Salt Marsh Conservation Planning For Coastal Long Island Sound in Westchester County, NY

NEIWPCC

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Long Island Sound Study
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CONTENTS

Executive summary 2
Project Introduction 3
- Objective 3
- Approach 3

Westchester County Marsh Resources 4
- Introduction 4
- Overview of Marsh Resources in this Study 5

Benefits from Westchester County Marshes 12
- Habitat 12
- Wave Attenuation 16
- Recreation and Natural-Area Proximity 16
- Water quality protection (Nutrient Sequestration and Denitrification) 17

Threats to Westchester County Marshes 18
- Sea-Level Rise 18
- Development 19
- Water Quality Issues 19
- Marine Debris and Microplastics 20

Marsh Conservation Planning 21
- Strategies 21
- Land Purchases and Easements 23
- Local Regulation 23
- Marsh Restoration 24
- Living Shorelines 24

References 27
Appendix A: Marsh Parcel Background and Sea-Level Rise Simulations 30
- Blind-Brook Wetlands 31
- Marshlands Conservancy 35
- Hen Island 39
- Otter Creek Preserve 43
- Hommocks Conservation 47
- Pine-Brook Wetlands 51

EXECUTIVE SUMMARY

Tidal wetlands in Westchester County, NY are a limited resource, both due to local geography and human population density. Nevertheless, there are many important wetlands within the county. This report discusses the history, benefits, and threats to the six largest coastal wetlands in Westchester County, and the methods that local planning groups and governments can take to ensure that the benefits of these marshes persist. The report also examines how wetlands may change their potential footprint under the influence of sea-level rise.

The history of wetlands in Westchester County includes significant human interference. During in the 20th century, many wetlands were filled to create land for housing and recreation (for example Harbor Island Park in Mamaroneck). In other cases, wetlands were modified to create coastal lakes (for example Manursing Lake in Rye was previously wetlands).

Westchester County marshes provide many important benefits, both to humans and natural systems. These coastal marshes provide critical habitat for birds, including endangered and threatened species, and habitat for invertebrates and small fish that form the basis for the near-shore ecological community. Other benefits provided by coastal marshes include protection of property from waves during storm events, the processing and reduction of nutrients in coastal waters, and local recreation and community access to ecological resources.

Continued provision of these benefits is at risk, however, as coastal marshes are threatened by a number of external factors. One important threat to coastal marshes is the potential impact of sea-level rise. If sea levels rise quickly enough, this has the potential to drown existing marshes. On the other hand, marshes can potentially migrate onto adjacent higher lands, if that land is available or made available for their movement. This report examines sea-level rise modeling for each of the six identified Westchester marshes. Some marshes are more vulnerable than others and have little adjacent land on which to expand (due to the high elevation of these lands). Other marshes have extensive adjacent lands that have suitable elevation for migration, but many of these areas are currently developed or used for recreation purposes. These findings suggest that the management of the dry-land to wetland boundary will be an important topic in this region over the next several decades.

Other important threats to Westchester County coastal marshes include encroachment from adjoining development, damage from excess nutrients, marine debris, and microplastics, and impacts from other contaminants in marsh waters.

To ensure that Westchester County marshes are preserved for current and future generations, local governments, planners, and NGOs have several tools available. These strategies will generally fall into the categories of "managing current resources," "land purchases and easements," "local or state regulation," and "marsh restoration." Education is also important to ensure that community members recognize the critical ecological role of salt marshes, and these marshes' impact on regional character. Modeling and data analysis can ensure that conservation plans have an eye towards anticipated future conditions.

Each strategy for marsh conservation planning is discussed in more detail below and several case studies are provided that show how local governments and landowners are already taking action. At the end of the report, detailed maps are presented showing sea-level rise modeling for each identified marsh system.

PROJECT INTRODUCTION

Conservation of coastal wetlands can provide a wide range of benefits to coastal communities, from increased resilience to storm events, to providing suitable habitats for animals and plants that are important ecologically and economically. Tidal wetlands are capable of sequestering carbon and other nutrients; they also filter upland and runoff waters from pollutants and sediments and provide a protective buffer to reduce shoreline erosion due to wave action. Marsh and natural areas can also be important for their social, historical, and recreational role within coastal communities.

Despite their value, tidal marsh areas have been degraded or lost over time as a result of human activities. In addition, changes in climatic and ecological conditions and pressures from infrastructure development complicate effective conservation planning and management. For example, the accelerating rate of sea-level rise (SLR) due to climate change requires coastal managers to consider not only existing tidal flooding conditions, but also potential changes that may occur in the future. In particular, marshes can respond to increased inundation by migrating inland and colonizing areas that were previously at higher elevations. However, in many coastal communities, marsh migration can be complicated by the fact that land is not available or developed areas may require proper restoration. *(Background text courtesy of Propato et al. 2018)*

OBJECTIVE

The objective of this project is to provide Long Island Sound municipalities, communities, and marsh-conservation groups with predicted changes to wetland habitat under a wide range of sea-level rise scenarios at select, large wetland complexes. These results are integrated with land-ownership information to assist in developing suitable marsh conservation plans that work towards increasing coastal resiliency.

APPROACH

This work leverages existing Sea Level Affecting Marshes Model (SLAMM) numerical and map based projections of the potential effects of sea-level rise on the wetland communities, for the entirety of coastal New York State (Clough et al. 2016, Propato et al. 2018).

WESTCHESTER COUNTY MARSH RESOURCES

INTRODUCTION

Tidal wetlands in Westchester County are generally a limited resource both due to geographical constraints and the history of human intervention in this densely populated region. In this report we will characterize some of the Westchester County coastal marsh resources, discuss the benefits from these habitats, the threats to these habitats, and examine some of the possibilites for marsh conservation strategies.

For the purposes of this report, we will be focusing on the six named marshes shown in Figure 1 below.

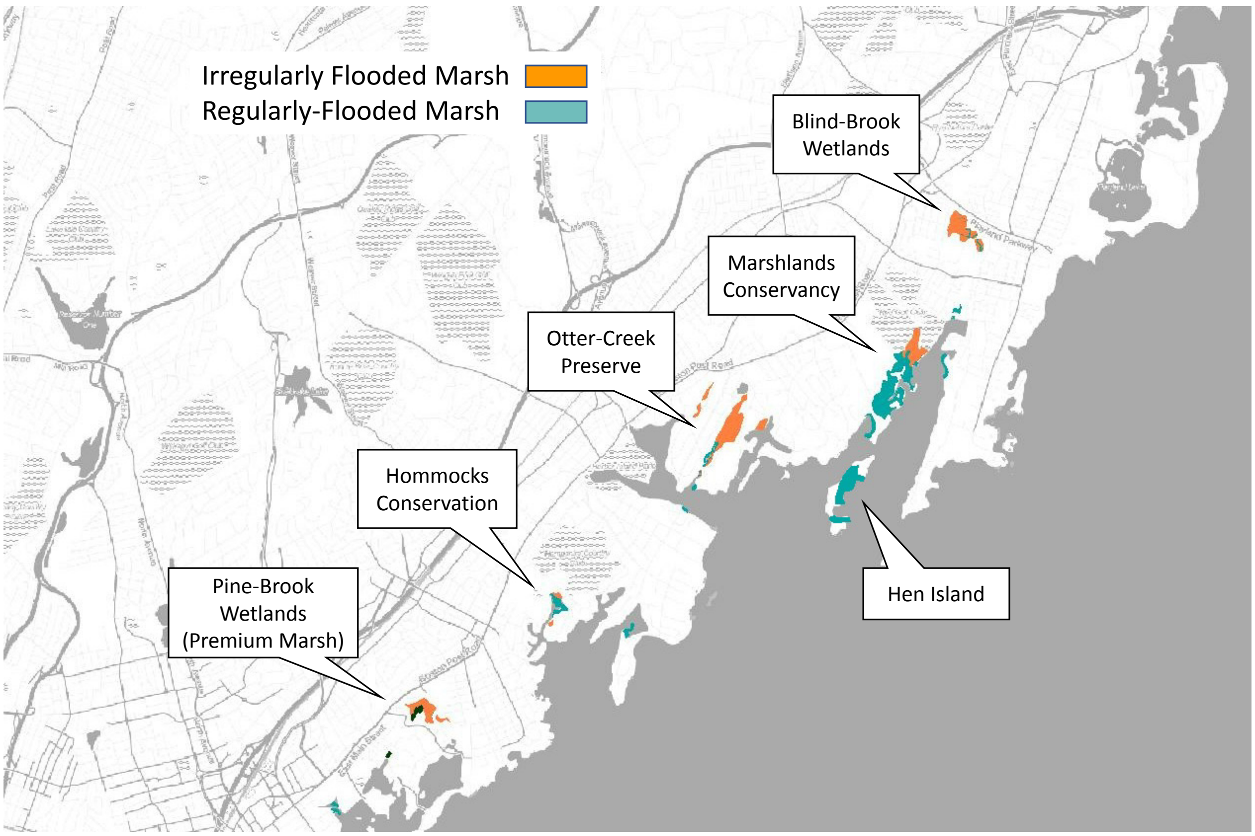

Figure 1. Some of the Larger Marsh Resources in Westchester County as identified by the National Wetland Inventory

It is important to note that this is not an exhaustive list of marsh resources in the county. There are many areas that are smaller or that might not appear on the National Wetlands Inventory. In addition, there are significant marsh restoration projects completed and underway at Manursing Lake in the City of Rye. Because this area is already under active management, this makes model results especially uncertain. For this reason, Manursing lake was not explicitly added to this report.

Overview of Marsh Resources in this Study

A brief introduction of each location follows. Full descriptions of each marsh and additional photos can be found in Appendix A of this document

- **Blind-Brook Wetlands.** This marsh or tidal wetland, with over 20 acres of irregularly-flooded marsh habitat is in the City of Rye. The bulk of the marsh is between Playland Parkway and the City of Rye-owned Disbrow Park and the Westchester County-owned Blind Brook Wastewater Treatment Plant. New York State DEC has designated Blind-Brook Wetlands a critical environmental area.

Figure 2. Aerial view of Blind-Brook wetlands, Photo Credit Google Earth 2021

- **Marshlands Conservancy.** Containing the largest acreage of wetlands in this study, Marshlands Conservancy is a 148-acre wildlife sanctuary in the City of Rye. The largest portion of the wetland is found at Westchester County-owned Marshlands Conservancy and City of Rye-owned Rye Golf Club along the northern shoreline of Milton Harbor. The Marshlands Conservancy is a New York State-designated Significant Coastal Fish and Wildlife Habitat and a Long Island Sound Study Stewardship Area. New York State DEC has designated Marshlands Conservancy a critical environmental area.

Figure 3. Marshlands Conservancy, Photo Courtesy of Robert Doscher, Westchester County NY

- **Otter-Creek Preserve.** Located in Mamaroneck, NY, the Otter Creek Preserve includes a mix of coastal waters, marsh, wooded wetlands, and edge habitats (Westchester Land Trust 2021). The Preserve is the largest privately-owned tidal wetland designated and protected as a nature sanctuary in Westchester County (Westchester Land Trust 2021). New York State DEC has designated Otter-Creek Conservancy a critical environmental area.

Figure 4. Otter Creek Preserve, Photo from https://westchesterlandtrust.org/ Photo Credit Dana Stetson

- **Hen Island:** Hen Island is a privately owned, seasonal waterfront community between Mamaroneck and Milton Harbors. Geographically and ecologically, Hen Island is a southwesterly extension of the Marshlands Conservancy consisting of 26 acres of marshland, wooded upland and lands underwater.

Figure 5. Aerial view of Hen Island from South to North. Photo Courtesy of David Spader

- **Hommocks Conservation Area.** The Hommocks Conservation Area is a 10.6-acre parcel comprised of woodland, salt marsh, and meadow areas, that includes 3.6 acres of tidal wetlands (Town of Mamaroneck NY 2021). The marsh is at the head of a narrow embayment called East Creek, which is part of Larchmont Harbor. A small parking lot and short trail extends into the marsh from Hommocks Road. New York State DEC has designated the Hommocks Area as a critical environmental area.

Figure 6. Hommocks Conservation Area, Photo Credit Google Earth 2021

- **Pine-Brook Wetland (Premium-River Conservation Area Complex).** The Pine Brook Wetlands, part of the 65-acre Premium Marsh Conservation Area, are located in the north east corner of the Village of Larchmont NY and partially within the Town of Mamaroneck NY. The 40-acre portion of the conservation area within Larchmont and Mamaroneck was designated as a critical environmental area under the State Environmental Quality Review Act (Town of Mamaroneck General Legislation). About 8 of those acres are considered tidal wetland (Town of Mamaroneck).

Figure 7. Pine-Brook Wetland, (Photo reprinted with permission from Nearmap.com, 2021)

The history of wetlands in Westchester County includes significant human interference. For example, Figure 8 to Figure 10 illustrate how wetlands adjacent to what is now called the Hommocks Conservation area were filled in to create land for housing and recreation, between 1926 and 1960. While the angles are slightly different between the three photographs, the red star, representing the same point, helps provide context.

Figure 8. Hommocks Road Mamaroneck, 1925-26. Photograph (Westchester County Department of Planning 2021)

Figure 9. Hommocks Road Mamaroneck, 1960. Photograph (Westchester County Department of Planning 2021)

Figure 10. Hommocks Road Mamaroneck, Current Day Photograph (Westchester County Department of Planning 2021)

The red star in the three figures above also represents the location of a case study in which a landowner is replacing vertical seawall with a nature-based living shoreline approach. More details on this case study may be found on page 26 of this document.

Similar wetland filling has occurred throughout Westchester County during the 20th century. For example, to the east of Otter Creek, wetlands were filled to create Harbor Island Park (Figure 11, Figure 12). Historical photos also show significant wetlands in the vicinity of Manursing Lake-- areas that are not wetlands in the present day (Figure 13, Figure 14).

Figure 11. 1924 Aerial Photo of Harbor Island Park, East of Otter Creek Preserve seems to show wetland filling in progress. (Westchester County Department of Planning 2021)

Figure 12. 1940 Aerial Photo of Harbor Island Park, East of Otter Creek Preserve. (Westchester County Department of Planning 2021)

Figure 13. 1925 Aerial Photo of Manursing Lake area (Westchester County Department of Planning 2021)

Figure 14. 2020 Aerial Photo of Same Location at Manursing Lake without Coastal Wetlands. Photo Credit Google Earth 2021

BENEFITS FROM WESTCHESTER COUNTY MARSHES

Coastal marshes of New York provide both human-centric and ecological benefits. Recently, an expert and stakeholder panel developed an "ecosystem service list" from New York State marshes and defined the following categories (Propato et al. 2018):

- Nutrient sequestration (C, N, P)
- Recreation
- Habitat
- Wave attenuation/Flood damage reduction
- Political/Cultural/Historic value
- General preservation of natural areas

Discussion of some of these benefits, and specifically how they pertain to Westchester County marshes, follows.

HABITAT

Salt marshes are highly productive systems, and therefore provide a multitude of services and resources to various wildlife – including finfish, shellfish, birds, mammals, reptiles, and other invertebrates. This immense productivity is driven by the high biomass and diversity of the marsh grasses. Smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*) are the two dominant plant species that are the foundation of the system. Marsh grasses are considered ecosystem engineers which, by definition, are organisms that have the ability to alter or change the surrounding habitat, and therefore affect the livelihood of other organisms in the surrounding area (Jones et al. 1994, 1997). Marsh grasses produce detritus (decaying plant material), and this is stored in the organic matter of the sediment. This organic matter is rich with nutrients and minerals that cascade up the food chain, and provides energy to the upper-level species.

The salt marsh can be divided into several different habitat types in the transition zone between the Sound and upland terrain, which are described by the New York Natural Heritage Program. These habitats include salt scrub, high salt marsh, low salt marsh and salt panne.

- ***Salt Scrub***- This shrubby habitat occurs at the transition between salt marsh and upland areas. Typical plants include groundsel tree (*Baccharis halimifolia*), marsh elder (*Iva frutescens*) and seaside goldenrod (*Solidago sempervirens*); however, this habitat is often heavily invaded by non-native common reed (*Phragmites australis*) (New York Natural Heritage Program).
- ***High Salt Marsh***- The high salt marsh is dominated by saltmeadow cordgrass or salt hay (*Spartina Patens*). Many high salt marsh areas were historically mowed for hay. The high salt marsh is typically flooded by particularly high tides, and it may not be flooded every day. Other plants such as glassworts (*Salicornia spp.*), smooth cordgrass *(Spartina alterniflora)*, and spikegrass (*Distichlis spicata*) may be present (New York Natural Heritage Program). The saltmarsh skipper (*Panoquina panoquin*), a butterfly that uses spikegrass as a host plant, is found in this habitat (Glassberg 1999).
- ***Low Salt Marsh***- The low salt marsh, which is often flooded by tides several times daily, is dominated by smooth cordgrass (*Spartina alterniflora*). Common animals include Atlantic ribbed mussels (*Geukensia demissa*) and fiddler crabs (*Uca pugnax*), which can be very abundant (New York Natural Heritage Program).
- ***Salt Panne-*** Salt pannes are shallow pools within the salt marsh ecosystem that rarely drain. As the water evaporates, the salt concentration can become much higher than in the surrounding ecosystem. The habitat is generally composed of standing water and mud. Smooth cordgrass (*Spartina alterniflora*),

glassworts (*Salicornia spp.*) and marsh fleabane (*Pluchea odorata*) are typical plants. Small fish may be present (New York Natural Heritage Program).

BIRDS

Marsh habitat is a critical component for the success of numerous bird species found throughout the Long Island Sound, including Westchester County. Furthermore, a study of New York area bird colonization found that bird-species habitat increased with proximity to marsh, salt marsh, *Phragmites*, and protected areas (Benscoter et al. 2019). These species include various ducks, geese, cormorants, herons, egrets, and sparrow species (see Table 1 below). Salt marshes provide a foraging site for many bird species as marshes support the base of the estuarine food chain. While some birds directly feed on the marsh plants, most will feed on other organisms inhabiting the salt marsh – algae, invertebrates, shellfish, and finfish.

Marsh birds utilize the salt marsh in Westchester County as predation refuge, breeding, mating, and/or nesting grounds, or a rest stop along the Atlantic Flyway. The diversity of marsh plant species increases the complexity of physical structure of the habitat, and therefore decreases competition by opening more niches for birds to utilize. Wading birds, such as great blue heron (*Ardea Herodias*) and black crowned night heron (*Nycticorax nycticorax*) may feed within the mudflat and intertidal low marsh habitat consisting of smooth cordgrass (*Spartina alterniflora*). Marshes in the study area Milton Harbor, in particular Marshlands Conservancy, can provide a critical feeding area for locally nesting wading birds on nearby Huckleberry Island off of the New Rochelle coast. Additionally, in the Long Island Sound, the invasive plant species, common reed (*Phragmites australis)*, provides habitat for some bird species (Benoit and Askins 1999).

High marsh habitat consisting saltmeadow cordgrass (*Spartina patens*), Spikegrass (*Distichlis spicata*), and black rush (*Juncus gerardii*), are especially important bird habitat for several species – including the highly threatened saltmarsh sparrows (*Ammospiza caudacuta).* Species like the saltmarsh sparrow rely on the high marsh habitat for nesting. Due to sea-level rise caused by climate change, saltmarsh sparrow populations have been in rapid decline, with 80% of the population disappearing in the past fifteen years (Atlantic Coast Joint Venture. 2021). The Atlantic Coast Joint Venture identified Marshlands Conservancy as falling within its top 20% of important marshes to protect in terms of saltmarsh-sparrow habitat with Blind-Brook and Otter-Creek Wetlands also identified as high-quality habitat for this species (Atlantic Coast Joint Venture. 2021).

Predator species, such as ospreys (*Pandion haliaetus)*, form the top of the salt marsh food chain relying on fish and mammals found within these ecosystems. Osprey populations declined severely throughout their range prior to 1971 due to the use of DDT, an insecticide, that when ingested by the animal caused their egg shells to thin and break, reducing productivity. In 1972, the United States banned the use of the chemical and osprey populations slowly began to recover. Today, osprey pairs can be found throughout Long Island estuaries.

A partial list of important and threatened bird species that utilize habitat in or adjacent to Westchester County marshes may be found in Table 1 below.

Table 1. Partial List of Westchester County Bird Species that Utilize Marsh Habitat with a Focus on Threatened and Endangered Species

Species	**NY Status** (State Endangered Species Act)	**Audubon Watch List**	**NY SGCN Status** (Species of Greatest Conservation Need)
American Black Duck			High Priority SGCN
Piping Plover	Endangered	Red	High Priority SGCN
Least Tern	Threatened	Red	SGCN
Common Tern	Threatened		SGCN
Northern Harrier	Threatened		SGCN
Bald Eagle	Threatened		SGCN
Least Bittern	Threatened		SGCN
King Rail	Threatened		SGCN
Lesser Scaup			SGCN
Surf Scoter			SGCN
White-winged Scoter			SGCN
Black Scoter			SGCN
Long-tailed Duck			SGCN
Common Goldeneye			SGCN
Ruddy Duck			SGCN
Horned Grebe			SGCN
Black-bellied Plover			SGCN
Ruddy Turnstone			SGCN
Purple Sandpiper			SGCN
Greater Yellowlegs			SGCN
Willet			SGCN
Bonaparte's Gull			SGCN
Laughing Gull			SGCN
Great Egret			SGCN
Snowy Egret			SGCN
Black-crowned Night-Heron			SGCN
Glossy Ibis			SGCN
Osprey	Special Concern		
Sharp-shinned Hawk	Special Concern		
Cooper's Hawk	Special Concern		
Sanderling		Yellow	Potential
Semipalmated Sandpiper		Yellow	
Canada Goose			
Mute Swan			
Wood Duck			
Mallard			
Killdeer			
Red-winged Blackbird			
Great Blue Heron			
Green Heron			
Snow Goose			

Source: eBird sightings for Marshlands Conservancy as accessed 2021

Nekton Habitat

Nekton are aquatic organisms that are able to swim in the water column, independent of currents or wind energy – including zooplankton, invertebrates, fish, reptiles, and mammals. Nekton communities adjacent to salt marshes heavily rely on the marshes for foraging, predation refuge, and breeding sites. Important fishery species rely on the marsh as a nursery habitat for their young. Salt marsh edge vs. interior is considered especially important habitat. For example, Peterson and Turner (1994) found evidence that "shorelines adjacent to marsh habitat are critical to various life history stages of ecologically- and commercially-important species."

Shellfish species, including Atlantic ribbed mussels, blue mussels, and eastern oysters, are found in marshes either attached to hard substrates, or even in some cases on the root structure of smooth cordgrass. Salt marshes are an important habitat for shellfish recruitment, settlement and survival as the water column provides necessary nutrients and substrate for the larvae. Shellfish larvae are a type of nekton species, in which spend part of their life cycle swimming within the water column until settlement. Once settled and anchored down, they feed by filtering nutrients from the water column.

Marshes are also inhabited by many important recreational and commercial fishery species. Some species reside in the marsh system throughout their life (mummichog, striped killifish, sheepshead minnow, Atlantic silversides), some reside as young (winter and summer flounder, tautog, and black sea bass), some migrate in and out during different life stages (American eel), and some migrate in from the open water to spawn (American shad, alewife, striped bass). These migrating species are called diadromous fish, in which they spend part of their life in salt water environments and part of their life in freshwater environments. For example, alewife spend their life in saltwater and migrate into the marshes to reproduce in the freshwater reaches of tidal rivers and streams. In this case, salt marshes provide a connector pathway for these fish species to complete their migration in order to successfully reproduce.

Another species that relies on tidal-wetland habitats is the diamondback terrapin (*Malaclemys terrapin*). This small brackish-water turtle is endemic to tidal wetlands, estuarine embayments, tidal flats, and tidal creeks from Massachusetts to the Gulf Coast of the United States. Adult terrapin feed on shellfish and crustaceans within tidal marsh systems and nest on coastal sandy beaches near tidal marshes during the summer nesting season. Juvenile terrapin reside in the upper reaches of tidal creeks and tidal marshes until adulthood (Ernst et, 1994). As the only brackish water turtle found in North America, diamondback terrapin are a key member of Long Island's tidal ecosystems, including Westchester County. Terrapin populations are in decline or unknown throughout their range (Seigel and Gibbons, 1995) and, as a result, the taking of terrapin is prohibited in New York State as of May 1st, 2018 (NYSDEC).

Avoidance of Marsh-Habitat Fragmentation

Larger-size marshes are especially important for bird and other wildlife habitat. A study of marsh utilization by birds in the Connecticut River found that colonization is directly related to the size of the marsh (Craig and Beal 1992). Furthermore, this study found that rare birds were more likely to colonize larger rather than smaller marshes.

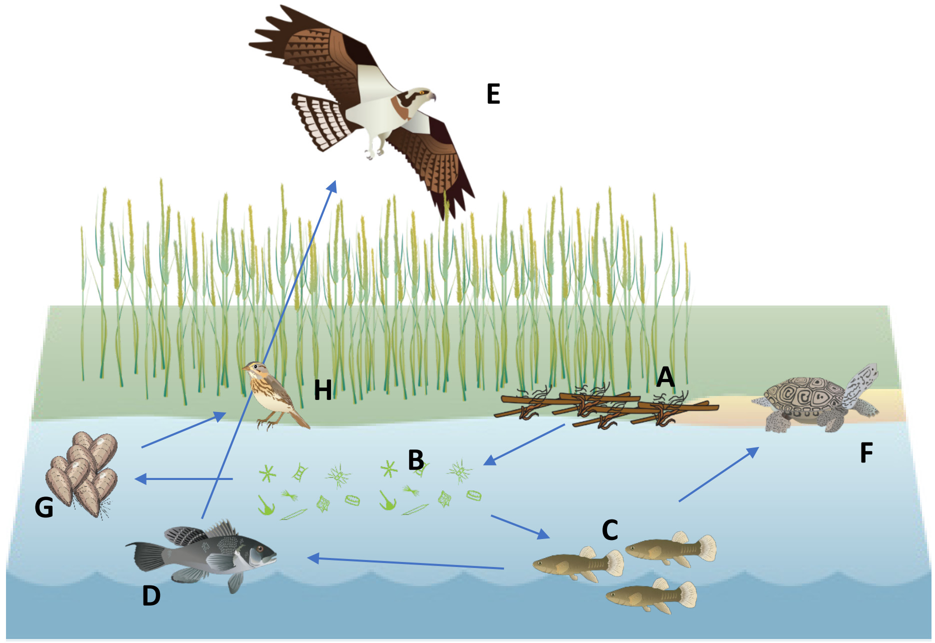

Figure 15. Conceptual Diagram of a Salt Marsh Food Web

The dominant salt marsh species, smooth cordgrass is the base of the food chain – providing organic matter in the form of detritus (A). The detritus is consumed by plankton species (B), which is then consumed by small fish species, such as striped killifish (C), and filter feeders, such as ribbed mussels (G). From there, two additional pathways are created, where smaller fish species are valuable food sources for larger predatory species, like black sea bass (D) and the diamondback terrapin (F). The black sea bass is then further consumed by the top of the food chain – the osprey (E). The other pathway of the food chain is from the ribbed mussels (G) who are consumed by the saltmarsh sparrow (H). Figure Courtesy of Cayla Sullivan, USEPA.

WAVE ATTENUATION

One key ecosystem service provided by salt marshes is a reduction of the impacts of waves on coastal erosion. Wave action can be significantly reduced on coastal shorelines as marshes act as a buffer zone and absorb the energy. By stabilizing sediment through their above and belowground biomass, marshes have been shown to reduce coastal retreat. This service is especially beneficial to coastal communities that face great risks with climate change implications, including increases in extreme weather events (e.g., storms, hurricanes, etc.). The presence of marsh vegetation substantially mitigates infrastructure damage to the shoreline as relative structural loss is correlated to the percent of wetland cover (Sheng et al. 2021).

RECREATION AND NATURAL-AREA PROXIMITY

Healthy marsh ecosystems provide a draw for human recreation, fishing, and wildlife viewing. There are recreational benefits provided by nearly all of the marsh areas listed in this document. A few examples follow:

- Marshlands Conservancy – A network of trails extends from a nature center and public parking lot at Marshlands Conservancy and the adjacent John Jay Heritage Center. These trails lead to the marsh, where other trails allow for recreation within the Marshlands Conservancy-portion of the marsh.
- Otter Creek – Otter Creek Preserve offers significant recreational opportunities as it has a forested upland trail (approximately three quarters of a mile in length) adjacent to the wetland. A seasonally active osprey

nesting platform can be viewed from the trail. The viewshed afforded from being nestled along the Mamaroneck coastline attracts birdwatchers (more than a 100 species of birds have been recorded here), wildlife lovers, photographers, botanists and others. (Source https://westchesterlandtrust.org/ 2021)

- Hen Island: Although there is no public access to Hen Island, there are many kayakers, paddle boarders, rowers and sailors that explore the surrounding waters and marsh. In addition, multiple osprey nests are located in the oak trees on Hen Island. The old growth trees provide ideal resting and eating perches for osprey.
- Hommocks Conservation Area – A small parking lot and short trail extends into the marsh from Hommocks Road.

Water quality protection (Nutrient Sequestration and Denitrification)

Tidal marshes are important for improving water quality. In particular they can sequester organic carbon and nutrients that may otherwise lead to additional climate disruption or eutrophication of estuarine systems (Loomis and Craft 2010).

Marshes have the ability to sequester, or store, nutrients in their biomass (above and belowground) and sediment, and therefore remove it from the water column. Nutrient sequestration includes carbon, nitrogen, and phosphorus. More specifically, salt marshes are hotspots for blue carbon storage, which are aquatic vegetated ecosystems that are able to store large amounts of carbon (Nellemann et al. 2009). In the United States, northeastern salt marshes have the ability to sequester about 41 to 152 g/m^2/year of carbon (Drake et al. 2013). This storage mechanism prevents carbon from being released into the atmosphere as carbon dioxide (CO_2) or methane (CH_4), which are dominant greenhouse gases. Blue carbon storage has the ability to mitigate global warming impacts, and prevent future increases in carbon emissions.

Denitrification is another nutrient-removal mechanism of salt marsh, in which excess nitrogen is removed from the ecosystem and released into the atmosphere. Bacteria that reside in marsh sediment convert nitrate (NO_3) – a form of nitrogen that can contribute to excess algae growth, into nitrogen gas (N_2) – which occurs naturally in the atmosphere. Denitrification rates can significantly vary regionally (Valiela et al. 2000), and are highest during the summer season (Velinsky et al. 2017). In the Long Island Sound, about 60% of the total nitrogen cycle is either buried in sediments or removed through denitrification (Vlahos et al. 2020).

Through nutrient sequestration and nutrient cycling, marsh habitat helps to create a stable and healthy environment for both wildlife and humans. For example, salt marsh nutrient cycling can prevent eutrophic conditions from occurring. Eutrophic conditions occur when there are excess nutrients, often in the form of nitrogen or phosphorus, in the water column. High nutrient conditions create hypoxic conditions, harmful low levels of dissolved oxygen, via algal blooms. Excessive algae growth and subsequent decomposition depletes the oxygen levels in water and can cause massive fish kills. Such die-offs cascade throughout the food chain and pose detrimental effects on many other marsh organisms.

THREATS TO WESTCHESTER COUNTY MARSHES

While Westchester County marshes have not been subject to the same type of filling and seawall construction that took place early in the 20th century, tidal-marsh losses continue. An analysis of marsh habitat from 1974 to 2005 found that total Westchester County tidal-wetland area decreased by over one third, with Marshland Conservancy and Blind-Brook wetlands each losing 25% of their habitat (Cameron et al. 2015). Ongoing threats to Westchester County marshes include sea-level rise, adjacent development, water-quality issues, marine debris, and invasive species.

SEA-LEVEL RISE

Recently, the New York State Energy Research and Development Authority (NYSERDA), NEIWPCC, and Long Island Sound Study funded an analysis of the potential impact of sea-level rise on coastal New York marshes (Warren Pinnacle Consulting, Inc. 2014, 2017). This section summarizes results for the six identified marsh complexes in Westchester County. These model results predict the location of wetland habitat given future sea-level rise and also take into account marsh accretion rates (increases of marsh elevation) due to additional inorganic-matter accumulation.

- **Blind-Brook Wetlands:** Figure 20 and Figure 21 show that most of the current wetlands are publicly owned, but future private-land flooding is possible to the east of the study area given the pressures of sea-level rise. Figure 21 to Figure 24 show the potential for wetland expansion and dry-land flooding under various sea-level rise scenarios. Current marsh habitat has the potential to stay viable under most sea-level rise scenarios, but will primarily convert from high marsh (irregularly-flooded marsh) to regularly flooded marsh under the highest SLR scenarios modeled.
- **Marshlands Conservancy:** Figure 26 shows that current marsh resources are exclusively publicly owned at Marshlands Conservancy. Figure 27 to Figure 29 show that most of the marsh is expected to remain viable under lower sea-level rise scenarios, but adjacent elevation means that little marsh expansion will occur. Figure 30 suggests that open water at this site will expand under the highest SLR scenarios.
- **Hen Island:** Figure 33 to Figure 36 show that Hen-Island marshes are expected to undergo more flooding and become more-saline regularly-flooded marsh habitat over time. Under the highest sea-level rise scenarios, the dry-land footprints to the north and south of the island are expected to be reduced. Sea-level rise is already accelerating shoreline erosion and has caused significant reduction of low and high marsh areas in areas that are most exposed to storms and wave action. Mitigation and restoration measures are being considered for the most impacted areas.
- **Otter Creek Preserve** is largely on private land, but the largest land-holders of tidal wetlands is Westchester Land Trust (Figure 38). Figure 39 to Figure 42 suggest that the elevation capital of this marsh is sufficient to withstand moderate sea-level rise, but under the highest scenarios there is significant conversion to regularly-flooded marsh and adjacent dry land flooding.
- **Hommocks Conservation Area.** Looking at Figure 44 and Figure 45, the current marsh footprint is publicly owned, but there is vast potential for expansion to low-elevation adjacent dry lands under sea-level rise. Figure 46 shows the potential for additional flooding by 2055, even under a medium SLR scenario. Figure 47 and Figure 48 indicate that vast expansion of flooded dry lands and developed dry lands are possible by 2100 under medium and high SLR scenarios.
- **Pine-Brook Wetlands.** Figure 50 and Figure 51 indicate that most current marsh resources are publicly owned. Figure 51 to Figure 54 show minimal changes to marsh fate or footprint under SLR

less than 0.5 meters, but considerable habitat changes and adjacent flooding under higher rates of sea-level rise.

Comparing these marsh parcels in terms of current-marsh vulnerability, Marshlands Conservancy shows the highest potential for marsh losses. The regularly-flooded marsh at the Marshlands Conservancy site has less “elevation capital” (height relative to sea-levels) than the other irregularly-flooded marshes in the study. On the other hand, the elevations of lands adjacent to Marshlands Conservancy mean that little marsh expansion onto dry lands are predicted at this site. It is worth noting that significant losses of marshes at this site are only seen in the highest sea-level rise scenarios.

At Blind-Brook Wetlands, Otter-Creek Preserve, Hommocks Conservation Area, and Pine-Brook Wetlands, there are significant areas of lateral marsh migration predicted as a result of lower-elevation dry lands. Many of these lands are currently developed or used for recreation purposes, suggesting that the management of the dry-land to wetland boundary will be an important topic in these regions over the next several decades.

Sea-level rise can also exacerbate salinity intrusion and ecological damage driven by large storm events. In some cases, marshes can recover from storm events, or storm events can even be a source of additional sediments (Fagherazzi 2014, Goodbred Jr. and Hine, 1995). However, when a marsh is under stress from sea-level rise, storm events are likely to provide more permanent damage or to trigger a permanent conversion from marsh to open water.

Sea-level rise will also have an impact on the fresh water table adjacent to oceans and estuaries. This is because in coastal zones the fresh water table is generally perched on top of the coastal (saline) water table (Rotzoll and Fletcher 2012). As the salt water elevation rises, some fresh water elevations will also rise, resulting in additional fresh-water flooding. This is especially important because fresh-water flooding is already increasing in the northeast United States, under climate change conditions, due to additional extreme rain events (Howarth et al., 2019). The likely impact of sea-level rise on the fresh water table and fresh-water flooding was not included in the modeling presented above.

Development

As illustrated in Appendix A and discussed above, as sea-level rise continues to accelerate, potential future habitat has the potential to overlap with existing developed areas. Given the value of adjacent lands and the degree of development present there, to some degree landowners are likely to build new vertical walls to keep coastal waters out, or to rebuild vertical walls that currently exist. This type of building prevents lateral wetland migration, producing a coastal “squeeze,” and will likely result in significant wetland losses under conditions of SLR (Nicholls et al., 1999).

Modeling results in Appendix A suggests that potential flooding of developed land is especially a risk adjacent to Blind Brook (Figure 23), Otter Creek Preserve (Figure 41), and Hommocks Conservation Area (Figure 47). Additional development on relatively low-elevation dry lands adjacent to wetlands will only exacerbate this potential problem.

Water Quality Issues

The Sound Health Explorer gave the Eastern Narrows basin a water-quality grade of C in 2019 indicating room for improvement (Save the Sound, 2019). This moderately poor grade is primarily driven by worsening chlorophyll-a conditions and low dissolved oxygen, which both received a D. On the other hand, water clarity was in good condition (receiving an A) and dissolved organic carbon was moderate (receiving a C). More specifically, the

Mamaroneck Harbor received a C-, where dissolved oxygen and seaweeds drove the poor grade by receiving a F. Furthermore, chlorophyll-a received a C, and water clarity and oxygen saturation received an A.

These moderately poor grades in the Westchester County area indicate that nutrient loading is having a negative impact on the water quality conditions. When there are excess nutrients in the water column, eutrophication occurs, stimulating algae growth (indicated by high levels of chlorophyll-a and seaweed) and therefore significantly depleting dissolved oxygen levels. As mentioned before, salt marshes are able to mitigate nutrient loading impacts through nutrient sequestration or removal, however there is a threshold and once exceeded, degradation occurs.

Fecal-indicator bacteria monitoring also suggested that there are water-quality issues adjacent to many county wetlands. Problem areas included Blind-Brook wetlands (in which 73% of water quality samples collected in 2020 from Blind Brook at Disbrow Park in Rye failed to meet the 35 CFU/100mL Enterococcus geometric mean required under New York State Coastal Recreational Water Quality Standards) and Hommocks Conservation Area (where 91% of water quality samples collected in 2020 from Flint Park in Larchmont failed to meet New York State Coastal Recreational Water Quality Standards; Save the Sound, 2021).

Other potential water-quality threats to Westchester County marshes include chemical bulk-storage facilities adjacent to several of the study-area wetlands. There are permitted chemical bulk-storage facilities adjacent to Blind-Brook wetlands, Marshlands Conservancy, Otter-Creek Preserve, and Hommocks Conservation area.

MARINE DEBRIS AND MICROPLASTICS

Marine debris has become a leading threat to many different aquatic ecosystems as it amplifies degradation, reduces biodiversity, and suppresses ecosystem services. In salt marshes, marine debris is a prominent issue as it is known to get trapped in tidal wrack (Viehman et al. 2011), injure marsh grass (Uhrin and Schellinger 2011), and severely harm wildlife – either through consumption or entanglement. Marine debris is defined as human created waste that is either deliberately or accidentally released into marine environments. Additionally, any type of debris or litter can ultimately end up in marsh ecosystems through wind, rain, or runoff. Marine debris comes in all different forms, including metal, rubber, glass, cloth, paper, fishing gear, and most commonly – plastics.

Plastics are the most abundant and persistent types of marine debris; it takes hundreds of years for plastics to naturally degrade. Furthermore, once in the environment, many plastics do not completely disappear but break down into smaller fragments. In salt marshes, the most abundant types of litter are these smaller fragments of plastic of 0-5 cm (Viehman et al. 2011). Salt marshes act as a sink for these plastics, and release even smaller pieces called microplastics (Yao et al. 2019). Defined as smaller than 5 mm, microplastics affect salt marsh communities in various ways, and pose a great problem for the environment and society. Because they are so small, microplastics affect the estuarine food web from the bottom up – meaning they start at the base of the food chain and have harmful cascading effects. Omnivores, like small fish, crabs, marine worms, and birds, all directly consume microplastics (Piarulli et al. 2020). Additionally, there is evidence that filter feeders, such as bivalves (mussels, oysters, etc.), ingest microplastics that are floating in the water column (Khan and Prezant 2018). Predators of these organisms are also at risk through biomagnification – in which higher concentrations of microplastics are ingested in prey items. Humans are also potentially at risk from microplastics, as we consume many different fishery species that are found in the marsh food chain.

Microplastics have also been shown to have an impact on microbial nitrogen cycling (Seeley et al. 2020). By altering marshes' ability to sequester and remove nitrogen from the habitat, this is another way that plastics can degrade the environmental quality of marsh ecosystems and their adjacent waters.

INVASIVES

Invasive and non-native species have the capability to degrade existing marshes and limit the ecological services that they can provide. For example, common reed (*Phragmites* sp.) is a highly invasive plant capable of degrading tidal ecosystems, and one that is having impacts on Westchester County coastal marshes. Non-native, more aggressive variants of Common Reed can dominate many of Westchester's marshes. Once established, common reed can force out native plants and disrupt the delicate ecological balance of the marsh. common reed generally does poorly in highly saline environments. However, it begins to prosper and spread when freshwater and nutrients are made available. As will be discussed below, restoration of salt-water flows or physical invasive species removal are two strategies that can and have been used in Westchester County to ensure that the ecological role of coastal marshes is maintained.

More generally, the Lower Hudson Partnership for Regional Invasive Species Management (https://www.lhprism.org/resources) is a local resource managing invasive species. This regional partnership provides information about local invasive-species identification, removal techniques, and laws and regulations that are relevant to managing invasive species.

MARSH CONSERVATION PLANNING

STRATEGIES

There are many tools available to local governments, planners, and NGOs that can be used to protect existing coastal wetlands, and to ensure that adjacent habitat is protected for future marsh migration. These strategies will generally fall into the categories of "managing current resources," "land purchases and easements," "local or state regulation," and "marsh restoration." Education is also important to ensure that community members recognize the critical ecological role of salt marshes, and these marshes' impact on regional character. Modeling and data analysis can ensure that conservation plans have an eye towards anticipated future conditions.

MANAGING CURRENT RESOURCES

Managing current resources includes mitigation of the threats to existing coastal marshes. This can include improving water quality issues through education, outreach, and regulation. Local towns may also choose to cite marsh vulnerability when creating water quality rules and considering septic upgrade regulations.

Another important management tool is the monitoring and removal of invasive species within salt marshes. This strategy is already underway within Westchester County. For example, in 2020, at Edith Read Wildlife Sanctuary, over 1700 square feet of mugwort, porcelainberry, knotweed, and *Phragmites* were removed, under the direction of Westchester Parks Foundation. In another example, the case study presented below illustrates how common reed is being kept under control at Marshlands Conservancy through restoration of water quality, marsh plantings, and monitoring.

Case Study: Managing Invasive Species at Marshlands Conservancy

Milton Harbor's salt marshes in Rye are a home and feeding ground for a variety of plants, fish and wildlife, including nesting shorebirds at Huckleberry Island off New Rochelle's coast. Nearly all of the marshes are contiguously situated at Westchester County-owned Marshlands Conservancy and adjoining Rye-owned Rye Golf Club. The collective Marshlands Conservancy Salt Marsh is the largest contiguous salt marsh along Westchester's Long Island Sound coast and covers much of the harbor's northeast shore. It and small pockets of treed upland within the marsh are especially attractive to birds, which come to feed, breed, build nests and look for shelter among or above the marsh grasses. The native plant community within the marsh is relatively diverse, containing both low and high marshes. The former consists of smooth cordgrass (*Spartina alterniflora*) and the latter consists largely of perennials, such as saltmeadow cordgrass (*Spartina patens*, a.k.a., *Sporobolus pumilus*), spikegrass (*Distichils spicata*), black grass (*Juncus gerardii*), and shrubs, such as marsh elder (*Iva frutescens*).

Common reed (*Phragmites* sp.) is a highly invasive plant capable of degrading tidal ecosystems, including those in and around Milton Harbor. Furthermore, non-native, more aggressive variants of common reed may dominate many of Westchester's marshes. Once established, common reed can quickly dominate, forcing out native plants and disrupting delicate ecological balances. Common reed generally does poorly in highly saline environments, such as that found in Milton Harbor. However, it begins to prosper and spread when freshwater and nutrients are made available.

Using old aerial photographs and other information, wetland scientists determined that common reed was rapidly spreading farther into and dominating a portion of the salt marsh at Marshlands Conservancy and Rye Golf Club. Over time, this intrusion would dramatically alter the marsh's viability. The likely cause was determined to be stormwater (freshwater) running off upland areas and into the marsh and carrying a considerable amount of nutrients, especially nitrogen and phosphorus.

To minimize or outright halt the spread of common reed, two drainage channels were excavated in 2003 generally along the common reed's line of farthest advance, e.g., along the intersection where the invasive Common Reed met the native plant community. The channels divert nutrient-laden stormwater runoff away from the marsh. They also allow salt water from the harbor to infiltrate deeper into the marsh during high tides. Any common reed remaining on the other side of the channels was eradicated and replaced with smooth cordgrass. This effort has reduced the density of common reed near the channels. Based on monitoring stakes placed after construction, the spread of common reed has now slowed dramatically.

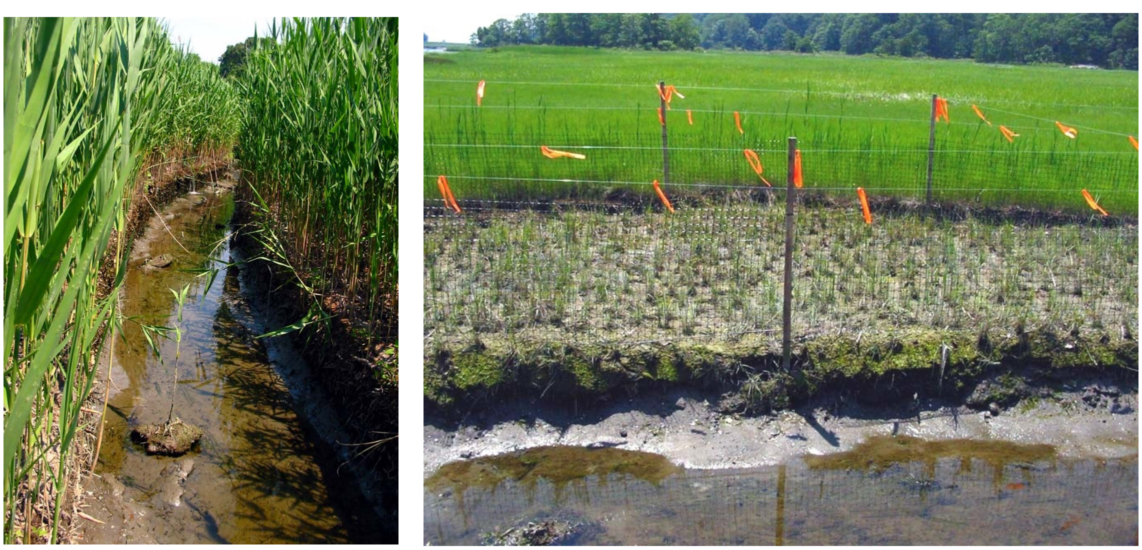

Figure 16. Constructed Channel and New Channel-Side Plantings at Rye Golf Club. Photos Courtesy of Rob Doscher, Westchester County

Land Purchases and Easements

To protect marsh ecosystems, private lands with current and future marsh habitats can be prioritized for purchase and future public ownership. In general, land without structures and restricted to human uses compatible with conservation provides the simplest means and greatest potential for wetland migration (Spidalieri, 2020). Additionally, and usually more economically, easements can be established to prevent future development on the parcels (or specifically on the portion of the parcels that have potential to become a marsh habitat).

It is also important to note that government funds can often be leveraged, using additional sources of public and private capital, to maximize their impacts. Public and private partnerships can be key to conserving current and future marsh habitats. For example, the Westchester Land Trust has a long history of protecting wetlands using easements among other tools. Spidalieri (2020) cites three reasons that public-private ownerships may be imperative: governments may have restrictions in terms of their ability to gain title to lands; property owners are often more willing to work with non-governmental entities; and, it can be costly for local governments to maintain properties when some level of human intervention is required to help wetlands become established.

One possible source of funding within New York State is the Regional Economic Development Councils (REDC) that offers grants for land preservation and heritage and also water-quality improvement. (REDC 2021). The Long Island Sound Futures Fund also provides grants to restore the health and living resources of Long Island Sound.

Local Regulation

To benefit marsh conservation and expansion, local towns and planning boards can consider marsh-fate modeling within land-use planning and zoning decisions. Town comprehensive plans can prioritize the preservation of marshes due to their specific habitat services and their general enhancement of a town's unique character. As noted above, regulation of local water quality can be important for marsh-ecosystem viability. Local efforts to reduce plastic contamination in marshes can improve marsh ecosystem functioning and increase the ecological and recreational value of local wetlands.

A partial list of legal tools that state and local governments can consider (from Spidalieri, 2020) is:

- Zoning;
- Setbacks;
- Restrictions on hard-armoring projects/support for living shoreline projects;
- Rolling easements;
- Transfer of development rights or land swaps.

Another tool available to local municipalities is the production of a Local Waterfront Revitalization Program (LWRP), prepared in partnership with the NY Department of State. An LWRP is a locally prepared land and water-use program for a community's natural, public, working waterfront, and developed coastal areas. It provides a comprehensive structure within which local coastal issues can be addressed. The LWRP also helps to coordinate local and State actions needed to achieve the community's goals for its waterfront (NYS DOS, 2021). Benefits to a community preparing an LWRP can include clear direction, technical assistance, State and federal consistency, and financial assistance, including State and Federal Grants. The Town of Mamaroneck and the Village of Mamaroneck, containing Otter Creek preserve, currently have LWRPs in place. The City of Rye also has an LWRP covering Marshlands Conservancy and Manursing Lake. Producing a comprehensive plan, such as an LWRP, can help a municipality solve issues of communication between planners, zoning, building inspectors, etc.

As an additional reference, New York State Department of State has produced a document called "Model Local Laws to Increase Resilience" (2019). This document includes a chapter dedicated to coastal shoreline protection measures and includes model laws with legal language that municipalities can use and adopt into a local code.

MARSH RESTORATION

Marsh restoration is the process of modifying former wetland locations to promote current and future marsh habitation. This process is often undertaken to restore critical habitats or provide flooding protection, among other benefits. Over the past several decades, the design and implementation of salt marsh restoration projects in the northeast United States has been rapidly increasing (Niedowski, 2000).

Marsh restoration remains a top priority of state and local governments. For example, Theme 2 within the 2015 Long Island Sound Study Comprehensive Conservation & Management Plan aims to restore and protect the Sound's ecological balance in a healthy, productive, and resilient state for the benefit of both people and the natural environment. Within this Theme there is a "Tidal Wetland Extent Ecosystem Target" that commits to restoring 515 additional acres of tidal wetlands by 2035 from a 2014 baseline. To date, Long Island Sound Study partners have restored 79.7 acres of tidal wetland habitat and are 15.5% toward the 2035 goal. The New York State Ocean Action Plan also commits to protection and restoration of tidal wetland habitat. Goal 1 of the plan strives to ensure the ecological integrity of the ocean ecosystem and, within this goal (Objective A, Action 3) the plan proposes to monitor tidal wetland loss (trends), water quality, and implement restoration in estuaries and embayments. In 2000, New York State established salt-marsh restoration and monitoring guidelines to improve standards of practice and outcomes for these projects: https://www.dec.ny.gov/docs/wildlife_pdf/saltmarsh.pdf.

Marsh restoration is already occurring within Westchester County. For example, in 2011 the restoration of Manursing Lake included the creation of salt marshes adjacent to the Edith G. Read Natural Park and Wildlife Sanctuary in Rye (Westchester County, 2011). Other examples of marsh restoration include the planting of native smooth cordgrass at Echo Bay in New Rochelle, NY, and the removal of fill and the planting of native wetland species in Harbor Island Park in Mamaroneck, NY. (Long Island Sound Study, 2021)

Guidance on tidal wetland restoration can be found in the Long Island Sound Habitat Restoration Manual: https://longislandsoundstudy.net/wp-content/uploads/2004/12/tidal-wetlands.pdf

LIVING SHORELINES

Marsh restoration can also be achieved through removal of vertical shoreline and restoration of a nature-based shoreline configuration. The case study below from Hommocks Conservation area illustrates how one local landowner is doing just that. Furthermore, state guidance is available to assist local governments and landowners implement natural-resilience measures to reduce risk from flooding and erosion.

- *Tidal Wetlands Guidance Document: Living shoreline Techniques in the Marine District of New York State*, 2017: https://www.dec.ny.gov/docs/fish_marine_pdf/dmrlivingshoreguide.pdf
- *Using Natural Measures to Reduce the Risk of Flooding and Erosion, 2020, Guidance from NYSDEC and NYSDOS:* https://www.dec.ny.gov/docs/administration_pdf/crranaturalmeasuresgndc.pdf

EDUCATION

In addition to the strategies discussed above, outreach and education about the benefits of salt-marsh habitats can bolster local support for marsh preservation. Educational topics can include options for adjacent property owners, or owners with potential future marsh migration on their lands. Sharing research about the effectiveness of marsh lands for erosion control, or as wave-attenuating barriers, could increase acceptance of sharing property lines with salt marshes.

Another topic could be the importance of sustainable lawn care practices (reduced or no fertilizer use) to local water quality and ecological viability. In 2016 NYSDEC formed a fertilizer management workgroup as part of the Long Island Nitrogen Action Plan (LINAP). This group's recommendations are available at https://www.dec.ny.gov/docs/water_pdf/linapfertilizer.pdf (LINAP 2019).

Through a mix of the strategies discussed above, local governments and stakeholder groups can take significant steps to ensure that Westchester coastal marshes are preserved for current and future generations.

Case Study – Hommocks Conservation Area

When Bryan Martin, an adjacent landowner of the Hommocks Conservation Area, bought his property in 2019, he knew he would have to repair/replace the property's 100-year-old seawall. Historical aerial imagery shows that the construction of this seawall is one of the earliest examples of the filling of tidal wetland and the hardening of shorelines in the Hommocks Conservation Area.

As shown in Figure 8 to Figure 10, the Hommocks Conservation Area was once a much larger tidal wetland that was filled in to create land for housing and recreation throughout much of the 1900s. Today, only 10.6 acres of woodland, meadow areas, and salt marsh remain and are protected by the Town of Mamaroneck (Town of Mamaroneck NY, 2021).

Over the years, the seawall became in severe disrepair due to decades of neglect and storm damage. While determining the best course of action to repair/replace this seawall, Martin decided that he wanted to restore the historic waterfront property but with a design that would work with nature. He had heard about the concept of nature-based shoreline designs when a 2-mile "living shoreline" was constructed along the road to his family home in Maryland. He decided to apply a similar concept to his home in Westchester County.

Working with a large team of landscape architects and coastal engineers, Martin came up with two nature-based approaches for sections of the seawall. First, a 150 ft. section of seawall that abuts tidal wetland will be removed and replaced with a "tidal terrace". The tidal terrace has three-tiers and allows for tidal inundation. The lowest tier will be a restored mudflat, the middle tier will be planted with native tidal vegetation and protected by a natural fiber coir log, and the highest tier will be another level of native tidal vegetation protected by a small sill of rock. The total restored area will be about 4000 sq. ft. of tidal wetland habitat that will become a potential tidal wetland migration pathway. Construction has begun and should finish in 2021.

Second to the tidal terrace, Martin has also opted to recreate a rocky intertidal cove. This collapsed section of seawall faces out towards the Long Island Sound and therefore was prone to frequent storm damage. Exploratory digging revealed granite bedrock ledges buried below the fill brought in during the initial seawall construction. Martin decided to expose the granite outcroppings to recreate a rocky intertidal cove area that was once existing and still commonly found on the Long Island Sound shores of Westchester County. Construction of the cove finished in 2020 and Martin has already seen natural recruitment of marine organisms and has had some great luck with recreational fishing in this space – including catching striped bass right from his own shoreline.

While permitting hurdles were a challenge, Martin and his team were able to successfully stabilize the shoreline of his property and simultaneously create two new intertidal spaces that benefit the Hommocks Conservation Area.

Figure 17. Vertical Seawall in the Process of Being Replaced with a Nature-Based Shoreline (left vertical seawall before construction, right the terraced design and native plantings following construction.) Photos courtesy of Bryan Martin and Angela Schimizzi

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APPENDIX A: MARSH PARCEL BACKGROUND AND SEA-LEVEL RISE SIMULATIONS

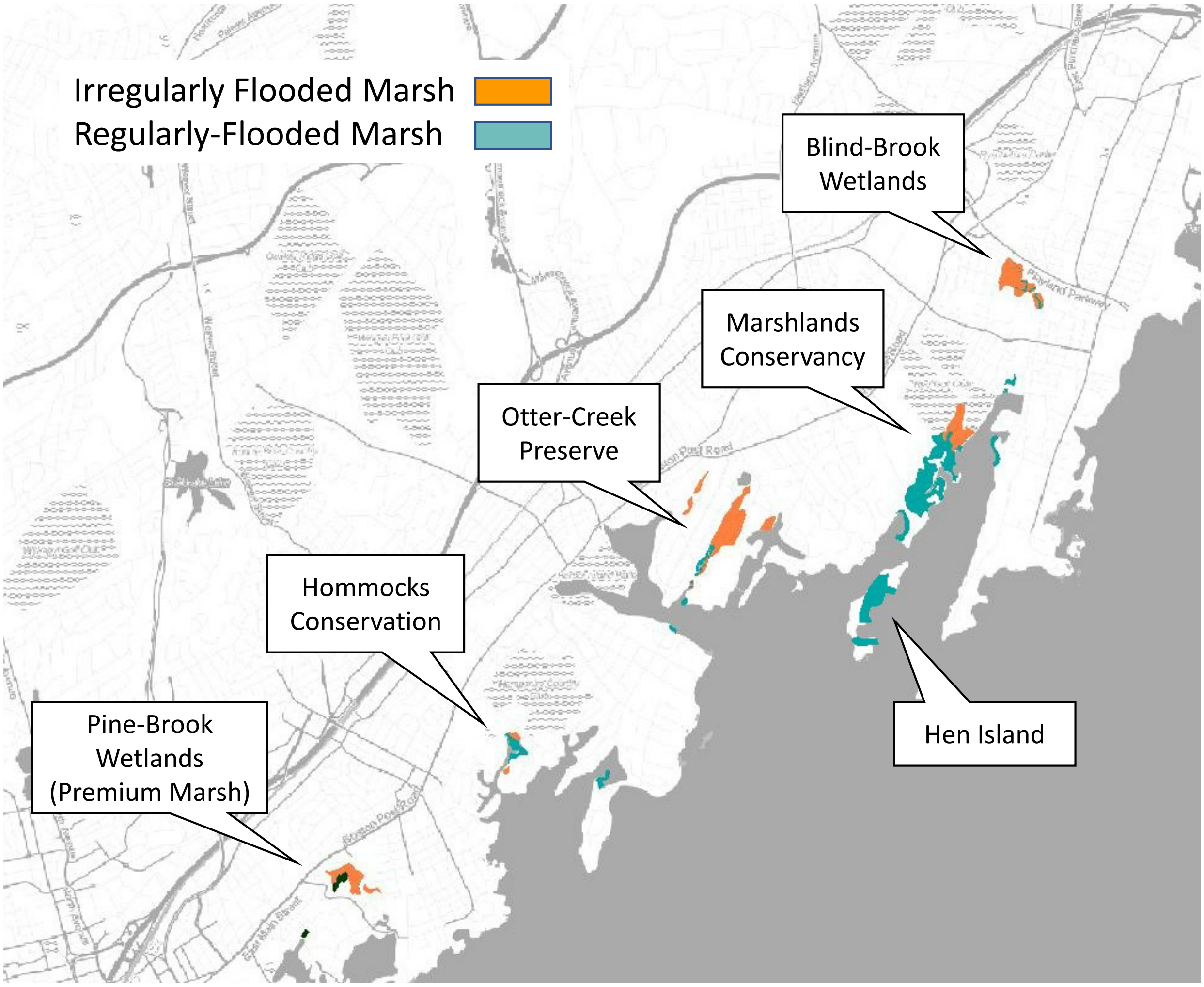

Figure 18. Westchester County Marsh Systems in this Appendix

Blind-Brook Wetlands

Blind-Brook Wetlands. This marsh or tidal wetland is in the City of Rye. It extends just north of Westchester County-owned Playland Parkway along both sides of Blind Brook to just south of a footbridge crossing Blind Brook next to Milton Road. The bulk of the marsh is between Playland Parkway and the City of Rye-owned Disbrow Park and the Westchester County-owned Blind Brook Wastewater Treatment Plant. Most of the marsh runs along the west side of Blind Brook, with a narrow portion along the east side. The Blind Brook wetlands are buffered by coastal forest to the north and east. The wetland is dominated by the invasive common reed (*Phragmites* sp.). It is irregularly inundated, with the daily ebb and flow of the tide largely impacting only the primary Blind Brook channel as well as a side channel extending into the wetland west of Blind Brook. During significant coastal storms, portions of the marsh will be inundated. Single-family residential properties flank the east and west sides of the marsh. At the south of the wetlands, views of the marsh are available from a highly-utilized path between Oakland Beach Ave and Milton Road, including a pedestrian bridge over Blind Brook. New York State DEC has designated Blind-Brook Wetlands a critical environmental area.

Figure 19. Blind-Brook wetlands, Photo Credit Ryan Prime

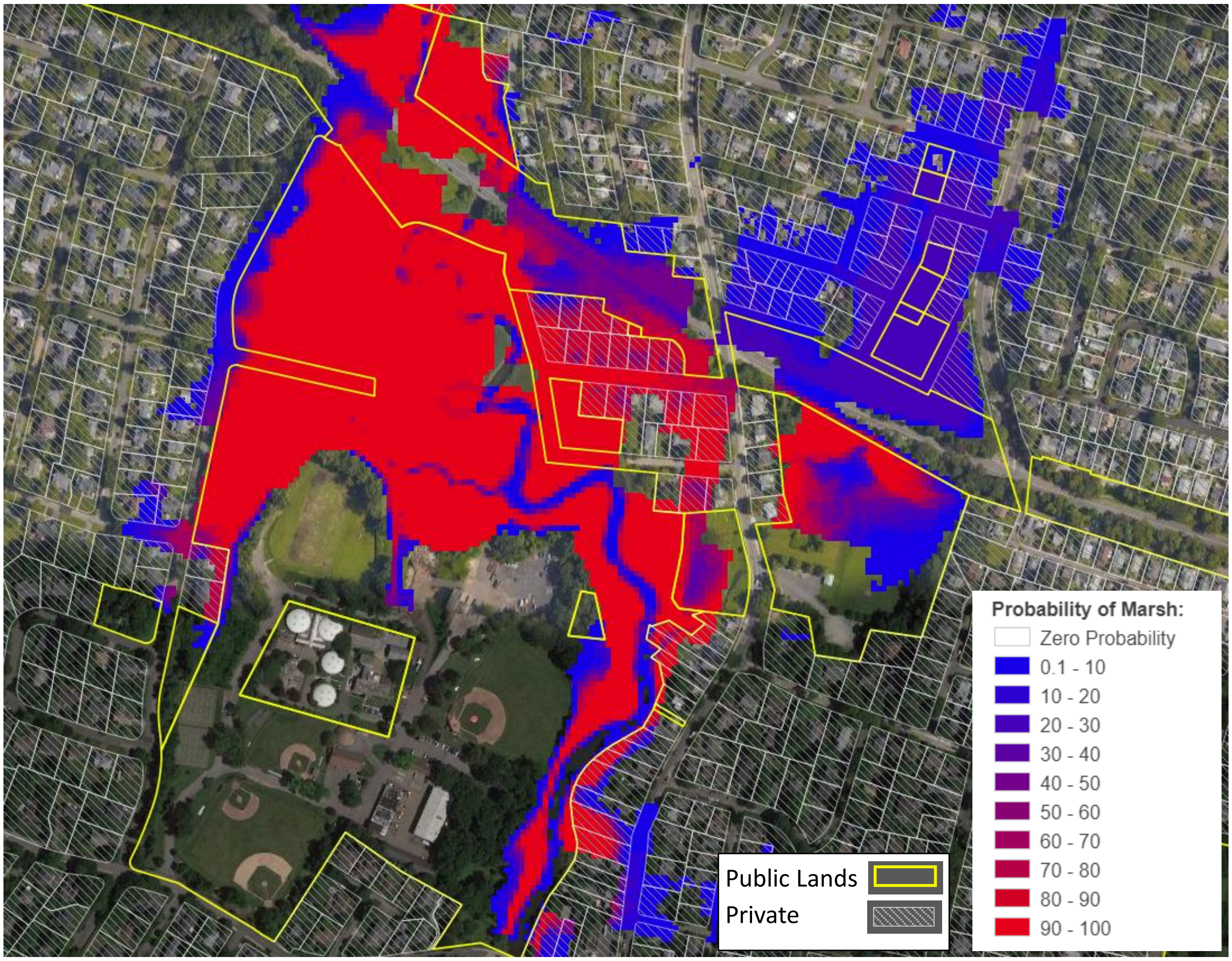

Figure 20. Blind Brook: Possible Marsh Habitat In 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

Public vs. private based on 2016 Westchester Tax Parcel Data. Authoritative and approved tax maps for this municipality ONLY reside with the local assessor.

This map shows current public vs. private ownership for Blind-Brook wetlands overlaid on marsh-fate modeling results. These model results show the possibility for marsh habitat due to sea-level rise by the year 2100 but also omit permanently flooded areas (areas too wet for marsh habitat). Model results take into account uncertainties in sea-level rise, elevation data, and marsh-accretion rates. A red area indicates a location where regular flooding is very likely by 2100 making that zone a potential marsh habitat. The blue region to the north shows regions where flooding is possible under the highest SLR scenarios by 2100, allowing for marsh habitat.

Notably, the historic Milton cemetery on Milton Road is shown to be threatened by SLR along with other historical and natural resources.

Much of the map is subject to public ownership but some potential for marsh/private land conflict exists by the end of the century, especially in the northeast of the study area.

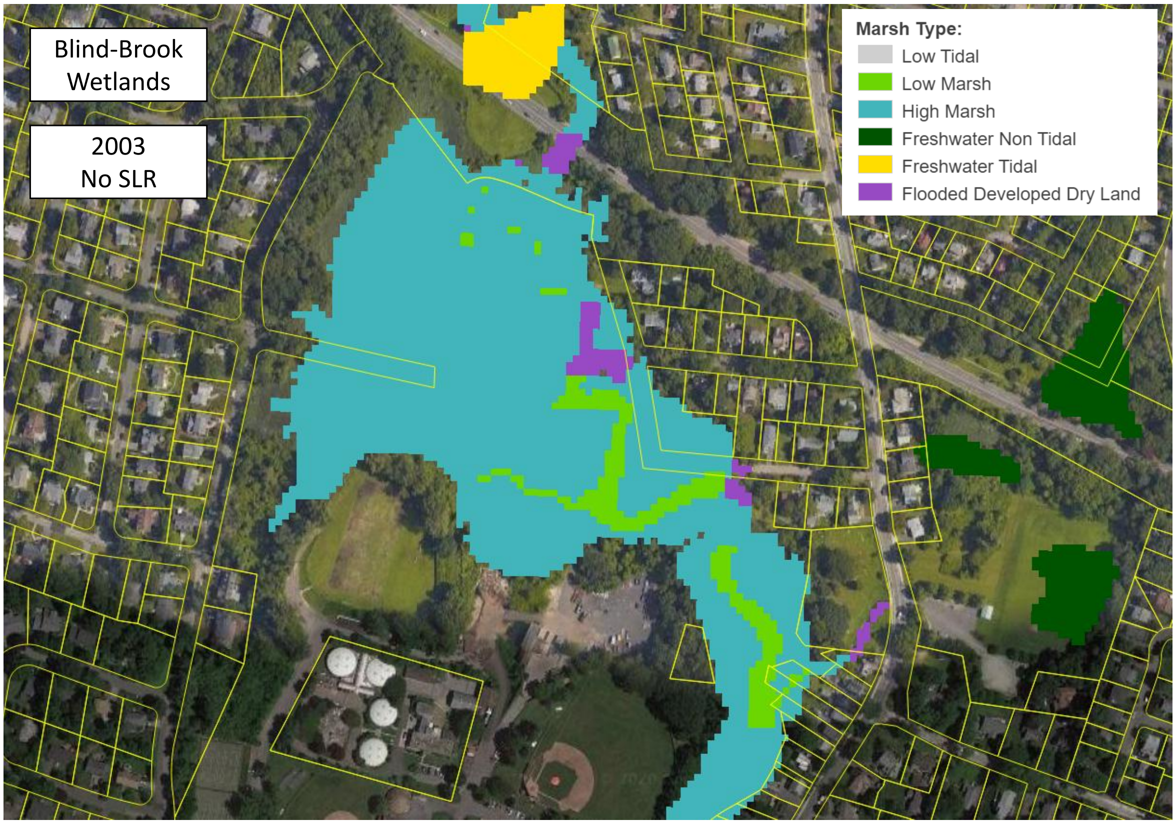

Figure 21. "Current Condition" of Blind-Brook wetlands from National Wetland Inventory and SLAMM modeling.

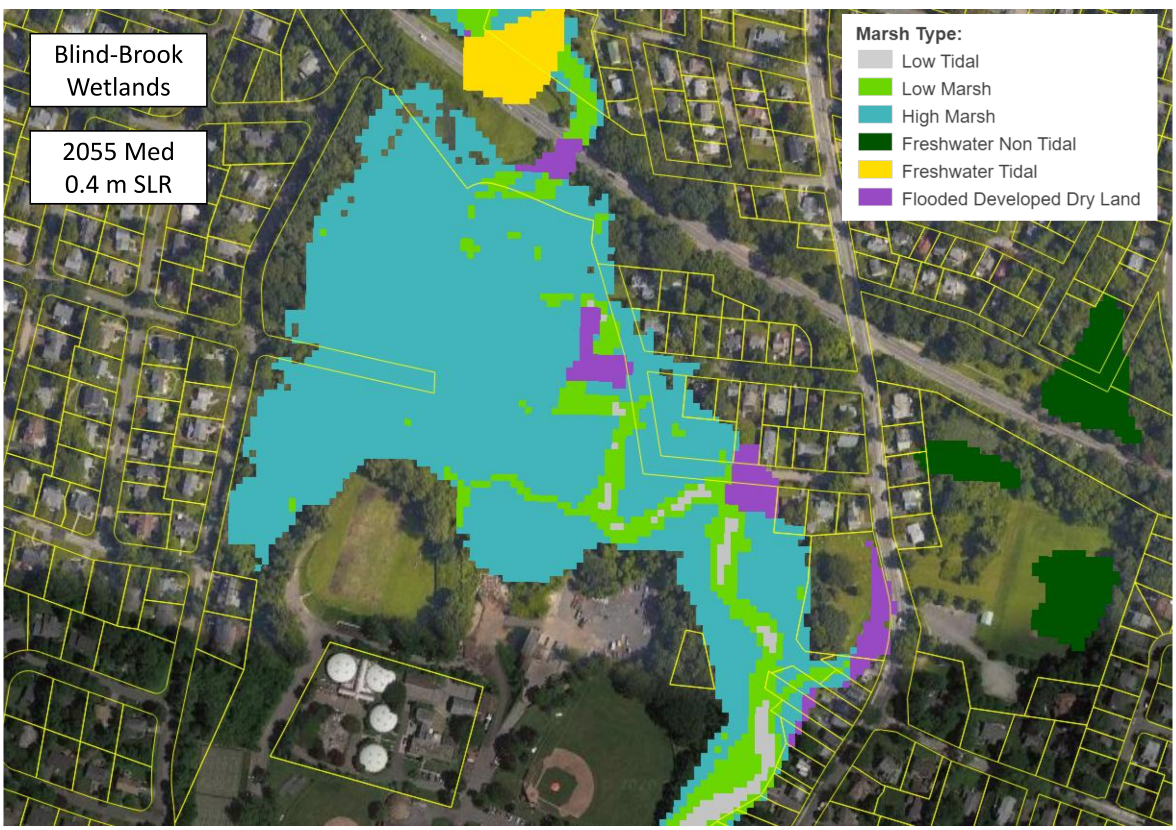

Figure 22. Potential condition of Blind-Brook wetlands in 2055 (0.4 meters of SLR) from SLAMM modeling.

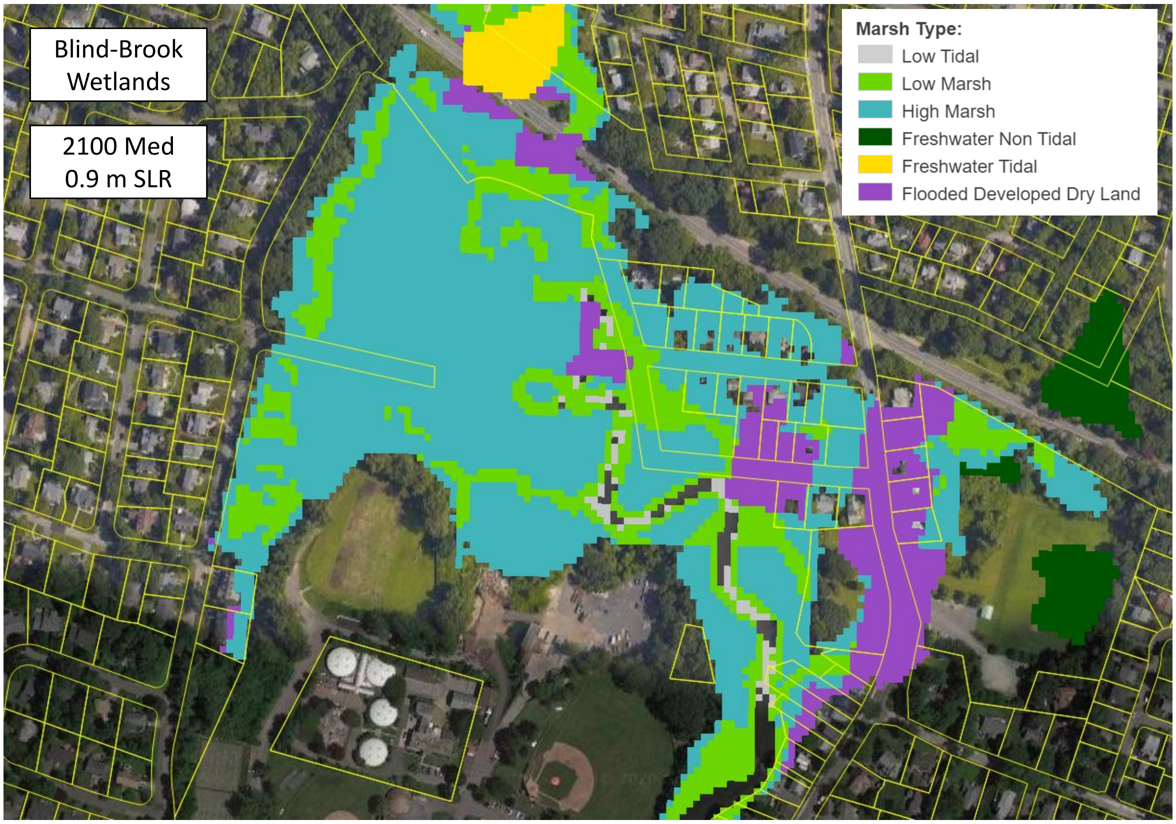

Figure 23. Potential condition of Blind-Brook wetlands in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

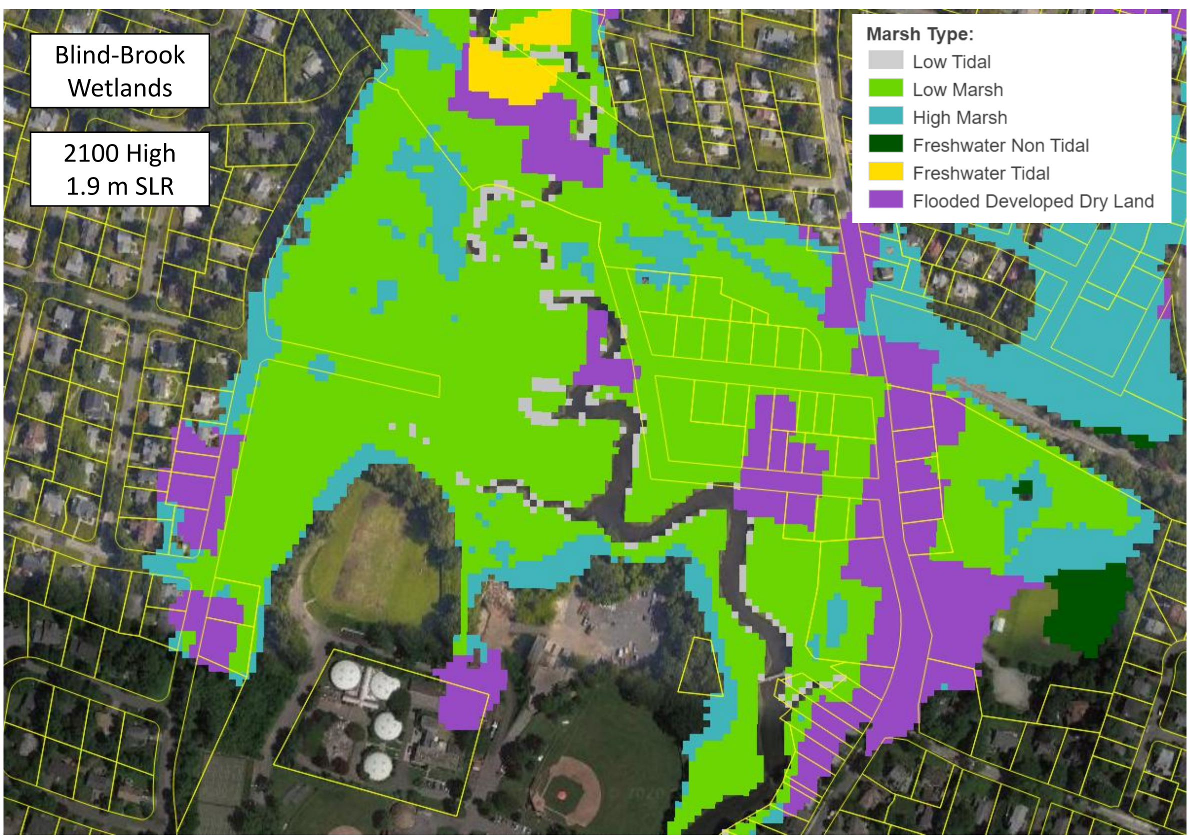

Figure 24. Potential condition of Blind-Brook wetlands in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.

MARSHLANDS CONSERVANCY

This marsh or tidal wetland is in the City of Rye. The largest portion of the wetland is found at Westchester County-owned Marshlands Conservancy and City of Rye-owned Rye Golf Club along the northern shoreline of Milton Harbor. Both properties are accessible from Route 1 (Boston Post Road). This marsh complex includes upland islands containing shrubs and trees tolerant of coastal conditions as well as tidal creeks. A tidal creek was constructed in 2003 to improve salt water intrusion into the marsh and funnel nutrient-rich stormwater runoff from the golf course away from the marsh to slow the spread of common reed (*Phragmites* sp.). The marsh's plant community of relatively diverse, containing both low and high marshes. The former consists of smooth cordgrass (*Spartina alterniflora*) and the latter consists largely of perennials, such as salt meadow cordgrass (*Spartina patens*, a.k.a., *Sporobolus pumilus*), spike grass (*Distichils* spicata), black grass (*Juncus gerardii*), and shrubs, such as marsh elder (*Iva frutescens*). Portions of the marsh are regularly inundated and other portions are irregularly inundated with inundation largely occurring during significant storms. A network of trails extends from a nature center and public parking lot at Marshlands Conservancy and the adjacent John Jay Heritage Center. These trails lead to the marsh, where other trails allow for passive recreation within the Marshlands Conservancy-portion of the marsh. A tidal creek largely prevents easy access to the Rye Golf Club portion of the marsh from Marshlands Conservancy and no trails exist into the marsh at Rye Golf Club. The Marshlands Conservancy is a New York State-designated Significant Coastal Fish and Wildlife Habitat and a Long Island Sound Study Stewardship Area. The site also has archaeological importance. For example, shell middens dating to the Woodland period (800 B.C. to A.D. 800) have been found on site and are the subject of continuing archaeological study (Lavin and Morse, 1985).

Figure 25. Marshlands Conservancy, Photo Courtesy of Robert Doscher, Westchester County NY

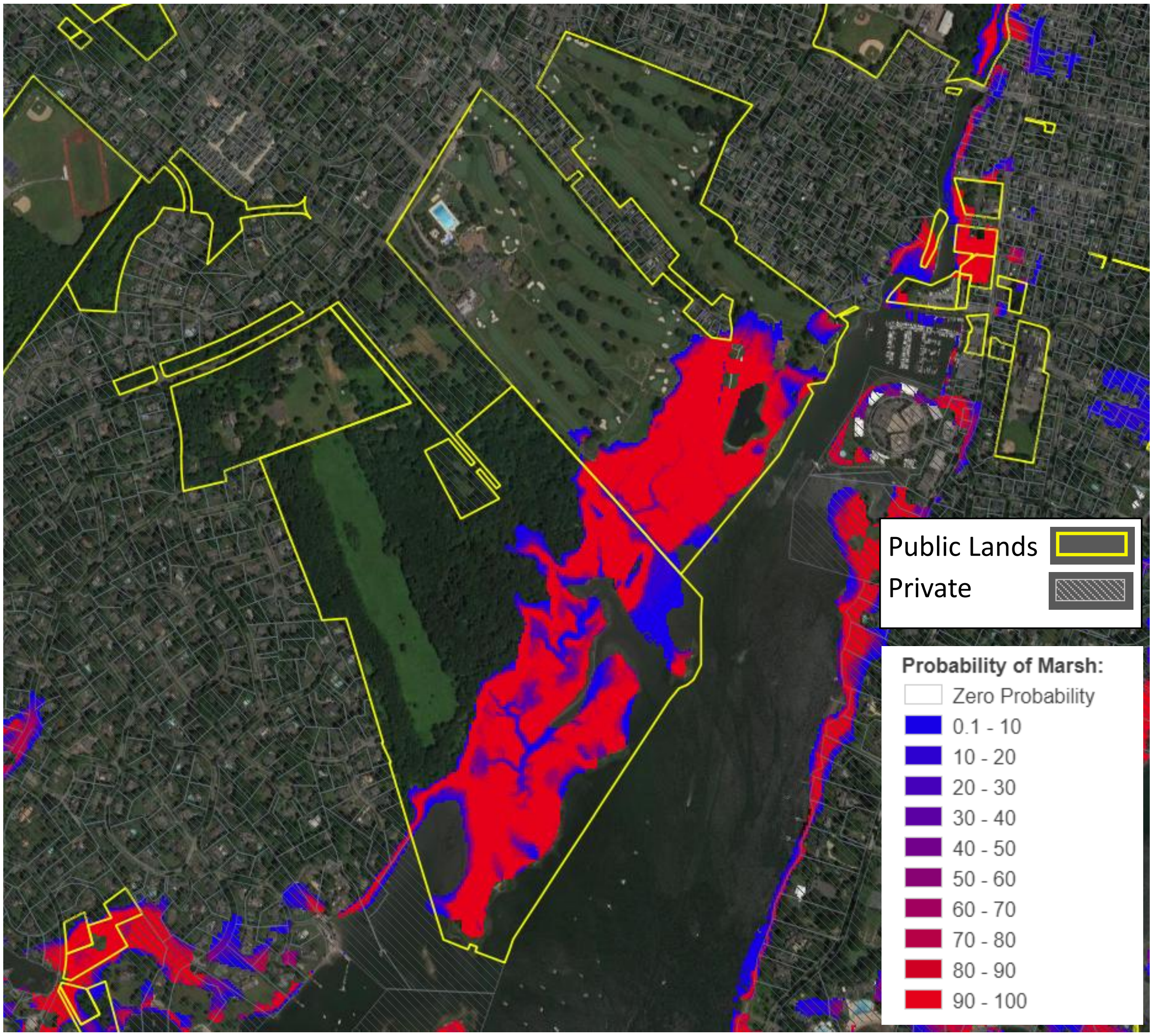

Figure 26. Marshlands Conservancy Possible Marsh Habitat in 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

Marshlands Conservancy wetlands and their envelope of expansion are predominantly publicly owned.

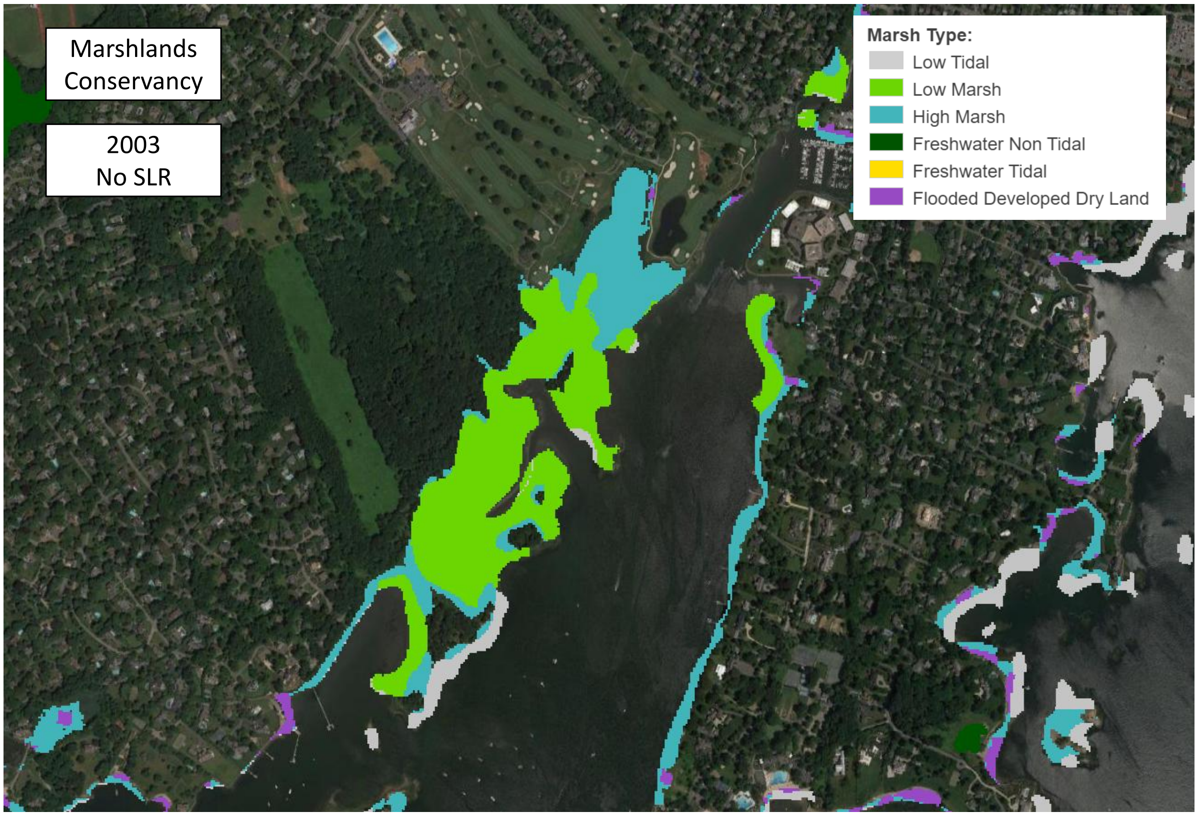

Figure 27. "Current Condition" of Marshlands Conservancy from National Wetland Inventory and SLAMM modeling.

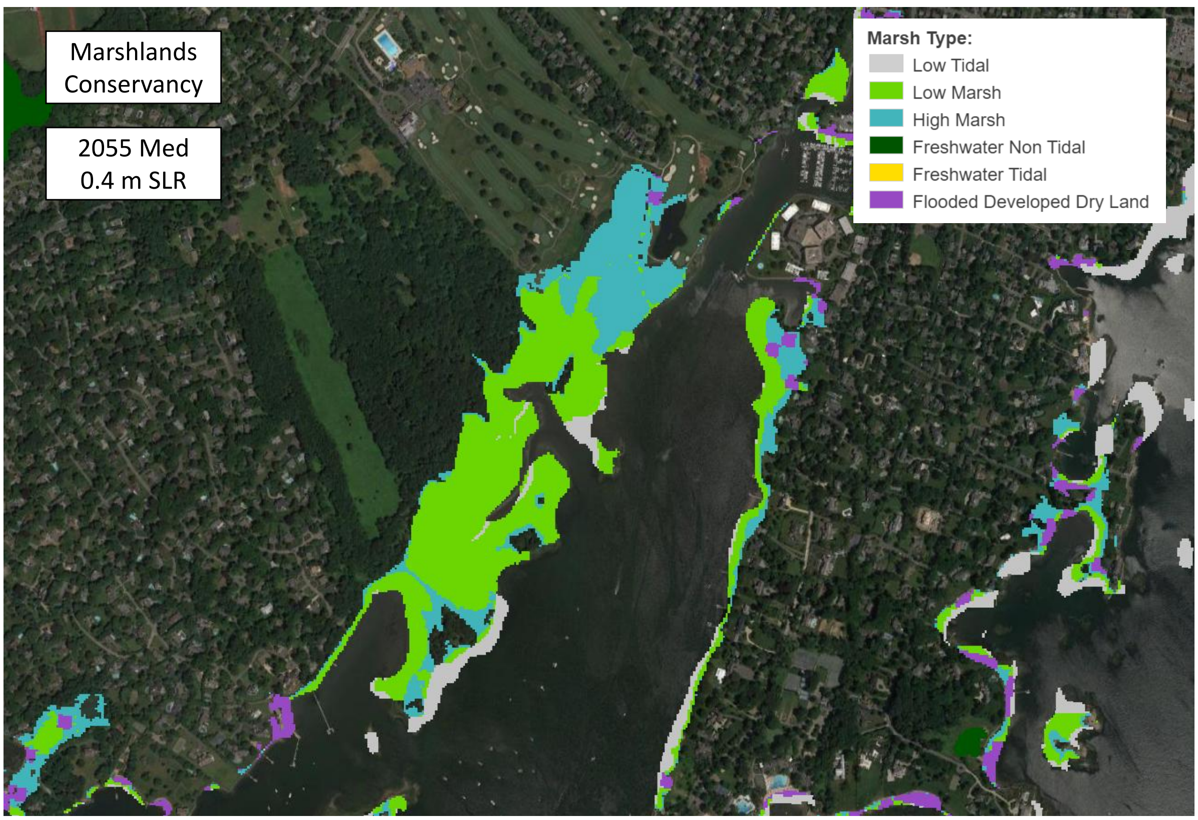

Figure 28. Potential condition of Marshlands Conservancy in 2055 (0.4 meters of SLR) from SLAMM modeling.

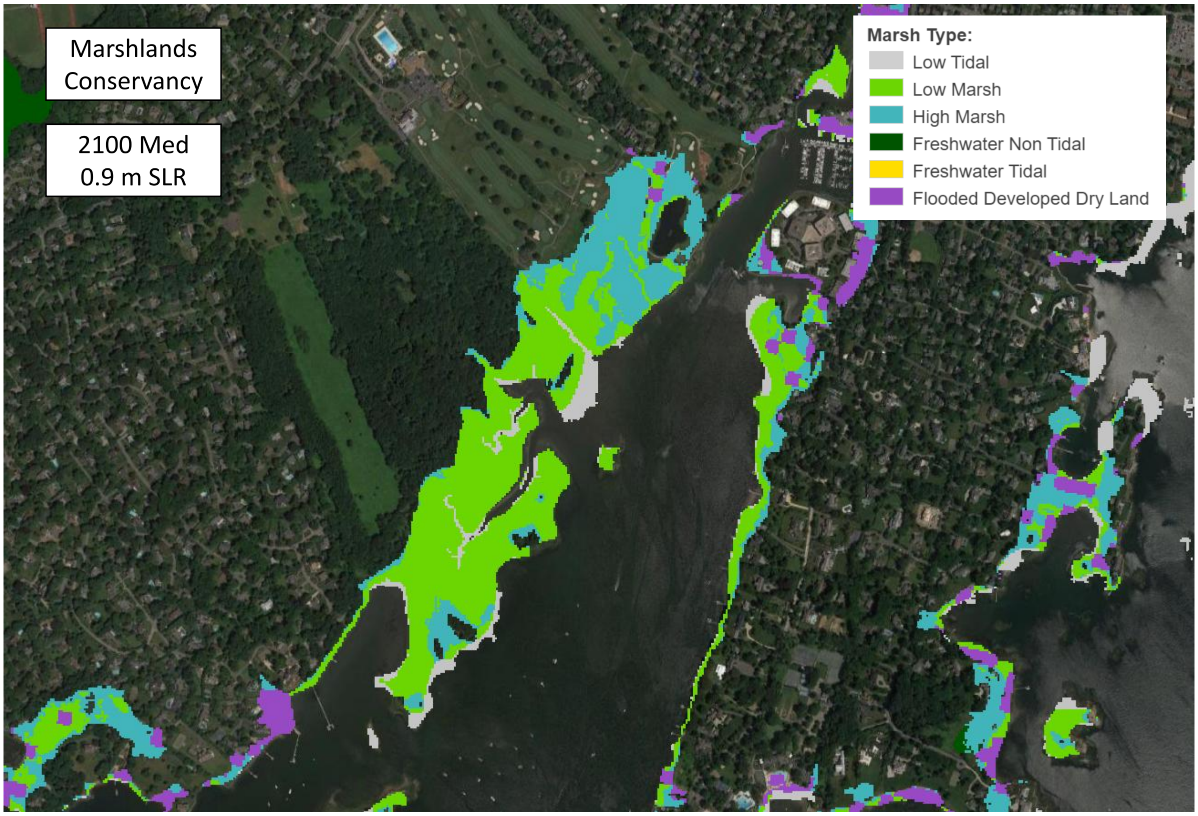

Figure 29. Potential condition of Marshlands Conservancy in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

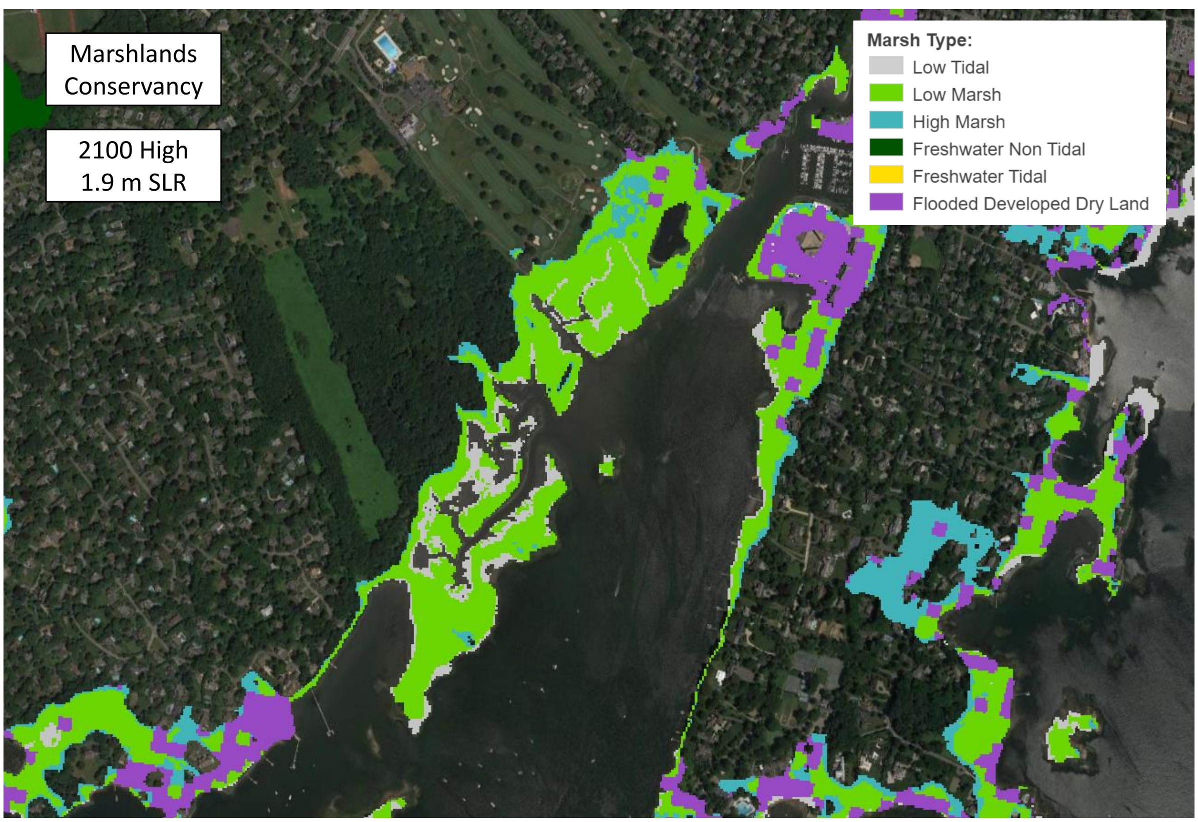

Figure 30. Potential condition of Marshlands Conservancy in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.

Hen Island

Hen Island: This privately owned marsh or tidal wetland is in the City of Rye. The marsh covers much of Hen Island, which sits at the mouth of Milton Harbor. The island is long but narrow and the southern portions of the island are exposed to the open waters of Long Island Sound. The three largest upland areas on the island are occupied by seasonal, privately owned cottages. The marsh is generally free from the threat of dominance by common reed (*Phragmites* sp.) and other invasive and/or non-native plants and consists of both low and high marshes. The former consists of smooth cordgrass (*Spartina alterniflora*) and the latter consists largely of perennials, such as salt meadow cordgrass (*Spartina patens*, a.k.a., *Sporobolus pumilus*), spike grass (*Distichils spicata*), black grass (*Juncus gerardii*), sea lavender (*Limonium carolinianum*) and shrubs, such as marsh elder (*Iva frutescens*). Much of the marsh is regularly inundated because a considerable portion of it is low, or intertidal, marsh. Although no public access is available and no landing allowed, passive recreation in the surrounding waters via kayak, paddle board and other small craft is very popular.

Figure 31. Hen Island Marshes. Photo Courtesy David Spader

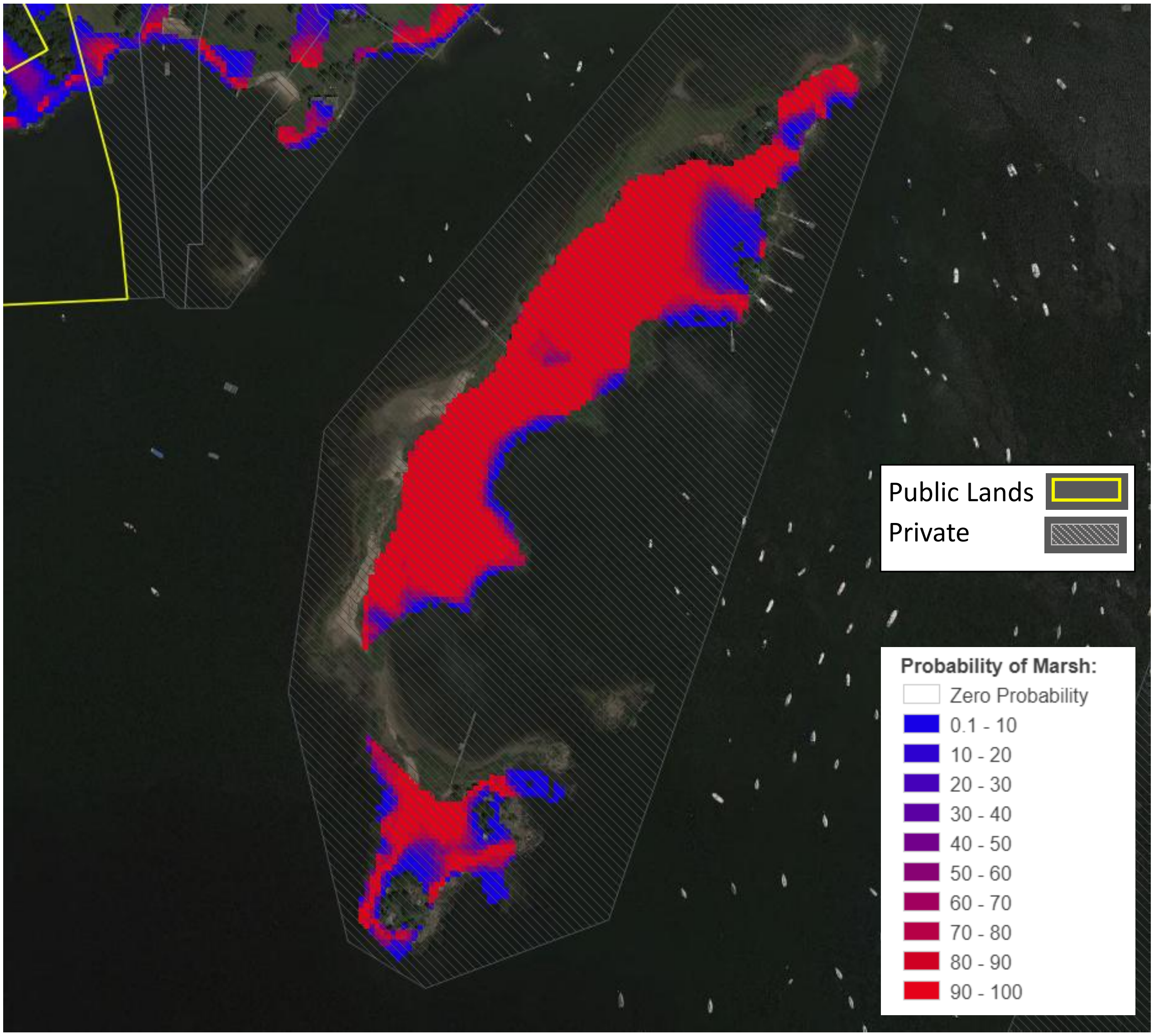

Figure 32. Hen Island Possible Marsh Habitat in 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

Hen Island is privately owned by Kuder Island Colony, Inc. Model results predict possible marsh habitat in 2100 taking into account uncertainty in sea-level rise, elevation data, and marsh-accretion rates. Model results suggest that Hen-Island marshes will be resilient to SLR, with most existing wetlands remaining in the high-probability category (in red). The blue regions show areas where current dry land could be regularly-flooded enough under the highest SLR scenarios by 2100, allowing for marsh habitat.

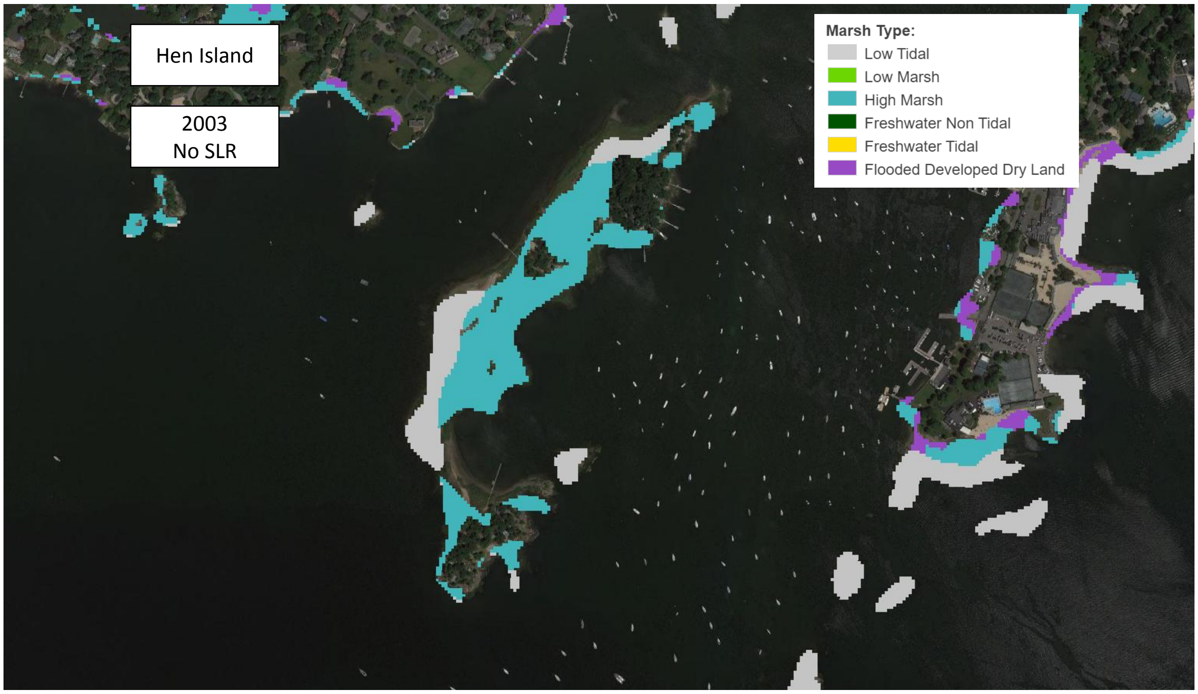

Figure 33. "Current Condition" of Hen Island from National Wetland Inventory and SLAMM modeling.

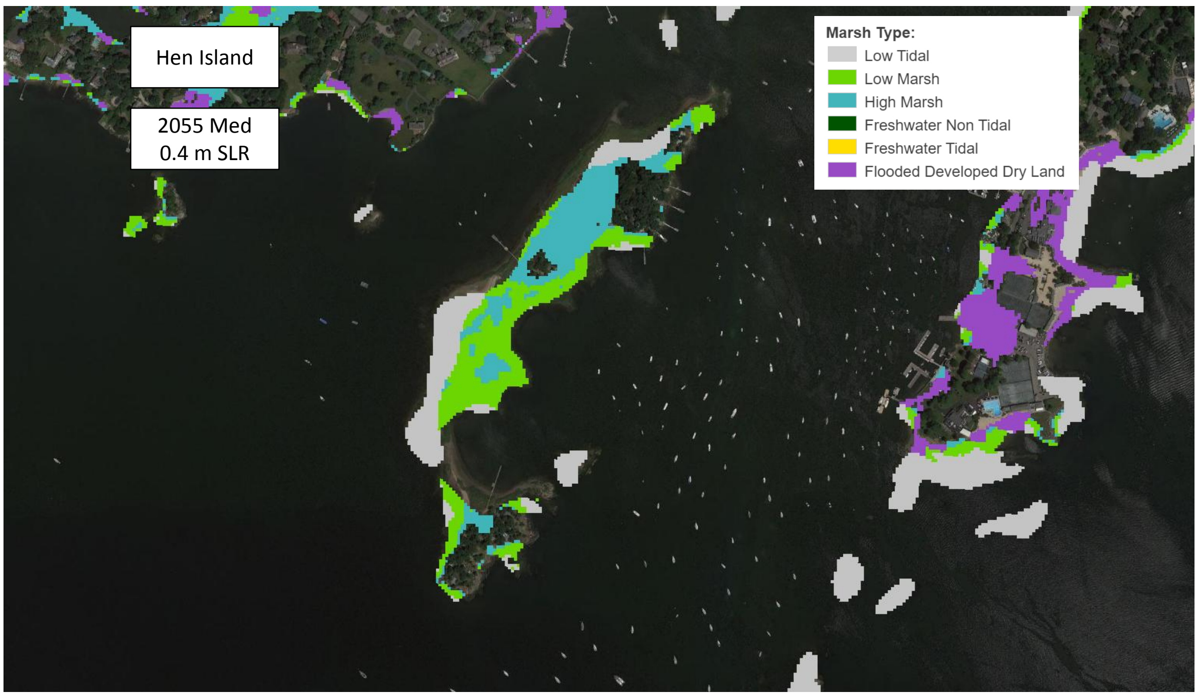

Figure 34. Potential condition of Hen Island in 2055 (0.4 meters of SLR) from SLAMM modeling.

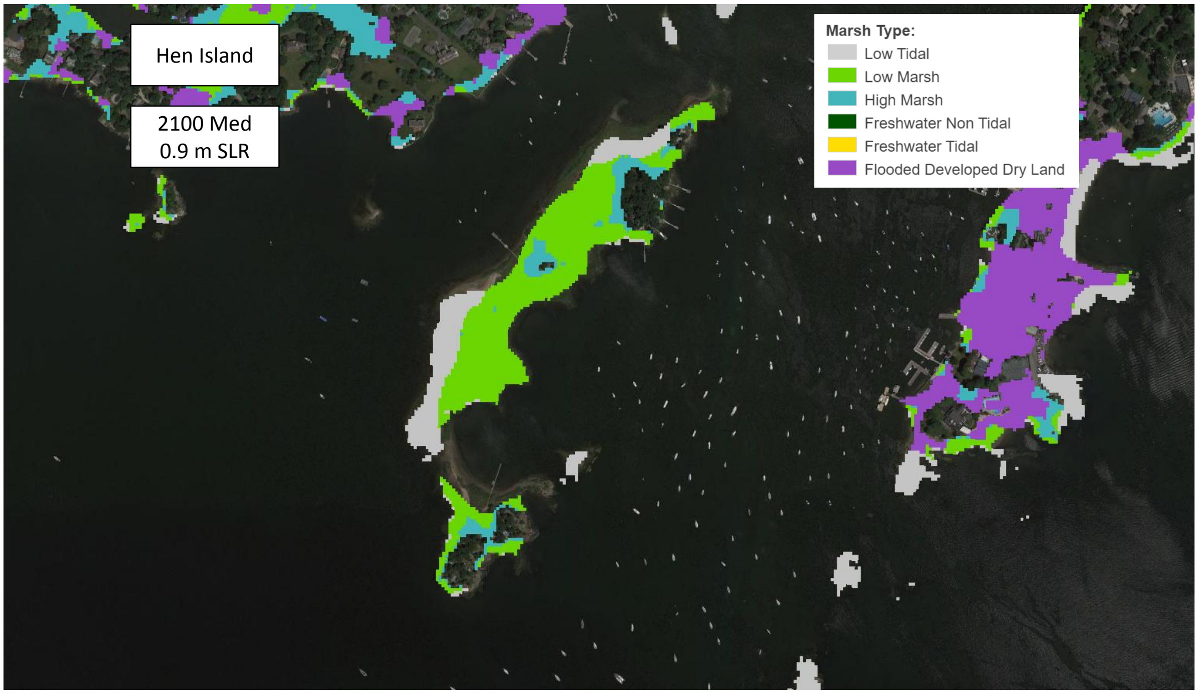

Figure 35. Potential condition of Hen Island in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

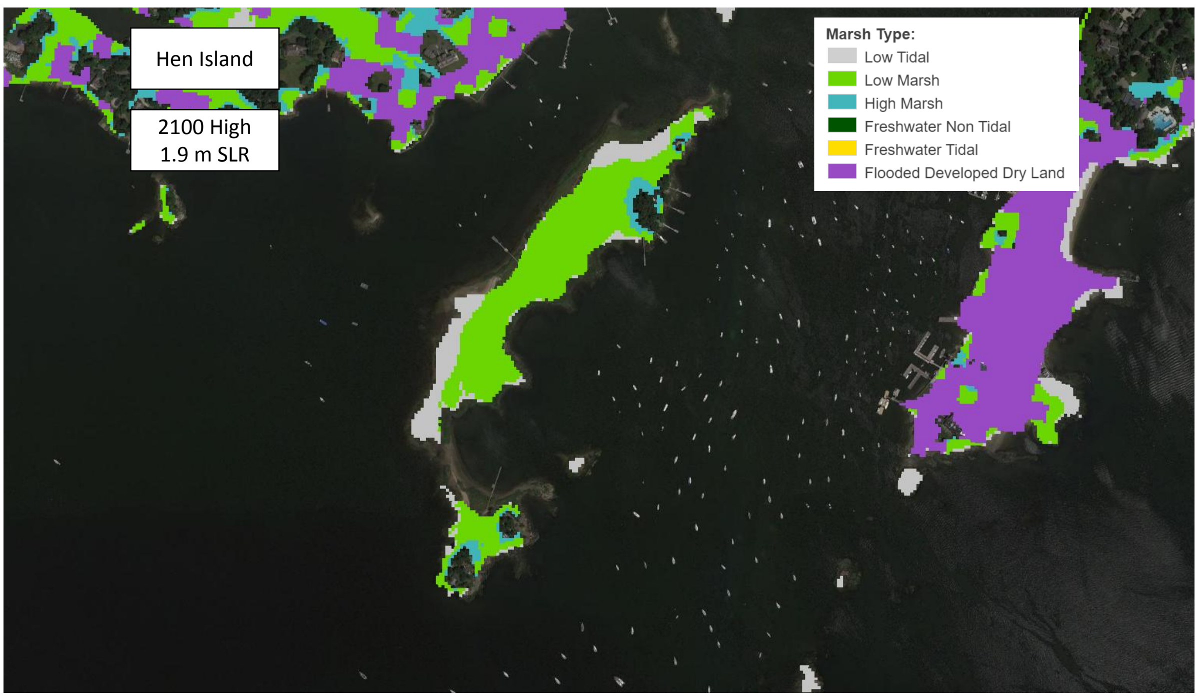

Figure 36. Potential condition of Hen Island in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.

Otter Creek Preserve

Otter-Creek Preserve. Located in Mamaroneck, NY, the Otter Creek Preserve includes a mix of coastal waters, marsh, wooded wetlands, and edge habitats (Westchester Land Trust 2021). The Preserve is the largest privately-owned tidal wetland designated and protected as a nature sanctuary in Westchester County (Westchester Land Trust 2021).

Figure 37. Otter Creek Preserve, Photo from https://westchesterlandtrust.org/ Photo Credit Dana Stetson

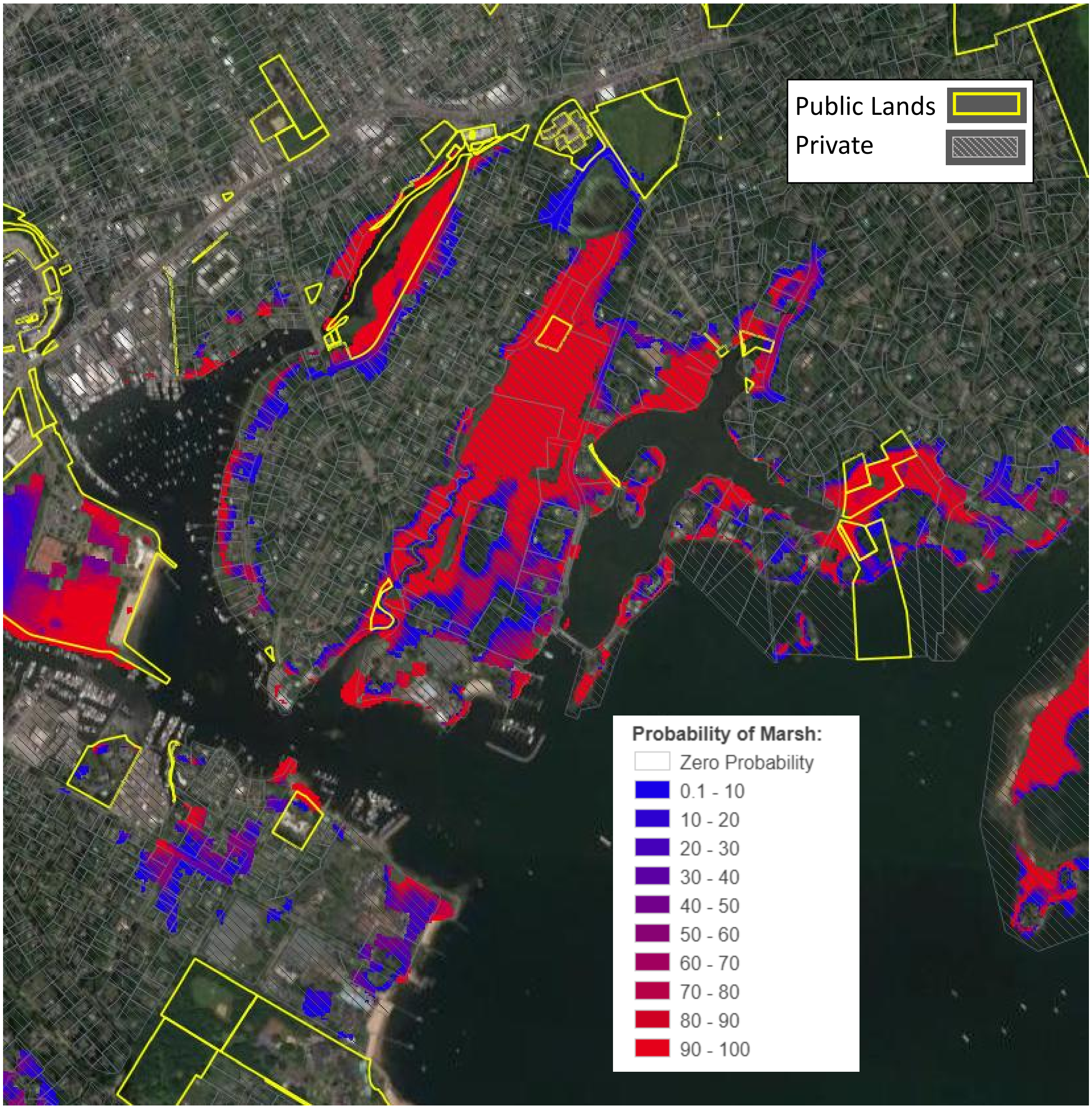

Figure 38. Possible Marsh Habitat in and Adjacent to Otter Creek Preserve in 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

While Otter Creek Preserve is predominantly privately owned, Westchester Land Trust, Inc. owns much of the potential marsh land in the center of the parcel.

Figure 39. "Current Condition" of Otter-Creek Preserve from National Wetland Inventory and SLAMM modeling.

Figure 40. Potential condition of Otter-Creek Preserve in 2055 (0.4 meters of SLR) from SLAMM modeling.

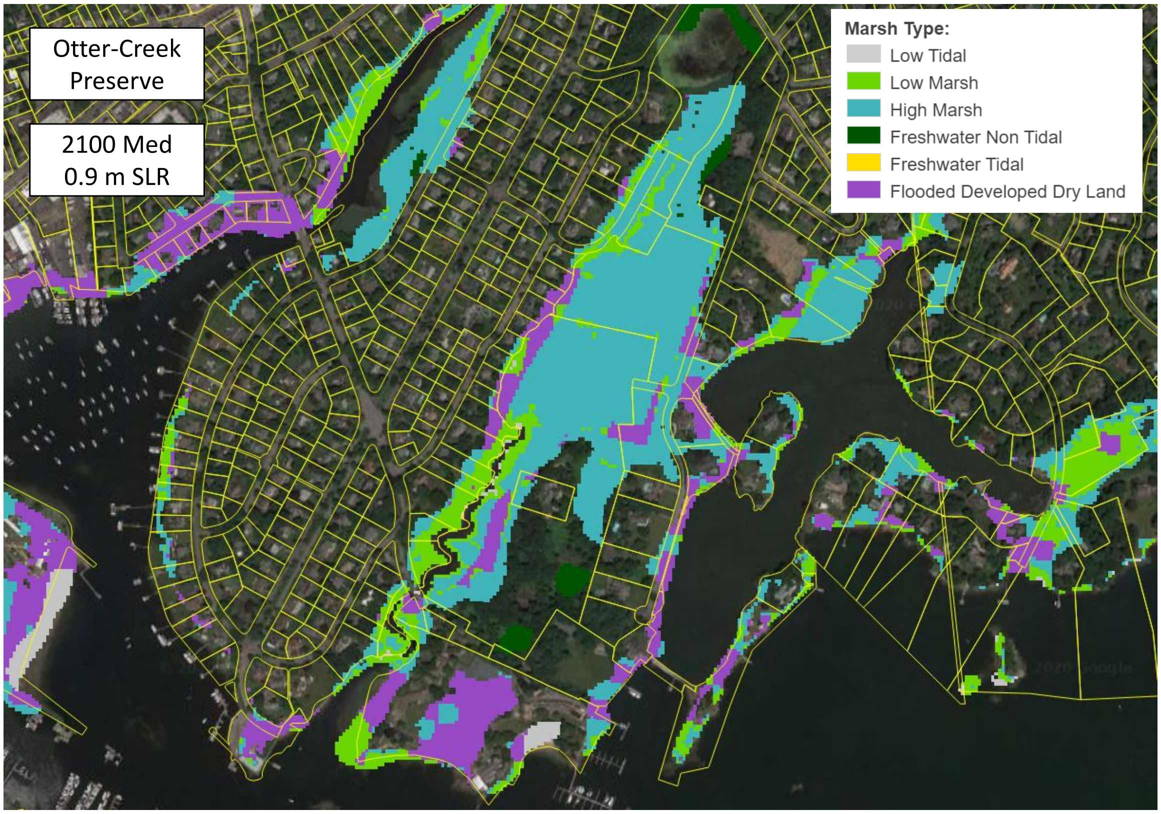

Figure 41. Potential condition of Otter-Creek Preserve in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

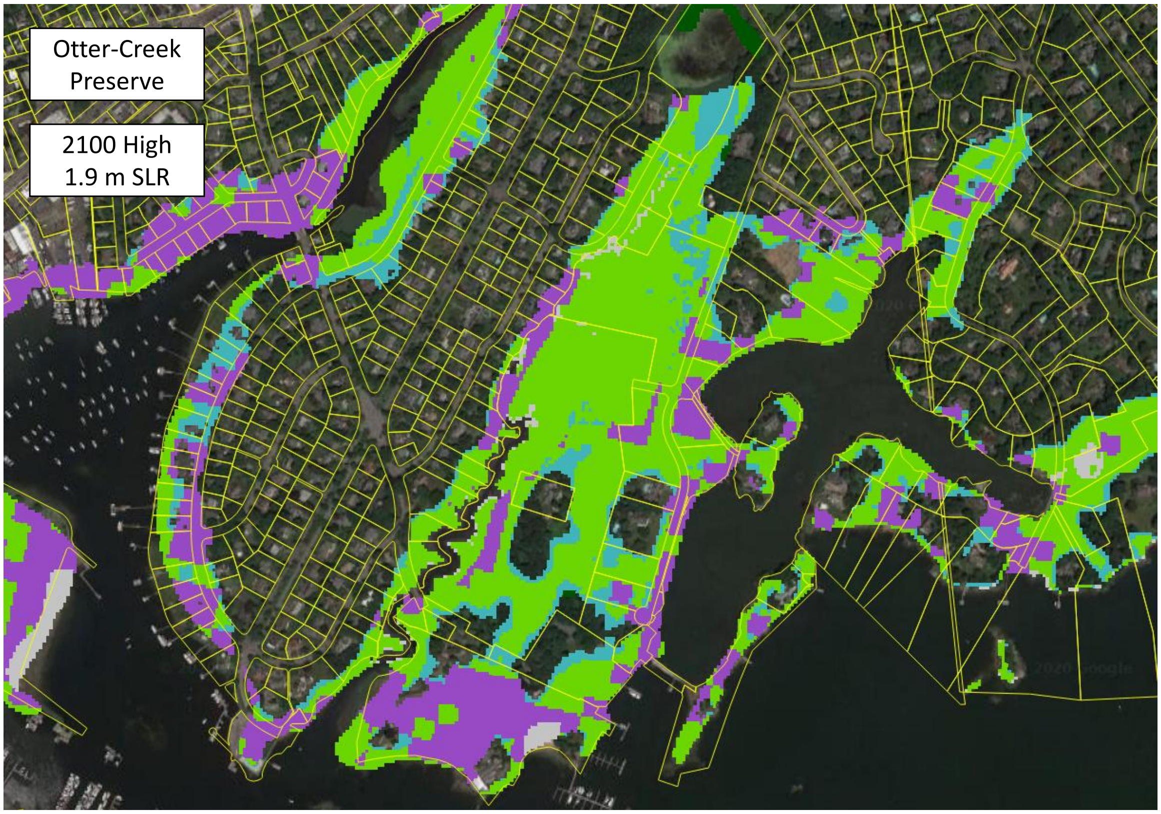

Figure 42. Potential condition of Otter-Creek Preserve in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.

HOMMOCKS CONSERVATION

Hommocks Conservation Area. This marsh or tidal wetland is in the Town of Mamaroneck. The marsh is at the head of a narrow embayment called East Creek, which is part of Larchmont Harbor. A freshwater turning brackish portion of East Creek drains into the embayment. The embayment is bounded to the west by Village of Larchmont-owned Flint Park, to the north by Town of Mamaroneck-owned Hommocks Conservation Area and Hommocks Middle School, Pool and Ice Rink, and to the east by single-family residential properties. Also adjoining the marsh is a former municipal leaf composting facility that still contains debris and stored materials. Much of Flint Park has been constructed on fill used to convert previously existing salt marsh into athletic fields and other active recreational facilities. The marsh is a mix of common reed (*Phragmites* sp.) and low and high marshes. The former consists of smooth cordgrass (*Spartina alterniflora*) and the latter consists largely of salt meadow cordgrass (*Spartina patens*, a.k.a., *Sporobolus pumilus*), spike grass (*Distichils spicata*), and black grass (*Juncus gerardii*). Areas of mud flats next to the marsh are exposed at low tide. A portion of the wetland is regularly inundated. During significant storms, the other portions of the marsh will be inundated. A small parking lot and short trail extends into the marsh from Hommocks Road.

Figure 43. Hommocks Conservation Area, Photo Credit Google Earth 2021

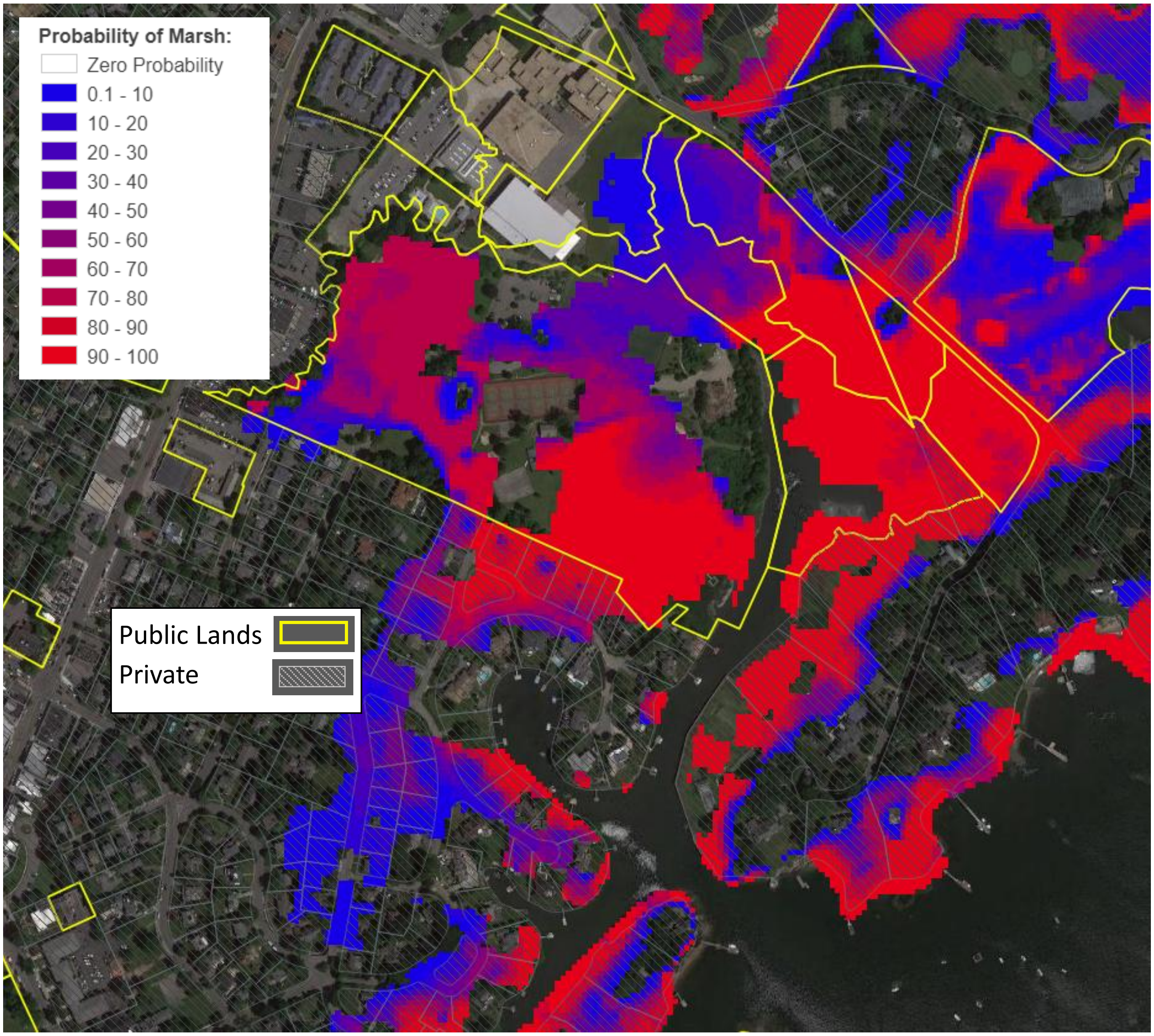

Figure 44. Hommocks Conservation Area Possible Marsh Habitat In 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

While extensive marsh expansion on public lands is possible, much of the lands shown here in red as "high probability of marsh expansion" are currently used for recreational purposes.

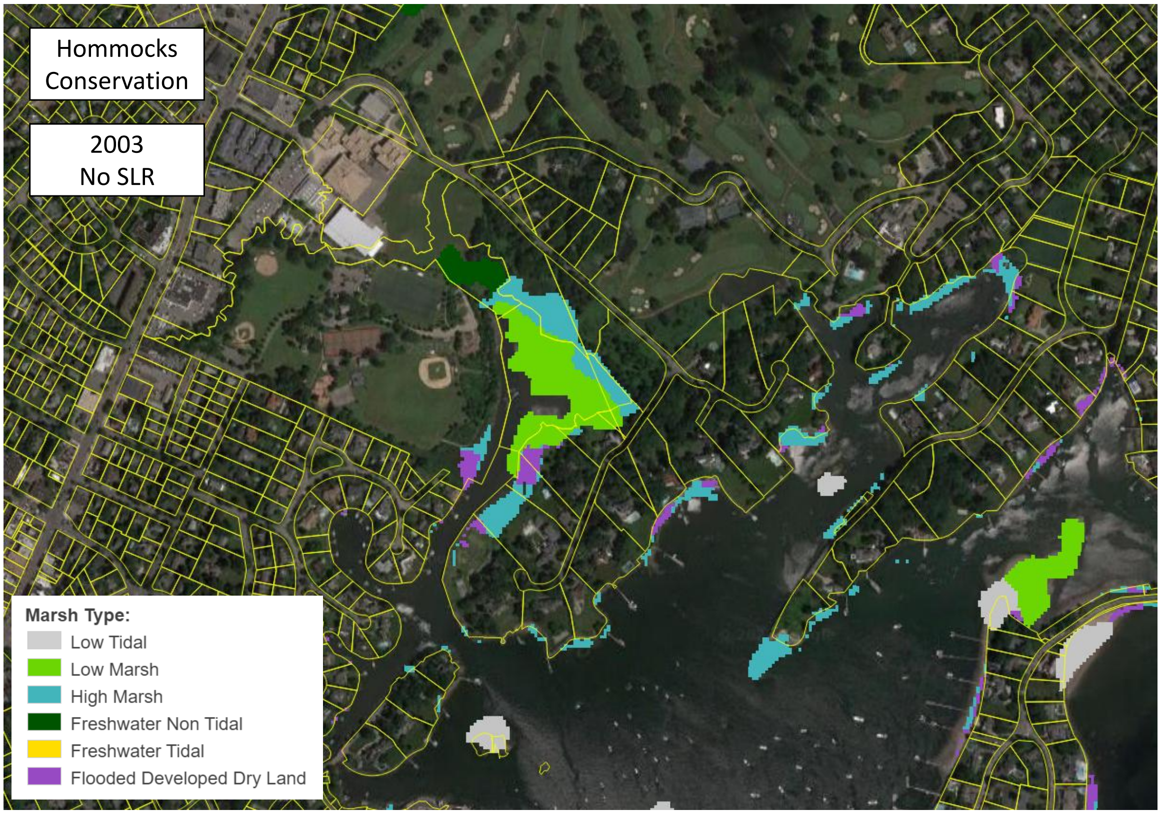

Figure 45. "Current Condition" of Hommocks Conservation Area from National Wetland Inventory and SLAMM modeling.

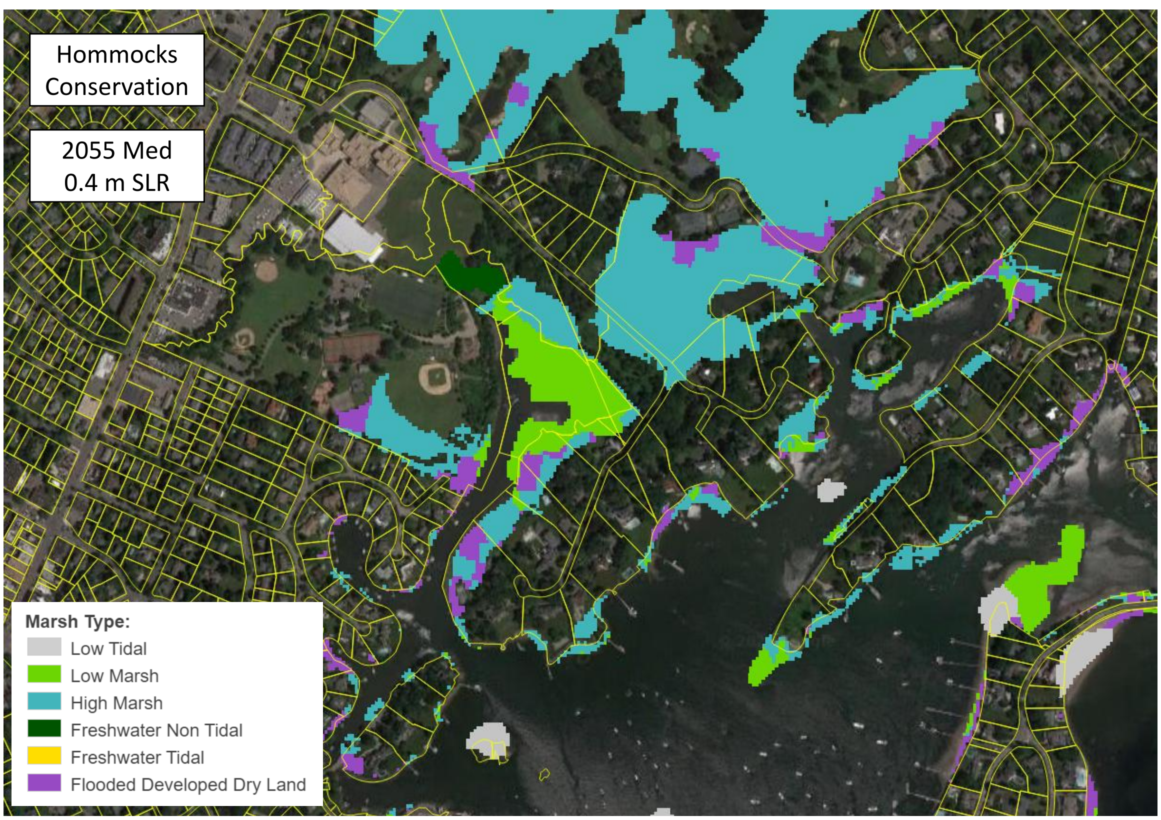

Figure 46. Potential condition of Hommocks Conservation Area in 2055 (0.4 meters of SLR) from SLAMM modeling.

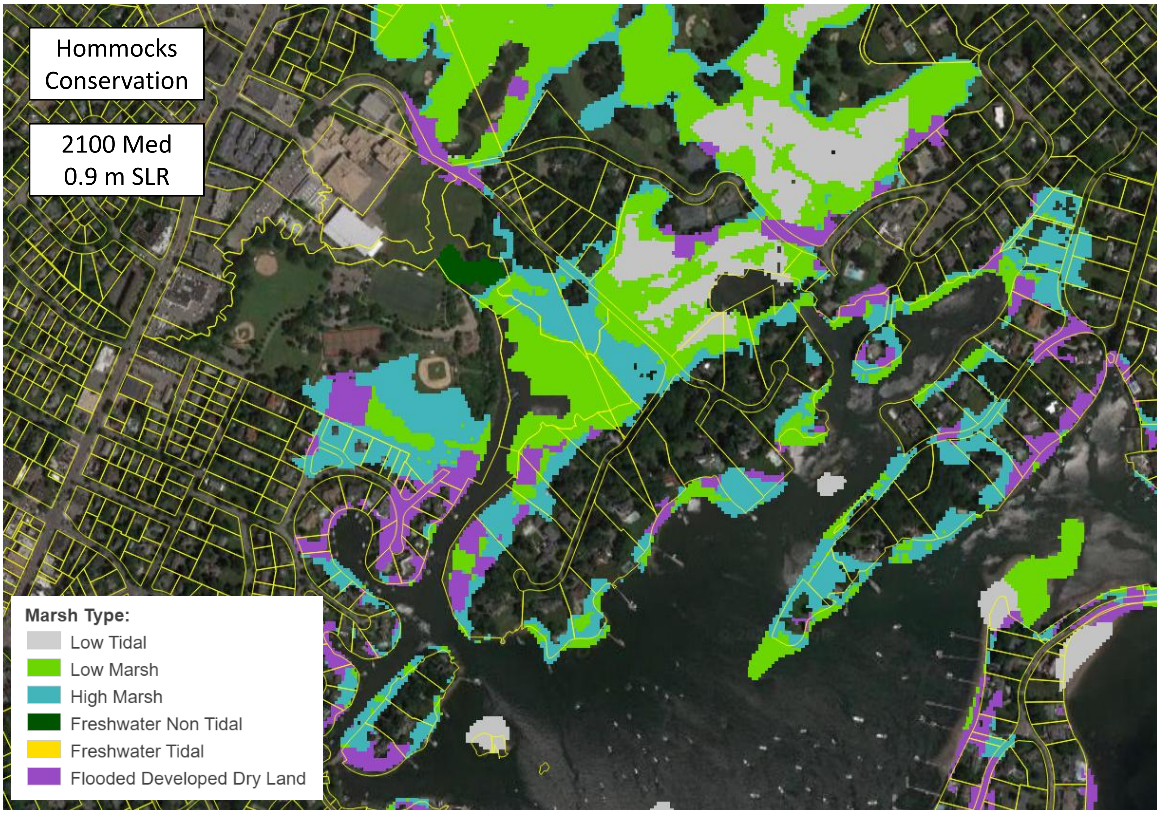

Figure 47. Potential condition of Hommocks Conservation Area in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

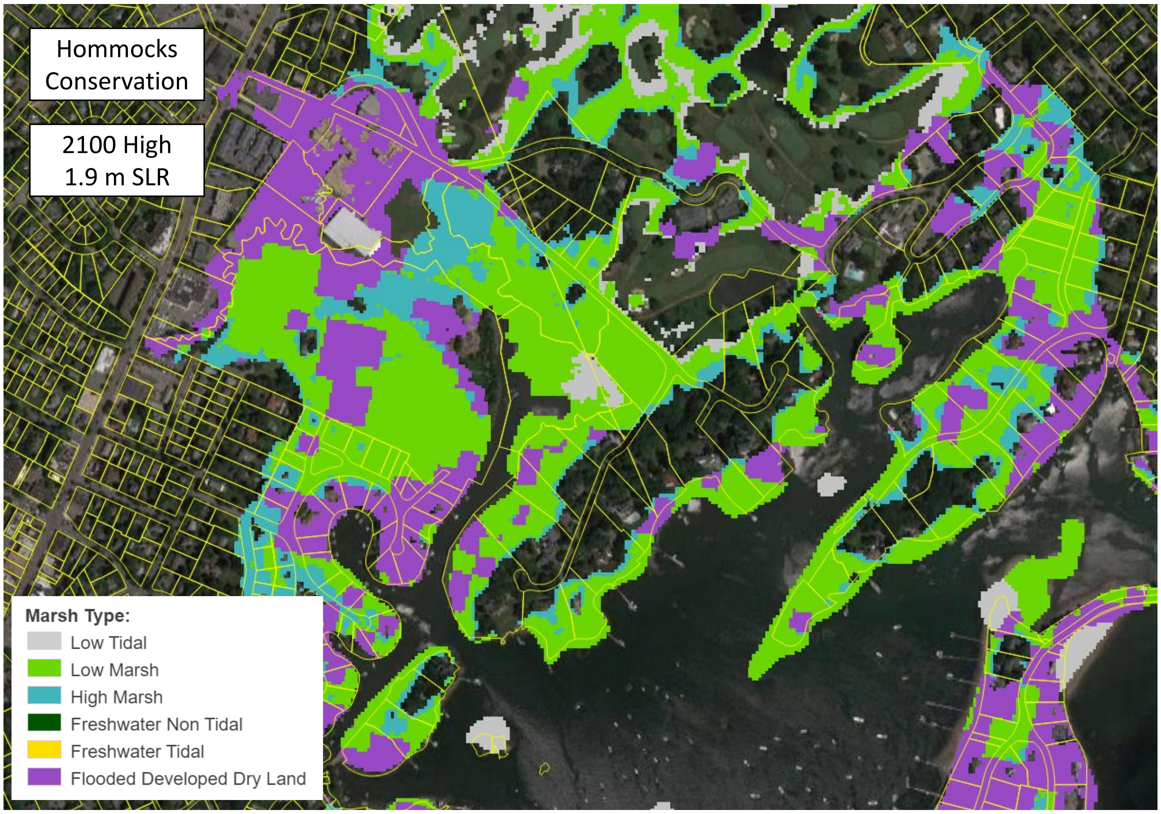

Figure 48. Potential condition of Hommocks Conservation Area in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.

PINE-BROOK WETLANDS

Pine-Brook Wetland (Premium-River Conservation Area Complex). This marsh or tidal wetland is in the Town of Mamaroneck. Pine Brook, a freshwater stream originating in northern New Rochelle, flows from north to south and eventually travels underneath Route 1 (Boston Post Road) in the Town of Mamaroneck. Pine Brook becomes the Premium River immediately south of Route 1. The Premium River is tidal and is flanked by salt marsh. Most of the marsh is situated at the northern end of the Premium River, west of the main channel. A small tidal creek extends westward from the main channel in this area. The northern end is largely bounded by Village of Larchmont-owned Lorenzen Park and Willow Park. Two commercial garden centers also sit at the northernmost end of the Premium River. The balance of the river and its adjoining salt marsh are flanked by single-family residences. At a bridge carrying Pryer Manor Road over the Premium River, the river empties into Premium Mill Pond. The "pond" is part of New Rochelle Harbor but is physically separated from it by a small dam or weir that supports Premium Point Road. The marsh's plant community is diverse but is dominated by high marsh species, including perennials, such as salt meadow cordgrass (*Spartina patens*, a.k.a., *Sporobolus pumilus*), spike grass (*Distichils spicata*) and black grass (*Juncus gerardii*), and shrubs, such as marsh elder (*Iva frutescens*). Common reed (*Phragmites* sp.) exists along its fringes and dominates. A distinct salt marsh, called Pryer Manor Marsh, is hydrologically connected to the Premium River and adjoining salt marsh but is physically separated from it by single-family residences and Pryer Manor Road. Most of the Premium River marsh is irregularly inundated, with the daily ebb and flow of the tide largely impacting only the primary Premium River channel and a couple of side channels. During significant storms, portions of the marsh will be inundated and flooding occasionally occurs over local roads. Limited public access for passive recreation is available via the Town of Mamaroneck-owned Premium River Conservation Area accessible from Dillon Road and Pheasant Run. The Premium River-Pine Brook Wetlands is a New York State-designated Significant Coastal Fish and Wildlife Habitat.

Figure 49. Pine-Brook Wetland, Photo (Westchester County Department of Planning 2021)

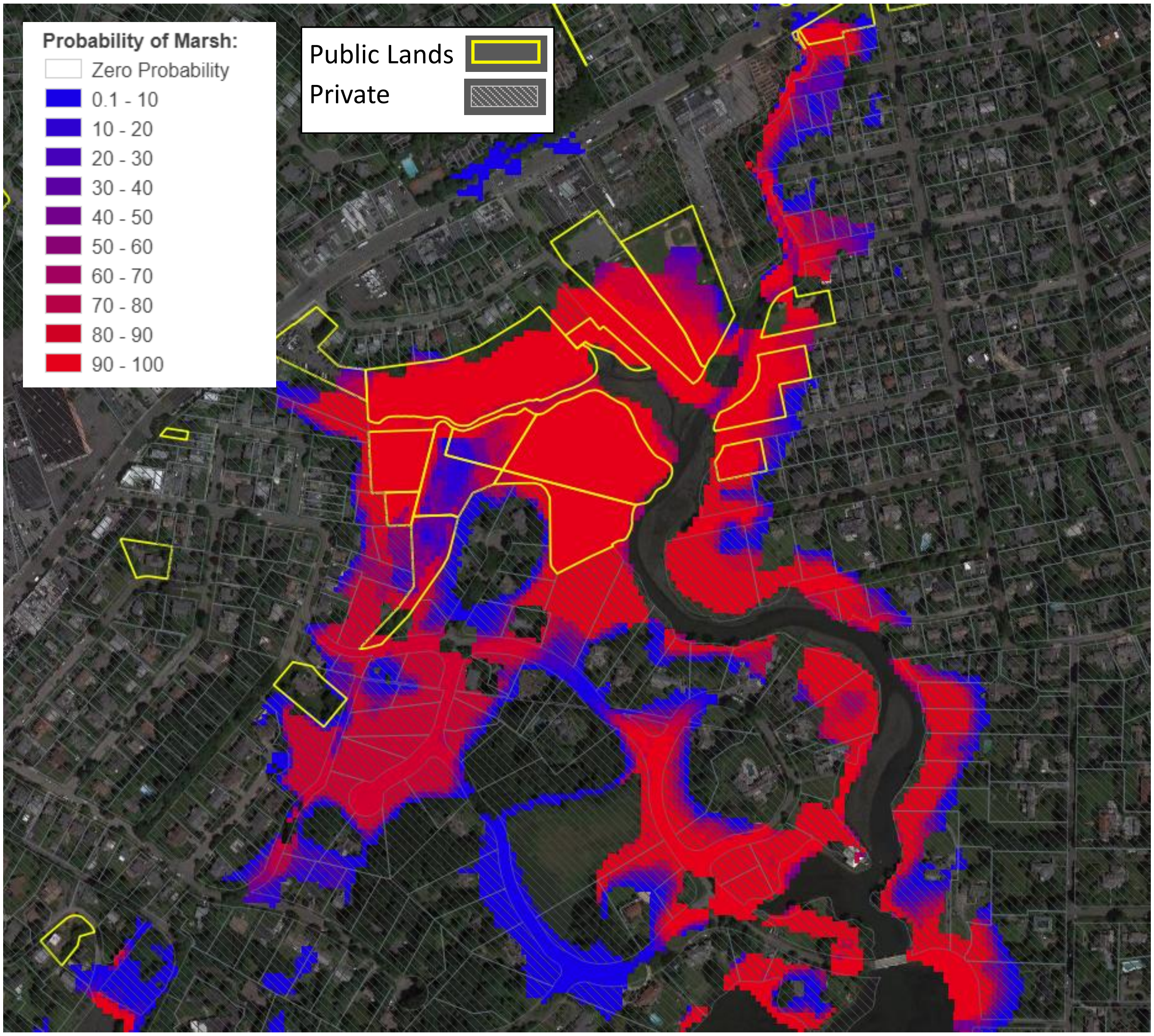

Figure 50. Pine-Brook Wetland Possible Marsh Habitat In 2100 Compared to Public vs. Private Lands. Yellow clear polygons are public lands, white hashed polygons are private lands.

The current marsh footprint is largely on public land (yellow parcels to the north), but there are extensive private lands that could be subject to marsh expansion by 2100.

Figure 51. "Current Condition" of Pine-Brook Wetlands from National Wetland Inventory and SLAMM modeling.

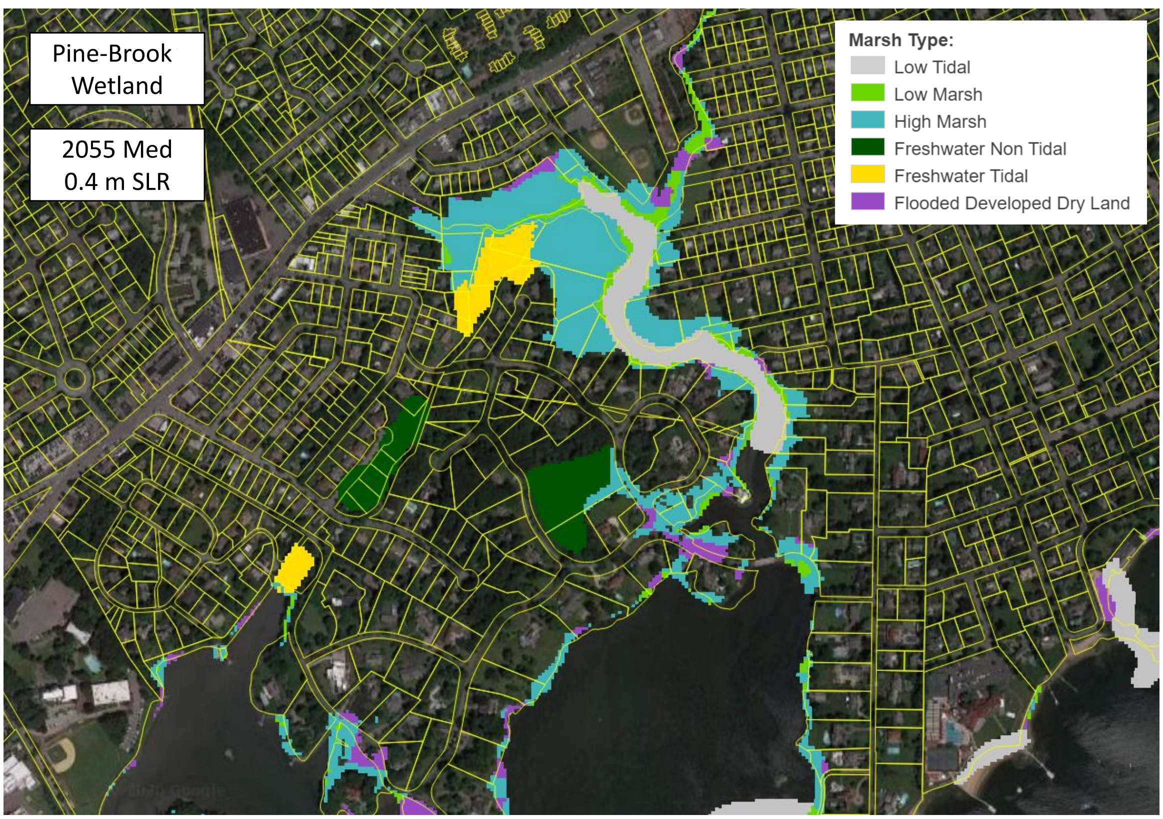

Figure 52. Potential condition of Pine-Brook Wetlands in 2055 (0.4 meters of SLR) from SLAMM modeling.

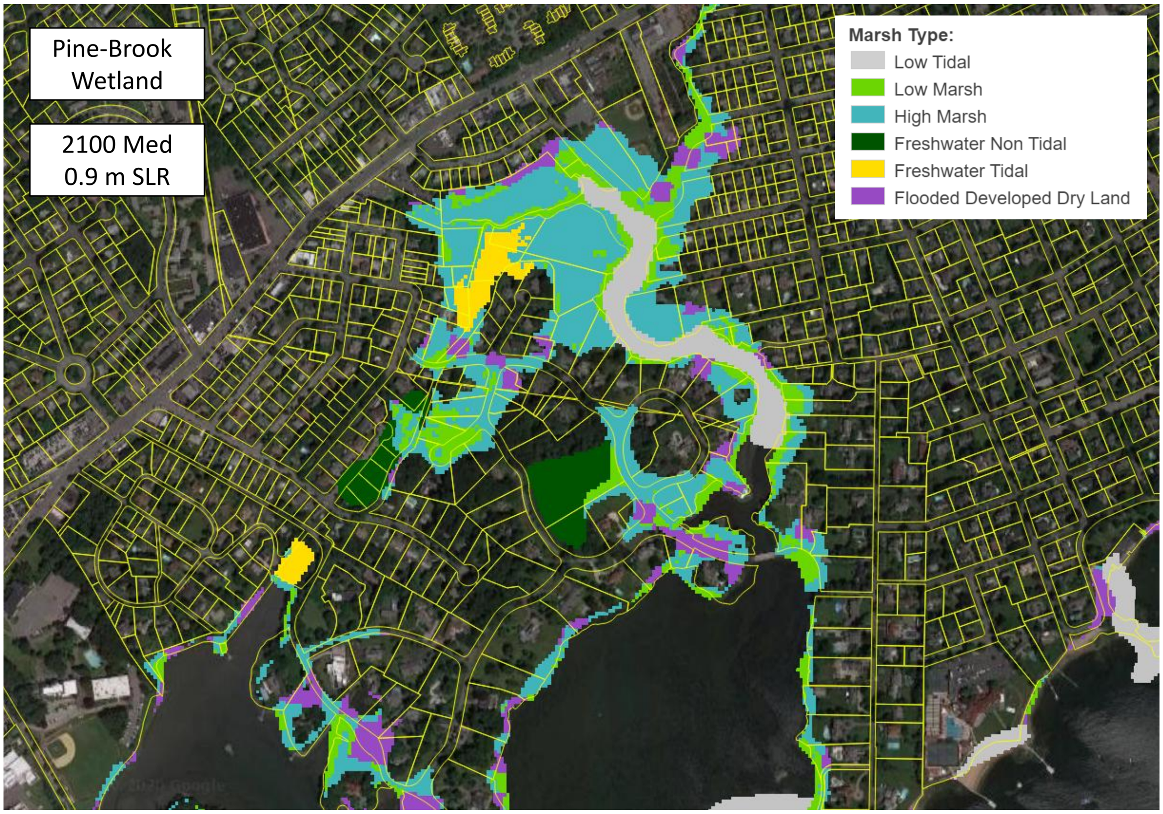

Figure 53. Potential condition of Pine-Brook Wetlands in 2100 under medium SLR (0.9 meters of SLR) from SLAMM modeling.

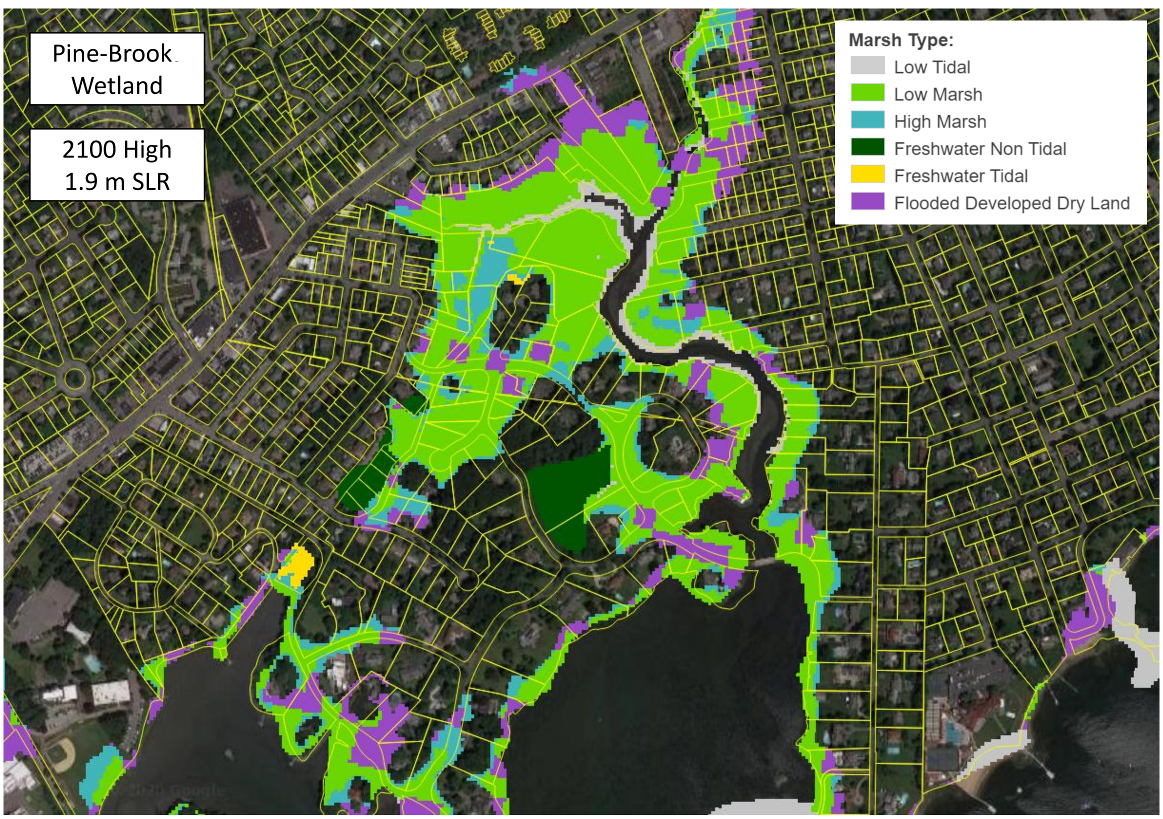

Figure 54. Potential condition of Pine-Brook Wetlands in 2100 under high SLR (1.9 meters of SLR) from SLAMM modeling.