided to the user. The spatial data used by the EAF mapping program to complete the new EAFs is based on the GIS data sets used and maintained by DEC, or actively maintained by various agencies and shared with DEC.
NYSDEC_nd_Short EAF Workbook	Website	The **Short Environmental Assessment Form is designed specifically for Unlisted Actions**. It has three parts. The first part (Part 1) is filled out by the applicant or project sponsor. Part 2 and Part 3 are filled out by the lead agency.
NYSDEC_nd_Full EAF Workbook	Website	The **Full Environmental Assessment Form (FEAF) is designed specifically for Type I Actions**. It has three parts. The first part (Part 1) is filled out by the applicant, or project sponsor. Part 2 and Part 3 are the responsibility of the lead agency. Throughout the workbook, the term 'lead agency' is also referred to as the 'reviewing agency'.
NYSDEC_nd_SEQR Background	Website	In New York State, **most projects or activities proposed by a state agency or unit of local government**, **and all discretionary approvals (permits) from a NYS agency or unit of local government**, require an **environmental impact assessment** as prescribed by **6 NYCRR Part 617 State Environmental Quality Review (SEQR)** [Statutory authority: Environmental Conservation Law Sections 3-0301(1)(b), 3-0301(2)(m) and 8-0113]. **SEQR requires the sponsoring or approving governmental body to identify and mitigate the significant environmental impacts of the activity it is proposing or permitting**. **On completing an Environmental Assessment Form (EAF), the lead agency determines the significance of an action's environmental impacts. The agency then decides whether to require (or prepare) an Environmental Impact Statement and whether to hold a public hearing on the proposed action.**
NYSDEC_nd_Introduction to SEQR	Website	How does SEQR work? -To whom does SEQR apply? What are the benefits of SEQR? What are actions that never require an EIS? etc.
NYSDEC_nd_Stepping Through the SEQR Process	Website	**A map of the SEQR Process with links to details on each step.**
NYSDEC_2010_SEQR Handbook	PDF	The **SEQR Handbook provides agencies, project sponsors, and the public with a practical reference guide to the procedures prescribed by the State Environmental Quality Review Act (SEQR)**--Article 8 of the Environmental Conservation Law. It addresses common questions that arise during the process of applying SEQR. The Handbook also attempts to address the needs of individuals who have varying degrees of experience with SEQR. Topics range from an introduction to the basic SEQR process to discussions of important procedural and substantive details.

NYS Coastal Management Program Federal Consistency Assessment		
NYSDOS_nd_Coastal Management Program Federal Consistency Assessment Form	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) **Federal Consistency Assessment Form (FCAF)** - An applicant, **seeking a permit, license, waiver, certification or similar type of approval from a federal agency which is subject to the New York State Coastal Management Program (CMP)**, shall complete this assessment form for any proposed activity that will occur within and/or directly affect the **State's Coastal Area**. This form is intended to assist an applicant in certifying that the proposed activity is consistent with New York State's CMP as required by U.S. Department of Commerce regulations (15 CFR 930.57). **It should be completed at the time when the federal application is prepared.** The Department of State will use the completed form and accompanying information in its review of the applicant's certification of consistency. **Is (DOS) Consistency Review required for my proposed project? (https://www.dos.ny.gov/opd/programs/consistency/)** The following links contain information designed to assist in determining if consistency review is required for a proposed project. Please see the individual bullet which describes the nature of your project. **Federal Permits/Authorizations** (for projects requiring federal permits or authorizations, such as U.S. Army Corps of Engineers Nationwide Permit Applications) **Federal Funding** (for projects involving applications for federal funding) **Federal Agency Actions** (for activities being undertaken directly by a federal agency) **State Agency actions** (State consistency only pertains to actions undertaken by State agencies. This section is not applicable for projects undertaken by private individuals and organizations, or federal agencies.)
NYSDOS_2017_Submission requirements for Coastal Management Program Federal Consistency Assessment	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) Federal Consistency Assessment Form (FCAF) - **FCAF Submission Requirements.** Also available here: https://www.dos.ny.gov/opd/programs/consistency/instructions.html
NYSDOS_2017_Determining when Coastal Management Program Federal Consistency Assessment is required	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) Federal Consistency Assessment Form (FCAF) - **Types of Federal permits requiring an FCAF.** Also available here: https://www.dos.ny.gov/opd/programs/consistency/federalpermits.html
NYSDOS_2017_Coastal Management Program Federal Consistency Assessment FAQs	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) Federal Consistency Assessment Form (FCAF) - Frequently Asked Questions. Also available here: https://www.dos.ny.gov/opd/programs/consistency/consistencyfaq.html
NYSDOS_2017_Coastal Management Program Boundary in NYC	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) geographic boundary map. Retrieved 11/27/2017 from: https://goo.gl/NVHjBf
NYSDOS_2017_Coastal Management Program and FEIS	PDF	NY State Department of State (NYSDOS) - Coastal Management Program (CMP) and Final Environmental Impact Statement (FEIS). Published in 1982; includes updates through 2017. Reference document for FCAF.

State Pollutant Discharge Elimination System (SPDES)		
NYSDEC_nd_SPDES Pesticide General Permit	Website	Information on the **SPDES Pesticide General Permit and required documentation/forms for submission.** The New York State Department of Environmental Conservation (NYSDEC) renewed the SPDES General Permit for Point Source Discharges to Surface Waters of New York State from Pesticide Applications Permit No. GP-0-16-005. This General Permit, GP-0-16-005 shall be effective from November 9, 2016 to October 31, 2021. Eligibility criteria are contained within Part I of the General Permit. This project is a Type II Action pursuant to the State Environmental Quality Review Act. To gain authorization under the SPDES General Permit for Point Source Discharges to Surface Waters of New York State for Pesticide Applications, an operator must: **Obtain any other relevant permits**, which may include: **Bureau of Pest Management Article 15 Permit** and **Article 24 Freshwater Wetlands Permit** **Develop the Pesticide Discharge Management Plan (PDMP)** **Submit a completed Notice of Intent for the SPDES Pesticide General Permit (GP-0-16-005) to the Department.** Please note that submittal of the electronic NOI (eNOI) will result in quicker authorization (5 days) than the submittal of a paper NOI (20 days), due to additional processing required for paper documents.
NYSDEC_2016_SPDES General Permit for Pesticide Applications GP-0-16-005	PDF	**SPDES Pesticide General Permit** Effective Nov 9, 2016 - Oct 31, 2021.
NYSDEC_2016_Pesticide Discharge Management Plan PDMP	PDF	**Pesticide Discharge Management Plan (PDMP) for SPDES Pesticide General Permit.**
NYSDEC_nd_SPDES Pesticide Notice of Intent	PDF	**Notice of Intent for the SPDES Pesticide General Permit (GP-0-16-005).**
NYSDEC_2016_SPDES Pesticide Notice of Termination Form	x	**Notice of Termination (NOT) for Pesticide Certification Form (under GP-0-16-005).** Coverage under the Pesticide General Permit may be terminated if no additional discharges will occur. A new complete NOI may be submitted in the event that a new discharge is planned. This may be an advantage to operators who anticipate no future aquatic pesticide applications, or pesticide use that is only within some longer time frame. Fees are applied for each calendar year of coverage for each NOI, and frequent termination and renewal within a year or consecutive years may lead to higher total fees. An operator may continue coverage throughout the period of PGP coverage (ending October 31, 2021) even if no additional discharges may occur, rather than terminating and re-applying for PGP coverage. Operators are not required to notify the Department that pesticide applications have ended, nor are operators required to terminate coverage under the PGP. However, termination of coverage through filing a Notice of Termination (NOT) will eliminate annual fees in the calendar year ***following*** NOT submittal.
NYSDEC_2016_SPDES Pesticide FAQs	PDF	**SPDES Pesticide General Permit FAQs** A. Who Must File the Notice of Intent (NOI)? B. Can a Single NOI Cover Multiple Pesticide Applications? C. What Are the Fees Associated With Permit Coverage? D. How Does the Operator Complete the Notice of Intent? E. Where Does the Operator Submit the Notice of Intent? F. What are the Other PGP Requirements for Operators? G. How does the Operator Terminate Permit Coverage? H. Where Can the Operator Obtain Forms and Other Information?

NYSDEC_2016_SPDES Pesticide NOI Completion FAQs	PDF	**SPDES Pesticide Notice of Intent Completion FAQs** A - How Does the Operator Complete the Sections of the NOI? B - How Does the Operator Submit the NOI? C - Where Can the Operator Obtain Forms and Other Information?
NYSDEC_nd_SPDES Stormwater Permit for Construction Activity	Website	Before commencing construction activity, **the owner or operator of a construction project that will involve soil disturbance of one or more acres** must obtain coverage under the **State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity.** In the New York City East of Hudson watershed, this requirement also applies to construction projects disturbing more than 5,000 square feet to one acre of land. Some exceptions to the requirements exist for agricultural projects, certain silvicultural projects and routine maintenance activities.
NYSDEC_2015_SPDES General Permit for Construction Activity GP-0-15-002	PDF	**SPDES Construction Activity General Permit** Effective Jan 29, 2015 - Jan 28, 2020.
NYSDEC_nd_SPDES Construction Activity Notice of Intent	PDF	**Notice of Intent for the SPDES Construction Activity General Permit (GP-0-15-002).** To obtain coverage under the general permit, the operator of a construction activity must file a completed Notice of Intent (NOI) with the DEC. Submitting a NOI is an affirmation that a Stormwater Pollution Prevention Plan (SWPPP) has been prepared for the site and will be implemented prior to the commencement of construction activities. Coverage under the general permit will begin either five (5) or sixty (60) business days after receipt of a completed NOI by the DEC.
NYSDEC_nd_Construction Stormwater Toolbox	Website	**Construction Stormwater Toolbox.** This page provides links to sources of technical information needed to comply with the requirements of the Construction Permit and references that are useful for the design of stormwater management practices. Owner/operators with projects covered under the State Pollutant Discharge Elimination System (SPDES) General Permit for Stormwater Discharges from Construction Activity (the Construction Permit) are required to develop and implement a **Stormwater Pollution Prevention Plan (SWPPP)** that meets criteria set forth by New York State Department of Environmental Conservation (Department). All SWPPPs must include practices consistent with the **New York Standards and Specifications for Erosion and Sediment Control (see "NYSDEC_2016_Blue Book Standards and Specs for Erosion and Sediment Ctrl"**. Many construction sites must also comply with the **New York State Stormwater Management Design Manual (see "NYSDEC_2015_Stormwater Management Design Manual")** to address post-construction stormwater discharges.

NYSDEC_nd_SHPA Cultural Resource Screening Process Flow Chart	PDF	**Visit "NYSDEC_nd_SPDES Stormwater Permit for Construction Activity" for more information** The Department and NYS Office of Parks, Recreation and Historic Preservation (OPRHP) have developed a process that an owner/operator of construction project shall use to identify and address potential impacts on archeological and historic resources. **This process is documented in a Letter of Resolution (LOR)** that was developed between the Department and OPRHP. **Construction activities that have the potential to affect historic and/or archeological resources would not be eligible for coverage under the general permit unless the screening and consultation process specified in the LOR has been completed and the required documentation demonstrating that potential impacts have been avoided or mitigated is obtained and maintained on site as required by the general permit (see Part I.F.8.).** This documentation must be in place to complete and submit the NOI. Owners or operators should refer to the following documents for guidance on addressing this eligibility provision: Letter of Resolution (LOR) (PDF) including the following Procedures Project exclusions Under 9 NYCRR Sections 428.12/428.13 SHPA Review (OPRHP/DEC) request form (PDF) **Cultural Resource Screening Process Flow Chart (PDF)** Resolution of Potential Cultural Impacts Flow Chart (PDF)
NYSDEC_2015_SHPA Letter of Resolution NYSDEC NYS OPHRP	PDF	**Letter of Resolution outlining required screening process for proposed construction activities. See Attachment 1 for Procedures for the owner/operator.** The owner/operator shall check the archeological sensitivity map and the National and State Registers of Historic Places (by either using DEC's EAF Mapper or OPRHP's CRIS website) to determine if the construction activity is located: a) in an archeological sensitive area, or b) on an historic property, or c) immediately adjacent to an historic property. **If the construction activity:** **a. is not within an archeologically sensitive area as indicated on the sensitivity map, and, b. is not on an historic property, and c. is not immediately adjacent to an historic property, and d. does not include the construction of a new permanent building on the construction site within the following distances of an Unevaluated Property**: (• 1-5 acres of disturbance - 20 feet • 5-20 acres of disturbance - 50 feet • 20+ acres of disturbance - 100 feet), **or e. does include the construction of a new permanent building on the construction site within the following distances from Unevaluated Property but OPRHP, a Historic Preservation Commission of a Certified Local Government, or a qualified preservation professional has determined it is not a historically significant building, structure or object:** (• 1-5 acres of disturbance - 20 feet • 5-20 acres of disturbance - 50 feet • 20+ acres of disturbance - 100 feet) **the construction activity is eligible for coverage under the General Permit provided all other eligibility requirements have been met.** **Answer "No" to Question 15 on SPDES NOI.** **Maintain on site: (1) Map showing not within an archeologically sensitive area and not located or immediately adjacent to a property listed or determined to be eligible for listing on the National or State Registers of Historic Places; and (2) Documentation showing the age of all buildings, structures, or objects within specified distances are less than 50 years old.** **If these conditions are not met, refer to Attachment 1 for details on required additional SEQR process steps.**

NYSDEC_nd_SPDES Stormwater MS4 Permit and Forms	Website	Small **municipal separate stormwater sewer systems (MS4s)** that are located within the boundaries of a Census Bureau defined "urbanized area" are regulated under EPA's Phase II Stormwater Rule. **This requires MS4s to develop a stormwater management program that will reduce the amount of pollutants carried by stormwater during storm events to waterbodies to the "maximum extent practicable".** The goal of the program is to improve water quality and recreational use of waterways. Discharges from Municipal Separate Storm Sewer Systems (MS4s) in Urbanized or Additionally Designated Areas must be authorized in accordance with a permit for stormwater discharges from MS4s. **This page contains the General Permit for Stormwater Discharges from Municipal Separate Storm Sewer Systems and the forms necessary to obtain coverage under that permit.**
NYSDEC_2015_SPDES General Permit for MS4s GP-0-15-003	PDF	**SPDES Municipal Separate Storm Sewer Systems (MS4s) Permit** Effective May 1, 2015 - Apr 30, 2017.
NYSDEC_nd_SPDES MS4 Notice of Intent	PDF	**Notice of Intent for the SPDES General Permit for Storm Water Discharges from Municipal Separate Storm Sewer Systems (MS4s)**
NYSDEC_2015_SPDES MS4s SWPPP Acceptance Form	PDF	**MS4 Stormwater Pollution Prevention Plan (SWPPP) Acceptance Form** for construction activities seeking authorization under SPDES General Permit Attach completed form to Notice of Intent and submit to NYSDEC Division of Water. See form for instructions.
NYSDEC_2016_Blue Book Standards and Specs for Erosion and Sediment Ctrl	PDF	**NY State Standards and Specifications for Erosion and Sediment Control (the "Blue Book")** The Blue Book provides standards and specifications for the selection, design and implementation of erosion and sediment control practices for the development of Erosion and Sediment Control Plans for the SPDES General Permit for Stormwater Discharges from Construction Activity. These standards and specifications were developed in cooperation with the USDA Natural Resources Conservation Service, New York State Soil and Water Conservation Committee (NYSSWCC), NYSDEC and other state and local agencies for use by planners, design engineers, developers, contractors, landscape architects, property owners, and resource managers. Proper use of these standards will protect the waters of the state from sediment loads during runoff events.

Aquatic Pesticide Permits		
NYSDEC_2016_Aquatic Pesticide Permit Application Form	PDF	ECL Article 15 states that an **Aquatic Pesticide Permit** is **required for the direct application of an aquatic pesticide to surface waters of the State of an acre or more in size**. This application form must be completed to obtain the permit.
NYSDEC_nd_Policy DSHM-PES-05-05 Aquatic Pesticide Permit Program	Website	**Detailed information on application requirements including attachments and map requirements** associated with the Aquatic Pesticide Permit applications.
NYSDEC_nd_Aquatic Pesticide Permit Information	Website	Information on the Aquatic Pesticide Permit Program in New York. The Bureau of Pest Management is responsible for the administration of the Program under the authority granted by Article 15-0313(4) of the Environmental Conservation Law (ECL) and Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR) Parts 327, 328 and 329.

Other Guidance Documents and References		
WaterfrontNavigator	Website	Waterfront Navigator is the official permitting guide for projects on or near New York City's waterfront and wetlands. Here you'll find resources to understand the government agencies involved in waterfront permitting - including their permits, programs, and requirements - and get help in navigating the process of obtaining your permits from start to finish.
NYSDEC_2016_Living Shoreline Guidance	PDF	The intent of this document is to provide guidance on the issuance of permits for living shorelines techniques in the Marine and Coastal District Waters of New York (the Marine District) and it answers the recommendations of the NY 2100 Commission report to encourage the use of green or natural infrastructure. **This guidance applies to permits issued pursuant to**: Environmental Conservation Law (ECL) Article 25, Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (6 NYCRR) Part 661 (**§661.9 Tidal Wetland Land Use Regulations**) ECL Article 15, 6 NYCRR Part 608 **(§608.8 Use and Protection of Waters** - *also includes* ***Section 401 – Clean Water Act – Water Quality Certification, §608.9***) This guidance is **not applicable** to areas subject to: ECL Article 34, 6 NYCRR Part 505 (**Coastal Erosion Hazard Areas**)
NYSDEC_2015_Stormwater Management Design Manual	PDF	The New York State Stormwater Design Manual is prepared to **provide standards for the design of the Stormwater Management Practices (SMPs) to protect the waters of the State of New York from the adverse impacts of urban stormwater runoff**. **This manual is intended to establish specifications and uniform criteria for the practices that are part of a Stormwater Pollution Prevention Plan (SWPPP).** This manual is intended primarily for engineers and other professionals who are engaged in the design of stormwater treatment facilities for new developments. Users are assumed to have a background in hydrology, hydraulics, and runoff and pollutant load computation. It is not intended to be a primer on any of these subjects. The manual may also be used by reviewing authorities to assess the adequacy of SWPPPs. The manual is limited to the design of structures.
NYC Parks_2016_D012 Permit Application Process	PDF	**This NYC Parks SOP describes the general processes for applying for city and/or state permits during the design process, which vary broadly by type of work and particular project.**
NYC Parks_2016_D012A NYSDEC Permit Applications	PDF	**This NYC Parks SOP provides information on obtaining a permit from the New York State Department of Environmental Conservation (NYSDEC). All NYSDEC permits must be received before a project can move from design into procurement.**
NYC Parks_2017_Design and Planning for Flood Resiliency Guidelines	PDF	In this document **NYC Parks suggests methods to plan and design for resilient waterfront parks, which include both parks and open spaces directly abutting the shoreline and those within the geographic floodplain**. We intend for these Guidelines to bring awareness about resilient waterfront parks to a broad audience, identify and define major risks associated with waterfront parks, outline a process for planning and designing these parks, and recommend resilient materials and best practices to be used in these locations. The Guidelines can be considered an addendum to NYC Parks' 2010 "High Performance Landscape Guidelines: 21st Century Parks for NYC," a first-of-its-kind manual for the design of New York City parks.
NYSDEC_nd_Check the Status of a Permit	Website	Detailed information on specific applications processed by the Department under the Uniform Procedures Act can be accessed through the **DEC Permit Applications (DART) Search**, including the status of applications issued, denied or currently under review. This search wizard also provides the means to do searches of applications by location, permit type, and date period. The results from these searches can be further sorted by applicant name, facility name and application status.

USFWS_2015_National Wetlands Inventory Mapper	Website	The **National Wetlands Inventory (NWI) was established by the US Fish and Wildlife Service (FWS)** to conduct a **nationwide inventory of U.S. wetlands** to provide biologists and others with information on the **distribution and type of wetlands** to aid in conservation efforts. This **web mapping application** provides users with access to over 32 million features that represent the extent, approximate location and type of wetlands and surface water habitats in the United States and U.S. trust territories.
USFWS_2015_National Wetlands Inventory Mapper FAQs	PDF	Frequently Asked Questions associated with **USFWS_2015_National Wetlands Inventory Mapper**.
OASIS NYC_nd_City Data Map	Website	OASIS online mapping application visualizes NYC spatial and administrative data, including: -Transit, roads, reference features, e.g. counties, subway routes, bike routes -Parks, playgrounds, & open space -Environmental characteristics, e.g. land cover classes, comprehensive restoration plan, Forever Wild sites, public access points on the waterfront, publicly accessible waterfront spaces -Environmental impact/cleanup -Zoning and landmarks -Land use -Historical land use, e.g. historical Bronx River, ponds and streams -Water and wetlands, e.g. freshwater wetlands, tidal wetlands, and National Wetlands Inventory wetlands -Administrative boundaries, e.g. community districts and zip codes
NYSDEC_2017_Environmental Resource Mapper online tool	Website	The **Environmental Resource Mapper** is an **interactive mapping application** that can be used to identify some of New York State's natural resources and environmental features that are state or federally protected, or of conservation concern. **Projects or activities occurring in or near any of these natural features may require permits from NYSDEC**. This tool includes: Freshwater wetlands regulated by the State of New York (outside the Adirondack Park). Federally regulated wetlands from the National Wetlands Inventory. New York's streams, rivers, lakes, and ponds; water quality classifications are also displayed. Animals and plants that are rare in New York, including those listed as Endangered or Threatened (generalized locations). Significant natural communities, such as rare or high-quality forests, wetlands, and other habitat types.
NYS_2017_Geographic Information Gateway online tool	Website	The **Geographic Information Gateway (Gateway)** is a one stop, state-of-the-art website providing public access to data, real-time information, interactive tools, and expert knowledge relevant to the **Office of Planning and Development's** activities throughout New York State. **Interactive map viewers enable users to easily download, visualize, and explore geographic data**. A Latest Conditions page provides access to real-time information across the State, such as water quality, tide levels, and beach conditions. Also included on this site are illustrated stories which highlight case studies, showcase community success stories, and demonstrate how the Office uses available geographic information to improve planning and decision-making. Includes, e.g.: **-Significant Coastal Fish & Wildlife Habitats** **-Landwater Coastal Area Boundary** **-Scenic Areas of Statewide Significance** -Local Waterfront Revitalization Program Approved Plans -Long Island Sound Coastal Management Program

NYC DCP_2017_NYC Flood Hazard Mapper	Website	A product of the New York City Department of City Planning, the **NYC Flood Hazard Mapper** provides a **comprehensive overview of the coastal flood hazards that threaten the city today, as well as how these hazards are likely to increase in the future with climate change**. It is intended to enable more informed decision-making by residents, property and business owners, architects and engineers, and policy-makers. Includes, e.g.: **-Preliminary Flood Insurance Rate Maps (PFIRMs) 2015 (V Zone, A Zone, Shaded X Zone)** **-Base Flood Elevation (2015 PFIRMs)**
NYC DCP_2017_NYC Waterfront Revitalization Program online mapper tool	Website	The **New York City Waterfront Revitalization Program (WRP)** establishes the City's policies for waterfront planning, preservation and development projects to ensure consistency over the long term. The goal of the program is to **maximize the benefits derived from economic development, environmental conservation and public use of the waterfront, while minimizing any potential conflicts among these objectives.** The WRP is authorized by New York State's Waterfront Revitalization of Coastal Areas and Inland Waterways Act, which was enacted in response to the Federal Coastal Zone Management Act, and allows municipalities to participate in the State's Coastal Management Program by creating their own local Waterfront Revitalization Program. Includes: -**Recognized Ecological Complex (REC)** **-Priority Marine Activity Zone (PMAZ)** **-Ecologically Sensitive Maritime & Industrial Area (ESMIA)** **-Significant Maritime & Industrial Area (SMIA)** **-Special Natural Waterfront Area (SNWA)** **-Coastal Zone Boundary**
USDA NRCS_2017_Web Soil Survey Map online tool	Website	**Web Soil Survey (WSS)** provides **soil data and information** produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. **NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.**
EPA_nd_National Environmental Policy Act Process	Website	The **National Environmental Policy Act (NEPA) process begins when a federal agency develops a proposal to take a major federal action**. These actions are defined at 40 CFR 1508.18. The environmental review under NEPA can involve three different levels of analysis, described on this website: Categorical Exclusion determination (CATEX) Environmental Assessment/Finding of No Significant Impact (EA/FONSI) Environmental Impact Statement (EIS)
EPA_nd_NEPA Major Federal Actions 40 CFR 1508.18	Website	**Definition of major federal actions. Major federal actions initiate the NEPA review process.**

Checklist: Tidal Wetlands Project Permits December 2017

Disclaimer: This is a general list of potentially applicable permit requirements and may not cover all circumstances. It is the responsibility of the applicant that all permit requirements are met.

ITEM	APPLICABLE (Y/N)	COMPLETE (Y/N)	NOTES
NYSDEC, USACE, NYS OGS, NYS DOS JOINT APPLICATION FORM (JAF)			
1. Joint Application Form for permits to undertake activities affecting waterbodies, wetlands and coastal areas, including (*for Tidal Wetlands*): a. NYSDEC Tidal Wetlands Permit, Environmental Conservation Law (ECL) Article 25 b. NYSDEC Water Quality Certification, Clean Water Act, Section 401 (DEC will specify if this or other Protection of Waters permits (ECL Article 15) are required upon application review) c. USACE Clean Water Act, Section 404 (wetland permit) d. NYSDOS Federal Consistency Assessment Form (FCAF) (only applicable in coastal zone; may be superseded by NYC WRP – see CEQR section 8g)			
2. Project Description and Purpose a. Project description narrative attachment to accompany the Joint Application Form, which expands upon items listed in JAF Section 6 and includes all project details specified on page 2 of 5 of JAF Instructions			
3. Location map a. USGS Quadrangle or equivalent, including project boundary outline b. Scale of 1 inch equals 2,000 feet is generally adequate (scale ratio 1:24,000) c. May obtain map from DEC's online Environmental Resource Mapper (http://www.dec.ny.gov/gis/erm/)			
4. Project plans a. Print at a scale of 1 inch equals 50 feet or larger, including topography at a contour interval prescribed by the DEC Regional Permits Office b. Sketch plan and cross-section views drawn to scale with dimensions, or engineering drawings showing the location and extent of work. Show the direction of the photographs (in 4, below). See sample plans at: http://www.dec.ny.gov/permits/70934.html , http://www.dec.ny.gov/permits/70807.html, http://www.dec.ny.gov/permits/6342.html			

c. Show existing conditions and the work to be performed d. Show the wetlands boundary as verified by DEC staff, and any streams and ditches on site e. Show the extent of all fill or excavation and the dimensions of all proposed structures f. If a septic system is part of the proposed project, the plan must show the location of the system			
5. Photographs a. At least three color photographs, taken from multiple directions, clearly showing the project site without snow cover b. Include all existing structures on the site and the area surrounding the site c. Indicate the photo's direction (on map) and the time and date when taken			
6. Other information a. Completed Structural Archaeological Assessment Form (SAAF). *Note: verify if needed minor projects. See: http://www.dec.ny.gov/permits/6327.html* b. Completed Permit to Inspect Property form c. Wetland Delineation Report — includes Location Map, USGS Topographic Map, NYSDEC Freshwater Wetlands Map, USFWS NWI Freshwater Wetlands Map, USDA NRCS Soils Map, historic aerial imagery (as available), and photos d. Coastal Erosion Management Permits require additional materials — refer to NYSDEC's Coastal Erosion Management Application Checklist e. Review NYSDEC 2016 General Permit for Management of Invasive Species GP-0-15-005 to determine if it applies & include appropriate info on Joint Application Form *f.* NY State Department of State (NYSDOS) Coastal Management Program (CMP) Federal Consistency Assessment Form (FCAF). *Note: may be required for projects that include Federal permits (e.g., USACE)* g. USACE Environmental Questionnaire – for projects that include USACE permits *h. Note: NYSDEC staff may require additional information to adequately review and evaluate the application* (http://www.dec.ny.gov/permits/6277.html)			
7. Application fee (paid by check; may be submitted separately after other application components): a. $200 for new Minor permit application $200 for permit modification $900 for other projects (e.g., Major projects) b. *Note: DEC will inform NYC Parks if project is Minor or Major upon application review and will inform NYC Parks if further processing funds are required above original check amount. This will result in*			

issuance of a Notice of Incomplete Application (NOIA) and will may require resubmission of the permit application. Ideally, DEC and Parks will determine if the project is major or minor during pre-application meetings and correspondence.			
CITY AND/OR STATE ENVIRONMENTAL QUALITY REVIEW			
8. City Environmental Quality Review (CEQR) Environmental Assessment Statement (EAS) Form a. Project description narrative b. Completed and signed CEQR EAS Short or Full Form c. Supplementary explanations to accompany EAS Form d. Maps: Site Location Map, Zoning Map, Tax Map, and Land Use Map; all must include a 400 foot radius drawn from the outer boundaries of the project site e. Photographs of the project site taken within 6 months of EAS submission and keyed to the Site Location Map f. Jamaica Bay Watershed Protection Plan Form – for projects in the Jamaica Bay Watershed i. Supplementary explanations ii. Pre- and post-design surveys showing 1 foot contours for projects with grading or fill g. NYC Waterfront Revitalization Program Consistency Assessment Form – for projects within the city's Coastal Zone i. Supplementary explanations ii. Complete Policy 6.2 Waterfront Revitalization Program Flood Elevation Worksheet, if project located within FEMA 1% or 0.2% annual chance floodplain and requires Detailed Methodology for assessment (see Waterfront Revitalization Program Policy 6.2 Climate Change Adaptation Guidance) h. Negative Declaration			
9. State Environmental Quality Review (SEQR) Environmental Assessment (EAF) Form. *Note that CEQR supersedes SEQR, therefore SEQR is not required for most NYC Parks' projects* a. Short EAF (Unlisted actions) or Full EAF (Type 1 actions) *Note: Type II actions are exempt from SEQR* b. Complete and sign SEQR EAF Form c. Negative Declaration d. Declaration of Lead Agency			
STATE POLLUTANT DISCHARGE ELIMINATION SYSTEM (SPDES)			
10. SPDES Stormwater Discharges Associated with Construction Activity for projects that will involve soil disturbance of one or more acres a. Stormwater Pollution Prevention Plan (SWPPP) b. Completed and signed Notice of Intent (NOI)			
11. SPDES Stormwater Municipal Separate Stormwater Sewer Systems (MS4) Permit – for projects located in Census Bureau defined "urbanized areas"			

a. MS4 Stormwater Pollution Prevention Plan (SWPPP) b. Completed and signed MS4 SWPPP Acceptance Form – attach to NOI c. Completed and signed Notice of Intent (NOI)			
12. State Historic Preservation Act (SHPA) Cultural Resource Screening Process — evaluates if project has an impact on historical structures or archaeological sites. *Note that SHPA must be completed to fill in the SPDES NOI.* a. Evaluate project using Cultural Resource Screening Process Flow Chart (CRSPFC) – Link to NY State Cultural Resource Information System (CRIS): https://cris.parks.ny.gov/ i. Eligible project that does not appear on list of categorical exclusions under 9 NYCRR Section 428.12/428.13: Maintain on site (1) Map and (2) Documentation of structure age (see CRSPFC for details) ii. Ineligible project: Contact the NY State Office of Parks, Recreation and Historic Preservation			
13. SPDES Pesticide General Permit. *Note that SPDES may be required for pesticide/herbicide application, if application is to surface waters* a. Obtain other relevant permits, which may include: ECL Article 15 Aquatic Pesticide Permit (*see Other Forms*); ECL Article 25 Tidal Wetlands Permit (*see Joint Application Form*) b. Completed Pesticide Discharge Management Plan (PDMP) c. Completed Notice of Intent (NOI)			
OTHER PERMITS/FORMS			
14. ECL Article 15 Aquatic Pesticide Permit a. Complete application package, including: i. Application for a Permit to use a Pesticide for the Control of an Aquatic Pest - Title 6 NYCRR Part 327/328/329 ii. A copy of the NYS accepted pesticide label iii. The relevant portion of a 7 1/2 degree USGS Quadrangle of the general area, indicating the location of the water body/streams (if a 7 1/2 degree quadrangle is unavailable, a 15 degree map can be used) iv. Detailed map of the water body indicating: the depths of the water body; areas to be treated; (*for pond/lake treatments*) inlets, outlets, and wetlands contiguous to the water body; if there will be outflow, data to demonstrate how far the outlet waters will flow during the use restriction period, in order to identify potentially affected downstream riparian owners, together with an estimate of outflow in cubic feet per second (cfs), as well as the location and type of outflow control; location of bathing areas, livestock watering areas, water intakes, public lands contiguous to the water body, public boat launches and any other features that may be relevant to the treatment.			

v. List of names and addresses of all affected riparian users (includes owners and persons with vested right of use) vi. Signed Certification of Notification of Affected Riparian Users and, if applicable, a copy of the letter sent to all riparian owners and users • *Note: If the proposed treatment is identical to the treatment of the previous year, a statement to that effect should be requested from the applicant and made part of the application. Any changes in the proposed treatment require a new map.* 15. National Environmental Policy Act (NEPA) – Note: NEPA is only required for federal actions (described in detail below with emphasis added); generally, projects that are federally funded or on federal property): • Major Federal action includes actions with effects that may be major, and which are potentially subject to Federal control and responsibility. Major reinforces but does not have a meaning independent of significantly (§1508.27). Actions include the circumstance where the responsible officials fail to act and that failure to act is reviewable by courts or administrative tribunals under the Administrative Procedure Act or other applicable law as agency action. a. Actions include new and continuing activities, including *projects and programs entirely or partly financed, assisted, conducted, regulated, or approved by federal agencies; new or revised agency rules, regulations, plans, policies, or procedures; and legislative proposals* (§§1506.8, 1508.17). *Actions do not include funding assistance solely in the form of general revenue sharing funds,* distributed under the State and Local Fiscal Assistance Act of 1972, 31 U.S.C. 1221 et seq*., with no Federal agency control over the subsequent use of such funds*. Actions do not include bringing judicial or administrative civil or criminal enforcement actions. b. Federal actions tend to fall within one of the following categories: i. Adoption of official policy, such as rules, regulations, and interpretations adopted pursuant to the Administrative Procedure Act, 5 U.S.C. 551 et seq.; treaties and international conventions or agreements; formal documents establishing an agency's policies which will result in or substantially alter agency programs. ii. Adoption of formal plans, such as official documents prepared or approved by federal agencies which guide or prescribe alternative uses of Federal resources, upon which future agency actions will be based. iii. Adoption of programs, such as a group of concerted actions to implement a specific policy or plan; systematic and connected agency decisions allocating agency resources to implement a specific statutory program or executive directive. iv. Approval of specific projects, such as construction or management activities located in a defined geographic area. Projects include actions approved by permit or other regulatory decision as well as federal and federally assisted activities.			

Appendix D: Example Rapid Vegetation Characterization Protocol

Objective

Identify and characterize site conditions, including high-level classification of existing vegetation communities; and the location and proportion of native and invasive species, tree density and location, and transplant or plant rescue needs.

Sampling Method Overview

Frequency

Sites with sections of high quality habitat should be visited twice during the growing season to capture seasonal diversity and any rare plants that may be present. If the habitat is degraded, it only needs to be assessed once during the growing season. Site visits may vary in length due to site size and complexity; however, assessment of each vegetation unit should take no more than 45 minutes to 1 hour per unit.

Protocols for vegetation characterization should be consistent with National Vegetation Classification methods to minimize reinventing protocols and will allow us to align with a national standard for classifying vegetation units. This consistency will also align with Natural Areas Conservancy data products. Vegetation communities will be assigned using the New York Natural Heritage Program's (NYNHP), which contains a dichotomous key for vegetation communities found on NYC parkland and assessed under the NAC's citywide Ecological Assessment. The key was developed by NYNHP for the NAC and the classifications are consistent with the National Vegetation Classification Methods.

Prior to Field Collection

Field Polygon Delineation

1. Review existing datasets for site including aerial imagery, US Fish and Wildlife National Wetlands Inventory, NYSDEC Regulated Wetlands (Tidal and Freshwater), National Hydrography Dataset, National Resources Conservation Service Soil Surveys, local digital elevation models, United States Geological Survey topographical surveys, and local tax lot data and/or property boundaries.
2. Draft potential **vegetation units/treatment areas** in GIS using a scratch shapefile.
    a. Delineate **vegetation units** in GIS by outlining a relatively homogenous vegetation zone using aerial imagery at approximately 1:1,000 scale; lines should be spot checked at 1:500 or finer resolution. Utilize the outlined internal and external datasets for reference.
        - Polygons should first be delineated using homogeneous vegetation. Individual polygons may vary in size. The minimum vegetation unit size should be approximately 0.5 ac and the largest around 2 ac; however, exceptions do occur including large vinelands or monocultures of *Phragmites* which may be much larger.
        - Polygons may also be delineated using existing features such as sharp contours, trails, roads, wetland boundaries, waterbodies, contract sites, etc.
    b. Manually distribute data collection, or **observation points,** evenly through each vegetation unit polygon using a scratch file in ArcMap. Points will be used to ensure diligent inspection of the entire polygon. A general rule of thumb for points is at least 3 points per polygon; but no more than 7.
    c. Label each vegetation unit polygon with a number (1, 2, etc.)

3. Assign a Site ID to each vegetation unit. The naming convention should be as follows: A two letter acronym for the park name, the number of the vegetation unit, and the two letter borough acronym. For example. Jones Woods vegetation unit 7 would be: JW.7.SI.
4. Print paper maps with labeled vegetation unit polygons and individual observation points to visit in the field, print data sheets and load GPS or tablet unit with vegetation units and observation points.
5. Prior to a field visit, add the NRCS Soil Series and the Restoration Opportunity Inventory Site ID, if applicable, to the data sheets to be used. If multiple soil series occur within a vegetation unit, list the two most prevalent series on the data sheet.

Data Collection

1. Navigate to each individual observation point in each previously identified vegetation unit polygon in the field.
    a. Verify that the vegetation composition of each observation point within an individual vegetation unit is relatively homogenous in community (e.g. meadow vs. forest); structure (e.g. height; young vs. mature forest; low marsh vs. high marsh); topography; and composition (e.g. natives versus invasives; switchgrass versus mugwort).
    b. If observation points or other areas discovered while navigating in the vegetation unit are found to be significantly different vegetation communities, then subdivide the predetermined vegetation units to create homogenous vegetation units, by drawing a line using GPS and/or paper maps for desktop editing in the office. Label each new polygon on the map with the letters (1a, 1b, 1c, etc.).
    c. In general, polygons should be lumped instead of split. The minimum size for mapping a work polygon should be approximately 0.1 AC; however smaller locations may be mapped for invasive species of concern (see step 6).
2. Using the vegetation section of the datasheet, assign one of the pre-determined coverage ranges for each species in the vegetation unit. Observation points should be used as navigational references throughout the site. One datasheet should be used per vegetation unit.

    As species are found throughout the site, assign whether it occurs in the canopy, mid-story, or understory layer and their assigned midpoint percentage. If a species occurs in multiple strata, check off all strata in which it appears. Do not create a new line item for each new stratum. Each line should describe that species' overall coverage throughout the vegetation unit and whatever strata it occurs in. The total of all species likely will not add up to 100% or may exceed 100 percent.
    Species may be noted both at the observation point and while navigating through the vegetation unit.
    - Trace (t) Only one occurrence or ≤1% cover
    - Low: 1 - 25%
    - Medium Low: 25 – 50%
    - Medium High: 50 – 75%
    - High: 75 – 100%
3. Describe other characteristics of each vegetation unit using the remainder of the datasheet.
    - Estimate the coverage of the following strata: Canopy, Mid-Story, Shrub, Herbaceous, Bare Ground, and Vines
    - Site Disturbances – Identify disturbances present within each vegetation unit and assign coverage estimates for that unit for each disturbance identified.

- Habitat – Identify the homogeneity, hydrologic regime, and stand maturity using the categories on the datasheet for the vegetation unit. See Data Dictionary here: J:\NRG\NRG Monitoring\Vegetation Assessment Protocols\Protocol\Data Dictionary
- Soils – Based on a visual assessment, describe in the notes section whether the soils are suspected to be primarily fill or native soils.
- If wetland areas are in the vegetation unit, assign a Cowardin Classification. See Data Dictionary.

4. Note any rare species (or assumed rare species) in the notes section that may need additional surveying.
5. For Capital Wetland Projects, if discrete areas of significant size are encountered with invasive species inside a vegetation unit dominated by native species, map these invasive polygons separately.
    - Noting invasive species separately is not needed if the area to be restored will be completely excavated and modified from its original state.
        - For example, if fill excavated from the wetland will be placed in the adjacent upland, you may skip this step.
        - If most of the fill must be removed from the site and the upland will be restored as it stands, then GPS individual areas of invasive species for treatment (herbicide, clear and grub, etc.). Polygons may overlap.
        - If soil placement strategy is unknown, GPS invasive species polygons.
6. Complete steps in section “Data Collection” for each vegetation unit polygon.

Data Handling and Management

- Download all data from the GPS unit and camera and scan and enter the field datasheets.
- Confirm all GPS points are labeled correctly.
- Label all photos as needed.

Analysis

- Label each polygon with the appropriate vegetation type using the National Vegetation Classification standards.
- Assign a level of disturbance to the plot (low, medium, or high).
    - Low – Relatively natural state
    - Medium – Some disturbance from dumping, erosion or soil disturbance, or invasive species
    - High – Heavy erosion and/or filling, dumping, and invasive species throughout the majority of the site

References

Natural Areas Conservancy. 2016. Inventory of Coastal Wetland Restoration Opportunities in NYC. http://naturalareasnyc.org/content/3-in-print/2-research/roi-project-summary-august-2016_final.pdf

Edinger, G. J., T. G. Howard, and M. D. Schlesinger. 2016. Classification of Natural Areas Conservancy’s Ecological Assessment plots. New York Natural Heritage Program, Albany, NY. http://naturalareasnyc.org/content/3-in-print/2-research/nynhp_classification_of_nac_plots.pdf

Nature Serve. 2008. Vegetation Classification Standard, Version 2.

Appendix E: Tidal Wetland and Transitional Plant Species in the Mid-Atlantic

Below is a list of common native tidal wetland species and their salinity ranges meant to provide a guide for planting palettes. Species in bold are typical in NYC salt marsh restoration projects.

Tidal Range	Habitat	Typical Plant Species	Salinity Tolerance
Mean Low Water (MLW) to Mean Tide Level (MTL)	Mudflat	--	
Mean Tide Level (MTL) to Mean High Water (MHW)	Low Marsh	*Peltandra virginica*	Mesohaline to Fresh
		Sagittaria latifolia	Oligohaline to Fresh
		Spartina alterniflora	Euhaline to Polyhaline
		Spartina cynosuroides	Polyhaline to Fresh
		Typha angustifolia	Polyhaline to Oligohaline
		Typha latifolia	Oligohaline
		Zizania aquatica	Mesohaline to Fresh
Mean High Water (MHW) to Mean Higher High Water (MHHW)	High Marsh	*Bulboschoenus fluviatilis*	Oligohaline to Fresh
		Bulboschoenus robustus	Polyhaline to Oligohaline
		Calamagrostis canadensis	Oligohaline to Fresh
		Distichlis spicata	Euhaline to Polyhaline
		Hibiscus moscheutos	Polyhaline to Oligohaline
		Iris versicolor	Fresh
		Iva frutescens	Euhaline to Polyhaline
		Juncus canadensis	Mesohaline to Fresh
		Juncus gerardii	Euhaline to Polyhaline
		Leersia oryzoides	Oligohaline to Fresh
		Limonium carolinianum	Euhaline to Polyhaline
		Scheonoplectus pungens	Mesohaline to Fresh
		Scheonoplectus tabernaemontani	Mesohaline to Fresh
		Solidago sempervirens	Polyhaline to Fresh
		Spartina cynosuroides	Euhaline to Fresh
		Spartina patens	Euhaline to Polyhaline
		Sueda maritima	Euhaline to Polyhaline
		Symphyotrichum novi-belgii	Mesohaline to Fresh
		Symphyotrichum tenuifolium	Polyhaline to Oligohaline
Above Mean Higher High Water (+MHHW)	Coastal or Transitional Uplands	***Asclepias syriaca***	Intolerant
		Baccharis halimifolia	Tolerant
		Chamaechrista fasciculata	Moderate
		Cyperus grayi	Tolerant
		Eragrostis spectabilis	Intolerant
		Eupatorium serotinum	Moderate
		Euthamia graminifolia	Intolerant
		Iva frutescens	Euhaline to Polyhaline
		Juncus greenei	Moderate
		Juncus tenuis	Intolerant
		Lespedeza capitata	Intolerant
		Morella pensylvanica	Tolerant
		Oenothera biennis	Intolerant
		Panicum virgatum	Tolerant
		Prunus maritima	Tolerant
		Pseudognaphalium obtusifolium	Intolerant
		***Rhus* spp.**	Tolerant
		Schizachyrium littorale	Tolerant
		Schizachyrium scoparium	Intolerant
		Solidago sempervirens	Tolerant
		Sorghastrum nutans	Moderate
		Symphyotrichum ericoides	Intolerant
		Symphyotrichum laeve	Moderate

** Euhaline (30-18 ppt); Polyhaline (18-5 ppt); Mesohaline (5-0.5 ppt); Oligohaline (<0.5 ppt); Fresh (0 ppt)

Appendix F: Biobenchmarking Protocol

Objective

Biological benchmarks (biobenchmarks) serve as reference points to determine optimal elevation ranges for the establishment and growth of plants in tidal wetlands (e.g. high marsh and low marsh in a salt marsh) at individual sites. Land managers can use this data to inform restoration design. Biobenchmarks use both survey techniques and observational techniques to predict the elevation and tidal regime under which individual species will thrive or struggle.

The outcome of this survey should be a table corresponding to topographical elevations, the topographical range of plant communities at the site and their optimal range, and an approximation of the hydroperiod based on the frequency and duration of inundation. While this protocol is specific to tidal wetlands, it can be modified for use in freshwater as well.

Sampling Method Overview

Biobenchmark surveys should be collected at naturally occurring salt marsh ideally at the project site. If no relict salt marsh exists on site, an adjacent naturally occurring salt marsh with a similar tidal regime and hydrologic position should be surveyed. If the site allows, the survey should be conducted on sampling transects perpendicular to the shoreline from the mudflat to the upland using a transit (or similar) to survey the topography, datasheets, and a 1 m^2 plot frame to record vegetation. Where plant communities begin to transition or change along the transect, record the elevation, dominant plant species present by estimating visual percent cover in a 1 m^2 plot, substrate (e.g. construction debris, gravel, natural peat). The elevations corresponding to the extent of vegetation on site are referred to as biobenchmarks. The biobenchmarks are then compared with tidal analysis results from National Oceanic and Atmospheric Administration (NOAA) tide gauges from the site, or an adjacent site with a similar hydrologic regime, to determine target elevations for each species and plant community.

The surveying component (using a transit or total station) of this protocol may be used in addition to a professional survey, or a professional survey that incorporates the biobenchmark locations can stand alone; however, at minimum, a site survey with a transit or total station along transects is necessary if there will be no professional topographic survey conducted at the site. Wherever a professional topographic survey will be conducted, the location of topographical measurements for the biobenchmarks should be flagged in the field at most 1 day prior to the survey, and project ecologists must be present to verify that biobenchmark data is collected with the site survey and labeled correctly showing:

- lowest extent of native low marsh species;
- densest locations (upper and lower extents) of dominant native low marsh species;
- beginning of transition to native high marsh species (both low marsh plants and high marsh plants present);
- densest locations (upper and lower extents) of dominant native high marsh species;
- beginning of transition to native upland species; and
- highest extent of native high marsh vegetation (Figure 1).

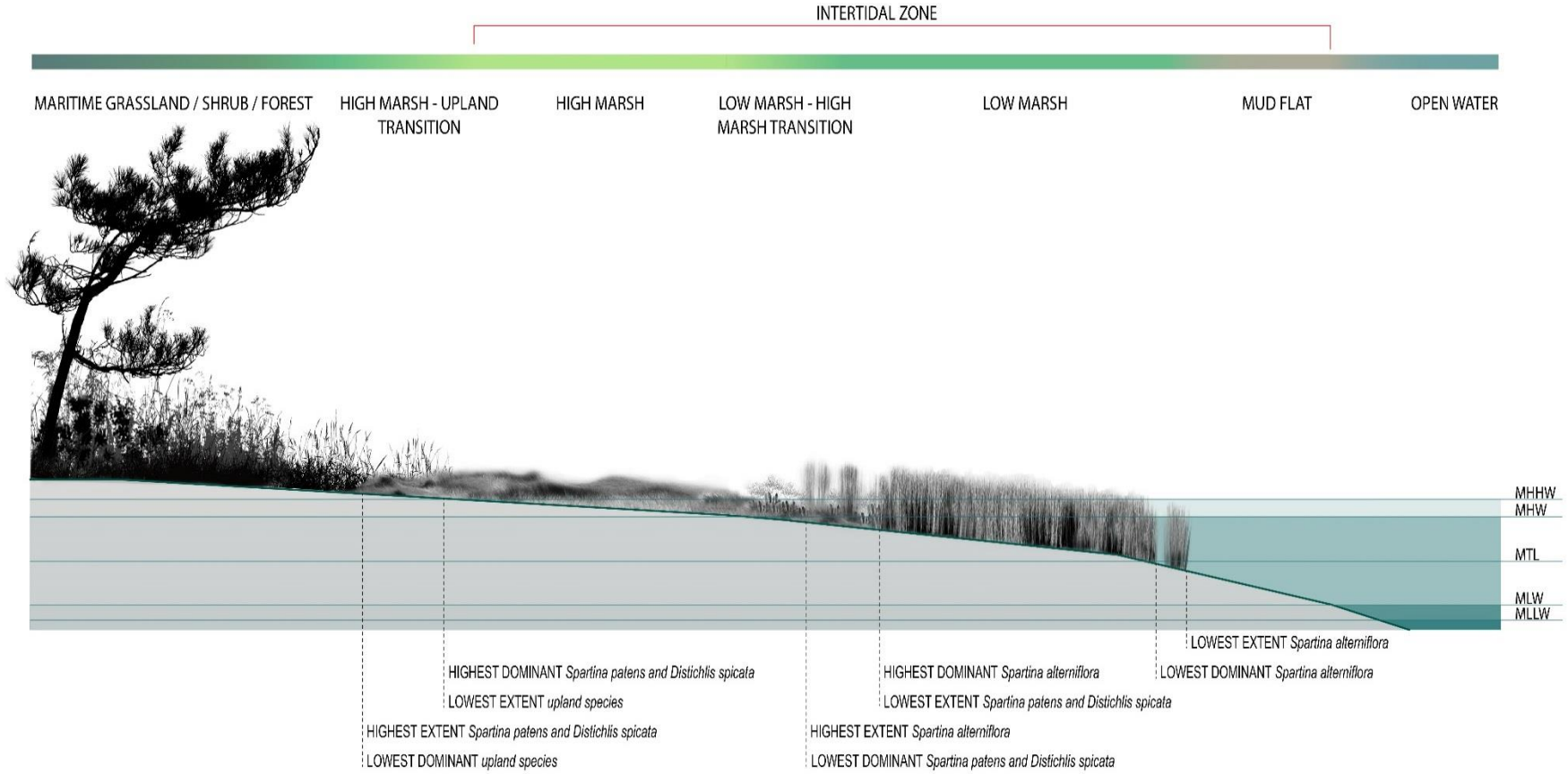


Figure 1. Diagram of a typical salt marsh elevation profile and associated biobenchmark labels.

Note that physical barriers, such as armored banks, culverts, or other tidal restrictions, may narrow the extent (both horizontal and topographic) of plant growth at a given site, especially when compared to an established tide gauge in open water. For this reason, reference sites in the same tidal regime are critical for determining the site-specific suitability of plant species for restoration design.

Sampling Design

- Timing of sampling
    - Surveying should be conducted during the growing season (approximately June – September) when vegetation is present at the site and the plant communities can be delineated.
    - Surveying should be conducted during low tide so that the lowest extent of vegetation can be reached.
- Location of sampling
    - Surveying should ideally occur along multiple transects evenly spaced throughout the site. Sufficient transects should be surveyed to gain a better understanding of the site as a whole.
    - Surveys should occur perpendicular to the shoreline so that species locations are recorded along the range of the tidal regime at the site.
    - Alternatively, if the reference site is very small, a minimum of 5 elevations total should be surveyed at the locations where the target species are most dense, as well as at the upper and lower ranges of their elevation on site (Figure 1).

Sampling Equipment

- Surveying equipment (in order of cost and accuracy from low to high)
    - Manual transit (telescope and locking levers for manually leveling) tripod, and extendable stadia rod;
    - Self-leveling rotary laser level or other automatic level, tripod, extendable laser receiver rod;
    - Total station, tripod, and extendable prism rod; or
    - Real time kinematic survey device (RTK)
- Measuring tape
- Flags or flagging tape
- Digital camera
- GPS unit (if not associated with surveying equipment)
- Clipboard, datasheets, pencil/pen

Prior to Field Collection

- Identify and record a known benchmark location (point with known elevation) in close proximity to the project site. Known benchmarks may be identified from contractor surveys or infrastructure surveys such as from the Department of Environmental Protection or located on site from National Geodetic Survey markers.[61]
- Using ArcGIS, create a rough polygon outlining the biobenchmark survey area at the site.
- Calculate the approximate total length of the shoreline and use this length to evenly distribute at least 3 transects perpendicular to the shoreline across the site (e.g. total shoreline length = 800-900 feet, spacing = ~265-300 feet between 3 transects).

[61] https://www.ngs.noaa.gov/NGSDataExplorer/

- Draw the evenly spaced transects perpendicular to the shoreline in ArcGIS.
- Save this map to the GPS unit and use it as a guide in the field.
- Alternatively, record the transect spacing on a blank datasheet and use it to create transects in the field using a meter tape.

Data Collection

This protocol assumes a manual transit, a self-leveling rotary laser level, or other automatic level; tripod; and general extendable elevation rod is used for surveying. Device operations may differ with a total station; however, if an RTK is used, standard surveying procedures (e.g. recording the instrument and turning point height and locations) may not be required. In this instance elevations only need to be recorded at the known benchmark and at appropriate biobenchmarks or vegetation transitions.

Scout Field Site

- Once in the field, navigate to the transects using a GPS unit and walk each transect to ensure they are appropriate for data collection. If another area exists on site that appears visually more optimal, shift transects accordingly (e.g. areas with complete distributions of low and high marsh or other habitat along a natural gradient that is not fragmented by disturbances such as historical fill or large debris).
- Mark biobenchmark locations along the transect with flags and using the GPS unit at (Figure 1):
    - lowest extent of native low marsh species;
    - densest locations (upper and lower extents) of dominant native low marsh species;
    - beginning of transition to native high marsh species (both low marsh plants and high marsh plants present);
    - densest locations (upper and lower extents) of dominant native high marsh species;
    - beginning of transition to native upland species; and
    - highest extent of native high marsh vegetation.
        - All ecologists on site should come to a consensus regarding visual percent coverage to determine species dominance and designate plant communities.
- Locate and mark the known benchmark point with a flag and using the GPS unit.
- Locate a place to set up the transit that is visible from all sampling transects and the known benchmark, record the location using the GPS unit. If one is not available, identify a suitable location for a turning point (a point that is surveyed from two different level instrument positions). (Figure 2).

Set Up Survey Equipment

- Set up the transit following the same protocol used for an automatic level device as described in other surveying protocols.[62] Please refer to the laser level manual for further details on the laser level operation.[63]

[62] Heitke, J.D., E.J. Archer, D.D. Dugaw, B.A. Bouwes, E.A. Archer, R.C. Henderson, J.L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. PACFISH/INFISH Biological Opinions Effectiveness Monitoring Program (PIBO-EM) Staff – Multi-federal Agency Monitoring Program; Logan, UT. https://www.fs.fed.us/biology/resources/pubs/feu/pibo/pibo_2008_stream_sampling_protocol.pdf

[63] http://www.johnsonlevel.com/Content/files/manuals/40-6541.pdf

- Once the automatic level device is set up, measure and record the height of the instrument by measuring the distance between the laser or viewfinder to the ground in a straight vertical line.
- To shoot an elevation, switch the laser level receiver ON and attach it to the rod. Hold the rod level and face the receiver towards the laser. Adjust the elevation of the receiver until it signals that it is level with the laser.
- If the elevation of the laser on the rod is too high to easily reach and adjust manually, then follow these steps:
    - Fix the receiver to a high point on the rod and use the rod extension mechanism to adjust the receiver height to be level with the laser.
    - Once the receiver signals that it is level with the laser determine the elevation needed from the laser point to the full extension of the receiver on the rod.
        - Example: the receiver is fixed at 8 ft and the first tier of the rod stops at 4 ft, the second tier of the rod immediately above the first tier reads 7 ft when the receiver is level with the laser, thus the second tier of the rod still has three feet to extend to reach 8 ft, making the elevation of the receiver = 5 ft (8-(7-4) =5 ft).

Figure 2. Example surveying area with instruments, bench mark, data, and turning point.

Record Survey Data

- Shoot and record the elevation of the known benchmark point on the data sheet on the "Benchmark" row under the "BACK SHOT" column (example data sheet in Appendix F.1).
- Shoot the biobenchmarks along the transect starting with the lowest elevation extent of the native low marsh species; moving up to the densest location of dominant native low marsh species; the beginning of transition to native high marsh species (both low marsh plants and high marsh plants present); the densest location of dominant native high marsh species; beginning of transition to native upland species; and highest extent of native high marsh vegetation, etc., as described in Figure 1.
- Record the biobenchmark locations and elevations in the data sheet by identifying the location of the benchmark under the "POINT" column with the plant species and elevation designation (e.g. "SPAL low" for the lowest extent of *S. alterniflora* or "SPAL dense low" for the highest density of *S. alterniflora,* etc.) and recording the elevation reading from the rod under the "ELEVATION" column (see example datasheet in Appendix F.1).
- Shoot the elevation of all the biobenchmarks in each transect across the site.
- Take overview photographs of the site showing the flagged locations of the biobenchmarks across the site.
- Prior to leaving the field, ensure all datasheets are filled out and complete.

Data Handling and Management

- Download all data from the GPS unit and camera and scan and enter the field datasheets.
- Confirm all GPS points are labeled correctly.
- Label all photos as needed.

Analysis

- Using the known benchmark elevation, correct the benchmark reading by adding the known elevation to the benchmark reading from the field, then subtract the corrected benchmark elevation from the height of the instrument and to each biobenchmark reading from the benchmark elevation to determine biobenchmark elevations (see example spreadsheet in Appendix F.1).
    - Example: The known elevation of the benchmark is 50 ft and the benchmark shot were 5 ft, thus the actual benchmark elevation is 55 ft, meaning that a biobenchmark reading of 4 ft has an actual elevation of 51 ft.
- Calculate the average elevations for the:
    - lowest extent of native low marsh species;
    - densest locations (upper and lower extents) of dominant native low marsh species;
    - beginning of transition to native high marsh species (both low marsh plants and high marsh plants present);
    - densest locations (upper and lower extents) of dominant native high marsh species;
    - beginning of transition to native upland species; and
    - highest extent of native high marsh vegetation.

- Compare data to tide level data[64] by calculating[65] the annual (make sure that tidal data uses the same datum as the known benchmark so that the data can be compared):
    - Mean Higher High Water (MHHW): mean of the single highest daily tide;
    - Mean High Water (MHW): mean of all daily high tides;
    - Mean Low Water (MLW): mean of all daily low tides; and
    - Mean Tide Level (MTL): average of MHW and MLW.
- Compare the biobenchmark information to the tide information; ideally the low marsh areas will occur between MLW and MHW and the high marsh areas will occur between the MHW and MHHW or higher.

Table 1. Example table comparing tidal datum and biobenchmark data. Example from Sunset Cove in Broad Channel, Queens.

TIDAL DATUM	USACE ELDERS POINT GAGE DATA	PROJECTED SEA LEVEL RISE ELEVATIONS (1)	NYCDPR BIOBENCHMARK DATA (2)	LOCAL TIDE GAGE ELEVATION (3)	PROPOSED PLANT ZONES	PROPOSED PLANT ZONE ELEVATION RANGES
MHWS **MEAN HIGH WATER SPRING**	3.03	3.53	4.47	N/A	HIGH MARSH	2.5 - 3.0
MHW **MEAN HIGH WATER**	2.43	2.93	2.71	2.17	HIGH MARSH/LOW MARSH TRANSITION	2.0 - 2.5
MT **MEAN TIDE**	-0.2	0.3	-0.16	-0.53	LOW MARSH	0.0 - 2.0
MLW **MEAN LOW WATER**	-2.83	-2.33	N/A	-3.23		
ALL ELEVATIONS IN FT. NAVD88.						
(1) 0.5 FT ADDED TO USACE ELDERS POINT GAGE DATA TO ACCOUNT FOR SEA LEVEL RISE PROJECTIONS.						
(2) DERIVED FROM NYCDPR SURVEY OF LOW AND HIGH MARSH ELEVATIONS AT SUNSET COVE, JUNE 2014 AND APRIL 2015.						
(3) DERIVED FROM LOCAL TIDE GAGE DATA OBTAINED AUG-NOV 2015 AND ANALYZED BY LOUIS BERGER, NOVEMBER 9, 2015						

Quality Control

Following data entry, a non-interested party will check the accuracy of 10% of the data entry once it is in digital format (once per dataset) to ensure that the data were entered correctly. If any errors are identified, a full comparison will be made between the raw data sheets and the digital dataset. Quality checks will be documented by the non-interested party by signing with his/her name, initials, date and documenting which data they have specifically checked on the last page of the field data sheet in which they have completed quality control (QC'ed).

Following data analysis and calculations, the project manager or supervisor will review 10% of the analyses and calculations for errors. If any errors are identified, a full review will be made of all analyses and calculations. Quality checks will be documented the project manager and supervisor by signing with his/her name, initials, date and documenting which data they have specifically checked on the last page of analysis in which they have QC'ed.

[64] https://tidesandcurrents.noaa.gov/tide_predictions.html
[65] National Oceanic and Atmospheric Administration (NOAA). 2003. Computational techniques for tidal datum handbook. NOAA Special Publication NOS CO-OPS 2. US Department of Commerce. National Ocean Service. Center for Operational Oceanographic Products and Services. https://tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf

References

Heitke, J.D., E.J. Archer, D.D. Dugaw, B.A. Bouwes, E.A. Archer, R.C. Henderson, J.L. Kershner. 2008. Effectiveness monitoring for streams and riparian areas: sampling protocol for stream channel attributes. PACFISH/INFISH Biological Opinions Effectiveness Monitoring Program (PIBO-EM) Staff – Multi-federal Agency Monitoring Program; Logan, UT https://www.fs.fed.us/biology/resources/pubs/feu/pibo/pibo_2008_stream_sampling_protocol.pdf

http://www.johnsonlevel.com/Content/files/manuals/40-6541.pdf

https://tidesandcurrents.noaa.gov/tide_predictions.html

National Oceanic and Atmospheric Administration (NOAA). 2003. Computational techniques for tidal datum handbook. NOAA Special Publication NOS CO-OPS 2. US Department of Commerce. National Ocean Service. Center for Operational Oceanographic Products and Services. https://tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf

APPENDIX F.1. Table 1. Example Biobenchmark Data Sheet

Survey Data Sheet
Source: Nandan Shetty, Sibel Ozbek - NYC Parks Green Infrastructure

Date:
Site:

EXAMPLE	POINT	STATION (FT)	BACK SHOT	HEIGHT OF INSTRUMENT	FORE SHOT	ELEVATION
	Instrument	N/A		5.76		99.85
	Benchmark	N/A	5.61	105.61		100
	A1	N/A			5.94	99.67
	A2	N/A			6.18	99.43
	A3	N/A			6.62	98.99
	..	..			..	..

Step 1	5.76 =	Read the number or measure the height with a tape	
Step 2	5.61 =	Read a bench mark (utility point, base of a sculpture etc)	
Step 3	105.61 =	100 + 5.61	Backshot is known elevation plus foreshot
Step 4	99.85 =	105.61 - 5.76	Elevation of instrument is backshot minus height of instrument
Step 5	5.94 =	Read point A1	
Step 6	99.67 =	105.61 - 5.94	Elevation of point A1 is backshot minus foreshot at A1

Instrument: ______________________________
Rod: ______________________________
Notes: ______________________________

BLANK	POINT	STATION (FT)	BACK SHOT	HEIGHT OF INSTRUMENT	FORE SHOT	ELEVATION	NOTES
	Instrument						
	Benchmark						

Step 1		Read the number or measure the height with a tape	
Step 2		Read a bench mark (utility point, base of a sculpture etc)	
Step 3			Backshot is known elevation plus foreshot
Step 4			Elevation of instrument is backshot minus height of instrument
Step 5		Read point A1	
Step 6			Elevation of point A1 is backshot minus foreshot at A1

Appendix G: Tide Gauge Protocol

Objective

The objective of tide level monitoring is to determine the frequency and depth of tidal inundation when there is no nearby or adequate tidal information available from an existing tide station or gauge (e.g. operated or calibrated by a NOAA, USGS, etc.).

Water level data will typically be used to refine estimates for mean high water (MHW), mean low water (MLW), mean tide level (MTL), and mean higher high water (MHHW) for the design of tidal marsh restoration projects (Figure 1). In addition, water level data can be used to produce depth-duration-frequency curves to assess frequency of inundation and can be used with detailed elevation data to determine the extent of the area that is flooded under a given tide, or a percent of time flooded over time (hydroperiod).

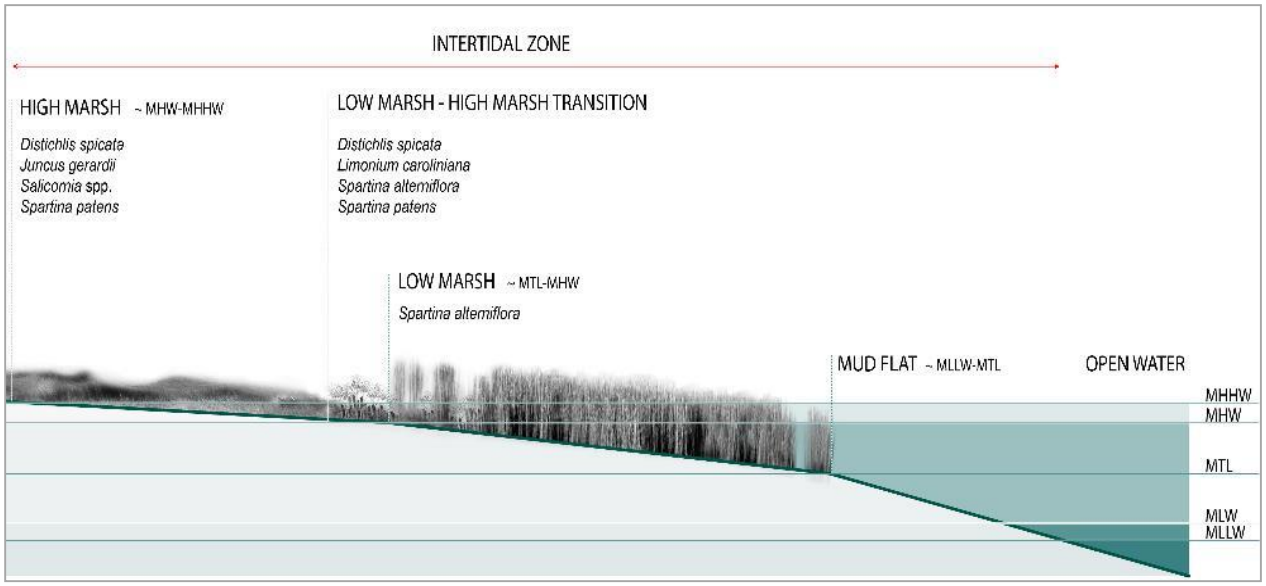


Figure 1. Typical profile of a natural intertidal zone. Salt marsh plant communities are defined relative to tidal inundation levels.

In most cases, adequate tidal data is available from regional tide gauge stations. Whether a tidal water monitoring is needed must be determined for each site. Criteria for determining whether local tidal monitoring is needed include proximity to NOAA tide station (within 3 miles) and configuration or exposure of the site to open water (the tides in back bay or narrow channel sites will be influenced by wind and other ambient factors that will reduce the accuracy of the NOAA tide stations).

Sampling Method Overview

The hydroperiod and tide levels are determined by collecting local water level data (typically with a depth sensor and data logger) and using the data to determine if there are differences between the local water level compared to the water level at the closest tide station (e.g. NOAA Tides & Currents[66]).

Sampling Design

[66] https://tidesandcurrents.noaa.gov/tide_predictions.html?gid=1407

Collect tide data at the site using at least one data logger in the water and one data logger in the air to correct for barometric pressure. The air pressure logger may be placed within 3 miles of the water logger.

- The data should be collected for at least 3 months to obtain and adequate sample and range of tidal cycles.
- Identify and collect data from the closest tide station(s).

At shallow water sites with very minimal water level changes or when resources are limited, an alternative method using a staff gauge (pole or wood stake with a plate or measuring scale attached to it) can be used to manually assess the change in the water level over time, rather than a data logger.

Sampling Equipment

- 2 HOBO Data Loggers – 1 air and 1 water (Use titanium or plastic for salt water)
- HOBO logger data cable/computer connector with appropriate unit receiver
- Laptop with HOBOware software
- Perforated PVC well/housing for data logger
- Mallet or sledge hammer, drill, stainless steel brackets, nuts, and bolts to secure housing
- Alternative to data logger: staff gauge (e.g. 4ft plate/measuring scale secured to stake)
- Digital camera
- Measuring tape
- Meter or yard stick
- GPS unit
- Clipboard, datasheets, pencil/pen

Installation of Data Logger & Housing

- Install water logger housing (PVC pipe) along the shoreline (hammer PVS housing into substrate and secure using drill, brackets, nuts, and bolts to a stable location e.g. next to bridge footing or wood pilings) at low tide so that the bottom of the housing and logger will be below the water line at low tide (Figure 1).
- Install an air logger or barometric sensor on a structure in PVC housing in a secure location within 3 miles of the water logger (Figure 1B).
- Record the location of the logger housing with the GPS unit.
- Identify a known benchmark at or in close proximity to the logger or site with a known elevation in vertical datum NAVD88.[67]
- Use surveying equipment (manual transit, self-leveling rotary laser level, or total station, and tripod and receivers) to survey the elevation of the known benchmark and the ground at the location of the data logger and calculate the elevation of the data logger location in vertical datum NAVD88. This elevation can then be used to determine the water level change relative to the elevation of the data logger location.
- Alternatively, a real time kinematic (RTK – a GPS unit that can determine horizontal and vertical location with millimeter accuracy) can be used and points only need to be recorded at the known benchmark and at the data logger location.

[67] Zilkoski, D.B., J.H. Richards, and G.M. Young. 1992. Results of the General Adjustment of the North American Vertical Datum of 1988. American Congress on Surveying and Mapping, Surveying and Land Information Systems 32(3):133-149. https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

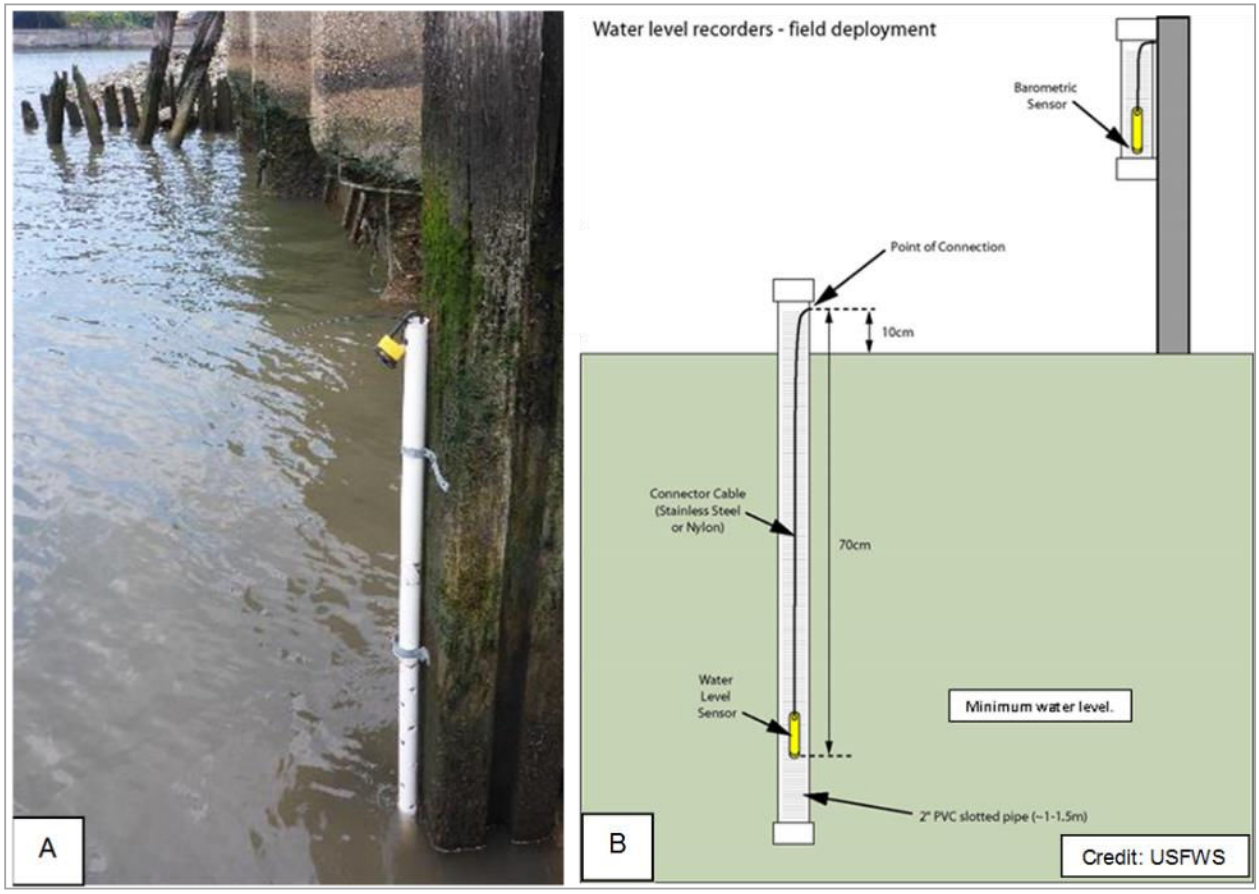


Figure 1. Data logger housing examples, A) water logger PVC housing attached to wood piling and B) diagram of logger housing in soil and the air or barometric sensor housing.

Deployment and Data Collection

- Set up the water logger and air logger to log at regular intervals (times may vary between 6 and 60 minutes), delaying launch to a time when you can be sure installation will be completed. See Appendix G.1, Phases 1-3.
- Place the water logger in the housing securely (e.g. hanging from top of housing using steel cable).
- Measure the total length of the housing, total length of the logger and cable or hanging apparatus, and distance from the hanging point to the top of the housing (Appendix G.1).
- Measure and record the height of the water and determine the distance from the top of the water to the bottom of the logger when the logger is installed.
- Measure and record the distance from the bottom of the logger to ground to determine difference in height between the surveyed ground elevation and the height of the sensor to determine accurate water levels relative to surveyed benchmark with a known elevation.
- Place the air logger inconspicuously in a secure location (e.g. hanging from a tree, telephone pole, or fence either in a secure facility or a location that is not easily visible or accessible).
- Record the date and time of installation/initial water measurement.
- Return to download data a few days after initial deployment to ensure all equipment is operating correctly.

- Retrieve logger and download data at least once every two weeks to ensure that the loggers are still physically present and operating (see Appendix G.1, Phase 5). Clean logger and housing as needed using wire brush.
- Allow the loggers to collect data for a minimum of 90 days.
- A full protocol for setting up and collecting data using an Onset HOBO U20 series data logger can be found in Appendix G.1.[68]

Data Handling and Management

- Download all data from the GPS unit and camera and scan and enter the datasheets
- Download and analyze data to determine tidal regime. An example protocol for retrieving or downloading data from and Onset HOBO U20 series data logger can be found in (Appendix G.1).

Analysis

- Correct data for atmospheric pressure (see Appendix G.1, Phase 5).
- Convert to the appropriate unit and vertical datum (feet, NAVD88). See Appendix G.1, Phase 5.
- Determine the local MHW by averaging the high tide level in each tidal cycle.
- Determine the local MLW by averaging the low tide level in each tide cycle.
- Determine the local MTL by averaging MHW and MLW.
- Determine the local MHHW by averaging the higher of the two daily high tides within a tidal cycle.
- Compare local water level datums to biobenchmark data collected for the site, if applicable.
- Use the local water level datum to correct or verify the closest tide station datum for MHW, MLW, MTL, and MHHW. This is a complex task that requires careful quality control, see the NOAA Computational Techniques for Tidal Datums Handbook (2003).[69]

Quality Control

- Periodically during monitoring, manually measure water levels next to the data logger housing and record the time and date.
- Cross reference the manual measurements with the data logger data to check for major differences or errors in the data.

References

http://edis.ifas.ufl.edu/media/SG064/FieldProcedures.pdf

https://tidesandcurrents.noaa.gov/publications/8210_guide.pdf

https://www.pwrc.usgs.gov/resshow/neckles/gpac.pdf

[68] http://www.onsetcomp.com/products/data-loggers/water-level

[69] National Oceanic and Atmospheric Administration. 2003. Computational Techniques for Tidal Datums Handbook. NOAA Special Publication NOS CO-OPS 2. U.S. Department of Commerce. https://tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf

G.C. Roegner, H.L. Diefenderfer., A.B. Borde, R.M. Thom, E.M. Dawley, A.H. Whiting, S.A. Zimmerman, G.E. Johnson. 2008. Protocols for Monitoring Habitat Restoration Projects in the Lower Columbia River and Estuary. Report prepared for the U.S. Army Corps of Engineers Portland District, Portland, Oregon. http://www.tidalmarshmonitoring.org/pdf/Roegner%20et%20al%202008_CRE%20monitoring%20PNNL-15793.pdf

National Oceanic and Atmospheric Administration. 2003. Computational Techniques for Tidal Datums Handbook. NOAA Special Publication NOS CO-OPS 2. U.S. Department of Commerce. https://tidesandcurrents.noaa.gov/publications/Computational_Techniques_for_Tidal_Datums_handbook.pdf

Zilkoski, D.B., J.H. Richards, G.M. Young. 1992. Results of the General Adjustment of the North American Vertical Datum of 1988. American Congress on Surveying and Mapping, Surveying and Land Information Systems 32(3):133-149. https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

Instruments / Equipment references:

https://www.geomatrix.co.uk/data-sheet/?q=/marine-products/oceanographic-and-hydrographic/tide-gauge/

http://www.onsetcomp.com/products/data-loggers/water-level

Appendix G.1. Example full data logger protocol

HOBO water level logger

Directions for the operation of the Onset Computer Corporation, HOBOware Water Level Logger

Phase 1: Setup

- From the “Start” -> “All Programs” menu, select “Onset Applications” -> “HOBOware” -> “HOBOware”.

Phase 2: Connecting the Logger to a Computer

- Unscrew the black plastic cap from the logger by turning it counter clockwise.
- Attach the exposed optic couple to the Optic USB Base Station.
- Insert logger into coupler with the flat side of the exposed threading on the logger aligned with the arrow on the couple label. Gently twist the coupler to ensure that it is properly seated in the coupler (it should not turn).
- Check Optic USB Base Station status window to make sure that the green light is on.

Phase 3: Status and Operation

- In the HOBOware toolbar click on “device status” and observe that the temperature corresponds to the temperature at your location and the absolute pressure corresponds to the barometric pressure (it is important to keep units and measurement systems in mind when making such comparisons).
- To launch the logger, select “Launch” from the toolbar. A window will open allowing you to choose the description of the data and the operation parameters of the instrument.
- It is imperative to make sure that both the “Absolute Pressure” and the “Temperature 10K Thermistor” options are selected and checked as the pressure readings must be corrected for the influence of temperature (logging voltage is not essential).
- When the selections are complete, press “Launch”, remove the logger from the Optic USB Base Station and screw on the black plastic cap by turning it clockwise.

Phase 4: Field Operation

- Make sure the stilling well that the logger is placed in is vented to the atmosphere.
- Use a no stretch wire to suspend the logger in the well.
- Suspend the logger so that it is always under water but does not touch the sediment, ideally it should be suspended so that it is halfway its maximum measuring depth (7.5 ft for the 15 ft, and 15 ft for the 30 ft) below the water’s surface for the most accurate data collection.
- Measure the distance between the suspension point (hook) and the surface of the water.
- Lower logger into well or stilling well.
- Measure water depth from desired reference point (top of pipe, ground level or sea level).
- Measure water depth.
- Record deployment time.

- For lake, river, and stream deployments, if the water level is referenced to a point above the logger, such as the top of the stilling well, record the water level as a negative number.
- Record the reference measurement date and time.

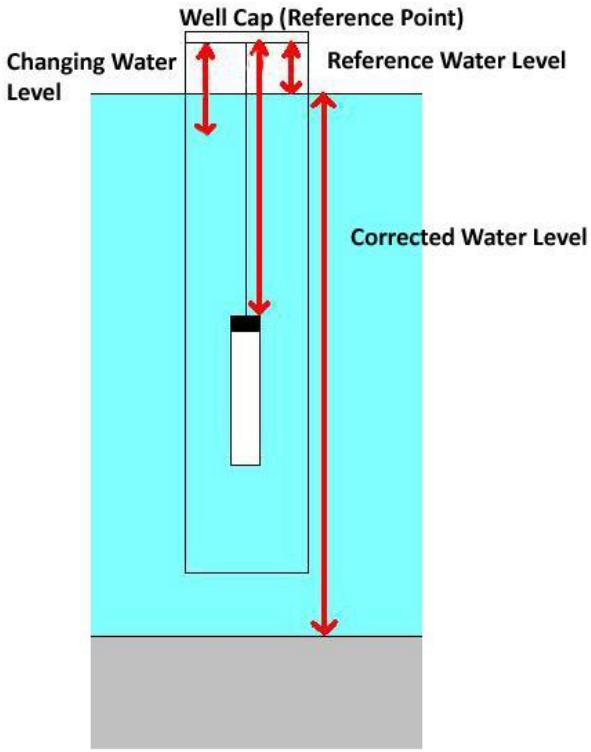


Figure 1. Collected field measurements and resulting measurements.

Phase 5: Retrieving the Data

- Measure the water depth using the original reference point.
    - This measurement is important for quantifying measurement error caused by manual measurement error, sensor drift, or change in suspension length and can be compared to calculated water level at the end of the plot.
- Record the date and time.
- Retrieve the data logger.
- Connect the logger to a computer (See Phase 2: Connecting the Logger to a Computer)
- Click on “Readout device” in the HOBOware toolbar.
- Select device “HOBO U20-001-01.
- Name a Text file for data storage.
- Double click on “Barometric Compensation Assistant”
- Provide fluid density information by choosing water type (fresh, salt, and brackish). It can also be manually entered, but does not significantly affect the results.
    - Provide a reference water level which is the distance between a reference point (most commonly sea level or the height of the well cap of the HOBO’s housing) and the water’s surface.

        - If the water level is measured downward from a reference point above the water's surface, such as a well cap, enter the water as a negative number.
        - If the water level is measured upward from a reference point below the water's surface, such as the water's height above sea level, enter the water level as a negative number.
        - If you don't use a reference water level, the resulting series data will contain values for absolute sensor depth. For the most accurate results, use a reference water level.
    - Upload the barometric data file that was collected from the HOBO that was deployed in the air. A constant barometric pressure could be used but would result in less accurate data.
    - Click "Create a New Series."
    - **IMPORTANT NOTE: The resulting water level data that is calculated is the distance between the reference point and the surface of the water. To calculate the water level from the ground to the water's surface, the data must be converted by subtracting the resulting water level data from the distance between the reference point and the bottom of the water body.**
- You can change the output of the units (m/ft).
- Click "Plot".
- Export the data into an excel spreadsheet.

Notes

- NOAA Barometric Pressure and Weather Stations
- **http://cdo.ncdc.noaa.gov/qclcd/QCLCD?prior=N**
- Depth to logger measured from the bottom of the hole in the black cap to the end of the wire connected to the hook.
- After launching data logger, measure time to deployment to compensate for erroneous data.
- The logger should be allowed to come to full temperature equilibrium (approximately 30 minutes) before the reference level is recorded.

Appendix H: Wave Height Measurement Protocol

Objective

The objective of boat wake monitoring is to characterize the wave action (frequency, duration, height) at a site. This data is then used as an indicator of wave energy and to determine whether shoreline protection is needed, as well as the size or height needed of that protection.

Sampling Method Overview

Boat wake measurements are determined using staff gauges and/or by collecting local water level data at short intervals (typically with a depth sensor and data logger), and then using the data to determine boat wake wave heights, frequency, and duration.

Sampling Design

- Measure boat wakes at one or more locations with one or more staff gauges and data loggers
- Place the staff gauge or data logger perpendicular to the direction of the waves
- Measure for the duration of at least one tide cycle (low tide to high tide), if possible
    - Timing should coincide with known large wave events that impact the site, e.g. shipping schedules, or summer boating activity

Sampling Equipment

- Staff gauge (e.g. 4ft plate/scale secured to wood stake)
- Mallet or sledge hammer to place stake
- Digital camera with photo and video capabilities
- Measuring tape
- Meter or yard stick
- GPS unit
- Clipboard, datasheets, pencil/pen
- 2 HOBO Data Loggers – 1 air and 1 water
- HOBO logger data cable/computer connector with appropriate unit receiver
- Laptop with HOBOware software
- PVC well/housing for data logger
- Mallet or sledge hammer, drill, stainless steel brackets, nuts, and bolts to secure housing

Staff Gauge Installation

- Install staff gauge along the shoreline at low tide so that the bottom of the plate is just below the water line. Secure staff gauge at a stable location next to bridge footing or wood pilings or between rocks, and hammer into substrate in open water (Figure 1).
- Record the location of the staff gauge with the GPS unit.
- If possible, identify a known benchmark at or in close proximity to the staff gauge or site with a known elevation in vertical datum NAVD88.[70] Use surveying equipment (manual transit, self-leveling rotary laser level, or total station, and tripod and receivers) to survey the elevation of the known benchmark and the ground at the location of the staff gauge

[70] Zilkoski, D.B., J.H. Richards, and G.M. Young. 1992. Results of the General Adjustment of the North American Vertical Datum of 1988. American Congress on Surveying and Mapping, Surveying and Land Information Systems 32(3):133-149. https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

and calculate the elevation of the staff gauge location in vertical datum NAVD88. This elevation can then be used to determine the water level change relative to the elevation of the staff gauge location.

Water Level Logger Installation

- Install water logger housing (PVC pipe) along the shoreline (hammer PVS housing into substrate and secure using drill, brackets, nuts, and bolts to a stable location e.g. next to bridge footing or wood pilings) at low tide so that the bottom of the housing and logger will be below the water line at low tide (Figure 2).
- Install an air logger or barometric sensor on a structure in PVC housing in a secure location within 3 miles of the water logger (Figure 2B).
- Record the location of the logger housing with the GPS unit.
- Identify a known benchmark at or in close proximity to the logger or site with a known elevation in vertical datum NAVD88.
- Use surveying equipment (manual transit, self-leveling rotary laser level, or total station, and tripod and receivers) to survey the elevation of the known benchmark and the ground at the location of the data logger and calculate the elevation of the data logger location in vertical datum NAVD88. This elevation can then be used to determine the water level change relative to the elevation of the data logger location.
- Alternatively, a real time kinematic (RTK – a GPS unit that can determine horizontal and vertical location with millimeter accuracy) can be used and points only need to be recorded at the known benchmark and at the data logger location.

Figure 1. Example of a staff gauge (white scale attached to wood stake in the foreground) located in the water on the shoreline as a large boat passes Bridge Park on the Harlem River in the Bronx.

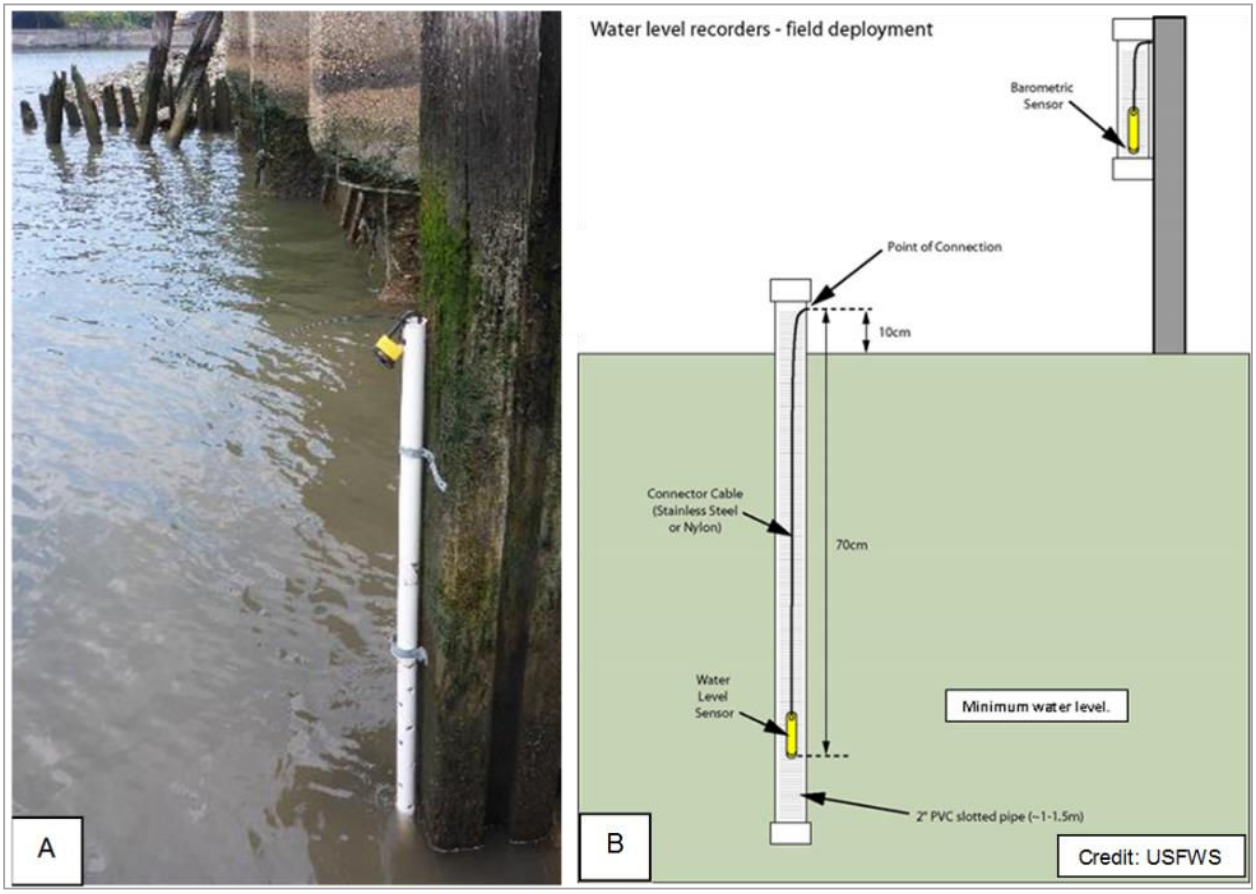


Figure 2. Data logger housing examples, A) water logger PVC housing attached to wood piling and B) diagram of logger housing in soil and the air or barometric sensor housing.

Staff Gauge Boat Wake Data Collection

- Record the start time and water depth on the staff gauge at low tide.
- Record the water depth on the staff gauge and take a photo from the same location every 15 minutes.
- At the end of sampling, record end time and water depth on staff gauge (e.g. high tide).
- As a boat or other vessel approaches the site, record the time and take a photo or record the water level.
- Note the approximate size of the boat (e.g. 0-20 feet, 20-50 feet, larger than 50 feet).
- Take video of staff gauge during boat wakes from fixed point from the start to the end of the wave action (calm water).
- Record the end time of the boat wake (or determine duration from video file)
- An example data sheet can be found in Appendix H.1.

Water Level Logger Deployment and Data Collection

- Set up the water logger and air logger to log every 1 second.
- Place the water logger in the housing securely (e.g. hanging from top of housing using steel cable).
- Measure the total length of the housing, total length of the logger and cable or hanging apparatus, and distance from the hanging point to the top of the housing (if applicable).

- Measure the height of the water and determine the distance from the top of the water to the bottom of the logger.
- Allow the loggers to collect data for a minimum of one tidal cycle (e.g. low tide to high tide).
- Record the start and end time of boat wake events and note the approximate size of the boat.

Data Handling and Management

- Download all data from the GPS unit and camera and scan and enter the datasheets from the staff gauge data.
- Download and analyze data to determine tidal regime.
- Staff Gauge Data
- Review photos to determine water depth change from low to high tide and rate
- Review video to determine average wave height (highest point of each wave), frequency (number of waves in each boat wake event), and the duration (time from when the boat wake event begins and to when it ends) of the boat wake event.

Analysis

- Analyze the data to determine average wave height (highest point of each wave), frequency (number of waves in each boat wake event), and the duration (time from when the boat wake event begins and to when it ends) of the boat wake event.

Quality Control

- Periodically during monitoring, manually measure water levels next to the data logger housing and record the time and date
- Cross reference the manual measurements with the data logger data to check for major differences or errors in the data.

References

http://edis.ifas.ufl.edu/media/SG064/FieldProcedures.pdf

https://tidesandcurrents.noaa.gov/publications/8210_guide.pdf

https://www.pwrc.usgs.gov/resshow/neckles/gpac.pdf

Zilkoski, D.B., J.H. Richards, and G.M. Young. 1992. Results of the General Adjustment of the North American Vertical Datum of 1988. American Congress on Surveying and Mapping, Surveying and Land Information Systems 32(3):133-149.
https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm

Instruments / Equipment references:

https://www.geomatrix.co.uk/data-sheet/?q=/marine-products/oceanographic-and-hydrographic/tide-gauge/

http://www.onsetcomp.com/products/data-loggers/water-level

Appendix H.1. Example staff gauge monitoring data sheet

Date:				Tide:	Field Staff:
Start Time				End time	
Weather					
Event	Time	Resting Height (ft)	With Wave (ft)	Wave Height (ft)	Notes

Appendix I: Equipment for Marine Debris Removal

Equipment and Materials for Marine Debris Removal

Use low tire pressure vehicles and small equipment to complete work in the wetland. Equipment should have between 1.2 and 1.5 psi of pressure. These are often called “Marsh Buggies”, “Swamp Excavators,” “Cargo Buggies,” and “Slide Pontoons.”

Explore water access - Barges with crane arms can remove collected debris without landing on the marsh, and can place marsh mats for small equipment access.

Barges can also carry landing craft vessels, to be used during high tide to access debris. The vessel gate should be lowered on a marsh mat as near to the debris as possible to allow lift access. The landing gate exerts 5-7 PSF of pressure on the marsh mat. Debris should then be re-positioned to allow access to the lifting points, and debris will be lifted on to the vessel gate with a crane. Heavy duty straps and/or multiple point lifting slings can be attached to the cranes for removal of larger intact items. Boats up

to 36’ and 40,000 lbs can be lifted in this manner. The landing craft typically only need 3-7’ of water depth for access.

Geotextile bags called “Dumpsters” are used to collect debris and left it on the barge.

Best Management Practices for Wetland Construction

Avoid stockpiling materials adjacent to a wetland if an alternative location is available. If it is necessary to stockpile near a wetland, use two layers of silt fence (spaced 5 to 8 feet apart) for large piles on slopes; one layer is sufficient for small, temporary piles. Place the silt fence at least 8 feet down slope from the pile edge to avoid overtopping the fencing during rainfall. Seeding or covering piles with tarps or mulch will reduce erosion problems. Do not allow construction materials or debris to spread or blow into the wetland.

Parking vehicles and equipment near a wetland damages vegetation and increases erosion.

Require the use of polyethylene construction mats – marsh mats - for all access roads. Marsh mats spread the weight of equipment and prevent compaction of the wetland. Where feasible, place mats in a location that would minimize the amount needed for the wetlands crossing. Install adequate erosion and sediment controls at approaches to mats to promote a smooth transition to, and minimize sediment tracking onto, swamp mats.

Mats should be cleaned before transport to another wetland location to remove soil and any invasive plant species seed stock or plant material.

Do not allow dragging or pulling of large debris. Large items such as boats should be cut in to small pieces with hand tools, or loaded directly on to the barge.

Suggested Specifications Include:

Polyethylene Construction Mats

Silt Fence

Hay Bales

Appendix J: Techniques for Control of Invasive Plant Species

NYC Parks Natural Resources Group (NRG) has managed invasive species on parkland for over 30 years. The following are from the "Guidelines for Urban Forest Restoration" developed by NYC Parks describing lessons learned for invasive species removal.[71]

Mechanical Control Methods

Trees and Shrubs

Removing invasive trees reduces the possibility of the re-colonization of prepared sites, but avoid clear-cutting, as the deep shade trees provide is often the sole force keeping the seed bank in check.

Unskilled staff or volunteers can usually uproot smaller trees and shrubs. Because some species will re-sprout from small amounts of root left in the ground, removal should include as many of the roots out as possible. There are many tools on the market to help remove root systems, such as weed wrenches, weed hooks and the honeysuckle popper.

Larger trees and shrubs can be felled using either a handsaw or chainsaw. Care should be taken to avoid damage to desirable trees and vegetation nearby. If the species being removed is prone to developing stump or root-sprouts, the stump should be treated with herbicide (see cut-stump treatment under herbicide below for a full-length description of this technique).

Another option for large trees is girdling. Removing a continuous band of cambium from around the lower trunk of the tree, at least one inch in width, will eliminate the flow of nutrients and kill the tree. An effectively girdled tree has the added benefit of offering habitat in the form of standing deadwood excellent for certain cavity nesting birds. Standing deadwood, however, is not appropriate in proximity to roads, paths, and benches. Take care that only well-rooted species with dense wood, such as white mulberry, are left as standing deadwood. Trees that are less well-rooted, have a narrow girth, or less dense wood, such as ailanthus, may easily blow down, thus providing little habitat value and possibly hazardous conditions for staff and volunteers.

Vines

Vines can be the most difficult of all invasive plants to remove. They have extremely fast growth rates, large underground nutrient storage capacities, fragile root systems that easily fragment when pulled, and large seed crops that can spread aggressively. Their foliage is also often difficult to distinguish from surrounding canopy leaves. Manual control of vines is similar to the control of small trees and shrubs described above. It is extremely important to remove as many roots as possible, as early as possible. Because of the persistence of vines, management of seed sources should be a priority. If full root removal is not possible, cut stems or branches prior to maturation of the seed crop, to prevent another year of seed dispersal. Even after you take control measures, vines are likely to return. If a site is extremely sunny, and/or the restoration plan will result in an open canopy in future years, it is wise to remove unnecessary structural elements (i.e. brush and standing deadwood) that could be used by vines as trellises for climbing to sunlight and expanding their potential seeding range.

Herbs

Some perennial and annual herbaceous species are nearly impossible to fully eradicate. Annual herbs have short life cycles and produce large amounts of seed. It is difficult to pull them without leaving parts of their root systems in the ground. If roots remain, herbaceous plants will re-sprout vigorously and attempt to produce seed before senescing. If seeds have been set or they

[71] NYC Parks. s.d. Guidelines for Urban Forest Restoration.

are active in the soil seed bank, invasive plants will grow anew. Minimizing disturbance and amendments to soil are also important; recurrence of many types of invasive herbs is closely associated with soil disturbance. The preferred option for manual control of herbs is hand pulling at the appropriate time of year over multiple years. This has been found to be an effective control for herbs such as garlic mustard (*Alliaria petiolata*) and saplings of Norway maples (*Acer plantanoides*).

Chemical Control Methods

Herbicide applications must be performed in accordance with the law and administered by someone with proper credentials and certification from applicable legal bodies such as the New York State Department of Environmental Conservation. New York City has passed further restrictive regulations (Local Law 37) concerning pesticide use.

NRG makes extensive use of systemic herbicides that are applied to parts of plants (foliar, basal or dormant stem) and translocated through the plant's vascular system to the roots, killing the entire plant. This approach to chemical control may call for multiple treatments of existing invasive species and additional follow-up treatments for new recruits and persistent mature rootstock.

Foliar Spray Method

Herbicide is sprayed on as much of the photosynthetic surface of the target vegetation as possible. This usually involves only the leaves and must be done in spring or summer. For species such as multiflora rose, however, this can also involve the stems, treatment of which can be performed year-round. Foliar spray is most effective when applied while the plant is actively photosynthesizing and translocating nutrients to roots. Inclusion of an adjuvant, such as an oil or soap, in the tank mix with some systemic herbicides can increase their efficacy by penetrating the cuticle of waxy-leaved plants. An adjuvant holds the herbicide to the foliage for a longer time, thereby increasing the absorption of the herbicide by the plant. Foliar treatments are often followed by cutting and removal of above ground portion of plants, both to improve access to the site and to make follow-up treatments more effective.

Basal Bark Method

Basal bark treatment involves spraying a mixture of herbicide and basal oil on the woody parts of a plant. The oil carries the product through the bark and into the plant's vascular system. Basal bark treatments can be performed in the winter when other work is not possible; this can allow for a smoother sequencing of site preparation. Herbicide treatment done during the winter is beneficial because plants that are leafed out during the growing season are dormant, thus limiting damage from herbicide drifting to actively growing herbaceous plants.

Foliar and basal bark treatments can be done in combination during the growing season. Combined treatment is often the most effective option for initial treatment of dense areas of mixed invasive vines with or without other types of invasive plant species. Very dense tangles of vines that have received basal bark treatment often need to be cleared in order to provide access for follow-up treatments and eventual planting.

Cut Stump Method

This method combines mechanical and chemical treatments and is one of the least disruptive methods of application. In the first step, shrubs, trees, or vines are cut close to the ground. Then, the remaining stump is treated with concentrated herbicide. For vines, large nodes and as much of the root structure that can be accessed should be removed when feasible and herbicide should be applied to all small diameter roots that cannot be extracted without breaking. For vines such as porcelainberry, large nodes and root structures can potentially filter

out herbicides, so their mechanical removal will help limit the number of repeat treatments required. Proper timing of cut stump treatments is essential. Do not perform this treatment in the spring when the sap is flowing because plants will push out the herbicide rather than translocating it throughout its vascular tissue. With the cut stump method, the likelihood of resprouts is relatively low. Thus, it is useful when a quick timeline is desired in the treatment of a relatively small site. The cut stump method is also useful for targeted treatment of persistent mature rootstock within larger work sites and for precise removal of individual shrubs or trees without disturbing other plants.

Direct Application

In some cases, NRG has found that direct application to an individual target plant, whether by hand-wiping or injection, has been the most effective and least harmful to non-target organisms. Hand-wiping and injection can only be performed on a very small scale but are valuable methods in sensitive ecosystems. They are especially useful in a site with many sensitive desirable plants and a very limited number of stems of the invasive target.

Hand wiping, or “bloody glove” treatments are done with a relatively high concentration of herbicide, typically around 30%, and directly applied to the inflorescence or photosynthetic surfaces of the target plant. The applicator wears a long protective glove, with the opening cuffed to prevent dripping onto skin, with a thin cotton glove over the top. The herbicide solution is either sprayed onto the cotton glove, or the cotton glove is dunked into the solution, and then used to directly wipe the herbicide onto the target surface.

Injection can be done with an awl and squirt bottle, or with specialized injector guns. A hole is made either by the awl or gun into the stem between the second and third node. The hollow inside the stem is then filled with a high concentration, typically 100%, of herbicide.

Combining Mechanical and Chemical Treatments

As described in Chapter 5, mowing, pulling, and spraying can be used in a variety of combinations. Mowing before spraying can be helpful when treating species that require active or new growth for herbicide to be most effective. For example, NRG has found that mowing hardy plants such as multiflora rose or mugwort first, and then spraying the new growth that emerges, is the most effective sequence for removal. Conversely, mowing after herbicide has been sprayed can be an effective strategy for controlling vine species because vines grow in long mats, making it difficult to see the origin of the root. To use this method, first spray herbicide to kill the tangled stems, wait 4-6 weeks for die-back, and then mow the dead stems. This will allow you to target the new growth that appears from the root directly.

While using mowing and spraying methods together may require a more complex schedule than simply mowing or spraying alone, it is effective and often the preferred approach for invasive plant control. Choosing the best sequence will depend on the traits and growth strategies of the invasive plant.

Appendix K: Example of Material and Chemical Specifications for Clean Sand

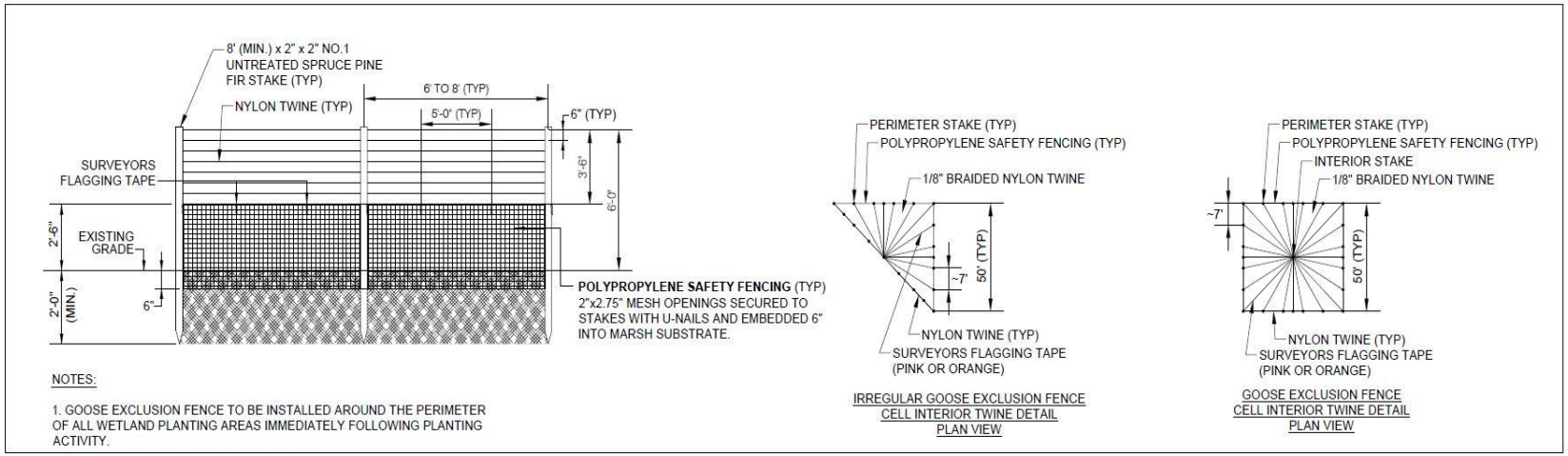
CLEAN SAND FILL material shall be within the following acceptable ranges:

Material Particle Size	Accepted Range	Trapped by Sieve Size
Rocks & Stone	0%	
Gravel (>3.4mm)	0%	No. 10
Very Coarse Sand (2.0mm to 1.0mm)	<10%	No. 18
Coarse Sand (1.0mm to 0.5mm)	<20%	No. 35
Medium Sand (0.5mm to 0.25mm)	>70%	No. 60
Fine Sand (0.25mm to 0.15mm)	<20%	No. 100
Very Fine Sand (0.15mm to 0.05mm)	<3%	No. 270
Silt and Clay (0.05mm to 0.002mm)	<10%	Passing through No. 270

CLEAN SAND FILL chemical properties shall conform to the table below:

Variable	Maximum Value	Minimum
Organic Matter	3%(loss on ignition)	0%
pH	8	4
Electro Conductivity	1 mmhos/cm	0
Total nitrogen (TKN)	200 ppm	0
Nitrate	1 ppm	0

Appendix L: Herbivory Fencing Detail



3 HERBIVORY FENCE DETAIL
SCALE: NOT TO SCALE

Appendix M: Site Inspection and Maintenance Cards

EXAMPLE SITE INSPECTION FORM

[FREQUENCY] Inspection, [DATE]

[SITE NAME], [BOROUGH/CITY], [STATE]

Inspected by: Inspection date:
Temperature/Weather/Tide (at time of inspection):
Recent Significant Weather Events (e.g. Nor'easter):
If Yes, Date(s), Describe:

Wetland Area Condition	**S or U***	**Corrective Action**	**Comment**
Debris accumulation—logs and floatables			
Stressed, damaged, or missing plants			
Erosion			
Storm/wave/tide damage			
Herbivory damage			
Undesirable invasive or non-native plant growth			
Vandalism			
Other			
Vandalism			
Boardwalk, signs, benches			
Other			

*S=Satisfactory; U=Unsatisfactory; TBD=To Be Determined

Inspector Signature:

Inspector Name:

Contact Information: (e-mail) or (office phone)

Inspection date:

NOTE - Inspections must be conducted by a qualified environmental professional.

Comments on condition e.g. vegetation, floatables, and signs of erosion or goose herbivory

General:

Low Marsh zone:

High Marsh zone:

Upland slope:

Action Items/Recommendations:

Table 1. Photo Stations with condition and comments. See Figure 1 for Photo Station Locations.

Photo Point No.	Condition	Comments

Note the location of photos and any observations above on a paper map or GPS these locations and transfer to a digital map.

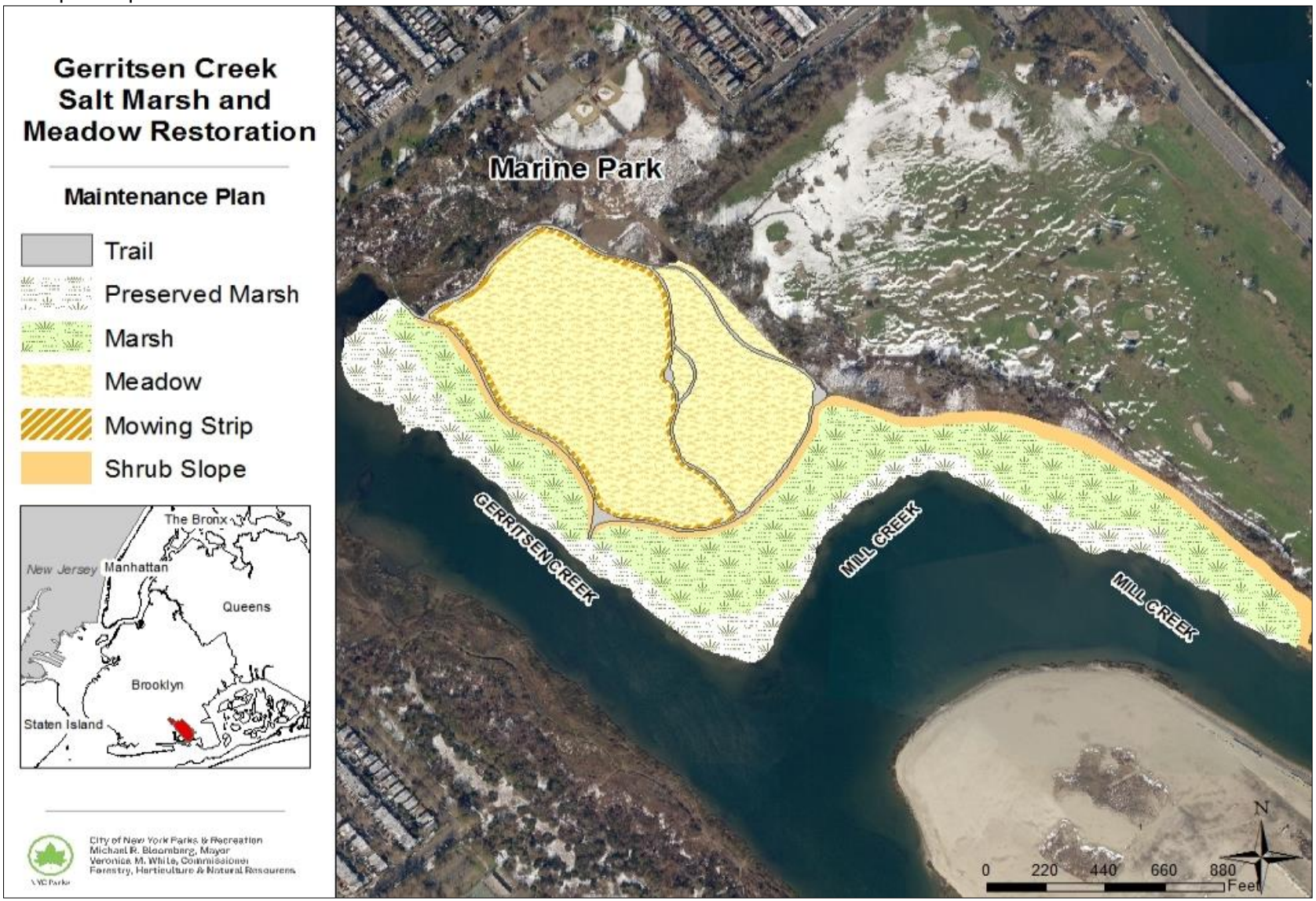
EXAMPLE SITE MAINTENANCE AND MANAGMENT CARD FOR X PROJECT

[Organization] oversees Park-wide maintenance and will contact [Project Manager] at xxx.xxx.xxxx if conditions at salt marsh restoration project site warrant attention. [Responsible Party] will conduct inspections [Frequency and season] and after severe storms to identify potential issues as listed below. See attached site map for locations listed in the elements column below. [Responsible Party] will also monitor salt marsh condition each fall for [X] years after project completion.

LOCATION	ISSUE	ACTION	LEAD	FREQUENCY
Entire Area	Trash/debris in upland	Remove trash/debris in upland.	[Responsible Party]	As needed
Marsh Vegetation	Dead, diseased or dying plants	Determine cause and replace plant material.	[Responsible Party]	As needed
	Phragmites australis invades salt marsh	Clear *Phragmites* using the schedule below as a guide. Clear dead standing plant debris Dec-March. Cut to below six inches three times: May-June, mid-July, and early September (when reeds are green). Herbicide in September if needed no less than six weeks after last mow (requires tidal wetland permit).	[Responsible Party]	As needed
	Geese eating marsh plants	Install or secure waterfowl barrier and replace plant material if necessary.	[Responsible Party]	As needed
	Excessive trash / debris	Clear or determine needed action especially after storm events.	[Responsible Party]	As needed
Upland: Shrub Slope and Meadow	Areas of bare soil and/or erosive gullies formed	Stabilize the soil with biodegradable erosion control fabric as is required and re-seed or replant vegetation if necessary.	[Responsible Party]	After storms; as needed
	Dead, diseased or dying plants	Determine cause and replace plant material.	[Responsible Party]	As needed
	Phragmites and other invasive plants found	Cut repeatedly (early June, mid July, early September). Replant with desirable plants if necessary. Properly dispose of cut invasives.	[Responsible Party]	~3x/year in summer
Meadow Vegetation	Invasive plants and tree seedlings colonizing meadow	Mow, using a brush hog if possible, to no less than 6" in late spring/early summer (by June 1) of even years. Mow in mid to late August of odd years. Top 1 foot of cover is sand. In early years test mowing equipment to assure the weight will not cause erosion. Additionally, mow in late March/early April if woody species become problematic. Remove woody species (cherry, black locust, mulberry, willow, etc.) by weed wrench. Invasive species may require herbicides, which should be applied in September. Consult [Project Manager] if mowing to less than 6". Remove thatch layer every 5 years, e.g. 2015; 2020.	[Responsible Party]	Mow 1x year in summer; Remove woody species in winter or as needed.
Meadow Mowing Strip	Keep paths clear; fire break	Mow, using a brush hog if possible, to a height no less than 6" from the path to 6'. From 6' - 12' from the path, mow to 12". Mow late March/early April each and in late June annually. Consult NRG if mowing to lower than 6".	[Responsible Party]	2x/year in late winter and early summer
Paths	Gravel overflow and path erosion	Rake gravel back onto path. Install water bars if necessary.	[Responsible Party]	1/week
Other				

Project Manager: [project manager name], [project manager email], [project manager phone number];
[ADD MAP OF MAINTENANCE AREA]

Example map:


Gerritsen Creek
Salt Marsh and
Meadow Restoration
Maintenance Plan
Trail
Preserved Marsh
Marsh
Meadow
Mowing Strip
Shrub Slope
The Bronx
New Jersey
Manhattan
Queens
Brooklyn
Staten Island
City of New York Parks & Recreation
Michael R. Bloomberg, Mayor
Veronica M. White, Commissioner
Forestry, Horticulture & Natural Resources
NYC Parks
Marine Park
GERRITSEN CREEK
MILL CREEK
MILL CREEK
N
0
220
440
660
880
Feet