MARSH CONSERVATION PLANNING FOR GLEN ISLAND NY

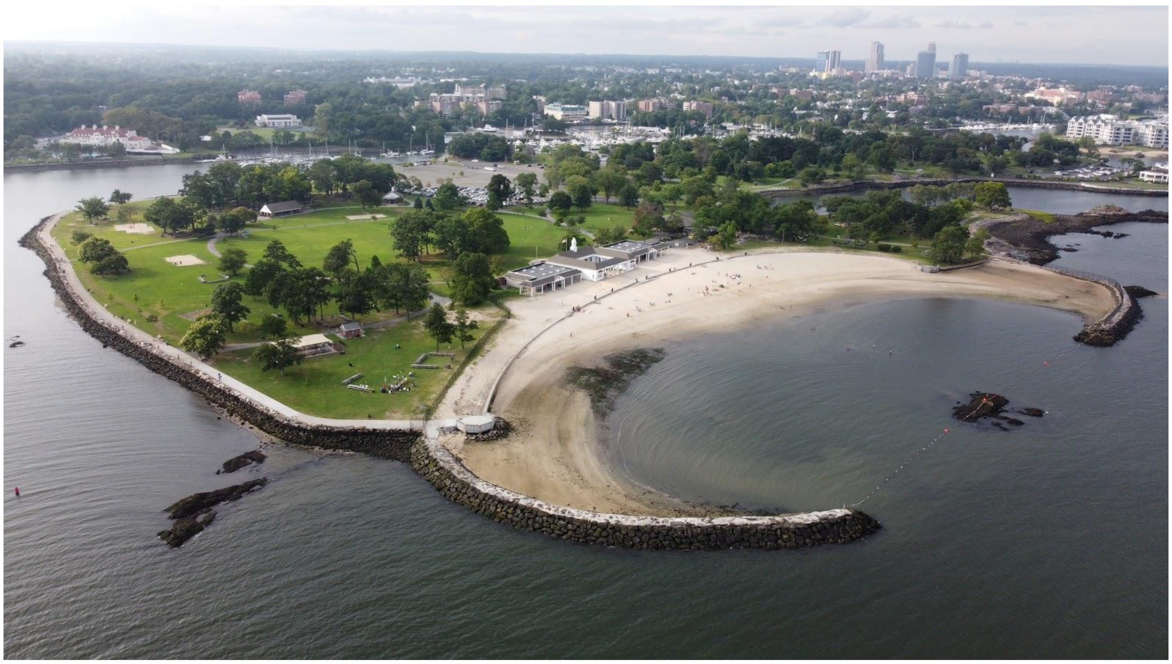

Photo Source: Westchester County Parks Conservation Division, 2023

NEIWPCC

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NOTICE

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Long Island Sound Study
A Partnership to Restore and Protect the Sound

Preparation of this document was organized by Jonathan Clough of Warren Pinnacle Consulting, Inc. with close oversight from Victoria O'Neill of NYSDEC and with the significant assistance of Sara Powell, NY Sea Grant's Sustainable and Resilient Communities (SRC) Extension Professional for Westchester County.

Completion of this document would not have been possible without the assistance of our stakeholder group who provided us with material and feedback on drafts over several months of meetings:

- Taro Ietaka – Westchester County Parks
- Jason Klein -- Westchester County Parks
- Dave Kvinge – Westchester County Planning Department
- Nicole Laible – Westchester County Planning Department and Westchester Soil and Water Conservation District
- Samarra Scantlebury – NYSDEC
- Jess Schuler - Westchester County Parks
- Julia Snook - Westchester County Parks

Contents

EXECUTIVE SUMMARY

Glen Island is a 64.4-acre park owned by Westchester County that is heavily used as a public beach and includes shoreline fishing opportunities (City of New Rochelle, 2016). The history of Glen Island includes a long and colorful period of significant landscape modifications and heavy public utilization. The park was originally composed of four islands connected by footbridges, with shallow waters and some coastal marshes in between. In the early 20th century, the waters between these islands were filled to form a single land mass.

The coast of Glen Island is currently augmented by well-maintained shoreline protection structures (City of New Rochelle, 2016). However, these structures were not necessarily designed to protect against future sea-level rise. Nuisance flooding, especially of the parking lot area, already occurs regularly. Without additional action, under most sea-level rise scenarios, much of the land of the island is predicted to become intertidal and potentially could host coastal marsh habitat. The basis for this prediction is a model driven by the New York Governor's office 2016 SLR scenarios for planning (Propato et al., 2018).

A recent ecological survey of Glen Island Park found that there are robust ecological aspects to Glen Island Park. However, the addition of some marsh habitat would likely enhance the biodiversity of the park, among other benefits. This could potentially take the form of a living shoreline that would provide dual ecological and flood-protection benefits.

In terms of threats to the current park usage, sea-level rise is important as discussed above. Water quality is another potential threat to the park's ecological and recreational resources. Recent data suggest that water quality around Glen Island Park is great for beachgoers and likely adequate for most forms of ecology (Save the Sound 2023). Continuing to limit nutrient and organic-matter pollution regionally will ensure that future water quality does not inhibit future human uses or ecological health.

Based on projected sea levels, it is likely that some action in coming decades will be required to protect Glen Island from rising coastal waters. Possible actions could include further augmentation of the seawall around the island, or bringing in additional fill as was done to create much of the island. Another approach could be to allowing some marsh habitat on the island to provide ecological, recreational, and flood-protection benefits.

If wetlands were reestablished at Glen Island Park, it would potentially produce benefits both to ecology and human users. These benefits include:

- Wave Attenuation (the prevention of erosive losses due to waves)
- Habitat (for birds, forage fish, game fish, and shellfish)
- Nutrient sequestration (marshes will absorb some harmful nutrients and carbon)
- Recreation and or Cultural Value (ecology is a draw for kayakers, bird watchers, and provides a natural setting for picnickers and beachgoers)

Another benefit of nature-based solutions to sea-level rise is that, unlike gray infrastructure, marshes will move vertically in response to water levels and can maintain their relative position against moderate rates of sea-level rise. Furthermore, state guidance is available to assist in the implementation and monitoring of natural-resilience measures that reduce risk from flooding and erosion. Recent legislation requires the State of NY to give preference to nature-based solutions when permitting shoreline management projects (Act 5221-A).

A nature-based solution can be complemented by other management options such as adding more fill to raise land elevations and the construction of vertical seawall. Each of these three approaches potentially have benefits and drawbacks; it is possible that an optimal engineering solution to preserve and improve the park-going experience over the 21st century would incorporate all three approaches.

In summary, this report found that due to the threat of sea-level rise, Glen Island is likely to require some landscape modification over the coming century. Considering nature-based solutions at this site could potentially provide benefits for recreation and habitat, and could also open up additional funding sources. Due to its heavy public utilization and its high potential for marsh restoration benefits, Glen Island may be looked upon favorably by funders if planners are able to act proactively now.

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)).

To better assist communities in planning and decision making these data are summarized in fact sheets and a stakeholder interactive viewer that includes marsh land cover projections and tax parcel information (http://warrenpinnacle.com/LIMaps/).

Additionally, in cooperation with municipalities or other marsh-conservation stakeholder groups, three marsh-migration conservation plans have been developed. The goal of these plans is to inform local municipalities and marsh-conservation groups as to where they might focus their conservation efforts to maximize the provision of marsh ecosystem services under sea-level rise conditions.

GLEN ISLAND ENVIRONMENTAL AND RECREATIONAL ASSETS

INTRODUCTION AND HISTORY

The history of Glen Island includes a long and colorful period of significant landscape modifications and heavy public utilization. In the late 1800s, Glen Island was a summer resort community developed as an amusement park and accessible by steamboats (City of New Rochelle, 2016). The property was sold to Westchester County in 1923 which opened it as a park to the public shortly afterwards (City of New Rochelle, 2016).

Glen Island was initially composed of four separate islands connected by footbridge, but these were later filled to form a single land mass (City of New Rochelle, 2016). A photo/illustration of the island in 1881 depicts its original configuration as separate islands and foot bridges (Figure 1). Remnants of this colorful history remain entrenched on the island. For example, the building that housed "Little Germany," that was originally built as a German Beer Garden and operated until World War I, remains standing (City of New Rochelle, 2016).

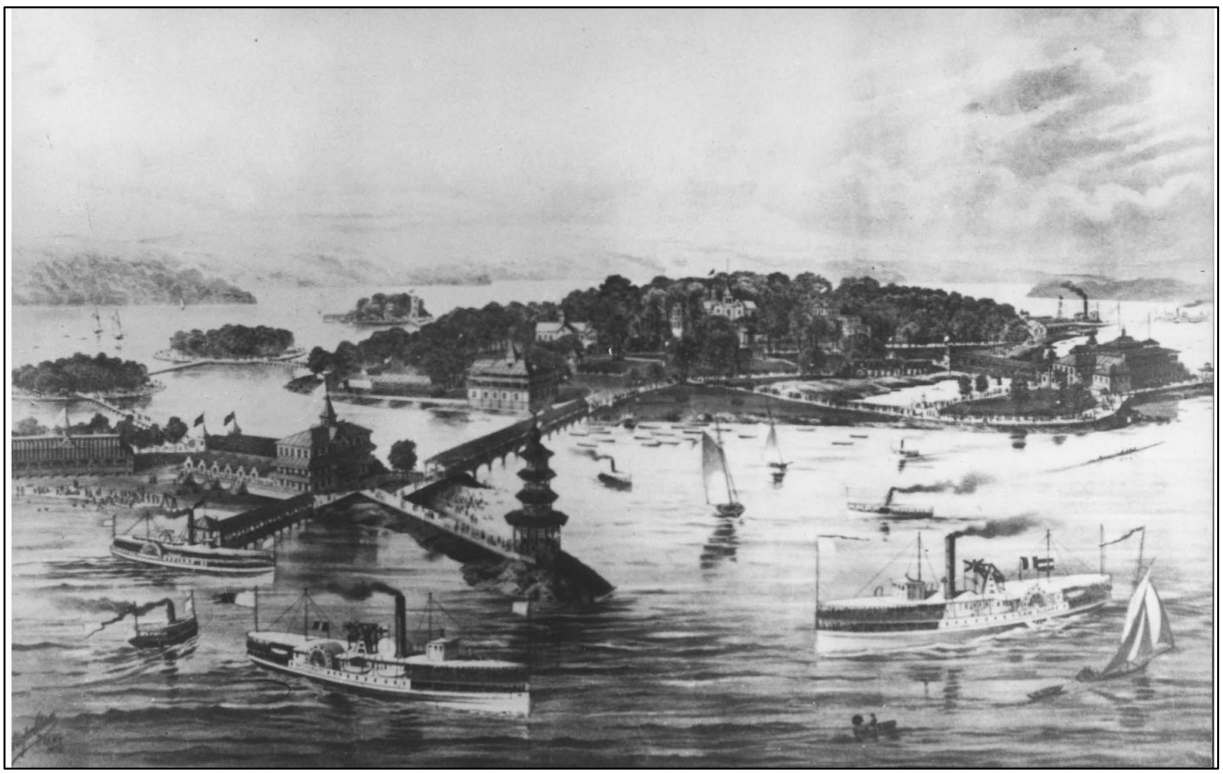

Figure 1. A photo/illustration of Glen Island's separated islands and footbridges dated 1881. (Source New Rochelle Library, 2019)

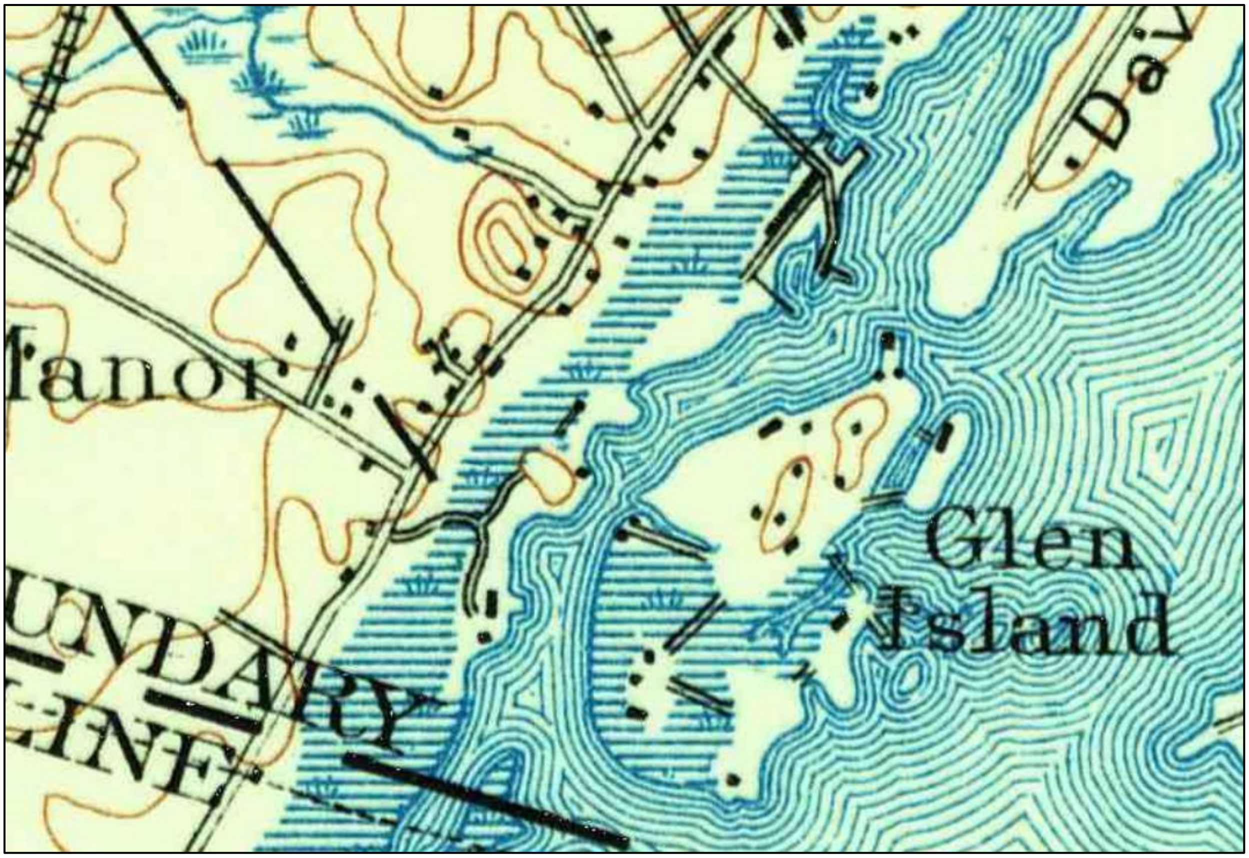

Figure 2. An 1897 Topographic Map shows shallow waters and some marshlands in between the four islands that now make up Glen Island Park. (US Geological Survey 1897)

At the end of the 19th century, Glen Island had not yet been modified to create the single island that is now present. A USGS Topographic map from that era shows several islands and footbridges with shallow waters and some marshlands between them (Figure 2). During the 20th century, the filling of land at Glen Island occurred incrementally. Aerial photography from 1925 shows that some of the shallow waters had been filled in to produce what was nearly a single land mass (Figure 3, top). Current satellite images show that additional fill has occurred to provide additional parking areas and green space (Figure 3, bottom).

Currently, Glen Island is a 64.4-acre park that is heavily used as a public beach and offers shoreline fishing opportunities (City of New Rochelle, 2016). The Glen Island Harbor Club restaurant also exists on site.

It should be acknowledged that the town of New Rochelle was formed on ancestral Siwanoy territory, as was the case for many towns in Westchester County. In the 1600s, thousands of Siwanoy lives were lost due to war with Dutch settlers and the Pound Ridge massacre of 1644 (Tribal Council of the Siwanoy Nation, n.d.). In the face of these tragedies, the lands of New Rochelle NY were acquired by the Englishman Thomas Pell who had befriended the leader of the Siwanoy, Chief Wampage. The lands were transferred through several treaties in 1654 and 1658 (New Amsterdam History Center, n.d.).

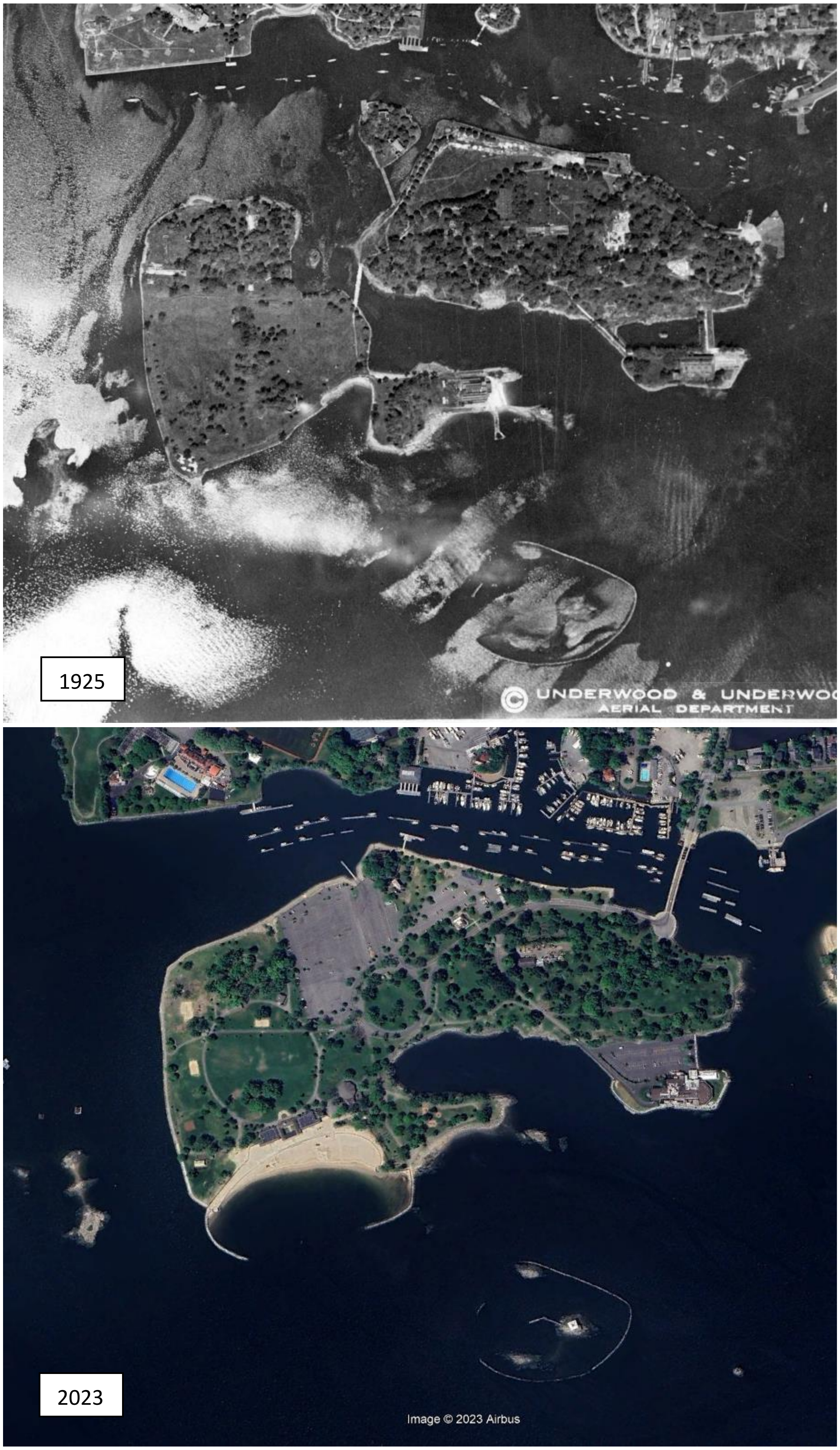

Figure 3. Aerial photographs of Glen Island from 1925 (top) and 2023 (bottom)
Photo sources: top Westchester County Historic Aerial Collection 2023, bottom Google © 2023.

ENVIRONMENTAL ASSETS

An environmental survey of the southern half of Glen Island Park was completed in May of 2023 by Westchester County Parks (Westchester County Parks Conservation Division, 2023). This survey found significant ecological assets in the park including the following species:

- Selection of Birds Present
    - Osprey *(State Species of Special Concern)*;
    - Common Tern *(State Threatened)*;
    - Snowy Egret;
    - Mallard;
    - Brant;
    - Canada Goose;
    - Oyster Catcher;
    - Cormorant;
- Selection of Crustaceans, Mollusks, and Jellyfish
    - Eastern Oyster *(State High Priority Species of Greatest Conservation Need)*;
    - Atlantic Ribbed Mussel;
    - Asian Shore Crab;
    - Horseshoe Crab

These results find that there are robust ecological aspects to Glen Island Park. As will be discussed below, the addition of some marsh habitat would likely significantly enhance the biodiversity of the park, among other benefits. This could perhaps take the form of a living shoreline that would provide dual ecological and flood-protection benefits.

THREATS TO GLEN ISLAND

SEA-LEVEL RISE AND CHANGING INTERTIDAL FOOTPRINT

The coast of Glen Island is currently augmented by well-maintained shoreline protection structures (City of New Rochelle, 2016). However, these structures were not necessarily designed to protect against future sea-level rise. Nuisance flooding, especially of the parking lot area, already occurs regularly. Perhaps due in part to this type of flooding, Glen Island trees have seen losses in recent years. In addition, the Ash trees on site are generally in decline due to emerald ash borer infestation (Westchester County Parks Conservation Division, 2023).

Glen Island was not included in this marsh conservation project due to its current marsh assets. Instead it is included because, without additional action, under most sea-level rise scenarios, much of the land of the island is predicted to become intertidal and potentially could host coastal marsh habitat. The basis for this prediction is a model driven by the New York Governor's office 2016 SLR scenarios for planning (Propato et al., 2018).

The combination of land elevations, sea-level rise scenarios, and tide ranges examined in this analysis found Glen Island to be especially vulnerable to additional flooding by mid-century. For example, under what has been defined as a "medium" SLR Scenario (0.91 meters by 2100), most of the southern half of Glen Island would become flooded by 2070 and by 2100 the majority of the island would be flooded each month (high-marsh habitat; Figure 5). In the high-SLR scenario (1.9 meters by 2100), extensive monthly flooding on the island would occur as early as 2040 and the majority of the island would be predicted flooded *daily* by 2100 (low marsh habitat; Figure 6).

Based on this analysis, it is likely that some action in coming decades will be required to protect Glen Island from future rising sea levels. Possible actions could include

- building a seawall around the island,
- bringing in additional fill as was done to create much of the island,
- allowing for some marsh habitat to provide ecological, recreational, and flood-protection benefits,
- or some combination of the approaches above.

These management approaches will be considered in the planning portion of this document, below.

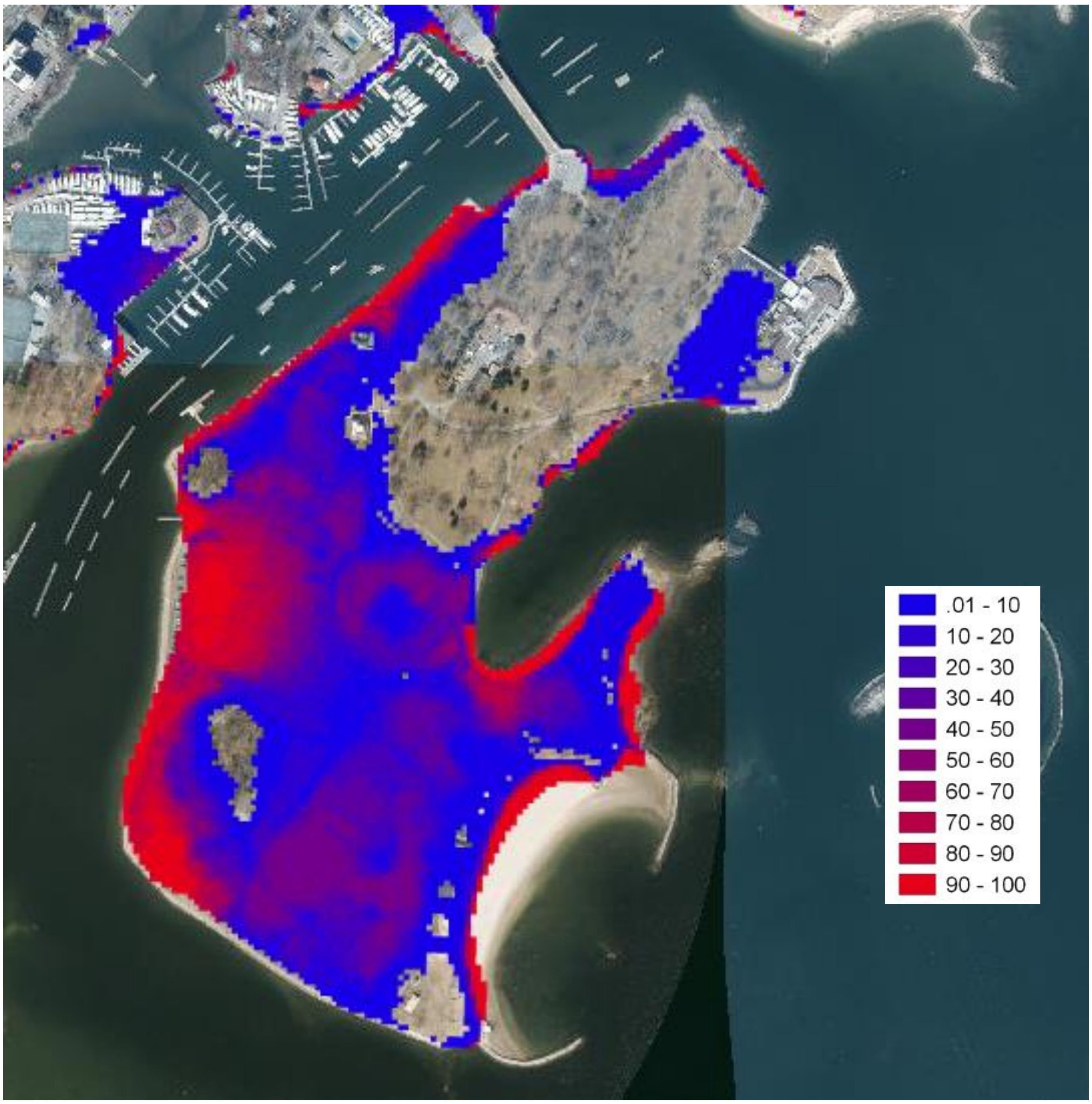

Figure 4. Likelihood of lands flooding at least once per month by 2040 (Propato et al., 2018) The red areas are most likely to flood.

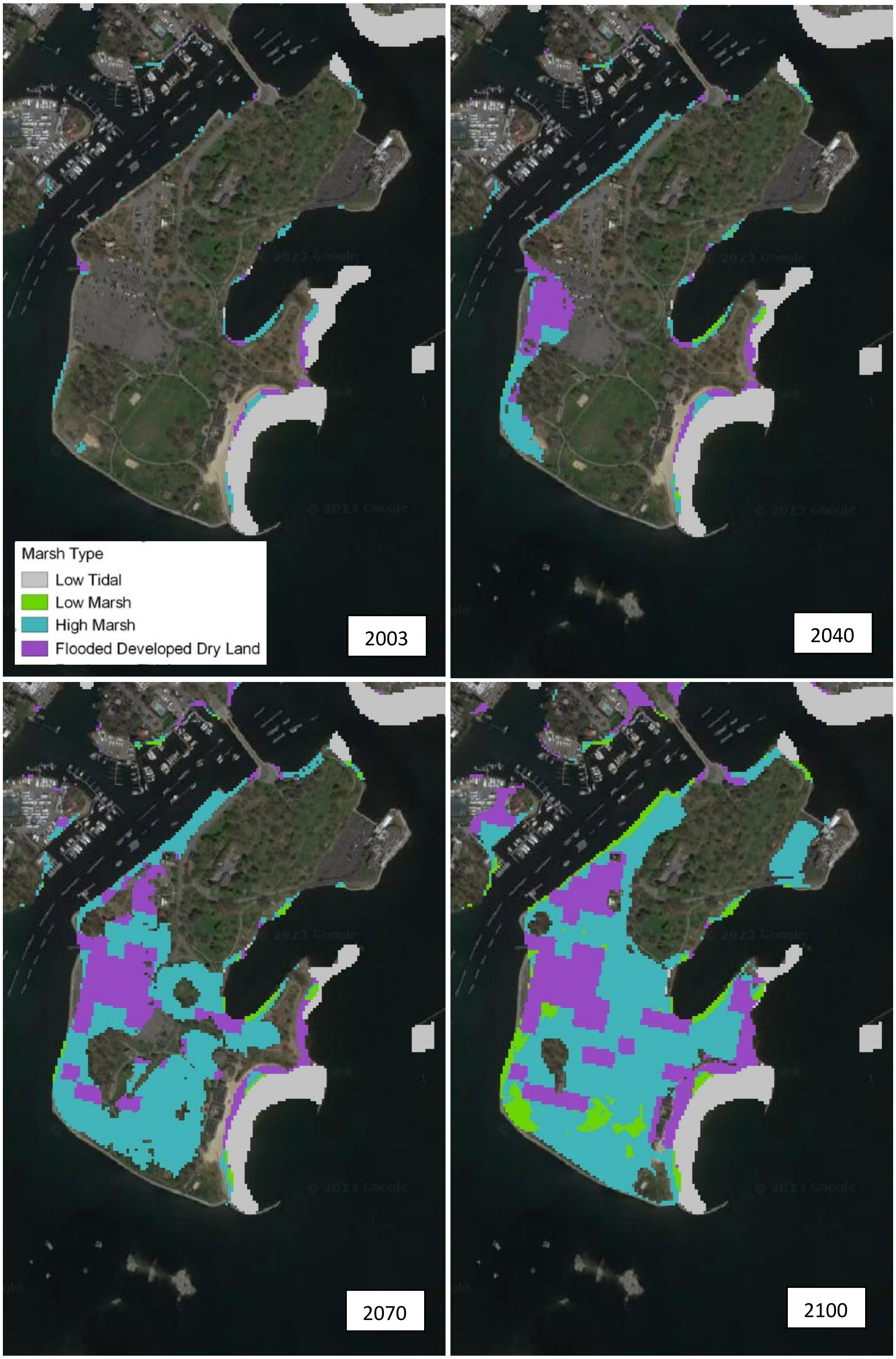

Figure 5. Predicted land cover through 2100 under a Medium SLR Scenario for Glen Island (0.91 meters by 2100)

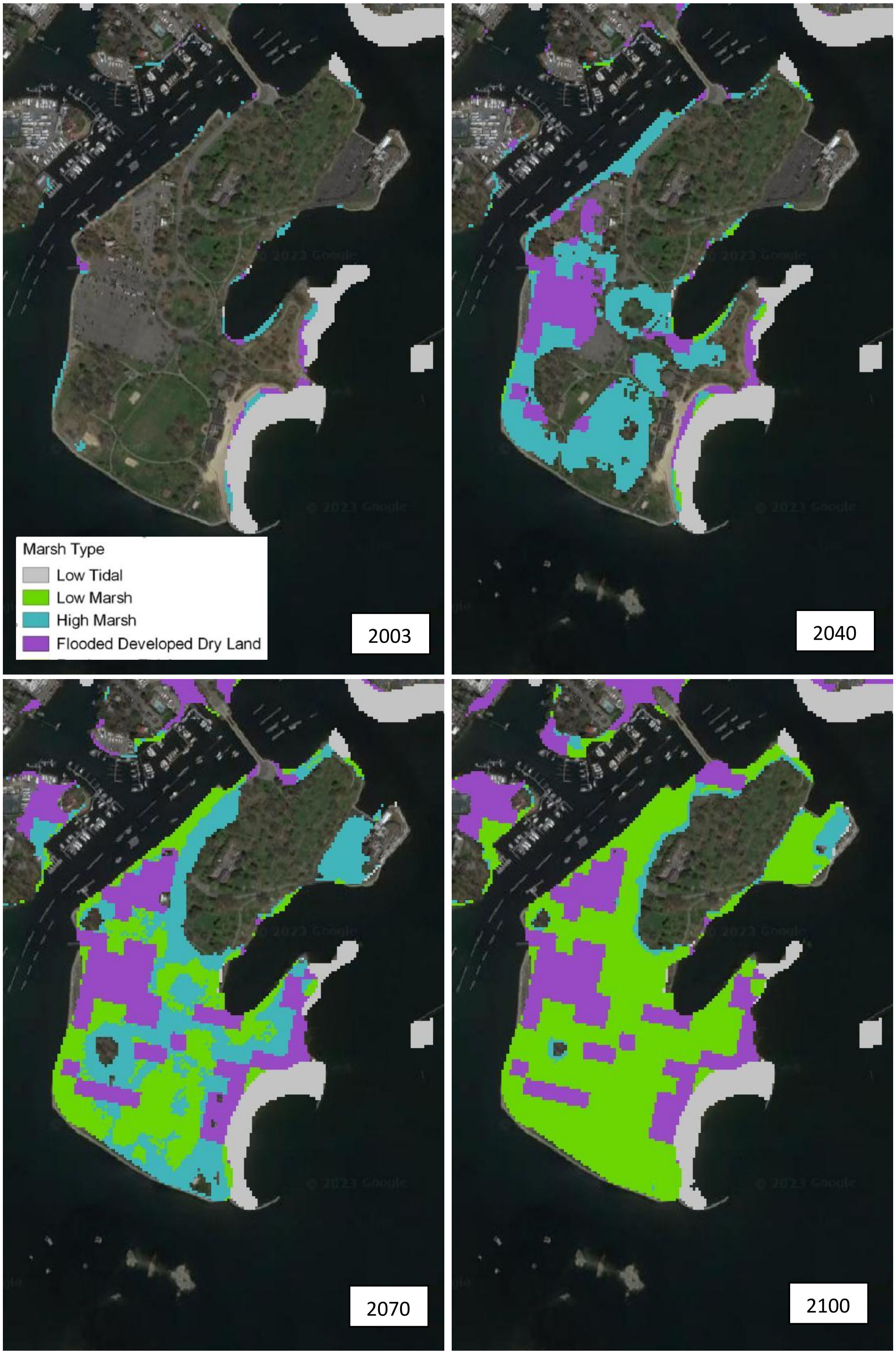

Figure 6. Predicted land cover through 2100 under a High SLR Scenario for Glen Island (1.9 meters by 2100)

WATER QUALITY INDICATORS

The Save the Sound beach report has given Glen Island Park an A+ for each of the years 2020-2022 based on excellent readings of fecal bacteria levels (Save the Sound 2023). Enterococci counts have consistently passed the NY State criteria for marine-swimming water quality under both wet and dry conditions (Save the Sound 2023).

Other water quality indicators have been somewhat less consistent. For example, there are two locations relevant to Glen Island that were individually assessed for water quality— New Rochelle Harbor that received a B grade[1], and Eastern Narrows that received a C grade (Figure 7). More information on local water quality may be found on the Sound Health Explorer: https://soundhealthexplorer.org/fishable/.

Some of the problem areas in terms of water quality include New Rochelle Harbor receiving the grade of F for anoxia, when water is depleted of oxygen which is often an indication of nitrogen pollution. The Eastern Narrows received a D for anoxia, and a C for relatively high levels of dissolved organic matter and chlorophyll a.

Figure 7. Sound Health Explorer Grades Relevant to the waters surrounding Glen Island Park. (Save The Sound, 2022.)

In general, the water quality around Glen Island Park is great for beachgoers and likely adequate for most forms of ecology, but continued improvements in limiting nutrient and organic matter pollution will ensure that the water around the park does not inhibit future human uses or ecological health.

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[1] Grades range from A to F like traditional classroom grades. "Grades for open water regions are created by comparing 4 indicators (dissolved oxygen, chlorophyll a, water clarity and dissolved organic carbon) to scientifically derived goals, or thresholds. These indicators are combined into an overarching Water Quality Index, which is presented as a regional open water grade." (Save the Sound 2023)

POTENTIAL BENEFITS FROM NEW MARSHES & ADJACENT HABITAT

In the future, if some of the current shoreline hardening at Glen Island were to be replaced with a living shoreline, including emergent marsh habitats, both human-centered and ecological benefits could accrue. Recently, an expert and stakeholder panel developed a list of “ecosystem services” that are provided by New York State marshes and those included the following categories (Propato et al. 2018):

- Wave attenuation/Flood damage reduction
- Habitat
- Water-Quality Protection
- Recreation
- Political/Cultural/Historic value

Discussion of these specific benefits, and how they could pertain to Glen Island follows.

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 (O’Donnell. 2017).

This service is especially beneficial to coastal lands that face great risks with climate change implications, including increases in extreme weather events (e.g., storms, hurricanes, etc.). For example, a 2017 study found that wetlands prevented hundreds of millions of dollars in direct flood damage during Hurricane Sandy and also that properties behind a marshes, on average, saved 16% in flood losses every year compared to properties where marshes had been lost (Narayan et al, 2017). Another study of Hurricane Sandy found that the presence of marsh vegetation substantially mitigated infrastructure damage to the shoreline and that relative structural loss was correlated to the percent of wetland cover (Sheng et al. 2021).

Given the risks that Glen Island faces in terms sea-level rise, the addition of coastal marshes or conversion of some shoreline to coastal marshes could provide long term benefits in terms of preventing erosive losses.

HABITAT

As noted above, Glen Island already has notable ecological resources; these resources would be significantly augmented by the addition of marsh lands. 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.

Salt marshes in Long Island Sound 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.

BIRDS

Marsh habitat is a critical component for the success of numerous bird species found throughout the Long Island Sound. 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. 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.

Birds are drawn to salt marshes partially by the diversity of marsh plant species. This diversity 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*). Additionally, in the Long Island Sound, the invasive plant species, common reed (*Phragmites australis)*, provides habitat for some bird species (Benoit and Askins 1999). If these habitats become available locally, wading birds are known to inhabit this portion of the Sound. For example, black crowned night heron and double crested cormorant have nested in nearby Huckleberry Island (Audubon 2022).

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).

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.

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 often 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. 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).

WATER QUALITY PROTECTION (NUTRIENT SEQUESTRATION AND DENITRIFICATION)

Tidal marshes can be also 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.

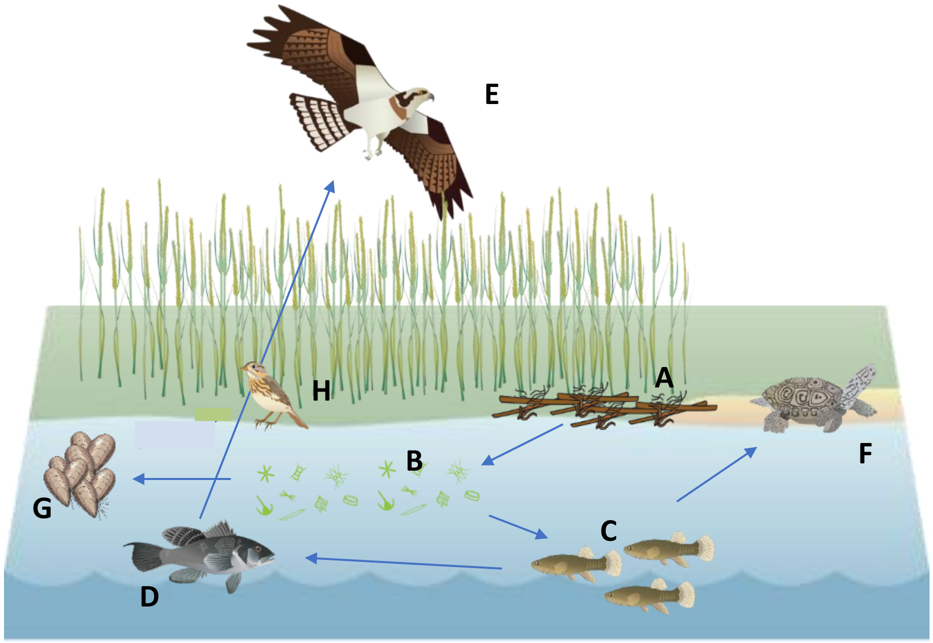

Figure 8. Conceptual Diagram of a Salt Marsh Food Web

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) that are consumed by crabs and shorebirds. Two additional pathways are created because 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 consumed by the top of the food chain – the osprey (E). The saltmarsh sparrow (H) also consumes insects, amphipods and spiders found in the high-marsh habitat. Figure Courtesy of Cayla Sullivan, USEPA.

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.

Unfortunately, if marshes are consistently exposed to nutrient levels that are too high, this can be devastating to their own viability. Specifically, under consistently eutrophic conditions, marshes have been found to produce more above-ground growth than roots, and the below-ground biomass of bank-stabilizing roots is reduced (Deegan et al, 2012). This can result in marsh collapse and conversion to non-vegetated mudflats. Deegen et al, 2012 noted that "current nutrient loading rates to many coastal ecosystems have overwhelmed the capacity of marshes to remove nitrogen without deleterious effects." In summary, marshlands can both improve local water quality, but also are vulnerable to excess nutrients if external sources are not controlled.

RECREATION AND CULTURAL VALUE

As many New York communities with existing wetlands have found, the presence of emergent marsh habitat can provide avenues for additional recreation including canoeing and kayaking, fishing, and wildlife viewing. Trails, board walks and piers, and launches for non-motorized boats may be added to augment these benefits. An existing boat ramp already provides kayaking and canoeing access at the park from April to October (Westchester County Parks, 2023). Additional fishers, kayakers, and canoeists will likely be drawn to a new ecological feature and the diversity of birds and habitat that it provides.

Marshlands and living shorelines have the potential to provide educational benefits as well. Environmental education could potentially highlight the value of the restored coastal ecology as well as the unique history of the island.

In terms of environmental justice, Glen Island is located in a "Potential Environmental Justice Area" based on New York's 2022 survey (NYSDEC 2022). Environmental justice efforts focus on improving the environment in communities, specifically minority and low-income communities (NYSDEC 2022). Glen Island is located in a U.S. Census block group that has this designation due to the percentage of minority populations. Because of this, adding ecological features to Glen Island can also help in providing natural-area access to underserved communities.

Finally, given the choice of management options under sea-level rise, added marshlands would likely have the greatest potential to improve recreational activities at the park. For example, a living shoreline would provide a natural backdrop to beach visits and picnicking that would often be more desirable than a vertical seawall.

MARSH CONSERVATION PLANNING

LIVING SHORELINES

When looking toward future sea-levels, a "living shoreline" could potentially provide both ecological restoration of habitat and benefits to coastal resilience and upland infrastructure. A living shoreline is a nature-based or soft structural measure to protect coastal lands. This type of construction enhances or includes characteristics of natural features and processes by constructing nature-based features, typically providing additional co-benefits like improving water quality and habitat (NYSDEC and NYSDOS 2020). Living shoreline projects have recently been completed in Alley Pond Park in Queens, at Shorefront Park in Patchogue, and Jamaica Bay Wildlife Refuge in Queens, NY. A living shoreline is planned at the Edith Read Wildlife Sanctuary in Rye. Marsh restoration and culvert resizing to improve marsh habitat has also been occurring in Pelham Bay Park, just south of Glen Island.

Living shorelines may be narrow, or an expansion to further meadow marshes can also be achieved by some degree of shoreline retreat. For example, Figure 6 shows that as early as 2040 some acreage on the westernmost portion of the island is already highly likely to flood at least once per month, making some of that terrain a potential emergent marsh habitat (excluding the impervious parking lot area). For any proposed project, the degree of ecological and wave-attenuation benefits will be closely tied to the extent of marshlands that are added. Because of this, the potential for ecological-based funding mechanisms to assist in funding park flood protection would also likely be increased.

One benefit of nature-based solutions to sea level rise is that, unlike gray infrastructure, marshes will move vertically in response to water levels and can maintain their relative position against moderate rates of sea-level rise (Kirwan and Megonigal, 2013). However, for this dynamic to be relevant, and for coastal wetlands restoration and nature-based solutions to be successful, an adequate sediment supply is required (Liu et al. 2013). Local sediment supply is a complex interplay between upstream river management, river flows, and currents and marine processes within Long Island Sound (Liu et al. 2013). However, one methods that can potentially be used to promote the retention of sediment by local marshes is the construction of adjacent oyster breakwater reefs. Like the marshes themselves, oyster reefs can act as ecological engineers. Oyster reefs have been shown to reduce erosion, trap suspended sediment, and support saltmarsh expansion (Chowdhury et al., 2019). Oyster reefs have been established in the Bronx River to the south (NYC Parks; NYNJ Harbor Estuary Program) and are being planned for City Island (City Island Oyster Reef Program). As Westchester County is uncertified for oyster harvesting, the purpose of these reefs would be for sediment retention, wave attenuation, and habitat benefits and some measures to prevent shellfishing might need to be implemented. Any project with shellfish implications would need to contact a regional NYSDEC permit administrator prior to performing that work.

A nearby living shoreline installation in Stratford Point Connecticut may provide some examples of the benefits of combined reef structures and living shorelines and also provide guidance based on lessons learned. The primary goals of the Connecticut project were erosion control, sediment deposition, and habitat restoration and ecosystem services (Mattei 2022). A study of the project's successes measured significant soil accumulation and wave attenuation (30-40%) after the installation of reef balls and planting of marsh grasses (Mattei 2022).

Another nearby living shoreline project at Edith Read Sanctuary in Rye New York provides an ongoing example of reef balls being placed to improve soil accumulation. The June 2022 permit application notes that the project will also have educational benefits. "The use of a living shoreline strategy in such a publicly visible and highly trafficked location, in between Edith G. Read Natural Park and Playland Park, will provide educational and outreach possibilities." (SLR Engineering 2022)

Another example of a combined bulkhead, recreational area, and nature-based shoreline may be found in nearby Roberto Clemente State Park in New York City (Figure 9). This recent renovation included intertidal marsh habitat along with tide pools and pedestrian walkways to provide flood protection, habitat, and recreation in a single shoreline installation.

Figure 9 Bulkhead at Roberto Clemente State Park in New York City (Photo courtesy of New York Governor's Office)

State guidance is available to assist local governments and landowners implement and monitor 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
- *Statewide Shoreline Monitoring Framework: Measuring the resilience of shorelines across New York, NYSDOS 2022* https://dos.ny.gov/statewide-shoreline-monitoring-framework

Historical USGS maps suggest that the in-fill area of Glen Island at one point did have wetlands located within it (Figure 2). Because of this, funding may be available for marsh restoration projects at this site as well. 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 166 acres of tidal wetland habitat and are approximately one third of the way 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.

Incorporating nature-based approaches will also continue to be important when applying for NY State permitting for shoreline-engineering projects. Recognizing the importance of nature-based solutions, the State of New York enacted a Living Shorelines Bill in 2023 (act 5221-A). This act reads in part that the state will "give preference to a permit application for a shoreline management project based on nature-based solution design unless an alternative analysis containing a review of nature-based solutions that have been evaluated using the best available information shows that such approaches are not suitable." (https://legislation.nysenate.gov/pdf/bills/2023/A5221A)

ADDITION OF FILL

In most cases, the primary function of a living shoreline is the stabilization of the shoreline edge as opposed to flood mitigation (Miller et al., 2022). Given the sea-level rise projections illustrated above, to prevent overland flooding, a living shoreline at this site would likely need to be augmented with a berm, or the addition of fill to the central part of the island. As noted above, Glen Island Park was constructed using fill in historically open water areas. Because of this, the continuation of that process on current dry lands seems like a possibility to allow the park to continue to function into the future. However, the costs of fill sources and permitting will likely make this process take considerable time and money. If a berm were added as part of a living shoreline that could provide some similar protection, but drainage would need to be closely considered in such an engineering plan. Allowing for moderate shoreline retreat in some of the lowest-elevation areas could also reduce costs and increase the diversity of funding sources.

Vertical Seawalls

A vertical seawall or the increase in elevation of existing constructed shoreline at the park (Figure 9) would be another potential approach to reduce regular flooding at the park due to sea-level rise. However, if this approach is not augmented by raising dry land in the center of the park, there could be an impact of reduced visual sight lines, reducing recreational benefits. Furthermore, drainage and the future water table would need to be expressly considered so that inland ponding will not occur. As sea levels rise, fresh water tables will also rise, potentially resulting in soil saturation within the park (Rotzoll and Fletcher, 2013).

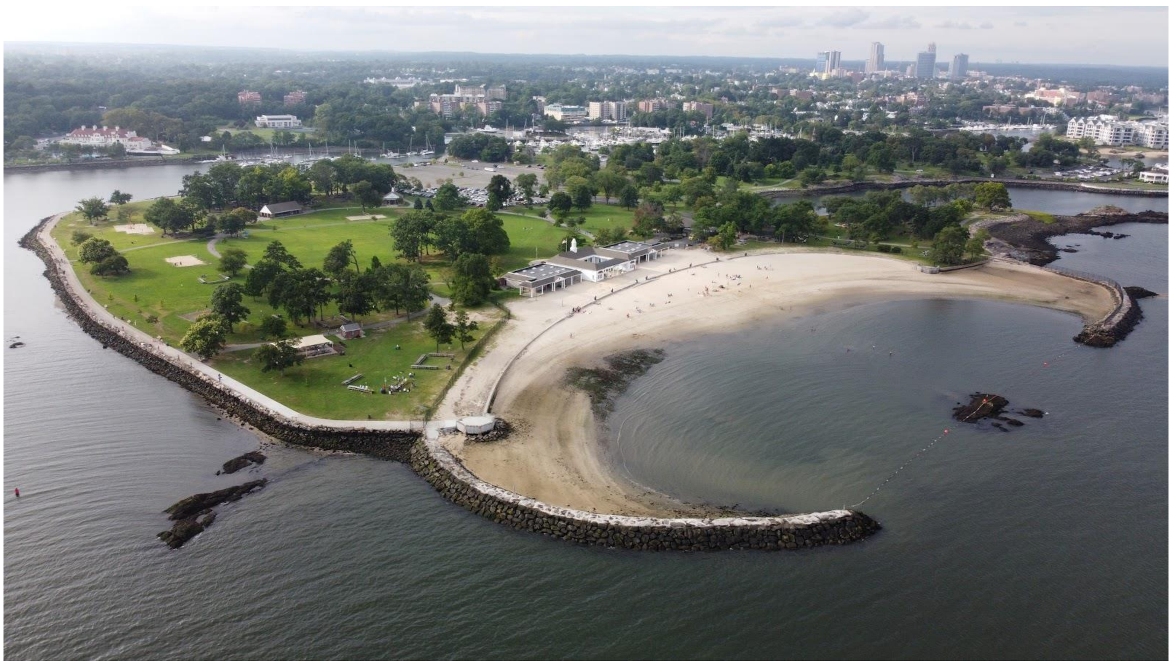

Figure 10. Glen Island Park photograph illustrating armored seawalls currently present (Source: Westchester County Parks Conservation Division, 2023)

Funding Sources

Focusing on nature-based solutions to help mitigate the risk of sea-level rise on Glen Island can potentially open up additional funding sources that would not be available for "gray infrastructure." Some examples of these types of funding sources and mechanisms are summarized here:

Long Island Sound Futures Fund

https://www.nfwf.org/programs/long-island-sound-futures-fund

Grants are available for habitat restoration, resilience, and water quality improvements. Grants range from $50K - $1.5M. Eligible applicants include non-profit 501(c) organizations, state government agencies, local government, municipal government, Tribal Governments and Organizations, and educational institutions. The Long Island Sound Futures Fund typically opens in early March, with applications due in May.

Long Island Sound Resilience Grant Writing Assistance Program

https://bit.ly/LISResilienceRFPInfo

This is a new opportunity for municipalities, community organizations, and nonprofits to get match-free monetary support to hire a grant-writing consultant to prepare applications for resilience and sustainability-focused projects benefiting Long Island Sound coastal communities. Awards range from $5,000-$9,950 per application directly to the consultant. Applications are accepted on a rolling basis. Applicants are encouraged to apply at least 6-8 weeks in advance of the grant opportunity deadline they would like to pursue.

NYS Consolidated Funding Application

https://apps.cio.ny.gov/apps/cfa/

A wide range of grant programs are available under the Consolidated Funding Application, released annually in May, including:

- NYSDEC Water Quality Improvement Project (WQIP) Program

  The Water Quality Improvement Project (WQIP) program is a competitive, reimbursement grant program that funds projects that directly improve water quality or aquatic habitat, promote flood risk reduction, restoration, and enhanced flood and climate resiliency, or protect a drinking water source. This program provides funding for project implementation/construction. Eligible applicants include municipalities, soil and water conservation districts, and non-profit organizations (for certain categories).

- Non-Agricultural Nonpoint Source Planning and Municipal Separate Storm Sewer System (MS4) Mapping Grant (NPG)

  The Non-Agricultural Nonpoint Source Planning and MS4 Mapping Grant (NPG) is a competitive, reimbursement grant program that funds planning reports for nonpoint source water quality improvement projects and mapping of Municipal Separate Storm Sewer Systems (MS4s). The program aims to prepare nonpoint source projects for construction and application for implementation funding, and to encourage and support cooperation among regulated MS4s to complete mapping of their stormwater system. Eligible applications include municipalities and soil and water conservation districts.

- NYSDEC Climate Smart Communities Grant Program

  The Climate Smart Communities (CSC) Grant program was established in 2016 to provide 50/50 matching grants to cities, towns, villages, and counties of the State of New York for eligible climate change mitigation, adaptation, and planning and assessment projects. This program provides grants of up to $2M for implementation of climate adaptation projects, including relocation or retrofits of critical infrastructure, living shorelines and other nature-based solutions, and replacing or right-sizing of flow barriers. Grants of up to $200K are also available for planning projects that build local capacity to respond to climate change and move municipalities toward designation as certified Climate Smart Communities. Municipalities do not need to be a registered or certified as a Climate Smart Community to apply for a grant.

- NYS Department of State (DOS) Local Waterfront Revitalization Program (LWRP) Grants

Grants are available for eligible villages, towns, and cities located along New York's coasts or designated inland waterways, or counties (with the consent and acting on behalf of one or more eligible villages, towns, cities) to advance the preparation or implementation of strategies for community and waterfront revitalization through the following grant categories: 1) Preparing or Updating a Local Waterfront Revitalization Program (LWRP) 2) Updating an LWRP to be more Resilient to Climate Risks 3) Preparing an LWRP Component, including a Watershed Management Plan, and 4) Implementing a Local Waterfront Revitalization Program or a completed LWRP Component

- NYS Environmental Facilities Corporation Green Innovation Grant Program (GIGP)

  Competitive grants are awarded annually to projects that improve water quality and mitigate the effects of climate change through the implementation of one or more of the following green practices: Green Stormwater Infrastructure, Energy Efficiency, Water Efficiency and Environmental Innovation. Eligible green infrastructure practices include bioretention, restoration of floodplains, riparian buffers, streams or wetlands, permeable pavement, stormwater harvesting and reuse, and stormwater street trees. Eligible applicants include municipalities, private entities, soil and water conservation districts, and state agencies. The maximum percentage grant is up to 90% of eligible project costs for a green stormwater infrastructure project in a municipality that meets the Median Household Income criteria, or that serves, protects, or benefits an environmental justice area. All other green infrastructure projects are eligible to receive up to a maximum of 75% of total eligible project costs.

NYS Environmental Bond Act

https://www.ny.gov/programs/clean-water-clean-air-and-green-jobs-environmental-bond-act

The unprecedented $4.2 billion Clean Water, Clean Air, and Green Jobs Environmental Bond Act prioritizes investments in environmental justice, climate change mitigation, shoreline restoration, flood resilience, water quality, open space conservation, recreational resources, and green jobs. State agencies, local governments, and partners will be able to access Environmental Bond Act funding over a multi-year process.

Federal Grant Opportunities

In addition to the funding sources listed above, funds may also be available through federal grants. Many grant opportunities for coastal restoration have been made possible by the "Climate Ready Coasts" provisions in the Bipartisan Infrastructure Law and Inflation Reduction Act. In April of 2023, 6.9 million dollars in coastal-restoration resources were allocated to New York State alone (NOAA 2023). These types of opportunities can be found by searching on "coastal restoration" at grants.gov (http://grants.gov). Most recently, an August 15, 2023 grant opportunity for "Transformational Habitat Restoration and Coastal Resilience Grants…" was announced with a November 17, 2023 application deadline (Funding Opportunity Number: NOAA-NMFS-HCPO-2023-2008081).

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