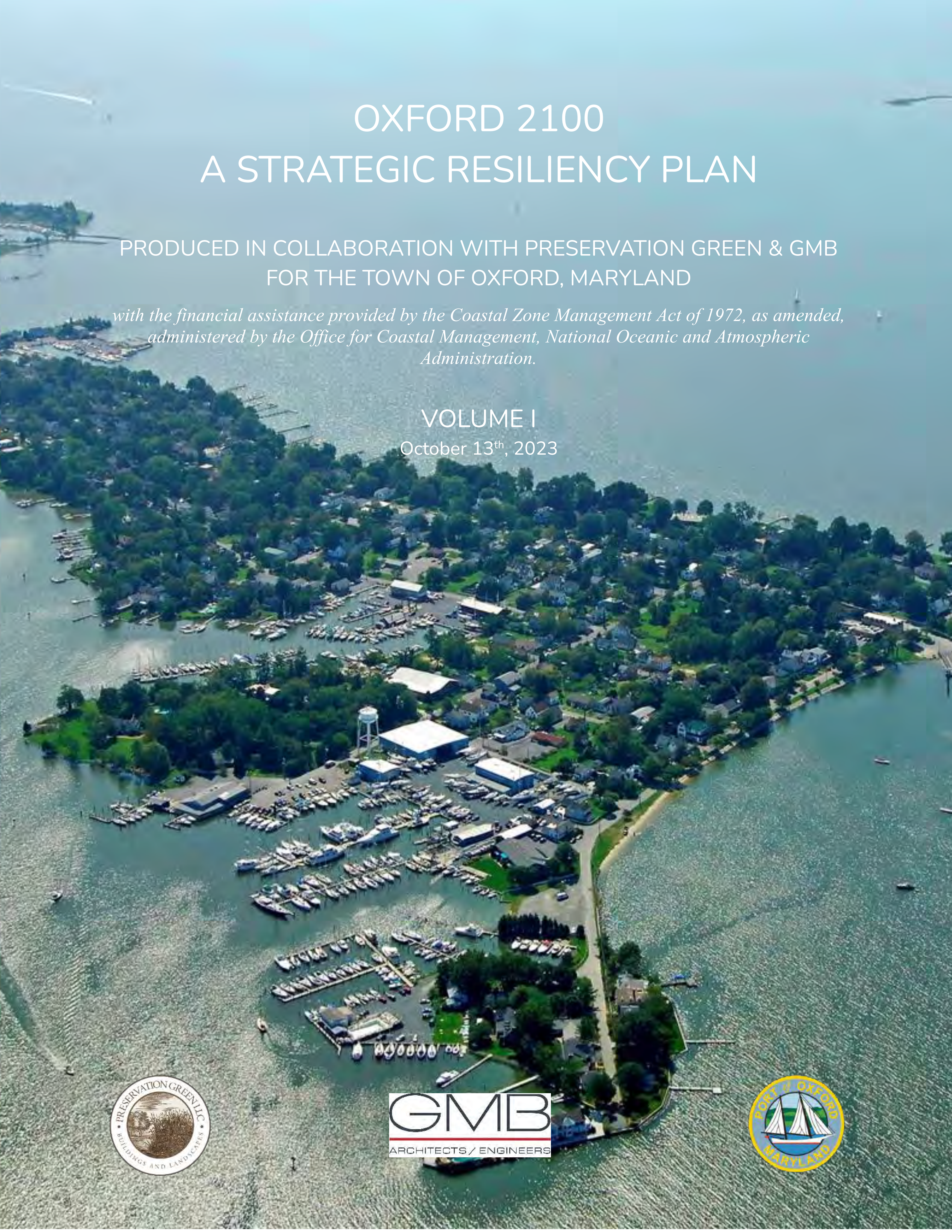

OXFORD 2100
A STRATEGIC RESILIENCY PLAN

PRODUCED IN COLLABORATION WITH PRESERVATION GREEN & GMB
FOR THE TOWN OF OXFORD, MARYLAND

with the financial assistance provided by the Coastal Zone Management Act of 1972, as amended, administered by the Office for Coastal Management, National Oceanic and Atmospheric Administration.

VOLUME I

October 13th, 2023

This *OXFORD 2100 A STRATEGIC RESILIENCY PLAN*
was prepared by PGLLC & GMB using Federal funds under award number NOS204190206 from NOAA, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of NOAA or the U.S. Department of Commerce.

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OXFORD'S PATH TO RESILIENCE

Background

The historic town of Oxford, founded in 1683 on Maryland's Eastern Shore, has faced numerous challenges throughout its existence. Today, it confronts a new threat—rising sea levels and intensified precipitation due to climate change. Oxford's unique geographic location makes it vulnerable to flooding, demanding a proactive approach to ensure its long-term sustainability.

Previous Initiatives

In 2013, Oxford initiated the Summer Event Series, a collaborative effort with organizations like the National Fish and Wildlife Foundation, the Eastern Shore Land Conservancy, and the Chesapeake Bay Foundation. These sessions led to the release of a comprehensive report on stormwater and flood management in 2013.

In 2021, with funding from the Maryland Department of Natural Resources (DNR) and the National Oceanic and Atmospheric Administration (NOAA), Oxford engaged graduate students from the University of Maryland in assessing the town's climate change impact by 2100. This project laid the foundation for the Oxford 2100 Strategic Visioning Project.

The Oxford 2100 A Strategic Visioning Project

This visionary project encompasses a range of strategies to enhance Oxford's resilience:

- Adapting to sea-level rise.
- Seizing opportunities presented by change, such as tourism and climate research.
- Establishing a new ferry terminal.
- Expanding wetlands where feasible.
- Promoting native plantings.
- Creating an extensive network of public boardwalks.

- Incorporating public overlooks and fishing piers.
- Elevating the causeway.
- Embracing oyster aquaculture.
- Implementing nature-based climate resilience strategies.

Challenges & Baseline Data

Oxford's topography and sea-level projections place it in a vulnerable position. With over 3.0 feet of sea-level rise projected by 2100, tidal inundation will become a frequent occurrence, exacerbated by tidal surges and extreme storms. Developing a long-range vision is crucial for Oxford's resilience and viability.

Community Engagement

Community involvement is pivotal for success. The report outlines a timeline for achieving goals, encourages regular reviews, updates, and community engagement to ensure progress toward resilience.

Design Considerations

Various factors, including topography, sea-level rise projections, best management practices, transportation options, and more, were considered in the development of the Strategic Vision.

Resilience Strategies

The report outlines a range of resilience strategies, from shoreline enhancements to public utility modifications and code updates.

Distinct Regions & Strategies

Distinct regions within Oxford require tailored strategies based on their unique characteristics and vulnerabilities. Recommendations are provided for each section.

Regional Perspective

The report considers Oxford's role in the broader region, addressing regional resiliency strategies, water-dependent commerce, transportation, recreation, legal concerns, and social and environmental justice.

Conclusion

The Oxford 2100 Strategic Visioning Project serves as a guiding document, adaptable for future adjustments. Short, mid, and long-term benchmarks are established to address vulnerabilities, offering a roadmap for a 100-year capital improvement program.

Oxford is committed to proactive climate change adaptation, aiming to coexist with water as it has for centuries.

I. INTRODUCTION & HISTORIC SIGNIFICANCE OF OXFORD

A. INTRODUCTION: A HISTORICAL CANVAS OF OXFORD'S RESILIENCE

The historic town of Oxford, founded in 1683 on Maryland's Eastern Shore, emerges as an enduring testament to resilience and evolution. As we embark on the journey of developing a comprehensive resiliency plan for Oxford, it's essential to delve into the rich tapestry of its past. This tapestry is woven with threads of British colonial rule, the American Revolution, the advent of industrialization, African American heritage, and the challenges and triumphs that have characterized the 20th and 21st centuries.

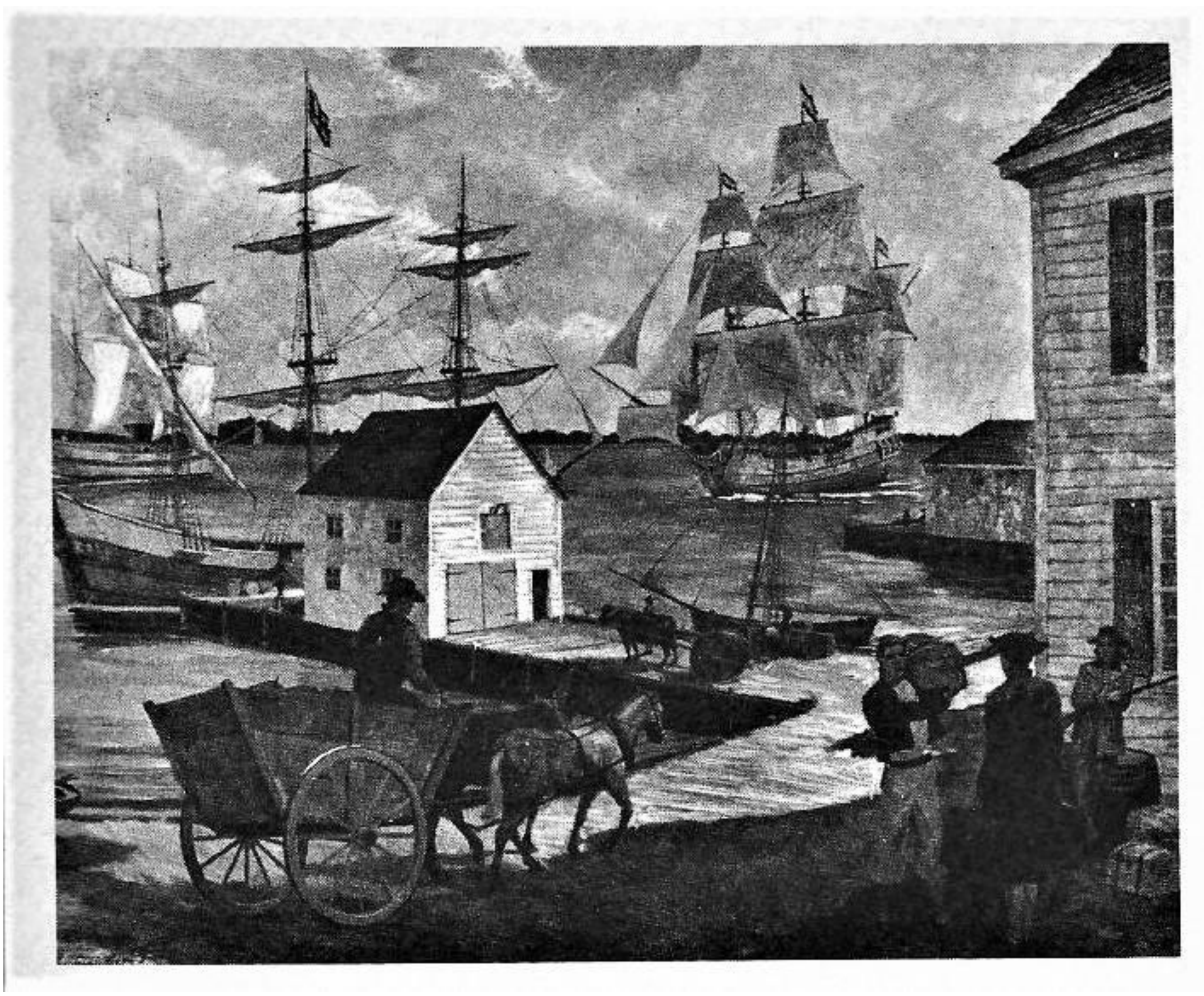

Fig. I.A.1. *The Port of Oxford under British Colonial Rule*
(Source: "A Port of Entry: Oxford, Maryland" by Jane Foster Tucker)

B. BRITISH COLONIAL RULE: ANCHORING OXFORD'S MARITIME IDENTITY

Established in 1683, The Town of Oxford, nestled on the Eastern Shore of Maryland, stands as one of the oldest continuously inhabited towns in the state and, by extension, the United States. Originally positioned on the elevated of two low-lying peninsulas along the southern bank of the Tred Avon River, near its confluence with the Choptank River, Oxford, initially known as Williamstadt, thrived as a hub of commerce with England, exporting a diverse range of goods including cotton, tobacco, hides, and lumber.

In the same year of its founding, the Talbot County Court granted authorization for the establishment of the Oxford / Bellevue Ferry, an enterprise that endures as the nation's longest-standing privately owned ferry operation, in continuous service to this day.

Under British colonial rule, Oxford rose to notable prominence, a reputation largely attributed to its status as one of just two officially recognized ports of entry for the British Province of Maryland. Its counterpart was the nascent town of Anne Arundel, later rechristened Annapolis.

In this era, Oxford flourished as an international maritime hub, chiefly serving the lucrative and influential vernacular tobacco industry. The town's significance as a pivotal player in trade is unsurprising, considering its distinction as the sole location of the official Middle Passage Marker on Maryland's Eastern Shore. This recognition, acknowledged by the UNESCO World Heritage Foundation and the United Nations, underscores the profound historical resonance of Oxford as a testament to the transatlantic slave trade's impact on the region.

C. THE REVOLUTIONARY WAR: TRANSFORMATIONS AND EMINENT FIGURES

The American Revolution wielded a swift and profound influence on Oxford, precipitating the cessation of its prominence and prosperity due to the decline of maritime trade and the replacement of tobacco with wheat as the primary cash crop. Consequently, the town's population dwindled to a mere fraction, numbering fewer than one hundred residents.

However, even amid this decline, the American Revolution had an unexpected consequence: it served as a catalyst for the presence and visits of several eminent figures, who left an indelible mark on Oxford's historical narrative. Among these distinguished individuals were President George Washington, Financier William Morris, Le Marquis de Lafayette Gilbert du Motier, Col. Jeremiah Banning, and other notable figures.

Oxford's earliest inhabitants included a cadre of remarkable personalities, each leaving an imprint on the inception of both the state of Maryland and the United States of America. Among them was Robert Morris Jr., an esteemed Founding Father who appended his signature to the Declaration of Independence, the Articles of Confederation, and the United States Constitution. Morris wielded influence as a member of the Pennsylvania Legislature, the Second Continental Congress, and the United States Senate. His role as Superintendent of Finance of the United States earned him the moniker "Financier of the Revolution."

Another prominent figure who called Oxford home was Lieutenant Colonel Tench Tilghman. He played a crucial role in the Revolutionary Army as Aide-de-Camp to General George Washington, contributing significantly to the success of the Revolutionary War through his invaluable service.

Oxford was also the residence of other distinguished individuals who played pivotal roles in shaping the state of Maryland and the United States. Reverend Thomas Bacon, the compiler of the first Maryland Statutes, and Matthew Tilghman were notable among them.

Matthew Tilghman's contributions were especially notable, including his early membership in Maryland's Committee of Correspondence, leadership during the Revolutionary era, role as Chairman of the Committee of Safety, presidency of the Revolutionary Assembly and Annapolis Convention, steadfast support for the Declaration of Independence, and instrumental involvement in drafting Maryland's Constitution, known as the Charter of Rights and Plan of Government. Moreover, Matthew Tilghman held the esteemed position of the first Senator of the State of Maryland, further cementing his legacy.

***Fig. I.C.1**. Robert Morris Inn, Oldest full service Inn in the United States visited by many dignitaries of the Revolution*
(Source: Post Card, Talbot County Free Library)

***Fig. I.C.2**. Robert Morris, United States Founding Father & "Financier of the Revolution"*
(Source: Portrait by Charles Wilson Peale)

***Fig. I.C.3**. George Washington with Lafayette & Tench Tilghman at Yorktown*
(Source: Portrait by Charles Wilson Peale)

D. THE CIVIL WAR, INDUSTRIALIZATION & THE AMERICAN RAILROAD

In the year 1847, General Tench Tilghman, the grandson of Colonel Tench Tilghman, undertook the establishment of the Maryland Military Academy with the aspiration of rejuvenating Oxford's vitality. This academy later supplied numerous cadets who would serve during the Civil War. However, the academy's fate took a tragic turn as it was ultimately consumed by fire, leading to its destruction.

General Tilghman's endeavors bore fruit when he recognized and harnessed the surging demand for oysters within the United States. Capitalizing on this phenomenon, coupled with the concurrent expansion of the railroad network during the post-Civil War reconstruction and the era of industrialization, brought newfound prosperity to Oxford. This period saw the emergence of what became known as the Victorian Oyster craze, a phenomenon that swept across the entire Chesapeake Bay Area. General Tilghman's initiative played a pivotal role in establishing a railroad terminus for the Maryland Delaware Railroad Company in Oxford in the year 1872.

This pivotal move heralded a fresh chapter of success for Oxford, ushering in a period of newfound affluence for the town. The railroad terminus worked in tandem with an adjoining Steamboat Port, interconnecting the terminus with the Tred Avon River, and subsequently, the Western Shores of Maryland and Virginia. Together, these modes of transportation extended Oxford's reach to major cities in the Northeast, including New York, Philadelphia, Washington D.C., Boston, and Baltimore. This expansion of connectivity broadened the town's sphere of influence, fostering a thriving export network. In this transformation, traditional farming exports were overshadowed by the rise of fishing, maritime industries, recreational pursuits, and seaside tourism, which formed the backbone of the region's economic base. This transition was further propelled by the establishment of boatyards, seafood packing plants, and other related industries, leading to a notable surge in both local economy and population.

In 1885, Confederate Colonel Oswald Tilghman, the son of General Tench Tilghman, made his mark by establishing the Maryland Military & Naval Academy. This institution served as a preparatory school for aspirants of the U.S. Naval Academy and the U.S. Military Academy. Concurrently, the Oxford Boatyard, an establishment that continues to operate to this day, was founded. Adding to Oxford's historical legacy, Molly Stewart, a resident of the town, secured her place in history as the first female Postmistress of the United States. Her appointment by President Rutherford B. Hayes marked a milestone in the town's annals.

***Fig. I.D.1**. Photo of Oxford Terminus Train Station (no longer standing)*
(Source: aabcd6f34241e5ca7d5d181ad39cd2a1.jpg (800×468) (pinimg.com))

***Fig. I.D.2**. Photo of Oyster Canning Houses by Oxford resident Howard C. Hopkins*
(Source: 4020211-R01-047.jpg (600×399) (oxfordmuseummd.org))

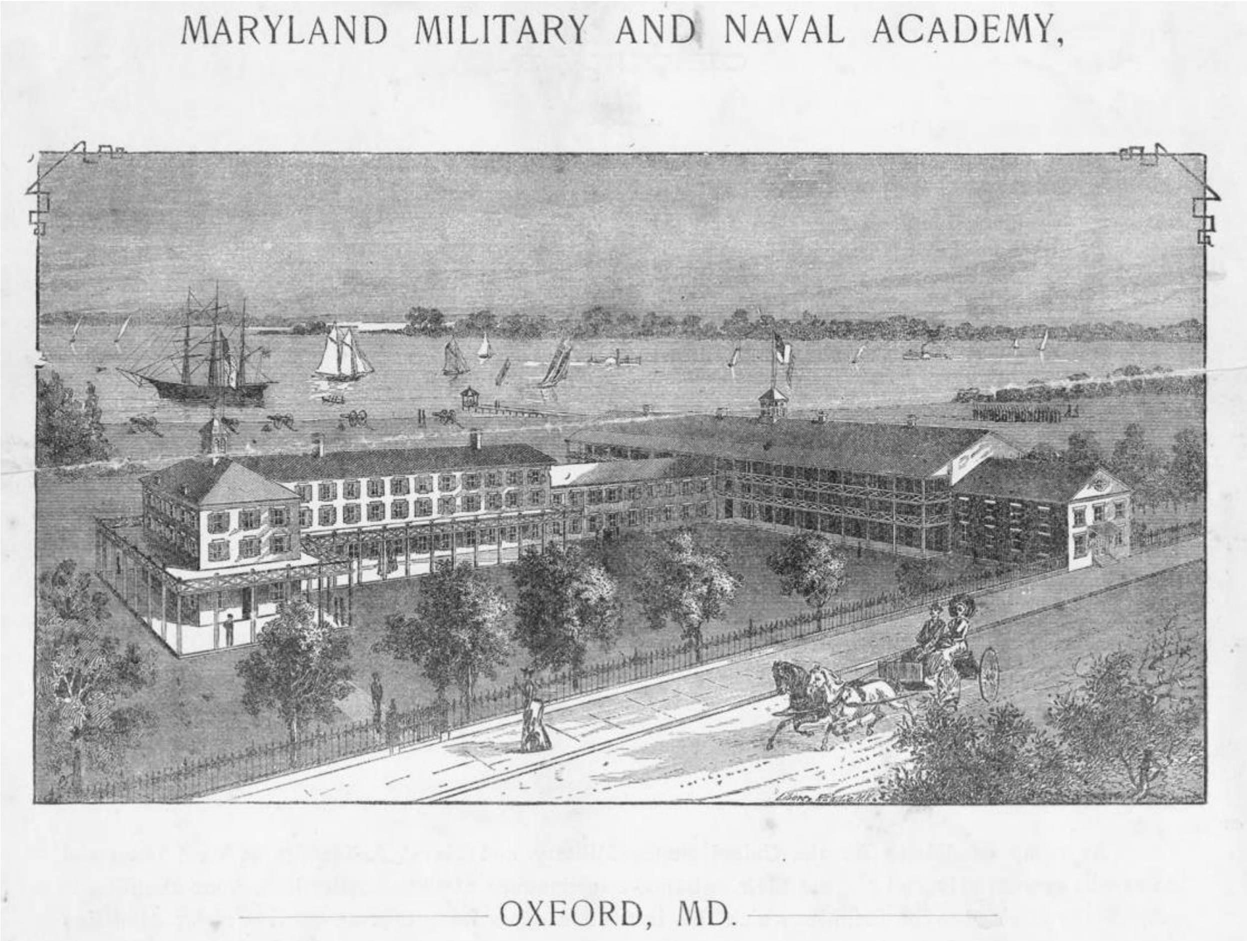

Fig. I.D.3. *Pamphlet of the Maryland Military & Naval Academy in Oxford (Source: "Images of America" by Julie Wells, Stuart Parnes & Leo Nollmeyer)*

Fig. I.D.4. *Aerial Photo of the Oxford Boatyard, Originally Brewer's Boatyard at Safe Harbor (Source: b90c47dfaf062a2476360e82a8ced537758fc30be761e3b6eae27c030b50be11.jpg (3408×1518) (marinas.com))*

E. AFRICAN AMERICAN HERITAGE: A STORY OF RESILIENCE

Distinguished by its historical significance, Oxford's character is uniquely shaped by the intricate contributions of both free and enslaved African Americans to its growth, prominence, and prosperity. Amid the complex backdrop of its association with slavery, the town's narrative is also intertwined with the pivotal roles African Americans played in shaping its trajectory. Notably, many of them answered the call to arms during the Civil War, fighting resolutely for the abolition of slavery. Oxford's ferry dock stood as a local embarkation point for those who enlisted, becoming a poignant symbol of African American participation in this transformative era.

***Fig. I.E.1**. Union Colored Troops of the Eastern Shore*
(Source: Emancipation in Oxford: Joining the United States Colored Troops - Secrets of the Eastern Shore)

Throughout the oyster boom, African American individuals played a pivotal role in revitalizing the town, assuming roles as watermen, pickers, packers, store proprietors, industrialists, and owners of sail repair shops. Their influence extended beyond economic endeavors to encompass vital roles in town governance, law enforcement, and leadership positions within esteemed institutions such as the Oxford Community Center, the Oxford Museum, and the John Wesley Preservation Society.

A testament to their enduring legacy, the first African American Chapter of the Oddfellows Hall was erected in 1894, serving as a fraternal lodge that provided a sense of belonging and community to African Americans residing in Oxford. This historic edifice still stands today, a tangible link to the past.

Captain Jack Waters, heralded as the proprietor of the first Waterman's business in Oxford, left an indelible mark on the town's history. His grandson, Waters Edward Turpin, a multifaceted talent encompassing American Novelist, Professor, playwright, and textbook author, weaved Oxford's rich oral histories into his literary creations. Notably, works such as "These Low Grounds" and "Rootless" encapsulated the essence of Oxford, with the latter inspiring the renowned 1976 novel and subsequent 1977 television mini-series, "Roots," authored by Alex Haley.

Even amid periods marked by expressions of persecution and exclusion against African Americans in adjacent towns and across Maryland and the United States, Oxford retained a relatively more congenial and inclusive atmosphere. This enduring spirit of inclusivity remains woven into the fabric of Oxford's history, a testament to the resilience and contributions of its African American residents.

Fig. I.E.2. *First African American Odd Fellow's Hall in the United States*
(Source: Home - The Oxford Museum (oxfordmuseummd.org))

F. THE 20TH CENTURY: FROM INDUSTRY TO LEISURE

The dawn of the 20th century marked a zenith in Oxford's history, with a population cresting at 1,243 residents in the year 1900. However, this peak would signal the beginning of a gradual decline that spanned the entire century and extended well into the 21st century, shaping the town's trajectory in unforeseen ways.

In 1910, The Kuehner Company emerged onto Oxford's industrial scene, establishing a manufacturing plant specializing in four to six horsepower gasoline and marine engines. As the world grappled with the upheaval of the First World War, the company played a significant role by supplying engines and shell components to support the industrial war effort.

***Fig. I.F.1**. Aerial & Profile of Kuehner Engine Manufacturing Plant*
(Source: THE KUHNER ENGINE COMPANY - Gas Engine Magazine)

The year 1920 brought a sobering reckoning - the overexploitation of oyster beds in the Chesapeake Bay sounded the death knell for the Oyster Craze, initiating Oxford's second era of decline. Boat building, a major industry in Oxford, persisted, but the focus transitioned from crafting working vessels to catering to recreational boating. This period marked the conclusion of The Kuehner Company's operations in 1924, a notable change that coincided with the establishment of the Cutts & Case Boatyard in 1928. Concurrently, local African American entrepreneurs and brothers, Albert & Downes Curtis, embarked on their own venture, opening a sail loft that swiftly gained renown for supplying sails to some of the fastest boats along the eastern seaboard, further contributing to Oxford's maritime legacy. Architect Henry Powell Hopkins left his mark on Oxford by designing the Oxford Schoolhouse, a structure that came to grace the town's edge and serves today as the town's community center.

Fig. I.F.2. *Cuts & Case Shipyard*
(Source: [Valentines, Boats, and Dining in Oxford – Maryland Maritime Heritage Foundation (mdmhf.org)])

Fig. I.F.3. *Oxford Schoolhouse, Now Oxford Community Center*
(Source: "Images of America: Oxford" by Julie Wells, Stuart Parnes & Leo Nollmeyer)

***Fig. I.F.4**. Downs Curtis Sailmaker Loft*
(Source: WatersEdgeMuseum.org)

The 1930s brought a notable influx of outsiders that catalyzed the expansion of Oxford onto its Southern Peninsula. The inauguration of a waterman's race in 1931 saw 124 boats partake in the first sailboat races, heralding the establishment of the Kap Dun Club, later rechristened the Tred Avon Yacht Club. Despite this influx of new blood and the transformation of Oxford into a leisure hub, the town's population dwindled to a mere 757 residents by 1950.

***Fig. I.F.5**. Oxford Regatta at the Tred Avon Yacht Club*
(Source: Log Canoe Sailors Facebook Group)

From 1950 onward, Oxford would suffer the battering of 143 hurricanes, tropical storms and tropical depressions growing in intensity and frequency. Congruently, Oxford represents a compelling exemplar for the preservation, sustainability, and resiliency discourse; its experience emerging as a poignant case study for the urgent need to safeguard heritage, cultivate sustainable practices, and fortify against the ever-shifting tides of climate adversity. The town's ability to endure these relentless climatic challenges underscored the imperative of fortifying its infrastructure and resilience strategies.

***Fig. I.F.6**. Ford Model-T Wading in Nuisance Tidal Flooding, 1920's*
(Source: "Images of America: Oxford" by Julie Wells, Stuart Parnes & Leo Nollmeyer)

G. THE 21ST CENTURY: A CALL FOR RESILIENCE

Stepping into the 21st century, Oxford faces a new challenge — the threat of increased flooding due to rising sea levels and intensified precipitation. Positioned at the confluence of the Tred Avon and Choptank rivers, the town's vulnerability necessitates a proactive approach. While present efforts mitigate current flooding issues, the focus is to build a resilient framework for Oxford's future, a framework that draws from its historical fabric while preparing it to weather the challenges ahead.

Oxford occupies two distinct peninsulas: a northern and a southern one. The northern peninsula finds itself bordered by the Tred Avon River to the west and north, with Town Creek flanking its southern edge. The southern peninsula is embraced by the Tred Avon River to the west, the Choptank River to the south, and Boone Creek to the east. The town's elevation generally remains below 10', subjecting it to nuisance flooding not only during "sunny day" tidal occurrences but also routine precipitation events.

Anticipated conditions portend a more serious flooding predicament due to escalating sea levels and increasingly intense precipitation events, both attributed to the changing climate. While efforts and preparations are presently in progress to combat the challenges of nuisance flooding, the town recognizes the imperative to formulate a comprehensive, forward-looking strategy aimed at tackling more significant flooding issues.

With this comprehensive resiliency plan, Preservation Green, GMB and the Town of Oxford aim to honor Oxford's storied past, celebrate its diversity, and secure its future against the backdrop of a changing climate. Oxford's resilience and historical significance serve as beacons guiding efforts to shape a more secure, sustainable, and vibrant future for generations to come.

Fig. I.G.1. *School Bus Wading Through Tidal Flooding down Tilghman Street*
(Source: "Images of America: Oxford" by Julie Wells, Stuart Parnes & Leo Nollmeyer)

II. BACKGROUND

In 2013, Oxford organized a Summer Event Series in collaboration with the National Fish and Wildlife Foundation, the Eastern Shore Land Conservancy, and the Chesapeake Bay Foundation. This initiative marked the inception of the town's first stormwater task force workshops, featuring multiple presentations and interactive sessions with the community. Notably, these sessions included presentations by PGLLC and GMB. The collaborative efforts culminated in a comprehensive report titled "Stormwater and Flood Management, Financing Study in Oxford, MD," released in December 2013 by the Maryland Environmental Finance Center. This report stands as a testament to effective analysis and community consensus-building, offering specific recommendations in land management and Best Management Practices (BMPs) for forthcoming town projects.

Since that time, the town has embarked on various reports and project identifications to address drainage, runoff quality, and overall resiliency.

As a follow-up to the Financing Study, the town initiated a "Stormwater Management and Shoreline Protection Inventory and Master Plan Study" in 2014, led by GMB. This study aimed to compile a comprehensive inventory of stormwater and shoreline infrastructure while concurrently devising a master plan for capital improvement projects. The intended timeline spanned 5-8 years, with the ultimate objective of mitigating flooding impacts.

In 2016, Maryland's Critical Area Commission for the Chesapeake and Atlantic Coastal Bays, in collaboration with Chesapeake and Coastal Service (CCS), the Office of Ocean and Coastal Resource Management (OCRM), and the National Oceanic and Atmospheric Administration (NOAA), crafted a "Critical Area Coastal Resilience Planning Guide."

Subsequently, in the same year, NOAA produced a report titled "Identifying Priorities for Adaptation Planning: An Integrated Vulnerability Assessment for the Town of Oxford and Talbot County, Maryland." This report has provided essential guidance for both current and future mitigation strategies.

Over the past decade, additional wetlands have been established in Causeway Park and the vicinity of the Wastewater Treatment Plant (WWTP). Stormwater ditch retrofits have been implemented along Bank Street and East Pier Street. Additionally, the creation of Wetlands Park at the town's entrance has facilitated tidal flow to minimize inundation, contributing to keeping areas in Oxford relatively drier.

In 2021, with funding from the Maryland Department of Natural Resources (DNR) and the National Oceanic and Atmospheric Administration (NOAA), the town embarked on a collaborative project involving graduate students from the University of Maryland School of Architecture, Planning and Preservation. This project was facilitated through the Partnership for Action Learning in Sustainability (PALS), which leverages the expertise of university students and faculty to address sustainability-related issues in Maryland communities. The project's focus was on evaluating the impact of climate change on Oxford by the year 2100 and devising potential adaptive strategies. The project incorporated design charrettes that led to the creation of project boards, outlining various sections of the town. The final student design project became the foundation for the Oxford 2100 Strategic Visioning Project.

Several of the students' concepts became pivotal elements in the Visioning Project, including:

- Embracing and adapting to the changing landscape resulting from sea level rise.
- Capitalizing on opportunities brought about by change, such as recreation, tourism, and climate research.
- Establishing an additional ferry terminal.
- Creating and allowing wetland expansion where feasible.
- Utilizing native plantings.
- Developing an expansive network of public boardwalks.
- Incorporating public overlooks and fishing piers.
- Elevating the causeway as a necessity.
- Enhancing and embracing oyster aquaculture ("oyster-tecture").
- Embracing nature-based climate resilience.

Furthermore, several key factors influenced the Strategic Vision, including:

- Employing elevations of 4.0' and 6.0' as benchmarks for sea level rise by 2100. Elevation 4.0 feet represents the potential daily high tide elevation in 2100, while elevation 6.0 feet represents a projected tidal surge of 2.0 feet in 2100 according to sea level rise projections. The Strategic Vision outlines progressive sea level rise projections leading up to 2100, guiding immediate, short-, mid-, and long-term goals.

- Omitting coastal retreat as an option. While specific areas might consider this due to unforeseen circumstances, the focus of the report centers on strategies applicable across diverse locations, ensuring Oxford's resilience and sustainability in 2100.

- Envisaging a blend of "soft" and "hard" protection systems for adaptation strategies.

- Expanding, extending, and modifying existing infrastructure to enhance resilience.
- Crafting sustainable, renewable, and resilient strategies that incorporate diverse techniques for flood mitigation beyond 2100.

- Aiming to preserve the town's historic character as much as possible, with the primary historic district remaining intact.

- Acknowledging that policies and regulations governing wetlands, waterways, buffers, and critical areas will evolve due to climate change. Strategies currently restricted by policy will be reconsidered for climate adaptation.

- Anticipating advancements in climate change modeling for more accurate sea level rise predictions, subsequently leading to adjustments in the Strategic Vision's timeline.

- Foreseeing technological advancements influencing both strategies and products, necessitating adaptations to the Strategic Vision.

- Recognizing the living nature of the Strategic Vision, subject to changes in technology, policy, implementation strategies, and funding availability.

- Anticipating a mix of public and private investments, as well as public-private partnerships, for implementing the Strategic Plan.

A Community Resilience Committee (CRC), composed of five members determined by the Commissioners, has been created in the interest of building and sustaining community resilience for the Town of Oxford. They have been instrumental in several recent projects carried forth in the past several years, including stormwater bioretention areas, shoreline enhancements, acquisitions and stabilization of the Oxford MEWS, and various façade grant programs. They have also been instrumental in the wastewater treatment plant updates and studies, water main improvements, park improvements, and successful application and participation in the Community Rating System (CRS.) This committee will continue to serve a vital role in the Oxford Community and its push for Resilience.

To address aging infrastructure and combat increasingly frequent extreme rainfall-induced flooding, the town has already implemented a stormwater fund. This initiative has led to a design-build project targeting two Oxford areas where the majority of the land lies below the 4.0' elevation mark, causing routine high-tide flooding. This flooding has transitioned from a mere nuisance to a significant issue, which GMB is currently addressing.

According to FEMA calculations, every $1 invested in mitigation techniques and strategies translates to $6 saved in recovery costs.

III. PURPOSE OF THE OXFORD 2100 A STRATEGIC VISION STUDY

Oxford is poised to confront a multitude of challenges in the realm of Climate Change and Sea Level Rise over the coming 75 years. Predominantly situated below the 10-foot elevation mark, the town currently grapples with bothersome flooding occurrences during particularly high tides and episodes of intense rainfall. The frequency of these events is on the rise, leading to an increasing number of flooding incidents each year, a trend projected to escalate significantly by the year 2100. While initiatives and preparations are presently in motion to address the persistent issue of nuisance flooding, the Town of Oxford acknowledges the necessity of formulating a forward-looking strategy to contend with more severe flooding situations. This undertaking encompasses the daunting task of engaging in necessary dialogues concerning adaptations required in the face of climate change and anticipated sea level rise.

The primary aim of this study is to delve into the climate-induced repercussions stemming from shifts in precipitation patterns and the ascent of sea levels. These impacts are critically evaluated in relation to the town's built environment and its capacity to preserve Oxford's status as a vibrant and habitable port community for the next century. Leveraging the groundwork laid by the UMD student project boards, this study endeavors to craft the definitive Vision that Oxford aspires to achieve by 2100.

By means of this project, the community is presented with a visual representation outlining a potential trajectory for Oxford in the year 2100. The final report, comprised of three volumes, encompasses the identification of plausible climate mitigation strategies, adaptations required for both public and private infrastructure, and an array of approaches and alternatives essential to the realization of this vision for a more resilient Oxford. Additionally, a prioritized timeline for requisite adaptations will be delineated, facilitating the community's resilience in the face of climate-driven impacts.

The ultimate report is intended to serve as a guiding document for the Town and its leadership, charting a course towards the year 2100. It is designed for periodic review and adjustment, as shifts occur in the landscape and engineering technologies evolve. Short-term, mid-term, and long-term benchmarks will be outlined, accompanied by pinpointing the most vulnerable areas within Oxford at present. Furthermore, a 100-year capital improvement program will be meticulously fashioned based on the insights provided, outlining priority zones and the formidable obstacles necessitating resolution for successful execution.

Oxford is committed to adopting a proactive stance toward climate change, particularly sea level rise, through meticulous contemplation, comprehensive planning, and determined adaptation. The key to the future lies in mastering the art of coexistence with water, as Oxford has done for centuries.

IV. DESIGN CONSIDERATIONS / OVERARCHING DESIGN PARAMETERS

When assessing distinct regions within the Town and identifying suitable practices for resilience and adaptation, numerous factors warrant incorporation into the overarching strategic vision. Although this report individually highlights several techniques and strategies, it's essential to recognize that many of these approaches are not isolated, stand-alone solutions. For instance, the installation of a seawall might necessitate the incorporation of supplementary stormwater practices, such as a pump station, to ensure the final landscape operates with minimal adverse impacts. This report outlines general methodologies while allowing for future determinations involving elevations, dimensions, permitting prerequisites, community consensus, and further refinements prior to implementation.

A. ELEVATION

As noted previously, a considerable portion of the Town's encompassed area lies below the 8-foot elevation mark, with only a few isolated ridges reaching an elevation of 10 feet. A notable expanse of the Town lies at or even below the 6-foot elevation point. This inherent low elevation renders the Town particularly susceptible to the combined effects of rising sea levels and the heightened intensity of storms brought about by climate change. Notably, the natural shorelines and certain existing bulkheads register below the 4-foot elevation threshold, which, if current projections hold, will result in daily submersion by the year 2100.

Fig. IV.A.1. *Existing Municipal Boundary and Topography of Oxford, MD.*

B. PROJECTED SEA LEVEL RISE

Sea level rise remains a persistent concern for both Oxford's residents and coastal communities spanning the state of Maryland. This phenomenon, driven by the combined impact of glacial melt and oceanic thermal expansion, can inflict flood damage, land erosion, and the encroachment of saltwater onto coastal areas. The incursion of saltwater can result in compromised drinking water sources and the depletion of crucial habitats such as forests and grasslands. Notably, due to Maryland's geographical proximity to the margins of glacier movement during the previous ice age, the land is also undergoing subsidence, heightening the vulnerability of its coastal communities to the effects of rising sea levels (Rising Sea Level, 2013).

Oxford has already begun to experience certain consequences of sea level rise, evident in amplified flooding occurrences within the Town. Extreme tidal events have led to the overtopping of bulkheads, while tidal backflow through the drainage system has inundated streets and yards, impairing proper drainage. Moreover, the rising sea level imperils the existence of existing marshes and wetlands—natural protective barriers—placing them at risk of submersion and inundation, a phenomenon often referred to as "drowning."

Year	Emissions Pathway	Central Estimate 50% probability SLR meets or exceeds:	Likely Range 67% probability SLR is between:	1 in 20 Chance 5% probability SLR meets or exceeds:	1 in 100 Chance 1% probability SLR meets or exceeds:
2030		0.6 ft	0.4 – 0.9 ft	1.1 ft	1.3 ft
2050		1.2 ft	0.8 – 1.6 ft	2.0 ft	2.3 ft
2080	Growing	2.3 ft	1.6 – 3.1 ft	3.7 ft	4.7 ft
	Stabilized	1.9 ft	1.3 – 2.6 ft	3.2 ft	4.1 ft
	Paris Agreement	1.7 ft	1.1 – 2.4 ft	3.0 ft	3.2 ft
2100	Growing	3.0 ft	2.0 – 4.2 ft	5.2 ft	6.9 ft
	Stabilized	2.4 ft	1.6 – 3.4 ft	4.2 ft	5.6 ft
	Paris Agreement	2.0 ft	1.2 – 3.0 ft	3.7 ft	5.4 ft
2150	Growing	4.8 ft	3.4 – 6.6 ft	8.5 ft	12.4 ft
	Stabilized	3.5 ft	2.1 – 5.3 ft	7.1 ft	10.6 ft
	Paris Agreement	2.9 ft	1.8 – 4.2 ft	5.9 ft	9.4 ft

Fig. IV.B.1. *Projected Sea Level Rise for Maryland based off the Baltimore tide gauge (Boesch et al., 2018)*

Sea level rise projections for Maryland are available in Figure IV.B.1. The analysis conducted for the Oxford 2100 Vision report utilized water level values derived from the Stabilized Emissions Pathway. These values were rounded to elevation 4' to symbolize the projected sea level rise and the new mean high water (MHW) anticipated in 2100 (Figure IV.B.3). Elevation 6' was selected to signify a typical storm surge, lunar tide, or wind-driven tide in addition to the new MHW that Oxford could potentially encounter in 2100 (Figure IV.B.4). Mean high water is defined as the average of all recorded high-water heights observed within the National Tidal Data Epoch (NOAA Tides and Currents, n.d.). Conversely, a surge denotes a sudden and heightened influx of powerful water, often stemming from a storm event.

The nearest NOAA tide gauge is positioned in Cambridge, MD, approximately 10 miles south of Oxford. This tide gauge is situated within the Choptank River and exhibits tide cycles similar to those of Oxford. Presently, the prevailing trend indicates a sea level increase of 0.15 inches per year; however, expectations point toward an escalation in the rate of change in the future (NOAA Tides and Currents, n.d.). By using the NAVD88 elevation reference, the following datums are pertinent to both the station and the study:

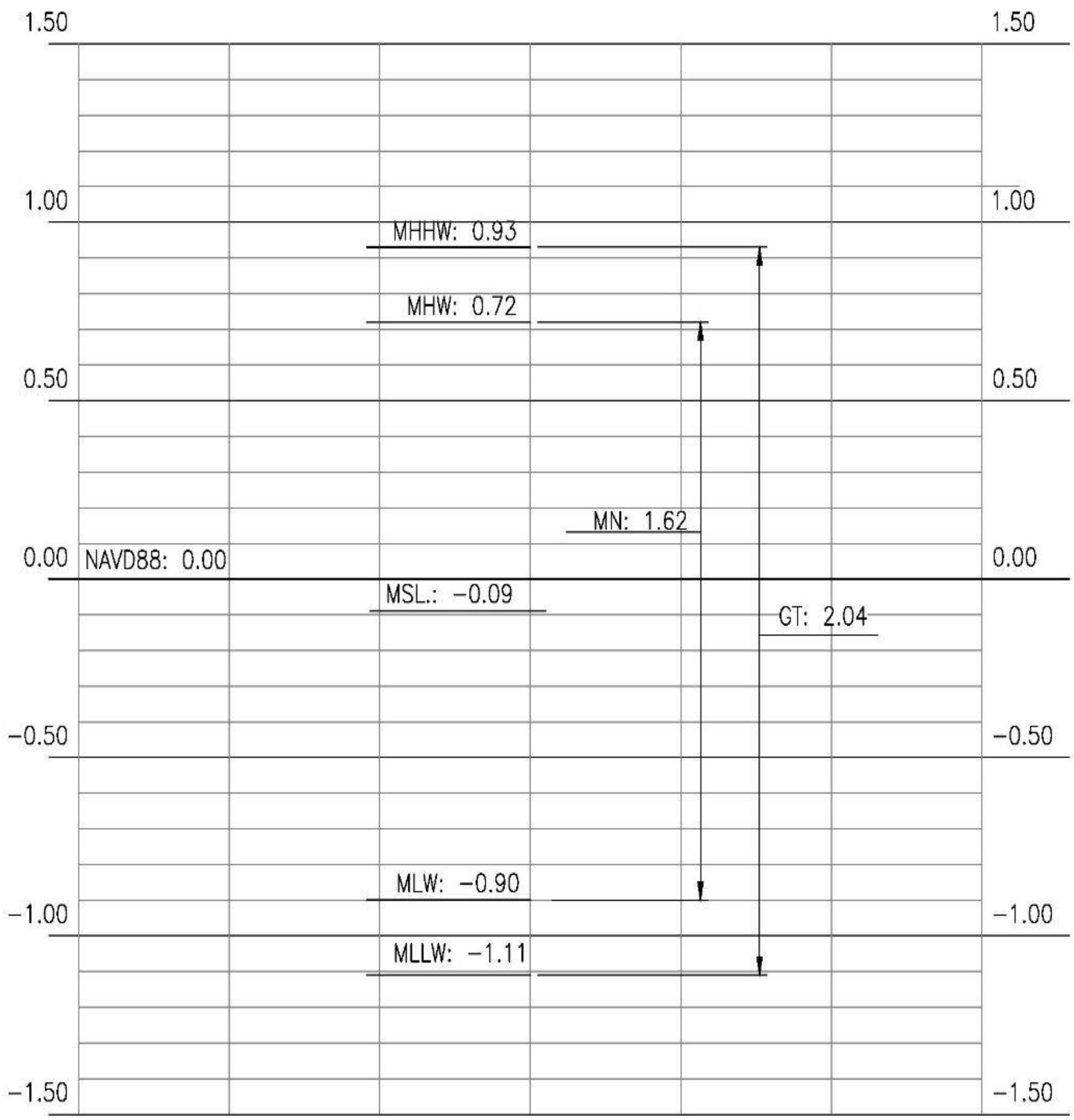

Fig. IV.B.2. *Datums for Cambridge, MD tide gauge system*
(Source : https://tidesandcurrents.noaa.gov/datums.html?id=8571892)

- Mean Higher High Water (Highest high tide of the day) = 0.93
- Mean High Water = 0.72
- NAVD88 0, base elevation for all current elevations = 0.00
- Mean Sea Level (No, not 0) = -0.09
- Mean Low Water = -0.90
- Mean Lower Low Water (Lowest tide of the day) = -1.11

The Mean Higher High Water (MHHW) is calculated as the average of the higher high-water height observed during each tidal day over the National Tidal Datum Epoch[3]. There is a distinction of 1.02 feet between Mean Sea Level (MSL) and MHHW.

This differential signifies the average potential elevation of the tide each day in addition to the predicted Sea Level Rise. The assumption is that the correlation between MSL and MHHW will remain constant; thus, a 3-foot surge in MSL will correspond to a 3-foot increase in MHHW.

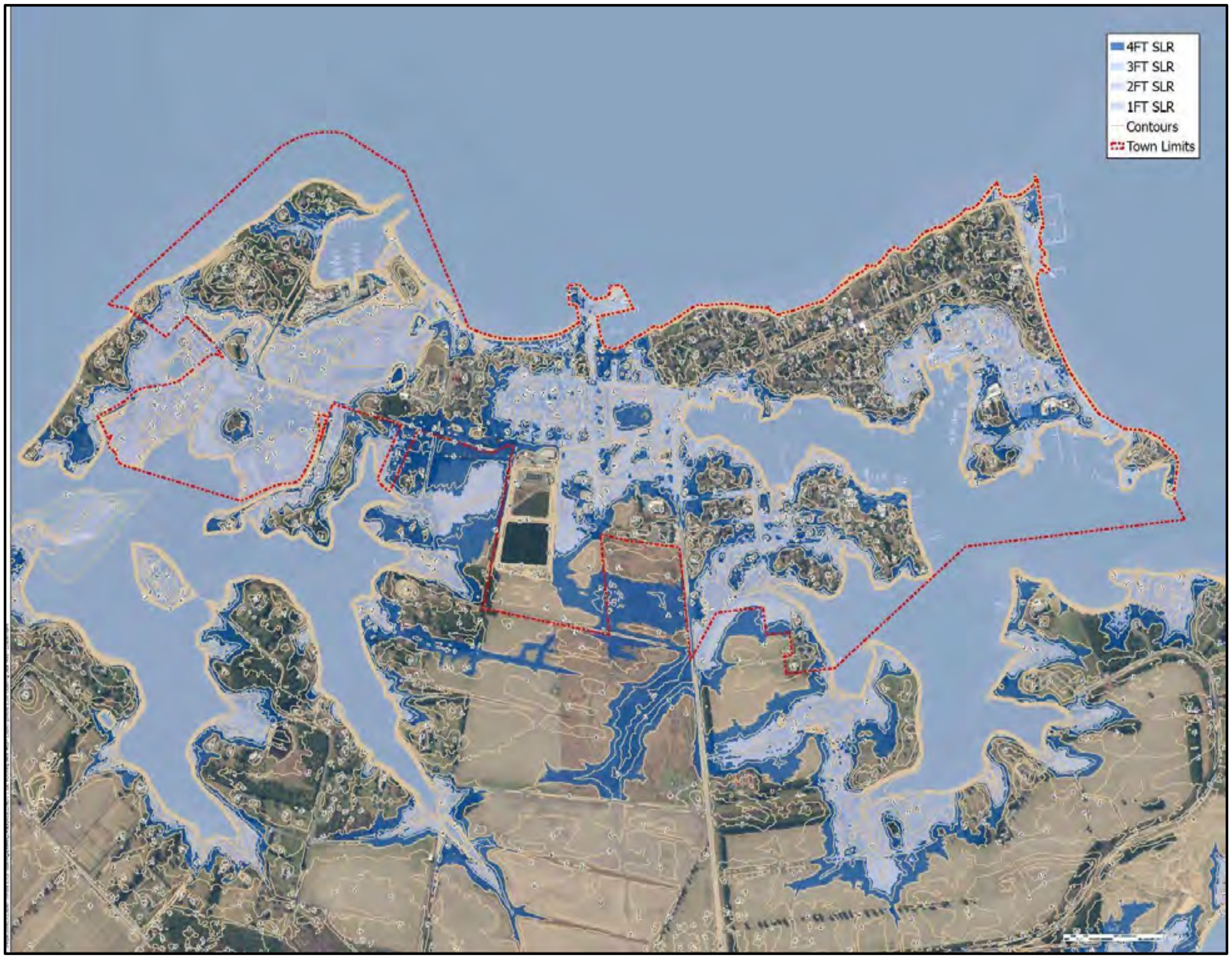

Fig. IV.B.3. *Inundation at elevation 4.0' due to sea level rise or storm surge for Oxford, MD.*

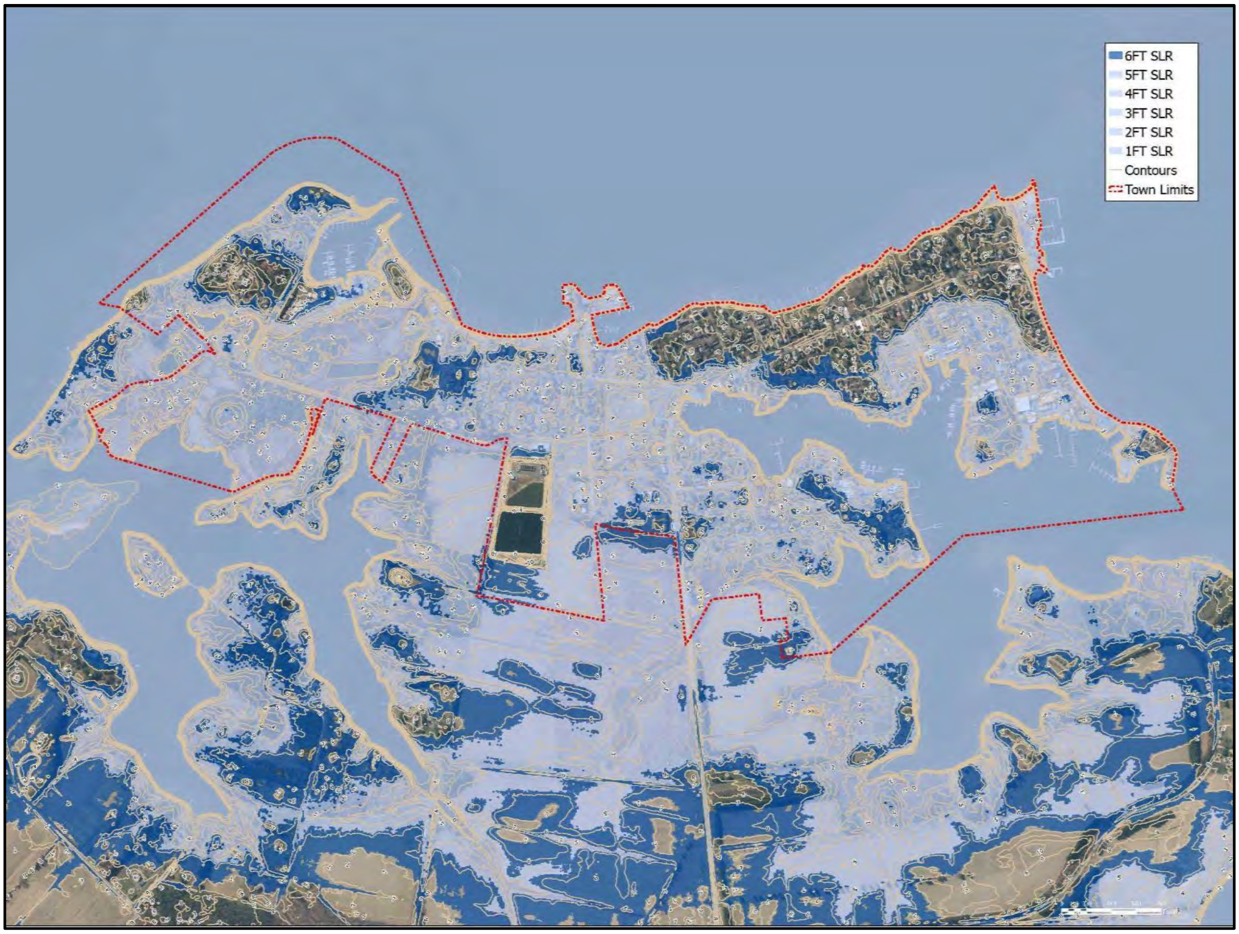

Fig. IV.B.4. *Inundation at elevation 6.0' due to sea level rise or storm surge for Oxford, MD.*

C. FEMA

With the rise in sea levels, it is foreseeable that the FEMA 1% Chance Flood elevations (Base Flood Elevation - BFE) will also experience an upward shift. While it might not entail a direct proportional increase, given the projected 3 feet of sea level rise (SLR) by 2100, it's prudent to prepare for a corresponding elevation requirement of 3 feet on future Flood Maps. Given Oxford's historical significance, the longevity of its constructed homes, and the aspiration to thrive into the next century, comprehensive preparation for all facets of climate change is essential. This includes vigilant management of building codes and elevations to ensure public safety and structural safeguarding.

The Town of Oxford is deserving of commendation for its mandate of a 3-foot freeboard on new constructions. Considering the national standard of 18 inches and the more rigorous 36-inch benchmark achieved by only a handful of communities, the supplementary freeboard adds an additional layer of protection. Maintaining a proactive stance toward elevated standards should be the central objective for floodplain regulations in Oxford.

As fresh FEMA maps are unveiled, the Town should conduct a comparative analysis of the BFE and projected flooding extents between the maps. It's crucial to assess the number of potentially affected properties, scrutinize shifts in the 1% Chance BFEs, and evaluate whether the existing 3 feet of freeboard will suffice for the forthcoming cycle of floodplain prerequisites. Should the maps show a significant vertical escalation (such as adding elevation in each successive iteration), consideration of additional freeboard requirements should be explored.
With the anticipated rise in sea level and the expansion of open water areas, it's likely that the boundaries of the VE flood zone and the Limits of Moderate Wave Action (LiMWA) will also expand. A comprehensive review of these boundaries is essential to ascertain the repercussions on individual residences (Figure IV.C.1-IV.C.2).

Maryland Coast Smart has introduced the Climate Ready Action Boundary (CRAB) model, illustrating potential coastal flooding depths across the state. This model amalgamates FEMA maps with local information and factors in a projected 3-foot elevation rise to determine potential Finished Floor Elevations (FFEs) for future constructions. This approach is more cautious than a straightforward application of a basic freeboard amount. Critical facilities funded by the state must consult this model to ensure the longevity of the structure is not prematurely curtailed. As the state advances and modeling techniques evolve, continuous reference to these models and available data is recommended to chart the optimal course for action and resilient construction.

Likewise, there might be a need for regulatory adjustments to ensure resilience and effective mitigation in Oxford and similar coastal regions. An in-depth understanding of the existing regulations, desired objectives, potential modifications, mitigation strategies, and appropriate collaborations will greatly assist in the monumental task of adapting and tailoring the currently in-place codes, policies, and permitting barriers. Oxford will need the capacity to construct in areas currently restricted, such as within Critical Area setbacks and tidal waters.

Adjacent to the Town's jurisdiction lies the juncture of the Choptank and Tred Avon Rivers. A former spit of land once projected into the Tred Avon River, serving as a buffer against potent tidal surges from the Chesapeake Bay and the mouth of the Choptank River. Although the volume wasn't dissipated, the energy was mitigated. Consideration of reinstating a breakwater between Benoni and Bachelor Point could prove beneficial in attenuating wave action and curbing the destructive potential of robust storm surges in a future characterized by additional SLR. While Oxford may not directly execute this reconstruction, active endorsement and support of this endeavor can be facilitated with the involvement of agencies like DNR, MDE, USACE, and other relevant partners.

Oxford's commendable foresight is evident in the requirement for newly installed piles for bulkheads, piers, mooring posts, etc., to be maintained at a height of 9 feet. This provision facilitates vertical migration of these structures without disrupting aquatic ecosystems. Permitting such adaptations as sea levels rise underscores a proactive approach toward bolstering resilience.

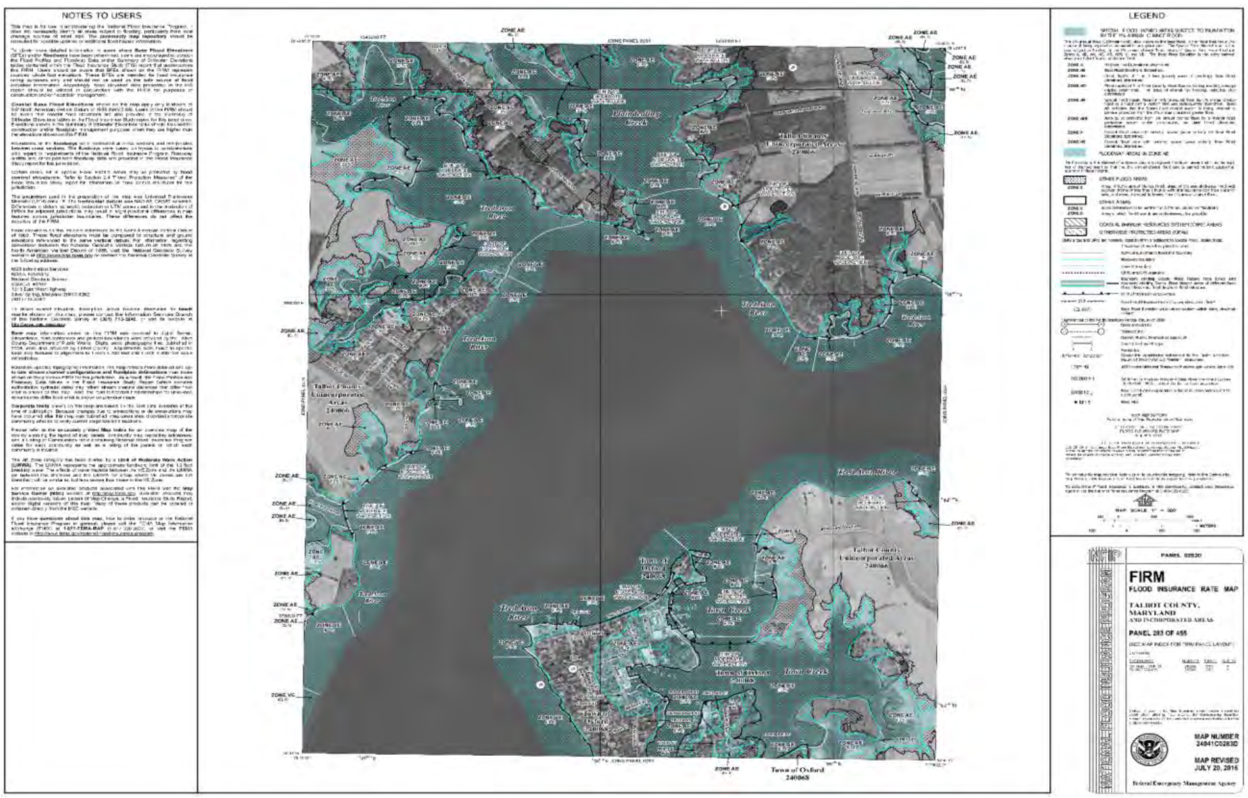

Fig. IV.C.1. *FEMA Flood Zone Map for Oxford*
(Source:https://www.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd)

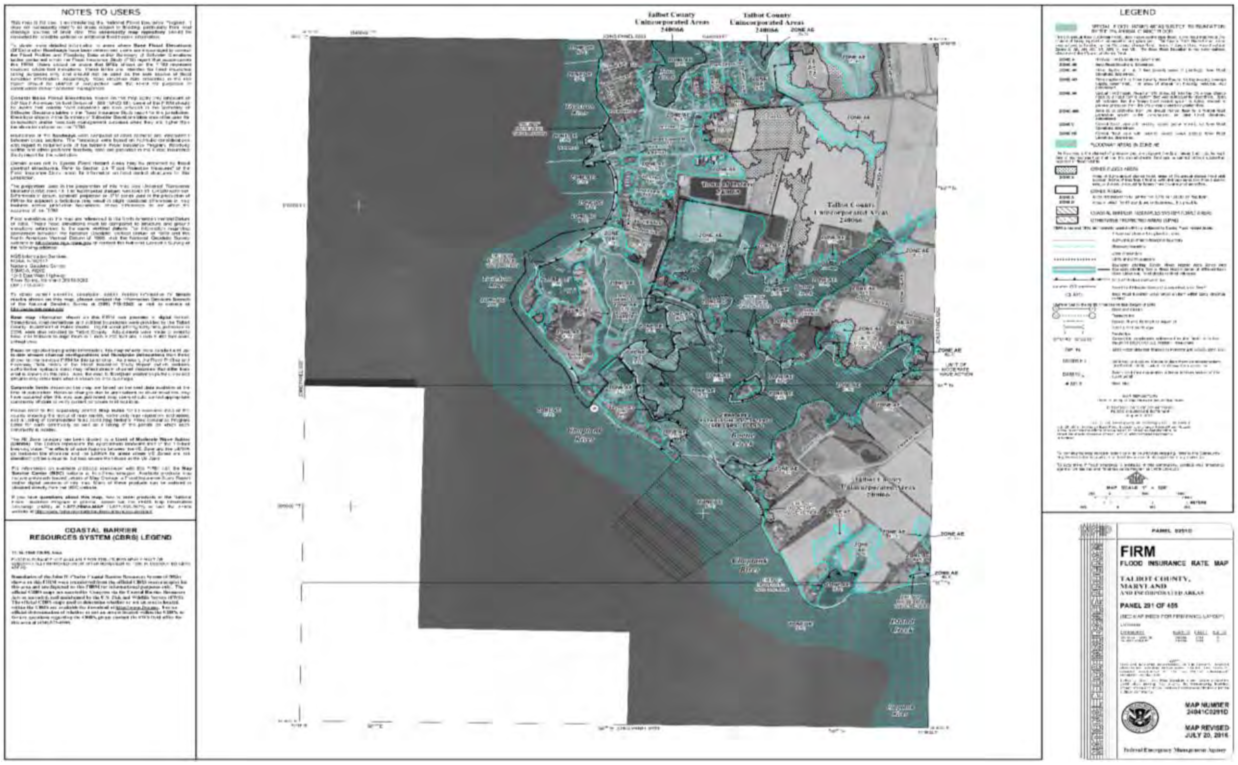

Fig. IV.C.2. *FEMA Flood Zone Map for Oxford*
(Source:https://www.arcgis.com/apps/webappviewer/index.html?id=8b0adb51996444d4879338b5529aa9cd)

D. CAUSEWAY ELEVATION:

Considering its role as a primary access point for a significant portion of the Town, the elevation of the causeway is of paramount importance, not only for day-to-day accessibility but also as a crucial evacuation route. The causeway is an integral component of the Maryland State Highway Administration (MDOT/SHA) road network. Enhancing access to ensure resilience and counteract the effects of tidal flooding, even in the near term, holds critical significance for Oxford's future. All potential avenues to sustain ingress and egress should be explored, including elevating the roadway at its current location, identifying alternative locations, or a combination of these approaches.

E. ELEVATED WALKWAYS AND BOARDWALKS:

With the ascent of sea levels, pedestrian pathways across the Town will assume heightened importance, particularly within low-lying zones. Concurrently, reimagining these pathways offers an opportunity to enrich pedestrian and multimodal connectivity, adapting to the evolving landscape shaped by rising tides. Elevated boardwalks traversing open water and tidal marshes are likely to weave through the Town, linking diverse neighborhoods. Walkways and viewpoints can be seamlessly incorporated into dunes and seawalls. Within the Historic District, traditional sidewalks will be retained. Multimodal infrastructure can synergize with berms and sea walls in the mission to thwart tidal incursion.

F. RAILS TO TRAILS:

The repurposing of the old rail bed could serve as a potential transit and multimodal route to Easton, either by utilizing the existing trail or extending/modifying it. This trail or rail bed could be elevated to function as a levee in specific areas, providing a sturdy edge for sea walls, berms, and dunes.

G. HIGH SPEED FERRY:

Envisioning a high-speed ferry link connecting Oxford with the Western Shore and/or other Eastern Shore communities represents an exciting prospect. A prime location for such a ferry terminal could be situated at the terminus of Pier Street, which would align with the spine of the proposed Rails to Trails network. This integrated linkage would further intertwine with pedestrian routes throughout the Town. Enabling accessibility to neighboring communities would permit Oxford to maintain its intimate small-town character while offering access to crucial services within a reasonable proximity.

H. INTERCONNECTION OF HARD AND SOFT EDGE:

Across the Town, both "soft" features like living shorelines and dunes, and "hard" features like sea walls and bulkheads, are proposed at various locales. Often, these elements will intersect and intertwine. The seamless transition between the hard and soft edges will be a pivotal aspect of the overall strategy.

I. STORMWATER PUMP STATIONS:

Given the utilization of sea walls and dune systems to mitigate tidal influence, stormwater pump stations will become indispensable within inland regions. Since mean high water will surpass the elevation behind the sea walls, any runoff necessitates pumping over or through barriers. Furthermore, underdrains will need installation in residential zones to address an elevated water table. These underdrains would also channel into the stormwater pump stations, potentially leading to the pump station activating during dry as well as wet conditions.

J. TIDE GATE SYSTEMS:

For all outfalls discharging into open waters, integrating Tide Gates is imperative. Restraining tidal ingress will alleviate groundwater pressure, diminish flooding in areas prone to elevated tides, and curtail strain on the Town's infrastructure. With higher tides and sea levels in the future, numerous stormwater culverts and systems within the Town are likely to be perpetually submerged. Tide gates are indispensable to prevent tidal waters from surging back through the drainage system and spilling into inland regions. Across roadbeds traversing channels, extensive sluice gate systems will be necessary. As sea levels rise and technological advancements progress, the efficiency of simple tide gates is expected to improve. Monitoring technological advancements and tide gate/check valve elevations will be pivotal to ensuring the protection of private properties and public lands from tidal inundation.

K. SOLAR BACK-UPS:

As renewable energy sources become increasingly efficient, the potential implementation of such sources at publicly owned facilities should be explored. The utilization of renewable energy, such as solar, could extend to the Wastewater Treatment Plant or even smaller-scale implementation at pump stations to serve as backup power sources when technology upgrades are necessary.

L. PLUMBING SOLUTIONS:

As tides progressively surge higher, the strain on individual plumbing systems will escalate. With still water elevations exerting more frequent influence on inland areas, conventional plumbing fixtures might encounter limitations. Staying attuned to the latest technology and disseminating information to local residents can promote the adoption of best practices to mitigate unintended consequences of elevated tides.

M. STRAND BEACH PROJECT:

Commencing in the fall of 2023, a beach protection project will be initiated. Leveraging the success of this undertaking will be pivotal for future installations and mitigation strategies, some of which could be on a significantly larger scale.

N. REGIONAL CONSIDERATIONS:

While this Strategic Vision specifically addresses Oxford, many of the recommended strategies could potentially be applied to other coastal communities in Maryland and along the eastern coast. Additionally, in the future, broader regional initiatives might emerge to provide protection not only to Oxford but to various other communities as well.

O. EXTREME EVENTS:

Projected to have a Base Flood Elevation ranging between elevation 12' and 13' in 2100, considering a sea level rise of three feet and a wave action depth within the VE Zone. For infrequent and extreme events, individual homes might need to consider floodproof doors and windows as a final defense measure.

P. TIMING:

For the purpose of this report's discussion, the timeframes are categorized as follows: "Immediate" refers to strategies that should be executed now or in the near future; "Short Term" encompasses actions to be undertaken between 2025 and 2040; "Mid Term" pertains to actions within 2040 and 2070; and "Long Term" signifies actions from 2070 to 2100. See the projected Timeline Chart in Volume Given aging infrastructure, outdated technologies, and end-of-life systems, evaluating the need for replacement or upgrades with innovative strategies and infrastructure is essential to ensure the continued effectiveness of existing systems.

V. RESILIENCE AND ADAPTATION STRATEGIES

A. SHORELINE ENHANCEMENTS

Climate change and sea-level rise remain pressing concerns for researchers, regulators, and coastal communities like Oxford. The interplay of climate change impacts, dense infrastructure, and rapid development often undermines the natural defenses of coastlines and coastal areas. Furthermore, intensified storm events, amplified tidal cycles, and escalating sea levels, all attributed to climate change, contribute to erosion and the subsequent degradation of vital coastal ecosystems. Oxford currently faces the impacts of these phenomena (Riggs & Ames, 2003; Dahl & Stedman, 2013; Polk & Eulle, 2018). Despite various efforts to mitigate climate warming's effects, the challenges persist and evolve. Coastal erosion and sea level rise remain substantial threats to both communities and ecosystems. As these consequences unfold, it's imperative that the strategies employed to combat them continually evolve.

Apprehensions about accelerated erosion and land loss to wave and tidal forces have led property owners and municipalities to lean on shoreline stabilization techniques (Smith, 2006). Beyond erosion prevention, drivers include safeguarding recreational beaches, enhancing navigation, improving aesthetic landscapes, facilitating riparian access, and reducing flooding (Duhring, 2006). Until recently, the prevailing approach to halt erosion and stabilize coastal shorelines was shoreline armoring. While various forms of shoreline armoring exist, seawalls, bulkheads, and revetments stand as prominent examples. These armoring structures have been widely deployed across the U.S. to counter erosion and flooding threats to communities (Charlier, Chaineux, & Morcos, 2005; Bilkovic et al., 2016). In the Chesapeake Bay region, a third of shorelines have been designated as eroding, with some areas experiencing erosion rates of up to 40 cm per year (Chesapeake Bay Program, Tidal Sediment Task Force of the Sediment Work Group, 2005; "Preface", 2006). This challenge has resulted in roughly 18% of tidal shorelines being armored, and more than 50% of urban sub-watersheds adopting armoring practices (CCRM, 2013; Bilkovic et al., 2016). Although these structures have shown efficacy in halting shoreline migration inland, there's a potential that they might eventually exacerbate erosion and disrupt the essential connectivity between upland, intertidal, and subtidal habitats (Currin et al., 2017). Ecosystem services that could be compromised due to shoreline armoring encompass carbon sequestration, erosion protection, nursery habitat provision, wave attenuation, shoreline stabilization, water filtration, and recreational opportunities. While armoring structures aim to replicate some of these protective ecosystem services, such as wave attenuation and shoreline stabilization, they can result in long-term negative outcomes that counter their initial intent and function. These lasting consequences include vertical erosion, loss of down-drift sediment, and erosion of adjacent natural and nature-based shorelines (Douglass & Pickel, 1999; Campbell, Benedict, & Thomson, 2005; NRC, 2007; Swann, 2008).

A pivotal aspect underpinning the allure of Oxford and its exceptional quality of life is the extensive public access to water throughout the Town. Safeguarding this access and ensuring unobstructed utilization of water resources will be a central consideration for project selection, location, and future procedures. Ensuring public ease of access to water while concurrently mitigating onshore impacts remains a foremost priority.

Fig. V.A.1. *(a) A seawall in Galveston, Texas; (b) Bulkheads in Florida; (c) Rock armor revetment on the coastline between Lucija and Seča (Source: https://www.galvestonunscripted.com/seawall-galveston-texas; https://www.eastcoastdocks.com/seawalls/; https://www.researchgate.net/figure/Rock-armour-revetment-coastline-between-Lucija-and-Seca_fig1_335930897)*

During the mid-1980s, the concept of "soft" shoreline stabilization emerged as an alternative to "hard" shoreline stabilization, commonly known as shoreline armoring (Jefferson Patterson Park and Museum, 2007; Subramanian et al., 2008). These "soft" methods laid the groundwork for today's "living shoreline" technique, which is highly regarded within the environmental community due to its multifaceted advantages (Jefferson Patterson Park and Museum, 2007; Subramanian et al., 2008). The living shoreline approach embraces the integration of natural coastal elements to stabilize and safeguard shorelines (Figure V.A.2; Pilkey et al., 2012). These shorelines are designed with the intent of preserving or minimally disrupting coastal ecosystems and processes (Jefferson Patterson Park and Museum, 2007; Subramanian et al., 2008). While shoreline armoring can address wave attenuation, flood prevention, and rising tides, the absence of the invaluable components present in natural coastlines can lead to community vulnerability. Leveraging the ability of living shorelines to stabilize coasts with minimal ecological impact positions them as potential enhancers of coastal community resilience to sea level rise (Sutton-Grier, Wowk, & Bamford, 2015; Van Slobbe et al., 2013; Mitchell & Bilkovic, 2019). Numerous studies suggest that the knowledge necessary to effectively curtail erosion through shoreline armoring already exists. These studies assert that integrating living shoreline principles may diminish the efficacy of hardening structures that are already in place (Smith, 2006). However, it's often overlooked that shoreline erosion is a natural process unfolding over time, exposing a flaw in structural systems, which lack the adaptability to erosion and sea level rise inherent to natural systems (Subramanian et al., 2006).

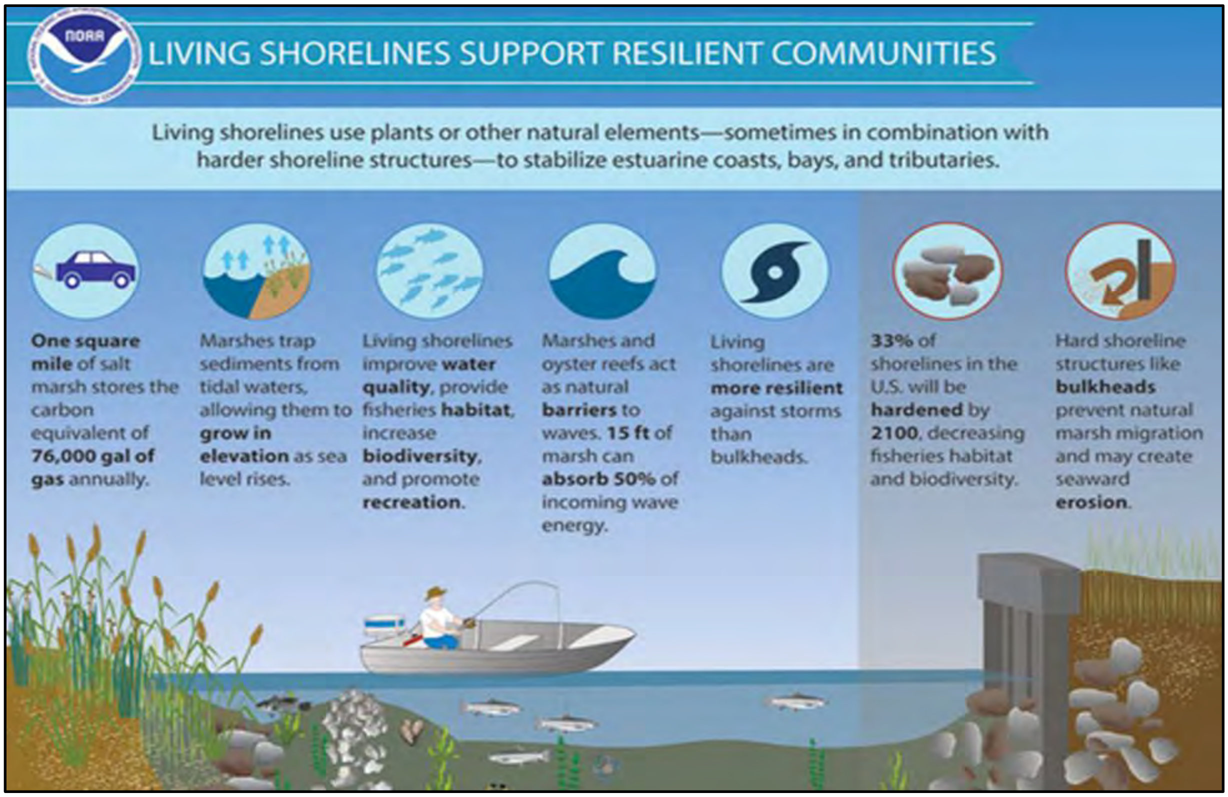

Fig. V.A.2. *Ways living shorelines contribute to the resiliency of coastal communities. (Source: http://www.fisheries.noaa.gov/insight/understanding-living-shorelines)*

There are two fundamental approaches to living shorelines. The non-structural methods are composed entirely of soft materials, such as marsh grasses, submerged aquatic vegetation, beach grass, upland trees, and shrubs. These methods are recommended for low-energy environments. While non-structural methods are preferred, their implementation may be hindered by site-specific conditions, such as high wave action or intense shoreline development.
In situations where the environment is medium to high-energy, a hybrid approach is often necessary to balance erosion control and vegetation growth (Currin et al., 2017; Mitchell & Bilkovic, 2019; Subramanian et al., 2008; Smith, 2006). Hybrid methods combine structural elements, like marsh toe revetments, rock sills, breakwaters, or oyster reefs, with biodegradable materials such as coir fiber logs or matting. This integration ensures both vegetation development and protection against waves, tidal currents, and storm surges (O'Donnell, 2017). For more exposed shorelines, factors like wave climate, coastal geomorphology, and land use are crucial considerations during the design of living shorelines (O'Donnell, 2017).

Ideally, hybrid living shorelines are designed to emulate natural environments, and when that's not feasible, they aim to complement natural elements rather than shield against them (Smith, 2006; O'Donnell, 2017). When crafting shoreline protection and stabilization methods, it's crucial to incorporate both environmental and, when necessary, structural components. Ongoing efforts involve implementing innovative strategies and methods that safeguard coastal communities while also preserving or restoring coastal ecosystems and ecosystem services.

Fig. V.A.3. *(a) An example of "soft" shorelines and (b) an example of hybrid shorelines (Source: (a) https://chesapeakebaymagazine.com/md-lawmakers-push-bill-to-strengthen-living-shorelines/ ; (b) https://chesapeakebaymagazine.com/state-guidance-va-waterfront-homeowners-must-use-living-shorelines-whenever-possible/)*

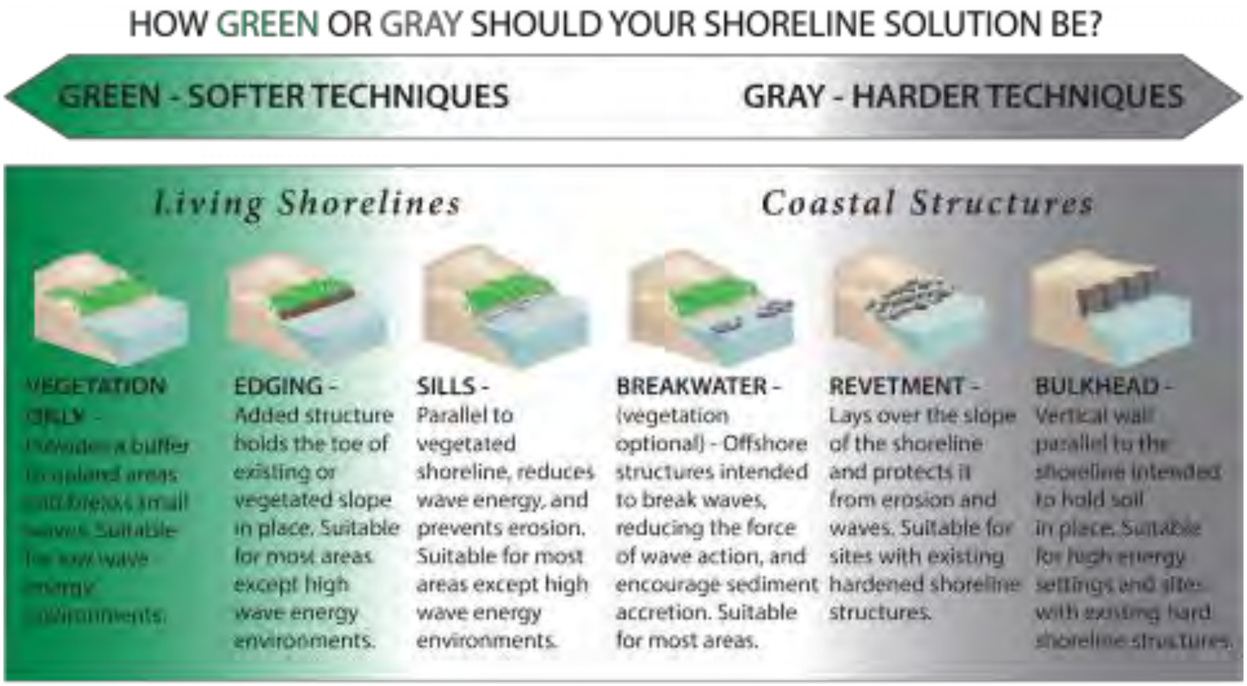

Fig. V.A.4. *A continuum of green to gray shorelines stabilization methods (Source: NOAA 2015; https://climateactiontool.org/content/restore-and-protect-natural-shorelines-use-living-shoreline-techniques)*

The Town of Oxford is encompassed by water on three sides, and the interactions between the upland and open water are in a constant state of change due to rising sea levels and the ebb and flow of tides. Much of Oxford's perimeter, which predominantly interfaces with the Choptank and Tred Avon Rivers, as well as Town Creek, falls within the VE zone as indicated on the current FEMA maps (Figure IV.C.1-IV.C.2). The VE zone designates areas within a coastal flood zone with velocity hazard (wave action) where waves exceed 3 feet in height. The majority of VE zones possess a Base Flood Elevation (BFE) of 6.0, with a section along the western front of the Tred Avon River having a BFE of 8.0. Notable areas within the VE zone along the Town's perimeter include Bachelors Point at the southern extremity, the western shoreline parallel to Morris Street, and the Strand at the northern tip. The interior regions of the Town, along Town Creek, are located within the AE Zones, where wave action affecting these areas is less than 1.5 feet (Figure IV.C.1-IV.C.2). This underscores Oxford's vulnerability to coastal erosion, storm surges, and sea level rise.

The prevailing shoreline stabilization methods implemented along Oxford's perimeter exhibit variability, mainly consisting of a combination of bulkheads, stone riprap revetments, and a few living shorelines. Historically, shoreline armoring was the favored defense against flooding and erosion, although more resilient alternatives such as living and hybrid shoreline methods are now considered crucial in light of escalating sea levels and the heightened frequency and intensity of storms.

The perimeter of Oxford, MD experiences assorted conditions, encompassing wave and wind activity. Given these diverse conditions, both non-structural and hybrid methods are imperative and delineated below as potential mitigation measures. Living shorelines have been established at Oxford Town Park, opposite the Oxford Museum, and within the vicinity of the Oxford Ferry Dock. Although the original landscape of this area was a sandy beach, the toe revetment that was implemented has facilitated the proliferation and growth of marsh grass over the past decade and more (Figure V.A.5). The influence of wave action (excluding substantial hurricanes) has been alleviated through the presence of living shoreline vegetation and the shallow onshore run-up. Replicating this approach and reinforcing it could offer a localized solution in various zones across Oxford to counter the impact of rising storm surges on vulnerable upland areas. The creation of a living shoreline at the ferry dock has also mitigated the frequent flooding that previously affected the parking lot.

Fig. V.A.5. *Photograph of the Oxford Town Park shoreline*
(Source : https://www.chesapeakeliving.com/oxford-md-beaches/)

1. Marsh Restoration or Creation (Non-Structural Method)

Marsh restoration or creation is a minimally disruptive method for managing vegetation in living shorelines (see Figure V.A.1.1; O'Donnell, 2017). The primary focus is on restoring or planting marsh vegetation, such as Spartina alterniflora, along coastal shorelines. These projects may also involve trimming overhanging tree branches to reduce shading over the new or restored plantings and to promote marsh grass growth (VIMS-CCRM, 2006; O’Donnell, 2017). While the creation of marshes is feasible for low-energy shorelines, it is not advisable to create marshes in areas where they are not a natural feature, especially when comparing to similar natural shorelines, as it could alter or hinder the project's success (Maryland Department of the Environment, 2008; O’Donnell, 2017). The viability of fringing marshes relies on factors such as shoreline configuration, existing shoreline width, exposure, orientation, and sunlight availability (Maryland Department of the Environment, 2008; O’Donnell, 2017).

Fig. V.A.1.1. *Photograph of a completed living shoreline project in Maryland*
(Source : https://whatsupmag.com/news/stunning-shorelines-save-bay-changing-landscape-waterfront-home-ownership/)

2. Grading (Non-Structural Method)

Soft banks along shorelines are highly susceptible to erosion, and this vulnerability increases when there is little to no vegetation present (O’Donnell, 2017). Wave and tidal action, even in low-energy environments, can lead to slumping of the bank (O’Donnell, 2017). Numerous factors and elements influence the bank's stability, including its height, sediment type, vegetation, waves, sea-level rise, runoff, and upland usage (O'Donnell, 2017). The objective of grading is to reduce the bank's steepness, effectively minimizing erosion caused by wave action and boat wake at the bank toe. A stable bank will feature abundant vegetation types, such as marsh grasses, shrubs, and mature trees (Slovinsky, 2011; O'Donnell, 2017). Upland vegetation not only aids in stabilizing the bluff but also reduces rainwater runoff (O'Donnell, 2017). Grading is generally not an effective shoreline protection method for high-energy environments experiencing increased wave action; however, when combined with other living shoreline methods, it can offer additional effectiveness and protection (O'Donnell, 2017).

3. Wetland/Beach Nourishment (Non-Structural Method)

When required, fill material is placed along the shoreline to gradually raise the elevation, enabling marshes to maintain their height relative to the water level and facilitating the retreat of wetlands and natural shorelines due to sea level rise (VIMS-CCRM, 2006; O'Donnell, 2017). This approach involves restoring marshes or beaches by introducing sediment from alternative locations or offshore sites, thus replenishing the sediment supply diminished by coastal erosion and sea level rise (O'Donnell, 2017).

Despite its popularity, particularly for beaches in high-energy environments, there are certain drawbacks to this method. Firstly, beaches nourished for recreational and unobstructed views often lack the necessary height to provide substantial protection against storm events and heightened tidal and wave activities due to sea level rise (O'Donnell, 2017). Secondly, the introduction of sediment to beaches, dunes, and marshes can inadvertently bury native vegetation and disrupt habitats (O'Donnell, 2017), further destabilizing the coastal ecosystem and potentially facilitating the establishment of invasive species (O'Donnell, 2017). Lastly, differences between the original sediment and the additional sediment may impact the nesting and foraging behaviors of shorebirds and other wildlife (Nordstrom, Lampe, and Vandermark, 2000; O'Donnell, 2017).

Primarily employed for maintaining recreational beaches or elevating marshes to stimulate vegetation growth and density, this method finds a local illustration in the case of Poplar Island (Figure V.A.3.1). Commencing in 2001, surplus sediment has been dredged from the Port of Baltimore and transported to Poplar Island as part of a restoration project spanning 50 years (Reynolds, 2019). The endeavor aims to reconstitute the island's original size, which has eroded by over 10,000 acres due to coastal erosion, and to reestablish diverse habitats, including nesting islands, tidal wetlands, ponds, and forested uplands (Reynolds, 2019). While this project remains ongoing, the island has already contributed more than 1,000 acres of vibrant wildlife habitat to the Chesapeake Bay (Reynolds, 2019).

Fig. V.A.3.1. *Restored marsh wetlands at Poplar Island in Talbot County, Maryland in 2019 (Source: https://www.chesapeakebay.net/news/blog/poplar-island-restoration-gives-chesapeake-new-life; Photo by Will Parson/Chesapeake Bay Program)*

4. Dune Creation and Restoration (Non-Structural Method)

Dune creation and restoration may be integrated into a beach nourishment project, or they can also function as stand-alone endeavors (Figure V.A.4.1; O'Donnell, 2017). These living shoreline projects are most effective when situated where the natural dune line already exists or in close proximity to it. Three fundamental strategies are employed in each design to accomplish dune creation or restoration: planting vegetation, transporting, and supplying sediment, and removing structures that impede dune migration (Lithgow et al., 2013; Martinez, Hesp, & Gallego-Fernandez, 2013; O'Donnell, 2017). For natural dune development, an ample quantity of windblown sand is necessary over time (O'Donnell, 2017). Consequently, dune creation and restoration may be the sole means to ensure dune longevity, offering defense against rising tides and intensified storm surges in certain regions. The incorporation of fencing and vegetation onto dunes can introduce an additional barrier to the wind, fostering sediment and sand accumulation around these elements (O'Donnell, 2017). Frequently, homeowner and coastal community preferences for unobstructed views and visually pleasing shorelines deter the construction of sufficiently elevated dunes, which would otherwise provide adequate safeguarding against the consequences of climate warming, including the heightened frequency and severity of severe storms and projected sea level rise.

Fig. V.A.4.1. *An engineered dune system in Encinitas, California designed to protect Pacific Coast Highway and enhance beach habitat.*
(Source : https://www.resilientcoastlines.com/projects/cardiff-living-shorelines-project)

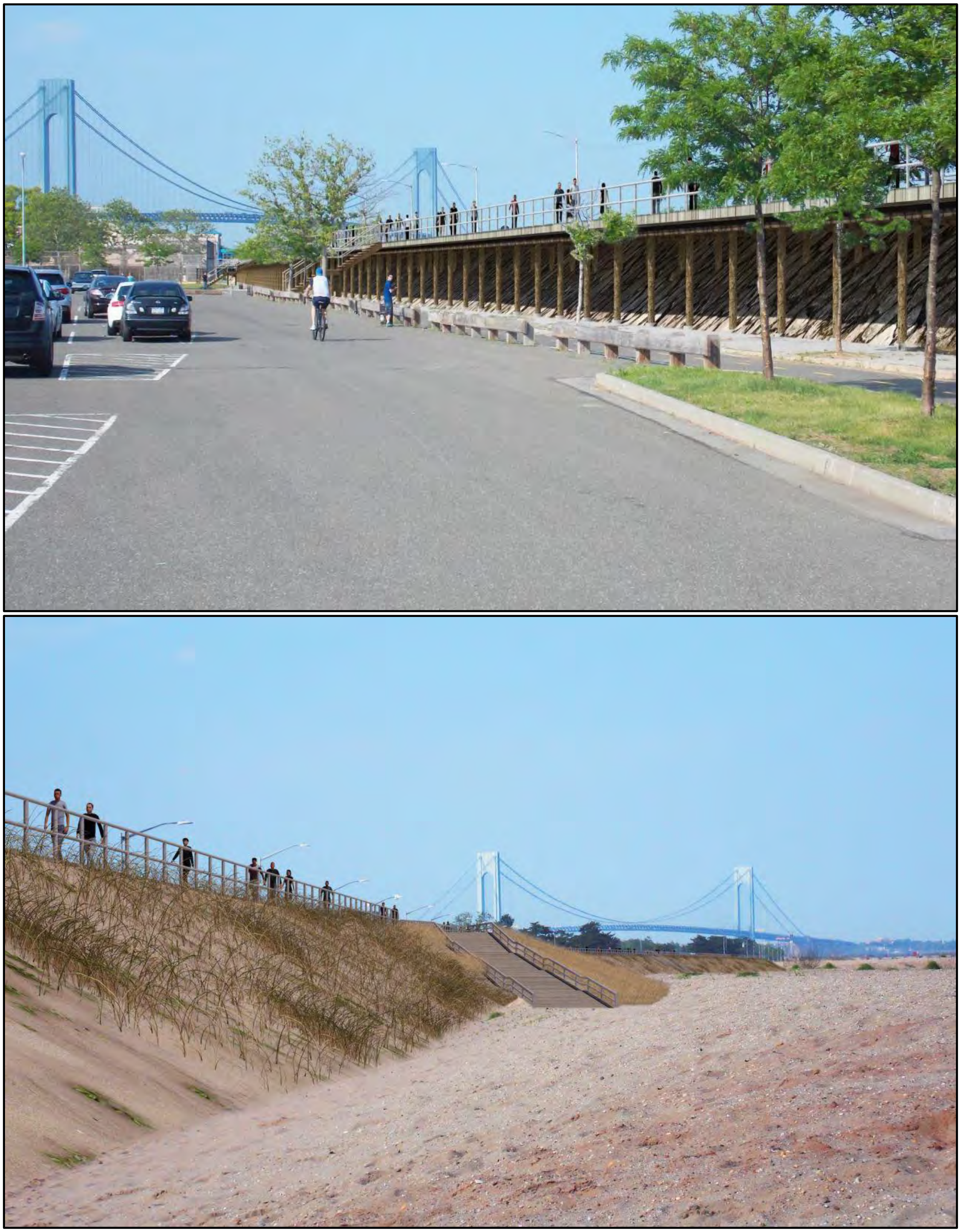

Fig. V.A.4.2. *Renderings of a proposed engineered dune system/seawall able to withstand the 300-YR flood event in Staten Island, New York*
(Source : https://www.cnn.com/style/article/staten-island-seawall-climate-crisis-design/index.html)

As sea levels continue to rise, it is advisable to explore the establishment of a dune system encircling the Town's perimeter from the Strand to Bachelors Point (Figure V.A.4.2). Existing installations can remain in place, serving as the base for gradually implemented new dune/living shoreline structures. Over time, the upper elevations can be raised to offer enhanced protection. Immediate attainment of the final desired height isn't imperative for safeguarding Oxford. While this initiative entails significant effort, as it mainly involves private property, it would substantially bolster Oxford's resilience against storm surges. Securing permits and approvals for such an approach will necessitate substantial coordination with entities such as MDE, DNR, and USACE. Presently, construction is not permitted waterward of the MHHW line. However, given the dune's design, height specifications, required slope, and the existing positioning of houses on individual properties, modifications to current regulations will be indispensable for a successful implementation.

5. Fiber Logs (Hybrid Method):

Fiber logs serve as a temporary defense against wave and tidal forces, enabling the gradual establishment and strengthening of vegetation root systems along shorelines (Figure V.A.5.1; O'Donnell, 2017). Available in various sizes and grades, these logs can be arranged in single or multiple rows based on the energy level of the environment (O'Donnell, 2017). In low-energy environments, fiber logs are biodegradable within approximately five years, a suitable timeframe for vegetation to mature and take root (Chesapeake Bay Foundation, 2007; Hardaway et al., 2009; Hardaway & Duhring, 2010; VIMS-CCRM, 2006; O'Donnell, 2017). However, in high-energy saltwater environments, these structures are not advisable due to the risk of premature degradation before vegetation establishment. Nevertheless, fiber logs offer a valuable alternative to long-term hybrid structures, as they eventually allow the shoreline to function independently, resembling a natural shoreline.

Fig. V.A.5.1. *Photograph of a living shoreline project in Delaware with fiber logs, installed to protect the marsh edge*
(Source : https://www.delawarelivingshorelines.org/).

6. Rock Sills (Hybrid Method):

Rock sills represent low-profile breakwaters that find application in safeguarding marsh edges (Figure V.A.6.1; Broome, Rogers, & Seneca, 1992; O'Donnell, 2017). Positioned parallel to the shore near mean low water, these sills are filled with sand to regulate slope (O'Donnell, 2017). Upon backfilling, marsh vegetation is introduced to stimulate a more natural marsh edge (Figure V.A.6.2; Duhring, 2008; Hardaway & Duhring, 2010; O'Donnell, 2017). This approach can be employed to restore formerly vegetated sites or to establish marshes in non-vegetated locations (Duhring, 2006).

Correctly designing the sill is crucial to allow tidal exchange and habitat access for both subtidal and intertidal species. Inadequate design could result in underdeveloped marsh and habitat, leading to ongoing shoreline erosion (Smith, 2006). Neglecting to facilitate this exchange may transform the marsh beyond the sill into a "dead zone" for species (Smith, 2006). Overly elevated sills that hinder exchange and connectivity, as seen in poor designs, could be counterproductive (Subramanian et al., 2008; O'Donnell, 2017). To ensure proper connectivity and habitat access, windows or tidal gaps are often incorporated with marsh sills (Smith, 2006). Utilizing tidal gaps may be essential to maximize connectivity among sub-tidal, intertidal, and upland habitats (Smith, 2006).

Additionally, a non-structural variation involves employing fallen trees, including trunks, roots, and branches, termed as sylvan sills (Figure V.A.6.3). These sills facilitate more water flow, ensuring tidal exchange; however, they degrade quicker than rock sills.

Fig. V.A.6.1. *Photograph of rock sill and marsh transplanting two years post-construction in North Carolina*
(Source: Currin, Chapel, & Deaton, 2010).

Fig. V.A.6.2. *(a) Photograph of rock sill and marsh transplanting in North Carolina (emphasizing the bare substrate) and (b) photograph depicting the vegetation that has filled the bare area behind the sill*
(Source: Currin, Davis, & Malhotra, 2017).

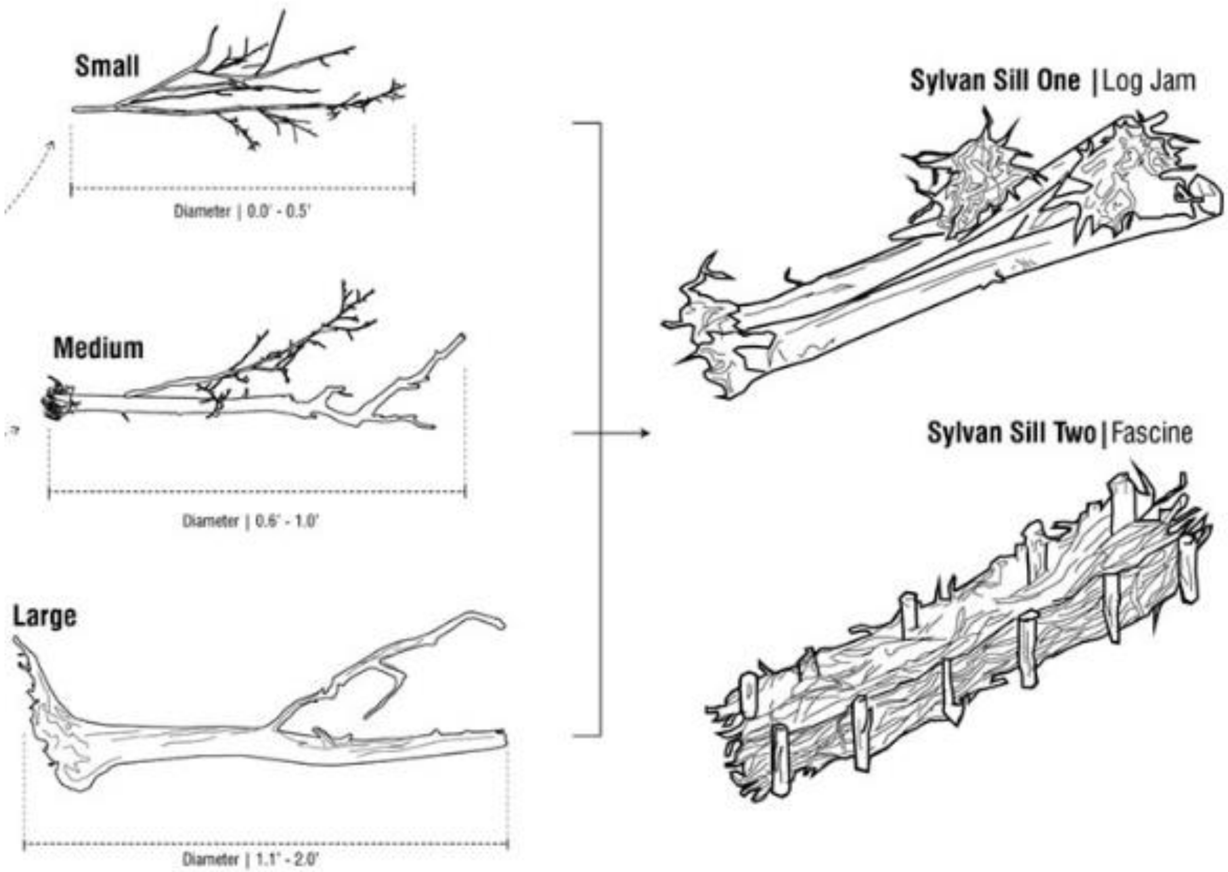

Fig. V.A.6.3. *Diagram of a sylvan sill*
(Source : https://www.mahanrykiel.com/portfolio/parsons-island-conservation-and-regeneration-plan/).

7. Toe Revetments (Hybrid Method):

Toe revetments resemble rock sills in many aspects; however, their primary purpose is to stabilize the eroding edges of natural tidal marshes (Figure V.A.7.1; Duhring, 2006). Unlike rock sills, when implementing a toe revetment, the upland area is not utilized for backfilling or new vegetation planting. The revetment is introduced to shield natural or previously restored marshes from erosion caused by waves (O'Donnell, 2017). Characterized by a low profile, these structures safeguard the shoreline edge while allowing tidal inundation to traverse over and through the structure (O'Donnell, 2017).

Nevertheless, just as poorly designed rock sills can yield adverse outcomes, inadequately designed toe revetments may lead to similar issues. Consequently, monitoring sites with these structures becomes crucial with rising sea levels. Such monitoring ensures consistent tidal exchange and proper erosion control protection.

Fig. V.A.7.1. Photograph depicting toe revetment in North Carolina
(Source: Currin, Chapel, & Deaton, 2010).

8. Oyster Reefs (Hybrid Method):

Marsh sills and toe revetments can also take the form of oyster reefs or shells. This hybrid solution offers erosion control comparable to rock sills and toe revetments while delivering additional ecosystem benefits (Figure V.A.8.1; Duhring, 2008; Scyphers et al., 2011; Skrabel, 2013; Swann, 2008; O'Donnell, 2017). Oyster reefs provide a more natural and cohesive substrate for oyster spat and recruitment (O'Donnell, 2017). Over time, these structures become self-sustaining, heightening the protection and restoration potential of the project (Atlantic States Marine Fisheries Commission Staff, 2010; Gedan et al., 2011; Scyphers et al., 2011; O'Donnell, 2017).

Furthermore, oyster reefs offer habitats for foraging and serve as filter feeders, enhancing water quality and clarity (Atlantic States Marine Fisheries Commission Staff, 2010; O'Donnell, 2017). Improved light transmission throughout the water column, facilitated by oyster reefs, benefits submerged aquatic vegetation and creates a favorable environment for diverse species (Atlantic States Marine Fisheries Commission Staff, 2010; O'Donnell, 2017). This environmental support is crucial for fostering a variety of species.

Given their self-sustaining nature and ability to shift landward with sea-level rise, oyster reefs might prove to be a cost-effective hybrid choice, demanding less long-term monitoring than fixed structures. Whenever possible, oyster reefs should be among the primary and favored options explored for hybrid living shorelines. They possess the capacity to adapt to rising sea levels while concurrently contributing to shoreline erosion control and protection.

Fig. V.A.8.1. *Photograph depicting an oyster reef restoration (Source: https://coastalscience.noaa.gov/news/nccos-award-helps-evaluate-wave-impact-reduction-and-shoreline-protection-provided-by-oyster-reef-living-shoreline-projects-during-storm-events-on-the-atlantic-and-gulf-coasts/; Credit Anna Windle, Sarah Poulin, NC Sea Grant)*

9. Breakwaters (Hybrid Method):

Breakwaters consist of larger rock structures with higher elevations compared to sills (Figure V.A.9.1; O'Donnell, 2017). These robust structures are strategically designed and implemented to safeguard shorelines from more intense conditions like storm waves (O'Donnell, 2017). By creating sheltered zones landward of the structure, they encourage sediment deposition and shoreline expansion (O'Donnell, 2017). While breakwaters effectively diminish wave energy and heights, they do not provide protection against coastal inundation (O'Donnell, 2017).

In areas of Oxford prone to high-energy conditions and erosion, breakwaters are a recommended choice. Moreover, these structures can also be fashioned using natural components such as oyster shells (Figure V.A.9.2).

Fig. V.A.9.1. *Photograph of modern curved breakwater islands and tee-shaped groin design in Fort Pierce Marina, Florida. The "hard" engineering is offset slightly by 21 acres of new habitat for oysters, mangroves, dune grass, and seagrass, as well as nesting grounds for birds (Source : https://www.cnn.com/style/article/staten-island-seawall-climate-crisis-design/index.html)*

Fig. V.A.9.2. *Photograph depicting a living breakwater system constructed with oyster shells (Source: https://reefinnovations.com/services/ecosystem-restoration/living-shoreline-reef-balls-are-being-used-across-the-coast)*

10. Jetties/Groins (Hybrid Method):

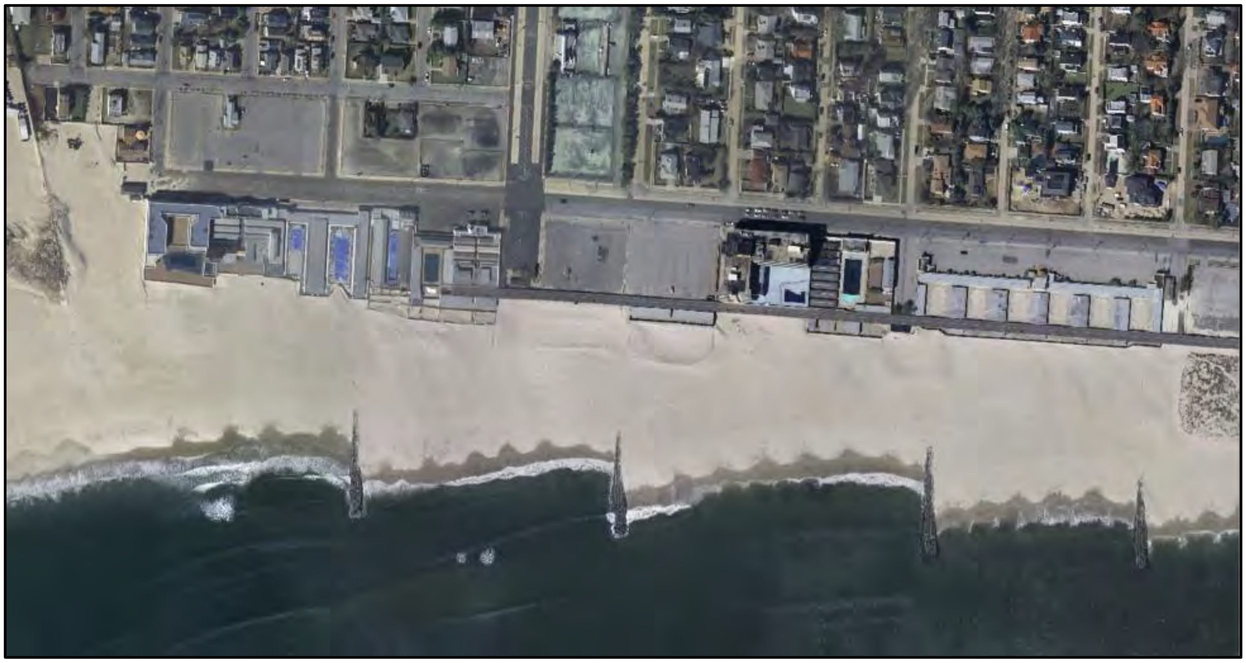

Fig. V.A.10.1. *Photograph of cascading groins, updrift accretion, and downdrift erosion on Long Island, NY*
(Credit: USGS: Earth Explorer; Source: https://serc.carleton.edu/integrate/teaching_materials/coastlines/student_materials/1075)

Fig. V.A.10.2. *Ocean City, Maryland inlet stabilization with jetties adjacent to Assateague Island National Seashore*
(Photo by Jane Thomas, UMCES/IAN Image Library; Source: https://www.nps.gov/articles/groins-and-jetties.htm#:~:text=Jetties%20are%20another%20type%20of,and%20disrupt%20natural%20sediment%20regimes.)

Jetties and groins are structural shoreline protection methods designed to mitigate erosion. Groins, oriented perpendicular to the shore, are employed to sustain updrift beaches or hinder longshore sediment movement by trapping sediment on either side of the groin (National Park Service). However, this action depletes the sand supply downstream of the structure (National Park Service). Property owners downstream of these structures often opt for installing their own groins to counteract erosion, resulting in a succession of groin installations known as a groin field (Figure V.A.10.1; National Park Service). While groins locally accumulate sediment, they exacerbate erosion further down shore and disrupt the natural sediment flow vital to these areas.

Jetties, also oriented perpendicularly to the shoreline, differ from groins in that they are positioned adjacent to tidal inlets to manage inlet migration and minimize sediment accumulation within the inlet (Figure V.A.10.2; National Park Service). Similar to groins, installing jetties leads to a reduction of sediment in the down-drift area. These structures can be fashioned from various materials such as armorstone, steel sheet pile, timber sheet pile, precast concrete blocks, rock-filled timber gabions, and grout-filled bags (National Park Service). Although jetties prevent excessive sediment buildup, some sediment can still amass within the inlet, necessitating periodic dredging.

Given the unpredictable nature of longshore sediment transport, it's recommended that any jetties or groins implemented in Oxford complement proposed natural or nature-based shoreline protection methods, rendering the structures a hybrid solution. Downstream of the dune system, a jetty or groin might be essential to forestall erosion, particularly if substantial sediment transport to Oxford's perimeter for replenishment isn't feasible.

11. Seawalls (Hybrid Method):

While seawalls are typically considered as structural methods or shoreline armoring, it's possible to integrate natural components to mitigate the structure's impacts. As mentioned earlier, site-specific conditions may render living or hybrid solutions impractical. The primary objective of a seawall is to safeguard upland regions against further erosion, wave impacts, and rising sea levels (Figure V.A.11.1; Weggel, 1988). Seawall construction can often disrupt local natural environments, but if the benefits outweigh the environmental and economic costs—such as ongoing erosion or flood damage—the installation of a seawall might be justified (Weggel, 1988). Comprehensive knowledge exists on seawall design, functionality, construction, and maintenance costs (Sutton-Grier, Wowk, & Bamford, 2015).

In the Town Creek area, a seawall proposal is outlined. This could be situated either at the existing bulkhead's location or landward as an additional protective measure. The existing bulkhead can remain to provide near-daily flood protection, even amid some sea level rise. However, the seawall would be pivotal during high tidal surges on lunar tides and storm events. The space between the bulkhead and seawall could be at a lower elevation, acknowledging occasional inundation. The seawall would shield against all but the most extreme high tidal surges in the distant future. Another option for the space between the bulkhead and seawall is the potential installation of gabion sills (Figure V.A.11.4). These sills could be tiered to maintain accessibility during inundation without disturbing vegetation.

Fig. V.A.11.1. *Rendering depicting a living shoreline seawall renewal project in Palm Beach, Florida (source: https://www.michaelsinger.com/project/living-shoreline-seawall-renewal/)*

Fig. V.A.11.2. *Seawall renewal project, Murray Boulevard at Ashley Avenue, Charleston, SC; (Source: https://storymaps.arcgis.com/stories/bc6e1790933b4c018a52dca8c1daec6a; photo by Jerry Martin)*

Fig. V.A.11.3. *Alice Wainwright Park, seawall, and baywalk proposed improvements in Miami, FL (Source: https://www.miamigov.com/My-Government/Departments/Office-of-Capital-Improvements/Alice-Wainwright-Park-Seawall-and-Baywalk-Improvements-District-2)*

Fig. V.A.11.4. *Photograph depicting a gabion sill stabilized shoreline (Photo credit: Brent Jett).*

Numerous shoreline protection options are available for the Town of Oxford to contemplate in the face of climate change impacts. Given the Town's extensive waterfront, a site-specific strategy is proposed, elaborated on in Section VI: Areas of Interest.

An immediate requirement is the replacement of the primary access route to Oxford, MD Route 333. Often referred to as the "causeway," it is, in reality, a ground-level roadway rather than an elevated bridge-like structure.

A proposition has been raised to allow for the flooding of the public recreation area, including the vicinity just south of it. With a projected nearly 4 feet of sea level rise in the future, this area will be submerged even during low tide. Expanding Town Creek's reach while linking adjoining inundation-prone zones could enhance water quality, waterway circulation, aquatic habitats, and offer an alternative living setting over water, all while embracing the Coastal Barrier Resource System areas to the southwest of Town. As sea levels rise, this area will naturally expand and transform into open water.

B. NATURESCAPES:

As the climate undergoes changes, the natural environment will also transform. Planting zones are shifting, weather patterns are becoming less predictable, new native species are thriving, and the ongoing struggle against non-native invasive species continues.

Over a third of Maryland's Lower Eastern Shore comprises forested land (McClure & Kedmenecz, 2023). These woodlands, along with other low-lying vegetation in both rural and urban regions, face the risk of flooding and saltwater intrusion due to rising sea levels (McClure & Kedmenecz, 2023). Saltwater intrusion occurs when saltwater is transported into soil, surface water, and groundwater through storm surges and tidal cycles, resulting in vegetation damage from the roots upward (McClure & Kedmenecz, 2023; Lambrecht & Todd, 2020). The exacerbation of this issue arises from sea level rise, allowing saltwater to penetrate farther inland (McClure & Kedmenecz, 2023). Rising sea levels also elevate the groundwater table and impede drainage in low-lying areas, causing increased wetness (McClure & Kedmenecz, 2023). Although many coastal species can tolerate sporadic flooding and seawater exposure, these escalating processes may lead to excessively wet and saline conditions unsuitable for woodlands and vegetation survival (McClure & Kedmenecz, 2023). Moreover, the strain from coastal changes can weaken trees and make them more vulnerable to pests like the southern pine beetle (McClure & Kedmenecz, 2023). The regeneration of Maryland coastlines faces challenges due to heightened flooding and groundwater levels, making conditions unfavorable for seedling and sapling growth (McClure & Kedmenecz, 2023). This phenomenon, known as "ghost forests," is already observable in numerous areas along Maryland's coastlines (Figure V.B.1; McClure & Kedmenecz, 2023).

Oxford, as climate change intensifies and sea levels rise, confronts the impending threat of increased flooding and saltwater intrusion. The Town is home to numerous old-growth trees, which may be adversely affected by climate stressors and stronger storms in the near future. Native trees require extensive time to mature and establish an adequate tree canopy. To ensure a seamless transition for both protective and aesthetic purposes, it's recommended that the Town initiates the planting of more resilient trees and vegetation. Species like hackberries, honey locusts, and swamp white oaks take decades to attain mature heights. In light of this, the Town should plan for replacement trees to ensure canopy coverage across Oxford. When sizeable old-growth trees are lost due to winds, storms, saltwater intrusion, or age, a readily available list of replacement species would prove valuable. Tree canopies offer shade, reduce ambient temperatures, and contribute to a sense of space. The absence of large, old trees is conspicuous. Additionally, vegetation aids in stormwater management. As floodwaters increase in salinity, the current stormwater vegetation should be substituted or enhanced with salt-tolerant, resilient vegetation. Some recommended resilient vegetation includes:

Herbaceous plants:
- Purple False Foxglove (Agalinis purpurea)
- Swamp Milkweed (Asclepias incarnata)
- Maryland Golden Aster (Chrysopsis Mariana)
- Wood Lily (Lilium Philadelphicum)
- Herbaceous Emergent:
- Saltgrass (Distichlis spicata)
- Black needlerush (Juncus Roemerianus)
- Seashore mallow (Kosteletzkya Virginica)
- Smooth Cordgrass (Spartina Alterniflora)
- Salt Meadow Hay (Spartina Patens)

Shrubs:
- High-tide Bush (Baccharis Halimifolia)
- Sweet Pepperbush (Clethra Alnifolia)
- Inkberry (Ilex glabra)
- Marsh elder (Iva frutescens)
- Beach Plum (Prunus maritima)

Trees:
- Persimmon (Diospyros Virginiana)
- American Beech (Fagus Grandifolia)
- Bald Cypress (Taxodium Distichum)
- Eastern Red Cedar (Juniperus Virginiana)
- Sweetbay Magnolia (Magnolia Virginiana)

For a more extensive list of native species, their ideal habitats, and salt tolerance, references such as https://dnr.maryland.gov/criticalarea/Documents/chesapeakenatives.pdf and http://ccrm.vims.edu/livingshorelines/ls_wetland_plants_zone.html provide comprehensive resources to determine suitable planting species for Oxford's various areas, ensuring successful and native plantings.

Fig. V.B.2. *Photograph of the Wild Mile in Chicago. Example of naturescape (Source:https://blockclubchicago.org/2022/07/13/the-wild-miles-first-stretch-is-ready-bringing-floating-gardens-paths-and-more-to-chicago-rivers-north-branch/)*

Fig. V.B.3. *Photograph of Floating Wetlands in the Wild Mile in Chicago (Source : https://www.sciencetimes.com/articles/27913/20201027/wild-mile-chicagos-floating-gardens-urban-habitat-restoration.htm)*

Plantings should be initiated proactively, prior to being mandated by redevelopment or the loss of old-growth trees townwide. Collaborating with nonprofits for a tree distribution day in Oxford or identifying species that thrive without causing issues like root intrusion into underground infrastructure or susceptibility to shedding branches in light winds could be beneficial. It's important to acknowledge that Critical Areas requirements currently enforce a 3:1 tree replacement ratio. Over the next 75 years, enhancing canopy cover in Oxford should be readily achievable.

Naturescapes not only offer new habitats for surrounding ecosystems but also provide opportunities for outdoor education and conservation efforts (The Wild Mile Chicago, n.d.). Depending on the purpose, some naturescapes can be developed for recreational purposes, such as wildlife viewing. These attractions draw nature enthusiasts, businesses, and tourists to the community, stimulating the economy (Figure V.B.2; The Wild Mile Chicago, n.d.). Given the loss of vital habitats due to sea level rise, establishing new wetlands, naturescapes, and marshes is crucial, providing a lifeline for organisms to persist and flourish.

Another facet of naturescapes involves floating gardens. These gardens can be situated in canals, rivers, and ponds, ranging in size from individual platforms to larger platoon systems (Figure V.B.3). Constructed using plant material or other buoyant materials like plastics or wood, floating gardens provide links to habitat corridors across urban boundaries (Floating Gardens, n.d.). They are often planted with diverse vegetation to create a habitat for native species (Floating Gardens, n.d.). Ensuring the use of native plantings resilient to climate change and sea-level rise in yards and around the Town will facilitate Oxford's journey toward greater resilience while nurturing the surrounding natural environments and ecosystems.

Floating naturescapes offer immediate nutrient reduction benefits when appropriately installed and maintained. These gardens harness the water source and planting media without necessitating the addition of extra nutrients. Over time, they gradually extract nutrients from the surrounding water, contributing to nutrient reduction. While potentially providing food sources, they concurrently purify the waters around Oxford.

C. FLOATING HOMES

Coastal communities face a significant threat of land loss due to these factors and should develop a framework to enhance resilience rather than succumb to community displacement. Floating homes present a long-term solution for flood defense against sea level rise and climate change while offering a harmonious way of living with water.

One immediate need in Town is to replace the main access to Oxford on MD Route 333. Known as the “Causeway,” it is not an elevated bridge-like structure but rather an at-grade roadway. With nearly 4 feet of projected sea level rise, this area will be submerged even during low tide. An element of the Strategic Vision involves allowing the area south of the Causeway in the Park and surrounding residential neighborhood to flood, thus transforming it into a floating home community. By allowing Town Creek to expand and connecting adjacent submerged areas, this approach will improve water quality, enhance waterway flushing, foster aquatic habitats, and offer an alternative living environment (over water) with diverse home types and price ranges.

Floating homes are defined as habitable spaces that rest on water and are anchored to a fixed location without being designed for navigation (Moon, 2015). In more technical terms, floating homes are engineered so that their structural load is either equal to or less than the buoyant force of water, enabling them to float (Floating Houses: Types, Principles, and Advantages, 2022). These homes are commonly secured to the shore using steel poles and are connected to mainland utilities such as water, sewer, and the power grid (Figure V.C.2; Rubin, 2021).

Typically, homes are situated 8-10 feet apart and share a communal dock for access (Figure V.C.1; fuzzmcpherson, n.d). To enter the home from the shared dock, each floating home is equipped with its own ramp. The steepness of the ramp varies based on the water level; in some cases, it may be steeper due to factors like high tide or storm events (fuzzmcpherson, n.d). The inherent buoyancy of these homes and floating docks offers protection against hydrological disasters and rising sea levels (Moon, 2015).

Fig. V.C.1. *Access from mainland to floating dock system.*
(Source: fuzzmcpherson, n.d)

In addition to the heightened flood protection offered by floating homes, they also yield diverse socioeconomic advantages. Through a shared floating dock system, neighbors tend to interact more frequently, fostering a robust social bond within the floating dock community (Moon, 2015). Floating home communities can enhance a sense of security as homes are surrounded by water with limited accessible entry points. Living in harmony with nature also contributes to a serene atmosphere for residents of floating home communities (Moon, 2015). Moreover, floating homes can be constructed in various sizes, providing options for affordable housing.

While offering security, safety, and social benefits, living in floating home communities also presents certain drawbacks. Although mostly stable, homes can sway due to variations in currents, winds, and wake. Additionally, the floating dock system might pose challenges for walking pets, especially during adverse weather conditions. Trash disposal bins are typically located in the mainland parking lot, and considerations for buoyancy must be factored in when rearranging weight within the home, such as moving furniture (fuzzmcpherson, n.d).

The consulting team has identified the South Morris Town Creek area, specifically the existing Causeway Park location and the neighboring residential neighborhoods, as a potential site for the future development of a floating home community.

Construction and Materials

Floating homes are typically manufactured in a factory and then transported to their designated locations by boat, where they are moored into place (Moon, 2015). To maintain buoyancy, a commonly used flotation device employs a polystyrene foam core encased within a concrete shell, a technique widely adopted in cities like Seattle and Vancouver (Endangsih, 2020). This approach holds the advantage of being applicable in shallower waters, a scenario akin to Oxford's projected conditions in 2100 (Endangsih, 2020). Each floating home is anchored into place to counteract potential movements caused by wind, tides, waves, and ice (Endangsih, 2020). For instance, Waterstudio, a Dutch Architecture firm, secured their floating structures with poles dug at least 65 meters into the ground to ensure stability (Rubin, 2021). The geometric design of the structure also plays a crucial role in developing floating communities. Research has indicated that rectangular structures offer greater stability due to the rotational behavior of the flotation component; the rectangular shape effectively replaces most of the water displaced during movement. Additionally, square structures have demonstrated comparable stability and present advantages in terms of functionality, social and psychological needs, as well as potential linear expansion (Stankovic et al., 2021).

Materials commonly employed in floating home construction encompass wood, steel, concrete blocks, wooden planks, plywood, and glass (Endangsih, 2020) (Figure V.C.2). To develop floating homes tailored to Oxford's requirements, it is recommended to implement a floating object model that assesses the community's needs. This model would involve research into room functionality based on furniture placement, accessibility areas, and performance zones. This concept was proposed by Stankovic et al., who found that in Vietnam, each area should ideally cover around 10 square meters. Alongside the suggestion of utilizing rectangular structures, square structures are equally viable and offer a suitable shape for accommodating functional, social, and psychological needs, while also facilitating linear expansion (Stankovic et al., 2021).

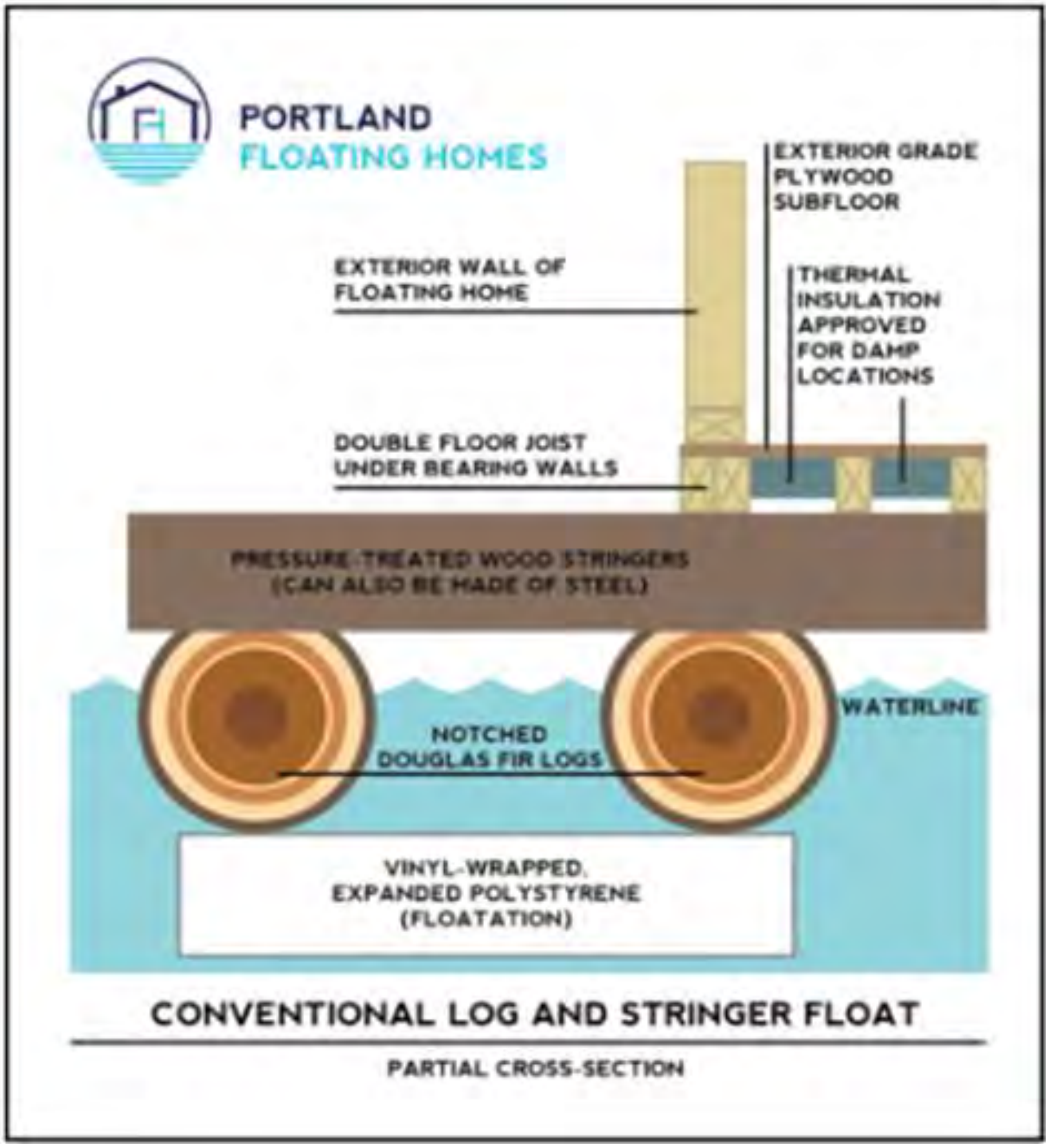

Fig. V.C.2: *Cross-section of typical floating home found in Portland, Oregon (fuzzmcpherson, n.d)*

Figure V.C.3 provides recommendations to establish guidelines for floating home construction. When designing floating homes, it is essential to consider climate change factors such as tidal variations, wave intensity, wind energy levels, and fetch distances.

Building Design

Landscape/Organization of Space

- The location of floating houses: less influenced by strong winds, have a slow water flow, have a low salinity and which are convenient for transportation
- The organization of architectural spaces should be flexible and open to increase ventilation and to reduce the level of humidity
- Offering spaces for social support provision to enjoy water leisure, nature view, landmark and social activities
- Developing floating garden concepts

Architectural Features

- Considering about local socio-culture and vernacular architecture
- Considering design solutions adapting to climate change and rising sea level
- Considering bioclimatic architecture, architectural elements should be designed for natural ventilation, minimum insulation standards (patio, porch, door, window, roof, etc.)
- The form of floating houses should ensure their stable position on the water
- Safety equipment: The floating building must have appropriate life safety devices and firefighting equipment sustainable for marine use

Material

- Natural and local materials
- Lightweight materials, durable materials, recycled materials with high corrosion protection

Structure

- Load-bearing structure: prefabricated, modular structures and lightweight structures
- Floating structures: safe, stable, high strength, high buoyance, high corrosion protection
- Moring systems: flexible, high strength, high corrosion protection

Utilities

Energy

- Using renewable energy (from water, solar, wind, recycling waste, etc.)
- Energy efficiency: minimize energy providing for heating and cooling system, air- condition, thermal isolation, sound insulation

Waste

- Waste recycling for transferring to energy

Water

- Using natural water resource
- Treating and recycling wastewater for usage in daily life

Fig. V.C.3. *Recommendations to guidelines of constructing floating homes (Nguyen, 2022)*

Environmental Impacts

The structures have the capability to utilize renewable energy sources such as solar, wind, and water, as these energies can be more readily harnessed due to their proximity to the waterfront. Living on top of the water allows aquatic life to persist without significant disruption to their habitat. One drawback of floating homes is that their coverage of the water's surface reduces the amount of sunlight reaching the creek's bottom (Moon, 2015). However, this concern should not apply to the areas where the floating homes are being discussed, as these areas currently lack open-water floors that could be affected. When the time comes for the introduction of floating homes and potentially additional structures over open water, a considerably larger expanse of open-water floor space will be available for aquatic life and vegetation.

How did we get here?

The following recommendations for building a framework to design a floating community in South Morris Town Creek are based on the principles developed by Nguyen for constructing floating communities in Vietnam. The framework consists of the following key aspects: Environment, Socio-Culture, and Economy.

- Environment: Promote the use of renewable energy within the community and the utilization of durable and accessible materials capable of withstanding water-related conditions.

- Socio-Culture: Establish an HOA or governance system to manage the floating home community and to uphold Oxford's historical culture.

- Economy: Develop a sustainable living environment using cost-effective materials and adopting efficient construction methods.

To thrive in a successful floating community, individuals must be prepared to adapt to both local conditions and broader factors such as climate change and social shifts (Nguyen, 2022). In the regions of South Morris Town Creek, the inevitable loss of low-lying land due to rising sea levels necessitates proactive measures. It is recommended to begin contemplating new zoning and local regulations (Rubin, 2021) that permit construction along and within Morris Creek as it expands. Establishing official management and regulations at this stage will facilitate a smoother transition toward the future development of sustainable floating home communities. In addition to regulatory adaptation, educating and raising awareness among current and prospective homeowners about the responsibilities associated with owning floating homes is crucial. This education should emphasize environmental protection and the promotion of a viable and harmonious community.

To realize a floating community along South Morris Town Creek, homeowners must possess the means to be self-sufficient. This includes ensuring access to mainland resources for water, sewer, and energy treatment if renewable options are not readily available on-site. Floating homes should also prioritize comfortable living conditions for residents and foster increased social interaction while maintaining affordability. To achieve affordability, houses can incorporate renewable energy sources and make use of locally sourced materials to minimize energy consumption and greenhouse gas emissions, thereby contributing to improved water and wastewater management. Strategic master planning and innovative design considerations can optimize the functionality of each section of the home, while intentional planning for communal spaces within the floating home community enhances community engagement (Nguyen, 2022). Furthermore, it's essential to factor in the average household size for Oxford when formulating plans for floating homes. This ensures that these homes offer sufficient livable space while retaining the historic charm of Oxford.

Case Scenarios

Floating home communities are found across the world and have been successfully implemented. Some examples include:

In the Netherlands, floating homes are often prefabricated and square-shaped. These homes are typically three-story townhouses and are built off-site and then permanently placed (Rubin, 2021).

- Floating homes can be found in Amsterdam, where a heavy storm once hit the community, and the homes were able to return to their original condition (Rubin, 2021).

- In Portland, Oregon, floating communities have been built along the Columbia and Willamette rivers. Some of these homes are net-zero energy equipped with a solar PV system and solar water heating (Moon, 2015) (Figure V.C.4). Other locations on the Pacific Coast include Seattle, WA (Figure V.C.5), and Sausalito, CA.

- After Hurricane Katrina, a floatable home was designed in New Orleans to withstand flooding up to 3.6 meters above the ground, as the home was anchored with guideposts to prevent it from drifting (Moon, 2015).

As a transition to the floating home neighborhoods, elevated boardwalk roadways and drives could be created (Figure V.C.6). This would allow the water to simply rise and fall, and if the boards become inundated, there is no stress on traditional infrastructure (roadways, underground utilities, overhead lines, and yards). The area can remain wet most of the time, being flushed with the tide, and the houses would be elevated above the inundation zone. Elevating the house on piles so the habitable space is well above the boardwalk would mimic current construction techniques in the V and VE zones as well as along coastlines all over the Atlantic coast. Utility mains can be bolstered and attached to the underside of the wooden roadway. When the time comes in the future, the roadway can be elevated, and the homes transitioned to floating platforms.

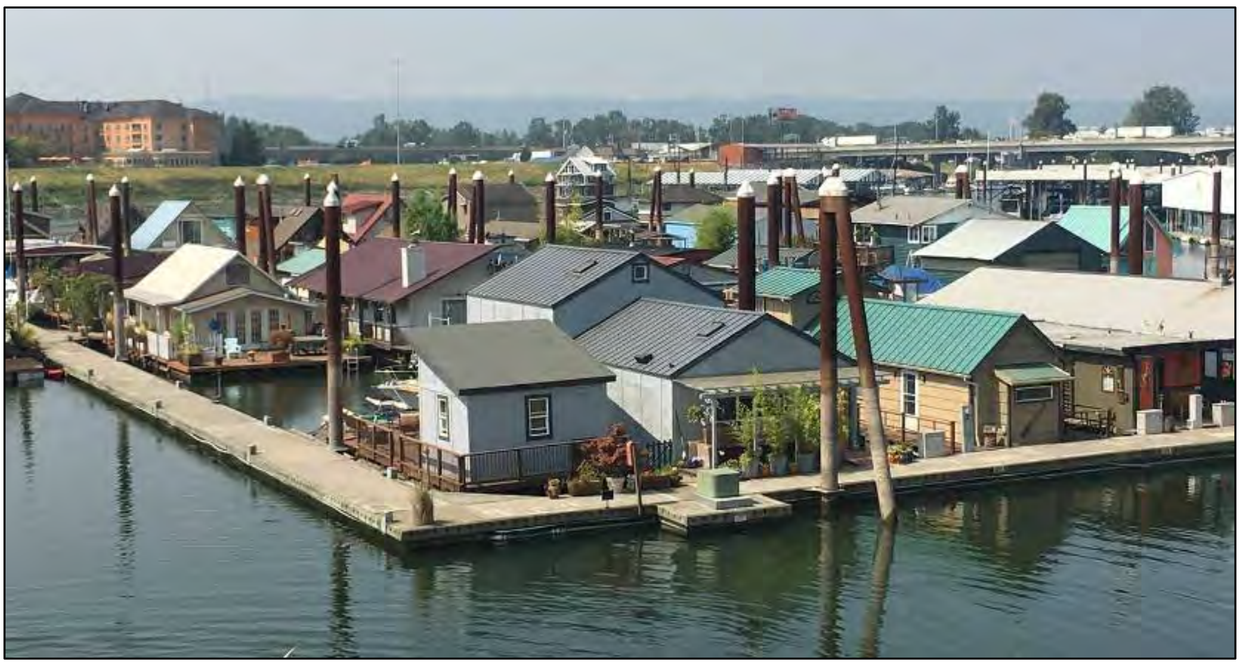

Figure V.C.4. *Floating homes located in the Portland, Oregon*
(Source: https://pdxtoday.6amcity.com/life-floating-home-portland-oregon)

Figure V.C.5. *Floating homes located in Seattle, Washington*
(Source: https://www.seattleafloat.com/stillwater-floating-homes-makes-a-splash-into-portage-bay/)

Fig. V.C.6. *Example of a boardwalk road and driveway network, Michelane Court, North Bethany, DE*
(Source: Long and Foster sales site)

Making a drastic alteration in the landscape with floating homes will not happen all at once. It will be a process to arrive at utilizing lands that will be underwater in the future. There are several options to arrive at the end destination:

- Existing homes are retrofitted to float in their current location.
- An area is created with the infrastructure in place for floating homes, and current structures are moved to the new location.
- At some point when the land is so frequently inundated, it is required that homes are elevated to an extent that the option to provide a floating structure makes more sense.
- The need for reconstruction is high enough to provide “units” that may serve more than one or two homes, and the transition is started.

However, it occurs, it will be an evolution to utilizing certain areas for habitable space in the future. There will not be a quick decision to change the way of life or greatly affect people’s private property investments. And the manner in which the float functions has yet to be determined. It could be on a piling system using them as guides, or possibly tethered to a dock of sorts on top of a barge system. There could be an interim step before fully floating a house where the structure is elevated for a generational cycle, enjoying that approach for 30 or more years.

D. BOATHOUSES

A boathouse is defined as a structure or shed at the edge of a body of water used for housing boats (Figure V.D.1-2). In order to protect the Town, a seawall is proposed in certain areas along the perimeter of Oxford. Theoretically, a seawall separates upland areas from the water to protect the property and buildings that lie beyond as climate change and the impacts associated with it, such as sea-level rise, progress. Boathouses are proposed along the seawall to protect and nurture the waterman way of life that is valued on Maryland’s Eastern Shore. The addition of boathouses along the seawall will encourage and facilitate continued interaction with the coastal ecosystems surrounding the Town after the seawall is constructed. Additionally, the boathouses are meant to support community culture and sustain and reinforce coastal and community water-related commerce and recreation.

Fig. V.D.1. Example of a modern boathouse construction
(Source : https://nydock.com/products/boathouses/)

Fig. V.D.2. *Example of boathouse construction*
(Source : https://thedockdoctors.com/floating-boathouse-foundations)

E. ELEVATED WALKWAYS

Elevated walkways are pedestrian pathways that allow water to flow freely back and forth underneath them or traverse open water or environmentally sensitive areas.

As the tide rises and falls, and sea levels rise, an elevated walkway provides pedestrian access to areas that are more consistently inundated. These walkways could increase connectivity within Oxford and provide access to various naturescapes and scenic views around the Town (Figure V.E.1-2). Moreover, these walkways aid in habitat conservation as the raised structures promote vegetation growth and are less invasive to coastal organisms and habitat (dfg.webmaster@alaska.gov, n.d.).

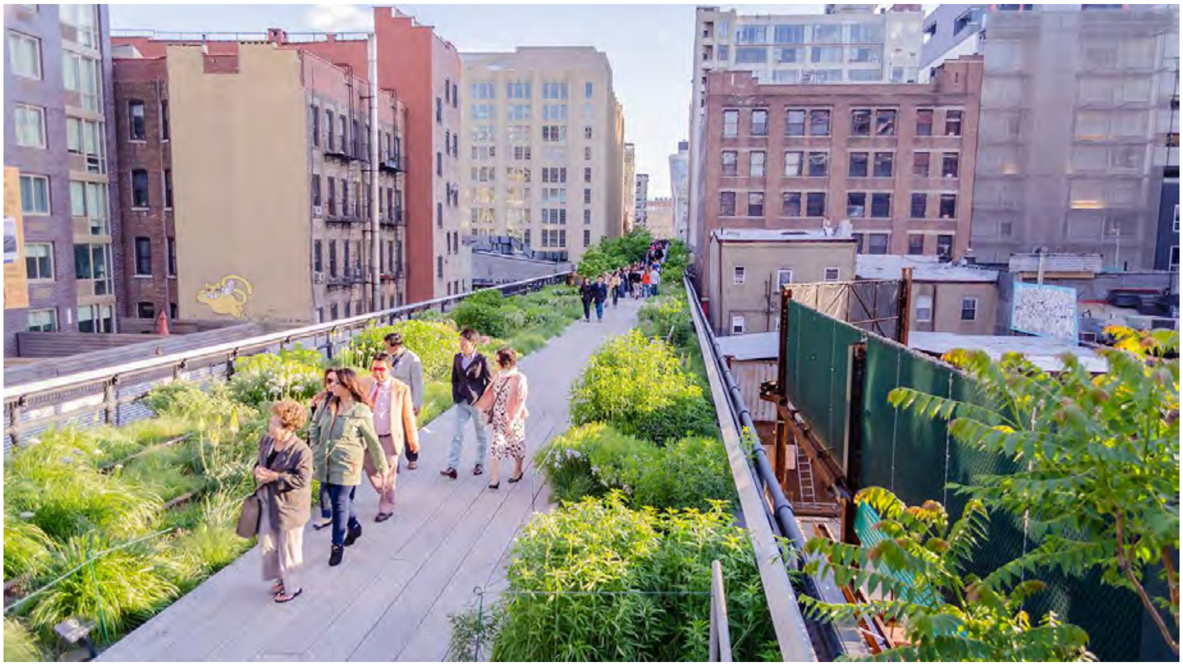

Fig. V.E.1. *Example of an elevated walkway*
(Source : https://www.timeout.com/newyork/parks/highline)

Fig.V.E.2. *Example of an elevated walkway through wetlands.*
(Source : https://wetlandsinstitute.org/visit-us/institute-map/elevated-marsh-walkway/)

F. CAUSEWAY MODIFICATIONS

The Causeway (MD 333) serves as the primary and sole artery into the Town of Oxford, historically connecting the agricultural areas in the County and the eastern regions to the historic district at the north of the Town for centuries. The term "causeway" was fittingly applied because it was once an elevated feature before being developed into a conventional roadway at the head of Town Creek. Ensuring its accessibility and functionality remains crucial to Oxford's prosperity. Without its passability, essential emergency services cannot promptly reach the rest of the Town, and residents face obstacles entering or leaving Oxford. Presently, during higher lunar and wind-driven tides, the road's edge becomes wet, occasionally encroaching into travel lanes. This situation exacerbates during storms. Encountering restricted access to and from the Town due to high tides is untenable and must not persist as a mere inconvenience or something to manage around, given that the situation will progressively deteriorate over time. As sea levels rise, the frequency of Causeway closures and impassable instances will escalate. This poses a substantial health and safety risk for Oxford's inhabitants.

A significant obstacle in elevating the causeway is that it is a Maryland State Highway Administration (MDOT/SHA)-owned and maintained roadway. Oxford cannot independently devise, design, and construct an elevated roadway for secure passage in and out of the Town. Establishing a resilient roadway necessitates MDOT/SHA's guidance and involvement. When exploring the prospects of a new resilient roadway, an elevated Causeway-type or bridge structure should be deliberated upon. With the rising sea levels, water will encroach into lower-lying sections of Town. The low-lying lands extend from the head of Town Creek to the south side of the causeway. Analogous to the wetlands park created at Oxford's entrance, this area is destined to become saturated and inundated in the future. The Strategic Vision regards the area "upstream of the Causeway and surrounding residential neighborhoods" as an ideal site for a floating home community. Allowing water to flow freely into this area will mitigate potential negative effects from tidal forces. Elevating the roadway to permit unobstructed tidal movement beneath the new elevated Causeway or bridge will ensure continual access to and from Oxford.

Initiating discussions with MDOT/SHA is pivotal to the success of the elevation project and the enhanced access to Oxford. Expect a protracted process, but the dialogues should commence without delay. As previously observed with only one primary access road, if a storm surge inundates the Town for an extended duration, it could lead to catastrophe. Preventing loss of life and significant financial repercussions should be of utmost priority for all stakeholders involved in the decision-making process.

Establishing an alternative, supplementary entryway into and out of Oxford could prove pivotal for the Town's sustainability. While introducing a secondary road for maintaining vehicular access might appear excessive, the cost of securing access is incalculable.

To uphold access, contemplation of an alternative entryway is also warranted. This would ensure minimal traffic disruption even during routine maintenance periods on the future Causeway, and vice versa. This could be located just south of the current main road, in the form of a fully-fledged two-lane road or an upgraded, traffic-bearing rails-to-trails segment that links back to MD 333.

G. PUBLIC UTILITIES CONSIDERATIONS

Although alternative measures for clean water and wastewater treatment are available, this project will assume that public, centralized services for potable water and sanitary sewer collection and treatment will be continuously provided by the Town. If alternative methods become available, the approaches can be altered in the future.

Centralized municipal water and sewer mains will be needed within the rights-of-way (for the majority) as Town services. These mains will deliver clean drinking water to individual homes and carry away the sanitary greywater to the wastewater treatment plant. As sea levels rise, groundwater tables will also rise. Ensuring watertight fittings on the mains will be key to maintaining a closed system and avoiding contamination. Furthermore, as the water table rises, watertight connections will limit inflow and infiltration into the system, which would reduce capacity at the treatment plant. The mains should be routinely inspected to ensure proper functioning.

The pump station along Bank St. should be investigated for replacement within 10 years. Initiating planning for a new pump station will allow the design to be completed and funding to be sought for replacement, whether through the MDE Water Quality Revolving Loan Fund, congressional earmark, or public sources like the CIP. The replacement station should be relocated to an area currently outside the FEMA floodplain. Additionally, it should be constructed with the CRAB (Climate Ready Action Boundary) model and the current Town requirement of 3’ of freeboard in mind. This will lower the risk of floodwaters entering the sanitary sewer collection system. Saltwater accelerates the wear and tear on equipment over time.

The pump station near the Causeway was recently upgraded. The life expectancy of the station suggests that replacement investigation will occur around the year 2050. When that time comes, as with the Bank St. station, a new location for the pump station should be sought outside the FEMA floodplain.

When rebuilding public streets, the overhead services currently in place should be updated for underground installation. This will be determined on a case-by-case basis, requiring coordination with electric, cable, telephone, and fiber optic owners of the various lines. Burying public services aligns with the goals of the Maryland Department of Emergency Management and the Department of Housing and Community Development.

The wastewater treatment plant is positioned above the current Town standard of 36” of freeboard. The facility currently stands outside the floodplain, but this could change over the next 75 years. The facility's elevations are 3’ higher than the adjacent 1% chance BFE, which is a positive aspect. In the future, as sea-level rise progresses and new FEMA maps are adopted, the Town should explore elevating the facility as necessary to keep pace with floodplain expansion. The technology used in the facility should be reviewed periodically to ensure its resilience against storms or extreme tidal surges.

Recently, it was discovered that around 75 homes are using potable water connections from the Town for irrigation purposes on lawns and gardens. To address this, and in addition to encouraging the use of rainwater cistern collection systems as currently in place at 103/101 Mill Street, a solution could involve investigating the use of treated effluent from the WWTP to provide irrigation water to these customers and others. With climate change and anticipated dry spells in the summer, providing irrigation to Town residents using treated water or collected rainwater would greatly enhance their quality of life. This would also reduce the demand for potable water, which currently strains the system, and offer groundwater recharge and an alternative discharge for treated greywater reclaimed from the WWTP as well as helping to control stormwater runoff. This reduction in discharge to Town Creek would benefit the habitat and plant life in Oxford. Utilizing greywater under MDE standards could assist with implementation plans. Currently, MDE regulations do not cover greywater use or handling. Advocating for this change and encouraging the use of rainwater collection systems could enable swift implementation of cutting-edge improvements. In the absence of state guidelines or legislation, local plumbing code updates or changes to the Talbot County Health Department ordinance could potentially regulate the available use.

As the Oxford landscape and elevations change over time, the need for subsurface utilities will persist. The positive news is that the current condition doesn't recommend lowering elevations in many spots. The central water and sewer mains can remain in similar positions for "scheduled" replacements as long as conditions permit. Upgrading to the latest materials is advised during these improvements, with watertight PVC replacing older materials like ductile iron.

H. ZONING CONSIDERATIONS

As time passes, construction materials and processes improve, techniques alter, living and transportation modes evolve, and general environments progress, the current Town zoning codes will need to be developed and adapted. Codes, zoning, guidelines, and regulations dictate our constructed environment around us. Currently, the Town of Oxford has a robust strategy to address development within Town limits. Keeping the historic character in the future is key, but so will be protecting and mitigating adverse effects from climate change.

1. **Timing:**

   The Comprehensive Plan is required to be reviewed and addressed every 10 years. As long as the state maintains this timing for updates, that timing should be held. Ensuring the focus of the Town is refreshed every decade will keep the focus of construction codes and techniques in the forefront without falling behind. The Comprehensive Plan should incorporate the recommendations from the Strategic Vision.

2. **Alternatives:**

   In order to be able to implement several of the strategies laid forth in this report, state codes will need to be altered. Due to the limited land mass area with development up to the edges nearly all the way around Oxford, allowing for waterward construction of protection measures will be critical for the Town's resiliency and presence in 2100 and beyond. Softer shorelines with natural buffers between the water and the protection area have proven to be more resilient and provide quicker recovery after facing storm events and tidal surges.

Altering current MDE constructability codes will be paramount for the construction of the dune system, stepped sills, boathouses, floating house network, and various other strategies and techniques. Working with MDE on this venture will not be an easy or an expeditious task, so starting the conversation with them will be key to begin authorization in implementing these strategies. Ongoing discussions, understanding objectives, and outlining the end goals will allow for a tailored approach specific to Oxford and allow for construction outside of the boundaries currently in place.

3. Goals:

Allowance for encroachment into the water past the MHHW line will be needed for the installation of several strategies. Currently, houses reside on the upland portion, and while not directly waterside, there is not enough room to build a dune system with an appropriate height and associated slopes on both sides on the land between MHHW and the structures. Understanding that the new dune system will be maintained with a partnership (similar to DNREC in Delaware along the Atlantic Coastal stretch from Fenwick to Lewes), the end goal isn't to expand the private ownership land area for the houses present but rather serves as the shield to protect the Town from the wave action on the Tred Avon and Choptank Rivers and hold back the rising seas. With a severe storm and major wave action, a similar result to the coastal areas in New Jersey during Sandy could be foreseen. Providing protection to avoid this scenario should be the goal for all parties; local, state, and national.

4. Purpose:

Nearly the entire exterior of Oxford is in the VE zone, meaning greater than 3' waves. With SLR projected at nearly 4' by 2100, those waves will not remain at 3'. Deeper waters bring higher, and stronger, waves as they draw from greater depths of water. More powerful waves require greater buffers. The dune systems have proven successful around the Atlantic region, and even in Maryland along the oceanfront in Ocean City. The dune network is not a new concept, but altering the ability to install them for protection will be needed for success.

5. Current codes:

The FEMA Floodplain codes are serving the Town well with the 3' freeboard requirement. As stated in other sections, this should continue to be the standard (at a minimum) with Oxford. As stated above, other codes should evolve with the times. An option, if desired down the road, would be to require all new construction to meet the FEMA V-zone construction requirements for elevation on piles with breakaway walls on the lower level.

6. Other codes:

As the sea level rises, and development pressure has little space to expand, investigating how the various state codes and policies affect the ability for Oxford to be resilient in the future and mitigate the effects of flooding should take place. Current Critical Area codes for individual houses may not provide the ability to maintain the Town. Nor may it allow for the installation of some strategies in the space and area needed as it is currently written. Additionally, wetlands codes, water access, and construction limitations over the open water may need updating, altering, or complete revisions to ensure Oxford can implement the various strategies.

As discussed earlier in this report, there is a Maryland CRAB model to provide guidance for construction within the coastal areas. This goes hand-in-hand with the Critical Area provisions that have been set forth for Oxford that are now over a decade old and due for review and possibly updating. Allotments for alternative construction practices in this area that are traditionally off limits will need to be relieved to ensure the resilience of Oxford and mitigate adverse impacts.

7. New Codes:

Two main components of the Strategic Vision are the introduction of Boathouses and a Floating Community as adaptation strategies. The Zoning Code and Comprehensive Plan will need to be updated accordingly. Maintaining the standard 10-year update cycles will be important in addressing the changing landscape that rising seas, more intense storms, and construction techniques have in store for life on the shore. Allowing the updates to go past their expected timing will not keep up with the times nor provide the attention required for such a unique idea and one that is outside the norm of construction and living in Oxford. Should any event occur that needs implementing quickly, Oxford should be prepared with an outline of what is desired to be implemented and allowed.

VI. AREAS OF INTEREST / STUDY AREAS

Through the evaluation of the Town's characteristics, topography, and constraints, the Town was divided into several "distinct" areas for study and the development of a resiliency plan, as follows:

A. North Morris Tred Avon Bluff & TAYC
B. The Strand, Ferry, and Town Creek Point
C. North Morris Town Creek
D. South Morris Town Creek
E. Jack's Point
F. Bachelor's Point, Marina and NOAA Lab
G. Treatment Plant/Recreation and Conservation Park
H. South Morris Beach/Pier Street Marina & Future Ferry

The areas are identified on the overall map of the Strategic Plan, included as Figure VI.1, and the Masterplan Locations Map, included as Figure VI.2, and in Volume II:

Fig.VI.1 *Oxford 2100 Visioning Strategic Plan*

Fig.VI.2 *Oxford 2100 Visioning Masterplan Locations Map*

A. NORTH MORRIS TRED AVON BLUFF & TAYC

1. Existing Conditions:

This area encompasses the shoreline that runs north/south, parallel to North and South Morris Street, from the general area of Holy Trinity Episcopal Church to the existing point at the Tred Avon Yacht Club (TAYC). The area currently features a few isolated beach areas, with significant "hard edge" shorelines in the form of rip rap stabilization, revetment, and bulkheads. Multiple individual piers and boat slips traverse the shoreline. The area behind the shoreline is relatively elevated and contains some of the highest ground in Town. Behind the shoreline lies the largest portion of the Historic District, the main Commercial District, Holy Trinity Episcopal Church, the Town Park and beach area, and the Sandaways. Due to the Town's orientation, this shoreline faces significant erosion risk. It faces west across the mouth of the Tred Avon to the Choptank, resulting in high wave energy during southwest winds. The Strand Beach protection project will be initiated in the fall of 2023 and concluded in the subsequent year, enhancing protection for Oxford's northern face.

2. Recommended Resiliency Strategies:

Given erosion potential, a dune system is advised along the shoreline, extending toward the water, with the existing shoreline edge serving as the dune slope's back toe. The dune system would integrate a living shoreline and a "hard edge" in specific areas like the TAYC. A breakwater, similar to the existing beach, would be added west of the dune system. Individual piers would extend beyond the dunes, with stairways over the dune system. Floating docks accommodating sea level rise would be installed. Drainage infrastructure behind the dune system would incorporate tide gates to prevent tidal backflow.

3. Additional Considerations:

The proposed resiliency infrastructure would enhance connectivity and public access throughout the Town. An overlook near Sandaways on the western edge of West Strand Rd. would offer a public amenity and leverage views from the TAYC point. Overlooks within the dune and living shoreline system, connected by boardwalks, and integrated with the existing sidewalk system, could be incorporated.

For future boatyards, new piers will be required to replace aging ones. With sea level rise projections over their lifecycle, the elevation of piles should be considered during maintenance and new installations. Floating or fixed piers could work due to SLR rates. An approximate 30-year life cycle allows elevations to be raised with each renovation/re-installation. Oxford's policy mandates piles at 9 feet to enable vertical migration of marine structures.

A peninsula that once buffered wave energy across the Tred Avon's mouth has eroded. Reconstructing and bolstering this peninsula, like other Chesapeake islands, could offer protection to Oxford and Tred Avon River communities.

4. Recommended Timeline:

a. Immediate:

Monitor erosion at Town Park Beach. Develop "typical" sketches and sections. Engage MDE and DNR in long-term practices discussions. Initiate conversations with adjacent landowners. Conduct a detailed topographic survey of TAYC and Town Park.

b. Short Term:

Complete a detailed topographic survey of the entire area. Explore funding options. Develop a detailed plan for TAYC.

c. Mid Term:

Implement resiliency upgrades at TAYC. Finalize detailed design and begin dune construction to a temporary height.

d. Long Term:

Complete dune construction, boardwalk, and reposition docks and slips. Determine final dune height during final concept, engineering design, and implementation. Consider future FEMA flood maps, sand transport modeling, wind directions, offshore Tred Avon depth, additional shoreline protections, fetch across open water, and dredging activities for proper storm surge protection and mitigation on River-facing properties.

B. THE STRAND, FERRY & TOWN CREEK POINT

1. Existing Conditions:

This area encompasses the shoreline that runs east to west, parallel to the Strand from the point at the Tred Avon Yacht Club to the point at the eastern end of the Strand. The area currently features bulkheads at the Yacht Club and the existing Oxford-Bellevue Ferry terminal, an existing seawall with rip-rap protection in front of it, the Strand Beach, and several bulkheads, private piers, and slips moving eastward past the Strand causeway. The area is also part of the Historic District. The primary land use is residential, but the area includes notable sites such as the Robert Morris Inn, the north face of Tred Avon Yacht Club with associated boat slips, and the Ferry Terminal. The western section of the Strand, behind the existing seawall, and the northeastern end of the peninsula at the mouth of Town Creek are relatively high in elevation. In between these areas, the elevation is relatively low. Along the Strand at Strand Beach, flooding is routine, causing the causeway to flood and resulting in the Tred Avon and Town Creek merging to form an island at the eastern edge of the Strand. The Strand faces direct exposure to wind and wave energy generated by the prevailing northwest winds between October and June, as well as year-round boat traffic. Low areas along Mill, Norton, Tilghman and Stewart Streets frequently experience flooding.

2. Recommended Resiliency Strategies:

A dune system is recommended along the shoreline, extending outward toward the water. This dune system could be an extension of the proposed Strand Beach project and could connect to the relatively high elevations of the seawall near the Robert Morris Inn at the western end of the Strand. The dune system should incorporate a combination of living shoreline and "hard edge" protections in specific locations, such as the Ferry Terminal and TAYC piers. Breakwaters should be positioned north of the dune system, following the approach employed for the Strand Beach project. Individual piers should be extended beyond the dunes, featuring stairways over the dune system. As the dune system continues eastward, it should integrate with the proposed seawalls for the North Morris Town Creek area (refer to later sections). To prevent tidal backflow, drainage infrastructure with appropriate tide gates must be established behind the dune system. Converting slips at TAYC to floating slips is advisable. Consider elevating low points along Mill, Norton, Tilghman and Stewart Streets temporarily to alleviate flooding.

3. Additional Considerations:

The existing Oxford Bellevue Ferry Terminal is situated at the intersection of Morris Street and the Strand, requiring elevation adjustments to account for sea level rise. The current street elevations at the intersection offer sufficient elevation to accommodate various sea level rise scenarios. Given the long-term plan for potential ferry locations, relocating the ferry terminal is an alternative to consider. An ongoing project to enhance the beach and protect the shoreline at Strand Beach incorporates offshore breakwaters, improved protections, and living shorelines along the eastern end of the Strand. This project is designed to serve the area for approximately 30 years, until the next set of sea level rise strategies need to be implemented.

Fig. VI.B.1 *Visual of year 2100 – The Strand Beach & Bluffs Perspective & Section*

4. Recommended Timeline:

a. Immediate:

Finalize the Strand Beach Enhancement Project. Conduct a detailed topographic survey of the area after completing the beach project, including Mill, Norton, Tilghman and Stewart Streets.

b. Short Term:

Initiate planning for improvements to the Strand causeway's elevation. Implement temporary enhancements to Mill, Norton, Tilghman and Stewart Streets. Develop a major protection project plan to safeguard the Town's V-zones during major storm events.

c. Mid Term:

Explore and plan the extension of the dune system east and west of Strand Beach, connecting to existing high ground and the current seawall. Install drainage infrastructure and tide gates in this focus area.

d. Long Term:

Complete the dune network to its final elevation, encompassing the region between Morris Avenue and the end of the Strand. Refer to preceding sections for further details.

C. NORTH MORRIS TOWN CREEK

1. Existing Conditions:

This area encompasses the region behind the Strand, situated at the mouth of Town Creek. It comprises single-family homes, condo buildings, the Historic Cuts and Case Shipyard, several operational marinas, and boatyards, Capsize restaurant, and The Water's Edge Museum. The primary Historic District seamlessly transitions into this area. Some of the lowest elevation infrastructure in Town (approximately 2.0 feet) is found in this vicinity, specifically along Tilghman Street, Norton Street, Mill Street, and Bank Street. These streets are prone to frequent flooding caused by both rainfall and tidal events, and they suffer from poor drainage. The existing drainage infrastructure often retains water, leading to saturated swales, mosquito breeding, muck accumulation, and unpleasant odors during wet periods and the summer months.

2. Recommended Resiliency Practices:

A proposal is put forth for the construction of a seawall along the northern and western shores of Town Creek, starting from its mouth and extending southward along the shoreline to the main causeway at the Town's entrance. The incorporation of the seawall "upstream" (land side) of the marinas is anticipated. The development of the seawall could occur in distinct sections and phases. Commercial and industrial spaces could be adapted to "float" in response to rising sea levels. To maintain residential waterfront access, traditional residential boathouses and terraces could be integrated (Refer to Figure VI.C.1-4). It is recommended that the Town explores and examines the possibility of adjusting and elevating grades along Mill, Tilghman, Norton, and Bank Streets. As a precursor to any seawall construction, improvements to drainage infrastructure are essential, extending into the residential neighborhoods. Upgrades to tide gates will be necessary to prevent tidal inflow into low-lying areas. The rise in groundwater due to sea level rise necessitates the implementation of residential underdrain systems. To address collected stormwater runoff and groundwater, a stormwater pump station should be constructed, conveying it over (or through) the seawall.

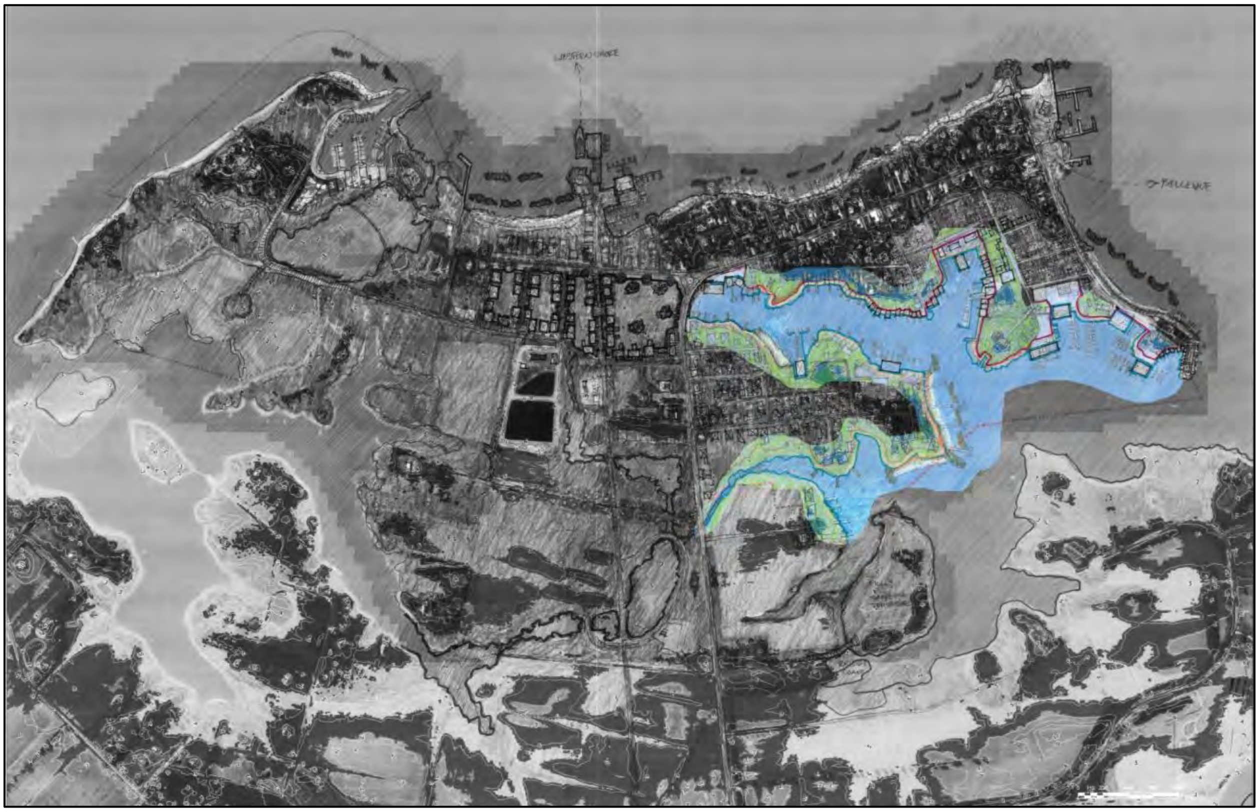

***Fig. VI.C.1** Visual of year 2100 - North Morris Town Creek Aerial View*

***Fig. VI.C.2** Visual of year 2100 - North Morris Town Creek Profile View*

Fig. VI.C.3 *Visual of year 2100 - North Morris Town Creek Boathouses*

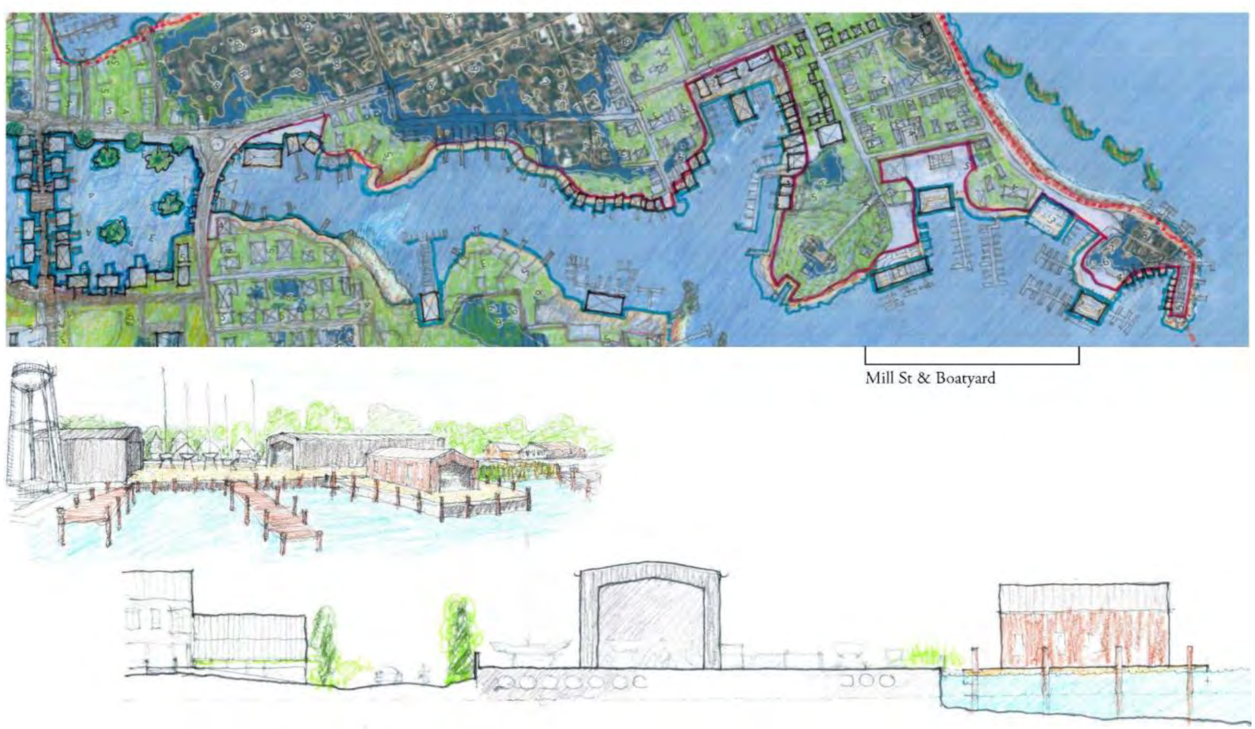

Fig. VI.C.4 *Visual of year 2100 - North Morris Town Creek Boatyard*

3. Additional Considerations:

Due to minimal opportunity for flushing, the head of Town Creek remains a dead spot at the causeway with poor water quality. The area contains significant commercial activity in the form of marinas, boatyards, and restaurants that must be incorporated into the final plan. Maintaining livability while also promoting commerce will lead to a successful Town in 2100. Having this area, outside the historic district, as a potential commercial hub could be a key factor for Oxford.

4. Recommended Timeline:

a. Immediate:

Replace tide gates and add tide gates where necessary. Prepare a full topographic survey of the area.

b. Short term:

Consider raising sections of Mill, Tilghman, Norton, and Bank Streets.

c. Mid term:

Begin construction of stormwater pump station and initial stages of the sea wall. Replace existing piers and slips with floating infrastructure.

d. Long term:

Extend and expand the sea wall. Given the gradual rise of sea levels in comparison to infrastructure lifecycles, the sea wall can be elevated through renovations and reconstruction after several decades of use. With each new construction phase, the top elevation for mitigating flooding can be raised. Investigate the initial iteration within the next 10 years, examining location, potential challenges for constructability and permitting, determining top elevations, addressing drainage challenges when constructing a wall and impeding runoff, and exploring funding options.

D. SOUTH MORRIS TOWN CREEK

1. Existing Conditions:

This study area encompasses the southern portion of Town located south of the Morris Street Causeway, which includes the Causeway Park, the Oxford Community Center, and the surrounding residential communities. This area is characterized by relatively low elevation and exhibits more typical suburban development patterns in contrast to the historic district. The Morris Street Causeway serves as a crucial ingress and egress point for a significant portion of the Town, but it experiences routine flooding due to tidal influence.

2. Recommended Resiliency Practices:

The Morris Street Causeway, being a vital entry point for the Town, necessitates a significant elevation increase. (Refer to the preceding section on the Causeway for detailed information on this area.) Given its location within the state's right-of-way (ROW), the possibility of abandoning and rerouting it is unlikely. Instead, the Causeway should be elevated or be transformed into a bridge, encompassing water on both sides. This design would allow tidal and rainfall runoff to flow beneath the elevated road section. Essentially, the elevated roadway would enable the natural expansion of Town Creek southward from its current bulkheaded terminal point at the northern end of MD Rt 333. The bridge section could offer sufficient clearance to accommodate passage for kayaks and skiffs, providing low-clearance water-based transportation. In the area behind the Causeway, including the Causeway Park and its surroundings, a section of floating homes could be developed (See Figure VI.D.1-2). Elevated walkways would facilitate pedestrian access. To ensure appropriate water depth during low tides, the region could be excavated to establish suitable depths for flushing and support natural habitats. The excavated material could also be repurposed for use as fill or incorporated into berms at various locations throughout Town, including cores for the dune system or elevation of roadways.

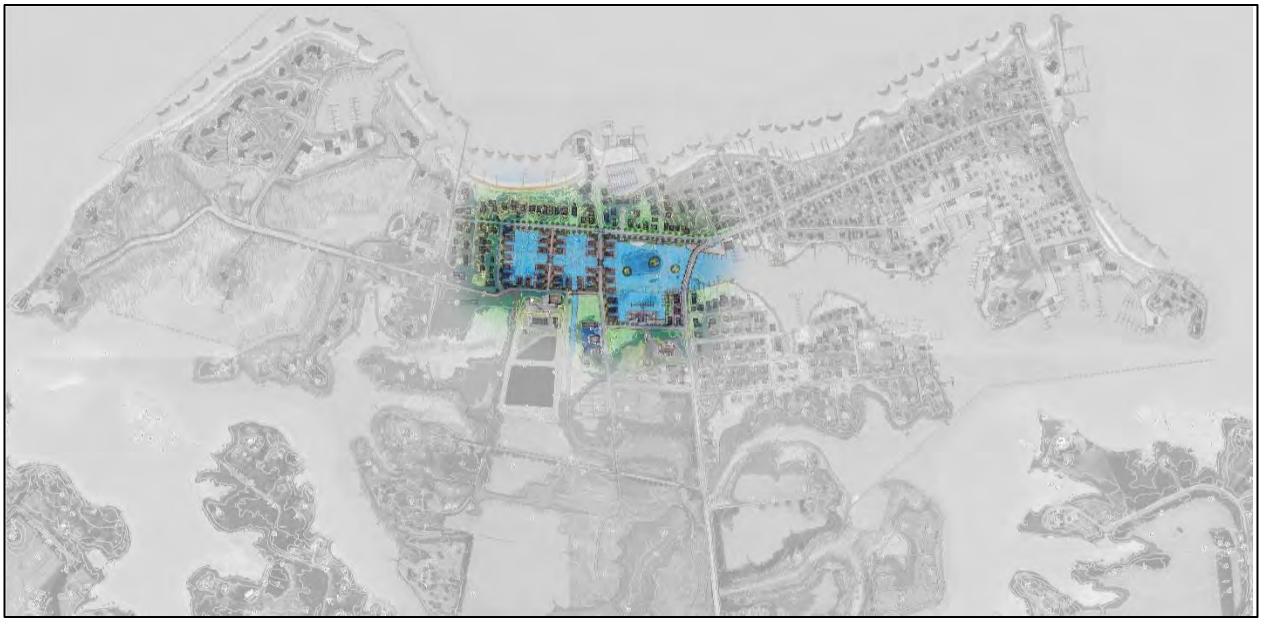

Fig. VI.D.1. *Visual of year 2100 - South Morris Town Creek Aerial View*

3. Additional Considerations:

A hybrid system comprising a sea wall and living shoreline could be integrated into the upland areas, which can be elevated using the excavated material. The elevation of the Causeway could be raised using the excavated materials, effectively serving as a seawall for the newly expanded Town Creek. A hybrid seawall and elevated walkways and roads could be installed around the perimeter of this section to provide flood protection and public esplanades. Ensuring proper elevation tie-ins with adjacent residential and community areas will be crucial and will require meticulous study and analysis. This area presents the potential for significant reimagining, offering an entirely new experience and landscape for Oxford. The Causeway Bridge will need a substantial elevation increase, and grade tie-ins should be carefully examined.

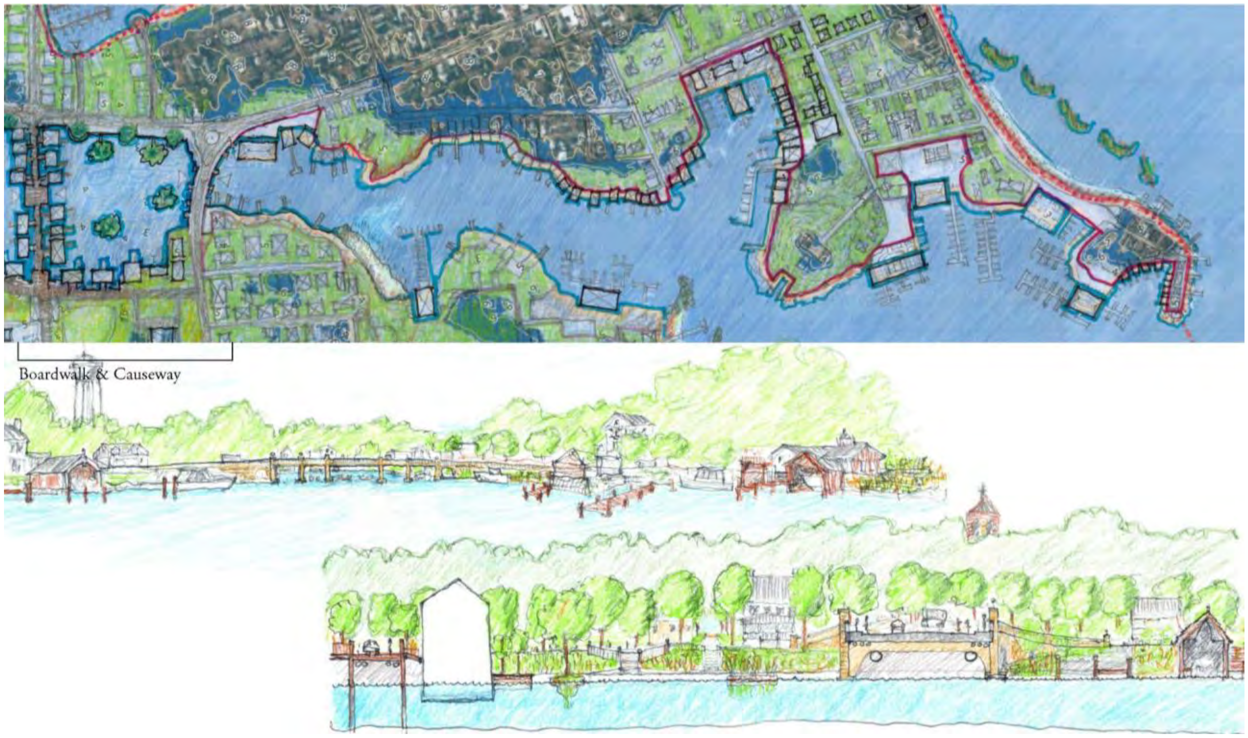

Fig. VI.D.2. *Visual of year 2100 - South Morris Town Creek Profile View*

4. Recommended Timeline:

a. Immediate:

Initiate discussions with MDOT/SHA concerning Causeway elevation and potential for a future bridge. Replace tide gates to prevent backflow into Causeway Park.

b. Short term:

Elevate the Causeway to a temporary elevation without implementing the bridge.

c. Mid term:

Install a temporary stormwater pump station behind the Causeway.

d. Mid to long term:

Construct a temporary Causeway bypass. Proceed with bridge construction. Excavate the Causeway Park areas. Develop infrastructure for floating homes, marina, a new commercial center to support a new floating home community.

E. JACK'S POINT

1. Existing Conditions:

This study area encompasses a north-south peninsula encircled by Town Creek, with multiple connections to Oxford Road east of the Causeway. The peninsula benefits from general protection against erosive wave action by the presence of the Strand and Morgan's Point. However, boat traffic still contributes to some degree of erosive activity. The primary land uses within this area are residential, including Campbell’s Boatyard-Jack’s Point. The elevation is moderately low, mostly around elevation 5.0', with elevated ridges located near Oxford Rd. and at the northern tip of the peninsula along Town Creek.

2. Recommended Resiliency Practices:

To enhance resilience, a combination of a sea wall and dune system is suggested along the interface of Jack's Point with Town Creek and east with the Oxford Cemetery. In the vicinity of the boatyards, the proposal includes the installation of floating commercial docks, work sheds, platforms, and new restaurant facilities. The sea wall can be situated "upstream" (land side) of the marinas. A phased approach can be adopted for the construction of the sea wall in sections. To maintain residential connection to the waterfront, traditional residential boathouses and terraces can be incorporated. Upgrades to drainage infrastructure should be implemented behind the sea wall, extending into the adjacent residential neighborhoods. The inclusion of bioswales and upgrades to tide gates will be essential to prevent tidal inflow into low-lying areas. As sea levels rise, residential underdrain systems will be necessary to intercept increasing groundwater. To manage collected stormwater runoff and groundwater, a stormwater pump station is recommended, capable of conveying it over (or through) the sea wall.

In the future, during roadway reconstruction projects, an exploration of box culverts with road-width dimensions could be considered. These culverts would offer stormwater retention, space for centralized utilities, and the capacity for tidal ebb and flow beneath the road surface. This boxed area could also function as a cistern, accommodating pump station equipment.

3. **Additional Considerations:**

The preservation and promotion of habitats are paramount considerations for any strategies in this area. The small cove positioned between the Oxford Cemetery and Jack's Point currently supports a thriving aquatic ecosystem. Preserving the vitality and health of this area for native species habitats is critical and should be thoughtfully studied alongside any proposed activities.

4. **Recommended Timeline:**

a. Mid-term:

Given the substantial private ownership within this area, addressing this challenge is paramount. Engaging in discussions with the neighborhood should commence within the next 20 years, aiming to prepare residents for the forthcoming resilient strategies. While a unanimous agreement may not be feasible, garnering substantial support for modifications to property, access from both land and water, and adjustments to housing layout within potential upgrades will be pivotal.

F. BACHELORS POINT, MARINA & NOAA LAB

1. **Existing Conditions:**

This study area encompasses the southwestern corner of Town at the confluence of the Tred Avon and the Choptank rivers. With Boone Creek flowing along its rear boundary, Bachelors Point is a peninsula bordered by water and marsh on three sides. The primary land uses within this region are residential and Campbell's Boatyard and Marina. Notable establishments like the Oxford Lab, NOAA, and Coast Guard Station are located just north of the entrance to Bachelors Point. The elevation is relatively low, featuring substantial tidal marsh and tidal ditches. A high ridge area spans across a concentrated segment of residential development. Similar to the North Morris Tred Avon Bluff section, the orientation of the shoreline exposes it to considerable erosion risk. Facing west across the Tred Avon's mouth to the Choptank, the shoreline experiences substantial wave energy, particularly during southwest winds. As sea levels rise, substantial portions of tidal marsh will transition into open water.

2. Recommended Resiliency Practices:

Due to the imminent erosion threat, the proposal suggests a combination of a dune and breakwater system along the shoreline, extending outward towards the water, while maintaining the existing shoreline as the back toe of the dune slope. This dune system should incorporate a blend of living shoreline and "hard edge" protections in specific locations. Sylvan Sills could be integrated at the point adjacent to Campbell's Boatyard and Marina. Positioned to the west of the dune system, a breakwater is advised. Extending beyond the dune system, individual piers and slips should feature stairways over the dunes. The area encompassing the boatyard should transition into a hard-edge sea wall that stretches along the entirety. In preparation for rising sea levels, floating docks are recommended. To mitigate tidal backflow, drainage infrastructure with appropriate tide gates is essential. As sea levels continue to rise, the implementation of a stormwater pump station will likely become necessary. The existing causeway will need to be elevated.

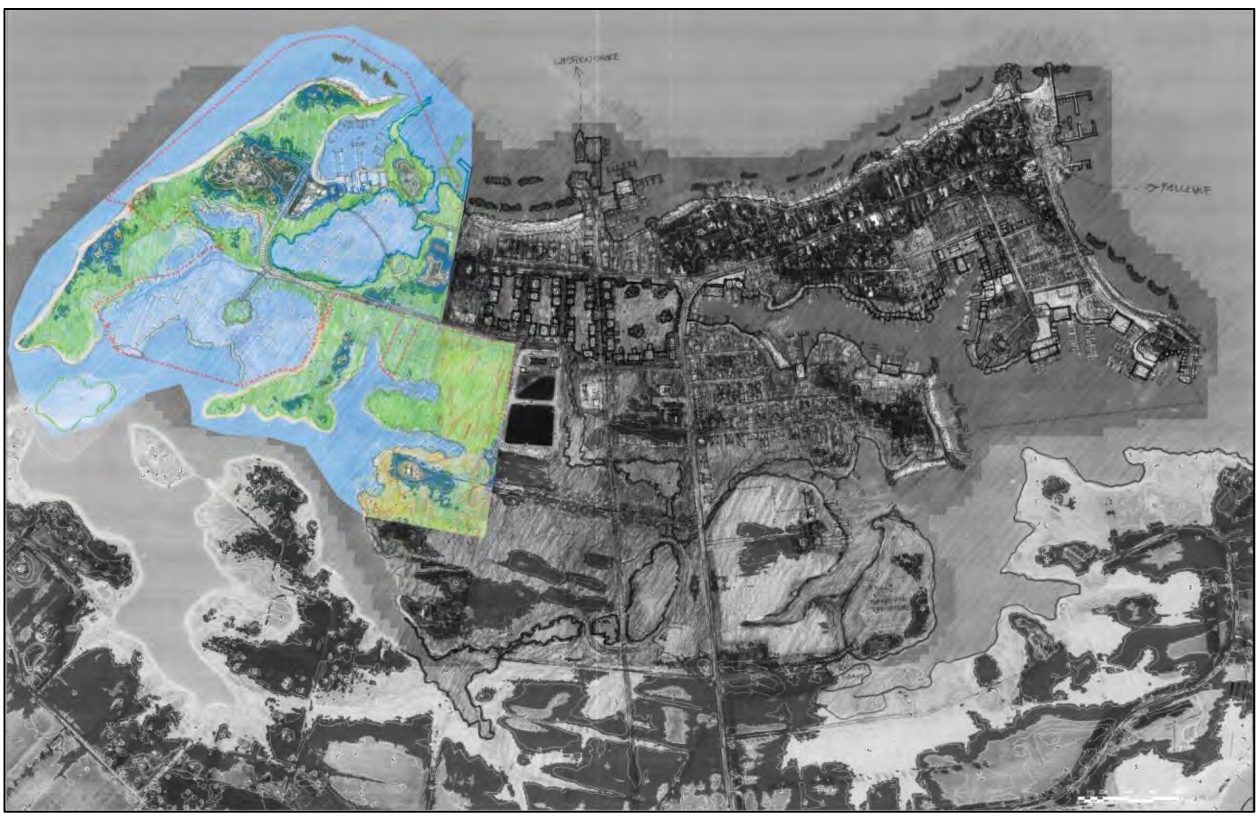

Fig. VI.F.1. *Visual of year 2100 - Bachelors Point, Wetland Marshes & Research Laboratory Aerial View*

3. **Additional Considerations:**

Given that a significant expanse of existing tidal marsh will be inundated with sea level rise, a network of elevated roadways and boardwalks will be required for connectivity. The present residential region of Bachelors Point will effectively become an island with sea level rise. In addition to elevating the existing causeway, a potential solution involves the creating a series of elevated boardwalks from South Morris to Bachelors Point. This network could be constructed from concrete or wood, serving as a distinctive feature at Oxford's southern end.

4. **Recommended Timeline:**

a. Short term:
Introduce Sylvan Sills and a breakwater at the point to counteract erosion. Initiate reinforcement efforts at Campbell's Boatyard and Marina. Develop a plan for a boardwalk system.

b. Mid term:
Commence dune construction with additional breakwaters. Initiate the development of the boardwalk system and elevate the causeway.

c. Long term:
Complete the dune system, alongside the implementation of additional elevated roadways and walkways.

G. TREATMENT PLANT/RECREATION AND CONSERVATION PARK

1. **Existing Conditions:**

This study area encompasses the section of Town located south of the Community Center, including the Public Works Yard and the wastewater treatment facility. It extends across the Town line into the Recreation and Conservation Park in Talbot County. The area is primarily flat and sits at an elevation of around 5.0'. There are sporadic ridges of higher ground in the park, with the highest point being the treatment lagoon embankment at approximately 10.0' elevation. Much of the region comprises open space, farmland, and tidal marsh.

2. Recommended Resiliency Practices:

The Public Works Yard and Wastewater Treatment Facility need to be elevated to keep pace with sea level rise. The remaining portion of the area will remain unchanged. With the rise in sea levels, tidal influences will cause the surrounding creeks to encroach further inland. This presents an opportunity to enhance water connectivity. By excavating channels, water connectivity can be improved. There's a possibility of linking Town Creek to Boone Creek through a network of waterways traversing this area. This waterway could connect to the new South Morris Town Creek which would permit the free flow of tidal and rainfall runoff throughout Causeway Park and floating homes. The installation of a "purple pipe" gray water reclamation system could minimize wastewater treatment plant discharges and offer irrigation water to the Town. This would reduce the demand for potable water used in irrigation and ease the strain on Town infrastructure and operational facilities amid changing climate conditions.

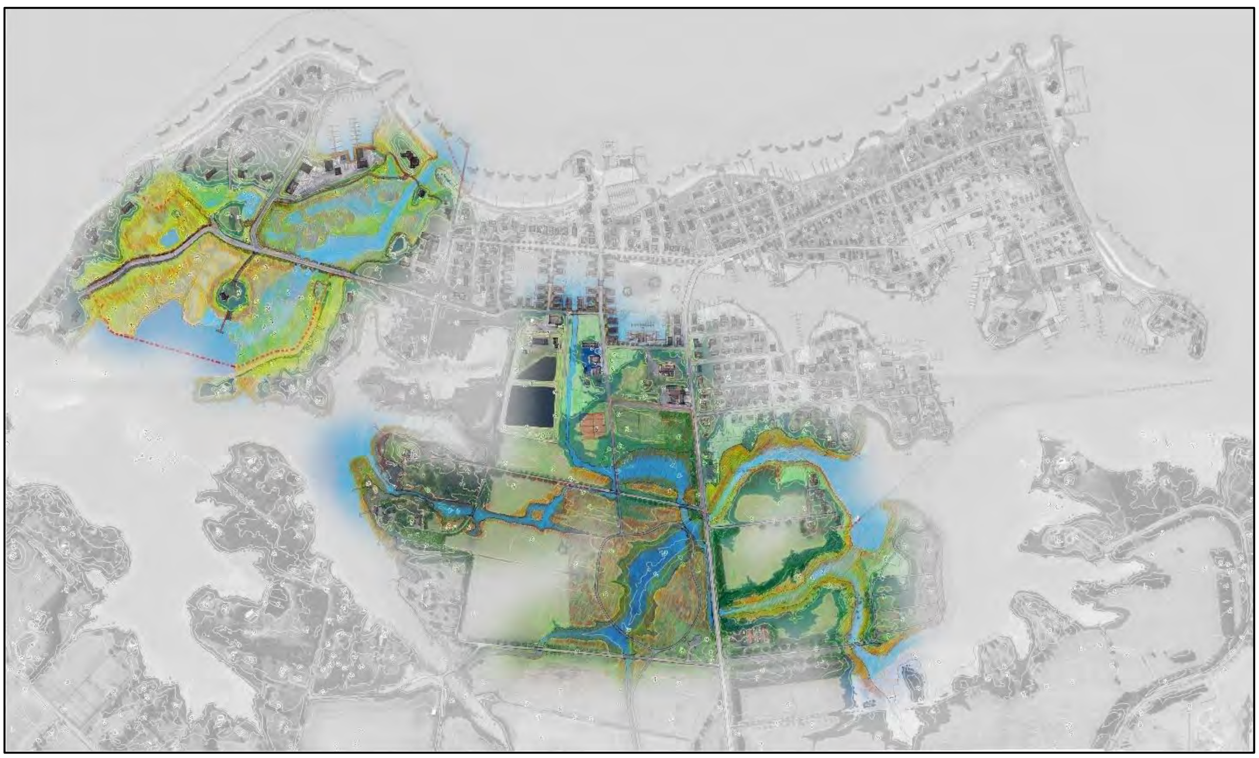

Fig. VI.G.1. *Visual of year 2100 - Water Treatment, Recreational Park, and Community Facilities Aerial View*

Fig. VI.G.2. *Visual of year 2100 – NOAA Lab & Water Quality Monitoring Station + Rails to Trails Perspectives*

3. Additional Considerations:

Incorporating a potential trail system to Easton or a transit line could serve as an embankment to prevent Tidewater backflow. The current fire department, wastewater treatment plant, and water tower are situated outside the 1% chance floodplain. Any new public critical services should also be established beyond this floodplain. This region should be designated as a public works and emergency services area, maintaining its criticality for emergency response, utilities, and infrastructures. Thoughtful planning is necessary to ensure its ongoing protection and elevation.

4. Recommended Timeline:

a. Immediate to Short term:

Initiate treatment plant resiliency planning. Evaluate the public service area around the public works building and fire station. Identify additional public service equipment needed for climate change adaptation. Commence long-term planning for the protection of the public services area and utilities.

b. Mid term:

Undertake treatment plant improvements and expand pedestrian connectivity. Enhance the public services area and procure additional equipment.

c. Long term:

Establish waterway connectivity and continue developing public spaces and multi-modal links.

H. SOUTH MORRIS BEACH, EAST PIER STREET MARINA & FUTURE FERRY

1. Existing Conditions:

This study area encompasses the transition zone between Bachelors Point and North Morris Tred Avon Bluff. It features a mix of residential and commercial spaces, including a marina and a restaurant. Pier Street acts as a central point in this area. The elevation is relatively low, and the region is bordered by the Tred Avon River to the west and the Causeway Park area to the east.

2. Recommended Resiliency Practices:

A dune and beach system is proposed, bolstered by breakwaters to mitigate wave energy. The existing beach could be improved, and individual piers should extend over the dune system. The marina and restaurant structures should be adapted into floating docks and synchronized with bulkheads or seawalls. Ensuring a smooth transition of these protective measures to the North Morris Dunes and Bachelors Point area is crucial.

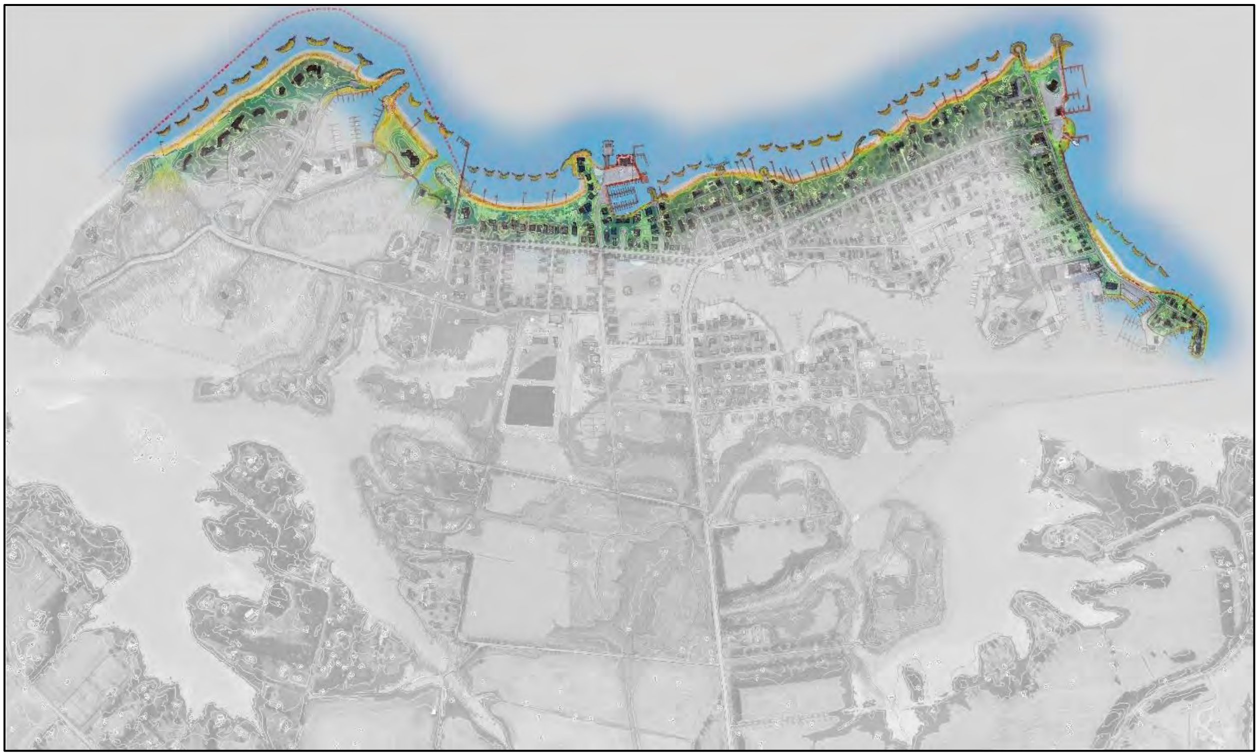

Fig. VI.H.1 *Visual of year 2100 – Shoreline Protection - Dunes & Bluffs*

Fig. VI.H.2 *Visual of year 2100 – Shoreline Protection – South Morris Beach & Bachelor's Point Estuary Perspective*

Fig. VI.H.3 *Visual of year 2100 – Shoreline Protection – TAYC Beach & Public Overlook Perspective*

3. **Additional Considerations:**

The marina zone at Pier Street could potentially evolve into a high-speed ferry terminal for connections to the Western Shore or other Eastern Shore Communities. Shielding this area is pivotal for the success of such an endeavor. If a suitable launching site can't be determined on the exterior side of Oxford, an isolated location along the Creek could be explored. The terminal might serve as a linkage point to a revitalized rail-to-trail project connecting to Easton, generating a transportation hub and commercial nucleus in Oxford.

4. **Recommended Timeline:**

   a. Immediate to Short term:
      Create a comprehensive topographic survey of the area.

   b. Short term:
      Initiate planning for an expanded marina and potential ferry terminal.

   c. Mid term:
      Commence construction on the revamped marina and commercial zone, initiate ferry terminal construction, and start developing the dune system with breakwaters.

d. Long term:

Finalize the dune system (preparing for the final elevation) and integrate it with the marina and adjoining resiliency measures.

VII. OTHER CONSIDERATIONS

REGIONAL RESILIENCY STRATEGIES:

While the Strategic Vision is tailored to Oxford, its recommended strategies could benefit other coastal communities in Maryland and along the East Coast. It's essential to consider how sea-level rise and climate change will impact all of Talbot County, potentially causing tidal 'backflow' from areas beyond the Town limits. Given the complexity and severity of the sea-level rise threat, complementary initiatives in neighboring areas are likely to emerge. Cooperation in resiliency planning at the county and state levels is thus necessary.

WATER DEPENDENT COMMERCE:

Oxford stands in a unique position to capitalize on commercial opportunities arising from rising sea levels. The Town's numerous boatyards, marinas, and waterfront restaurants generate substantial commercial activity, with the potential for expansion. Leveraging existing waterfront infrastructure can enhance and adapt to climate change, offering a foundation for these commercial ventures. The Cooperative Oxford Laboratory (NOAA) brings research potential and synergies with aquaculture, including the use of oyster beds for breakwaters and shoreline stabilization. This further bolsters the Town's economic prospects and resilience efforts.

TRANSPORTATION LINKAGES:

The Strategic Vision introduces the potential for Oxford to become a pivotal node in a broader regional transportation network. Creating a high-speed ferry terminal that connects to Easton through a multimodal project, such as a "rails to trails" initiative, would yield substantial regional advantages. This endeavor not only carries significant regional benefits but also opens up considerable commercial prospects for Oxford. (Refer to Figure VII.1 for visualization.)

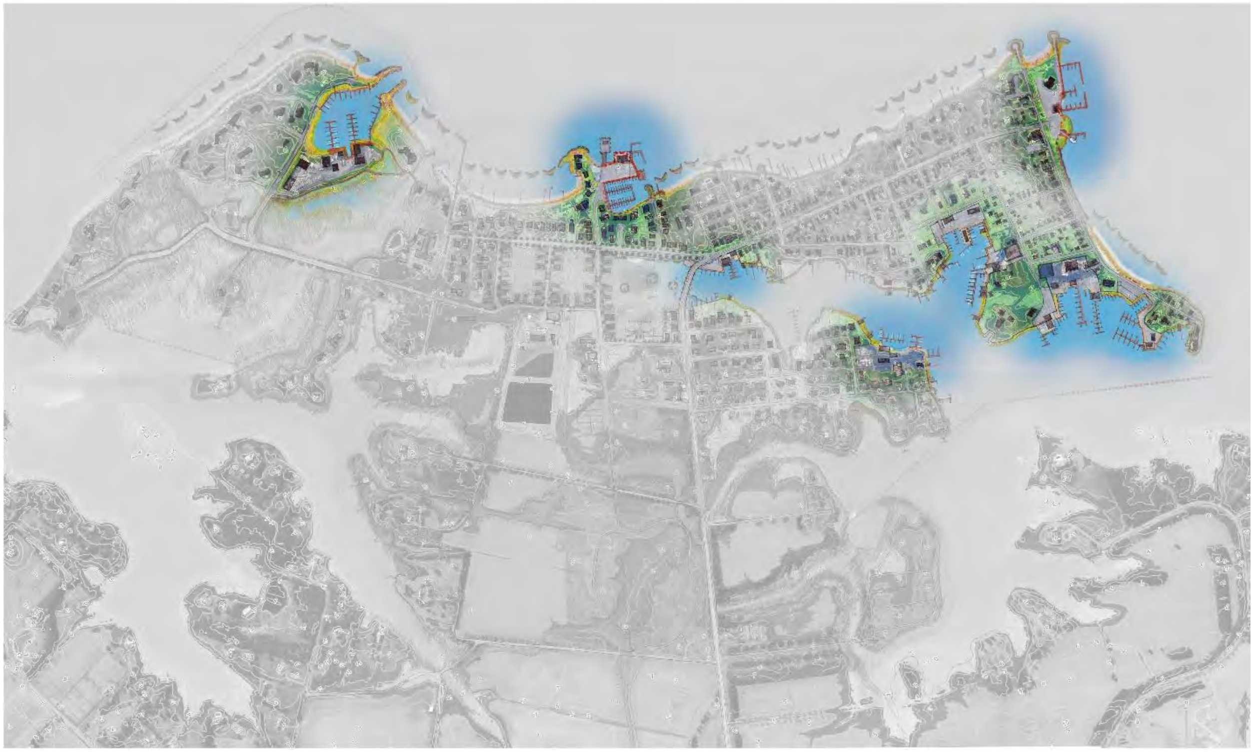

Fig. VII.1 *Visual of year 2100 - Oxford Transit Linkages*

WATER DEPENDENT RECREATION AND ECOTOURISM:

Oxford's strategic position allows for the expansion of water-dependent recreation and ecotourism activities in conjunction with adaptation efforts. The existing marinas and waterfront restaurants already contribute to water-related tourism. As sea levels rise, the water surface area will expand, creating new opportunities for linkages and sheltered waterways suitable for activities like kayaking, canoeing, paddleboarding, and potentially even transportation via skiffs. These evolving linkages could also accommodate additional recreational pursuits such as punting. Integrating aquaculture, utilizing oyster beds for reinforcement, and establishing living shorelines, combined with research collaborations from institutions like the Oxford NOAA Lab and the University of Maryland Horn Point, can create a thriving platform for ecotourism. It's worth noting that the Town's existing waterfront infrastructure will undergo further enhancements and modifications in alignment with climate change adaptation. (See Figure VII.2 for a visual representation.)

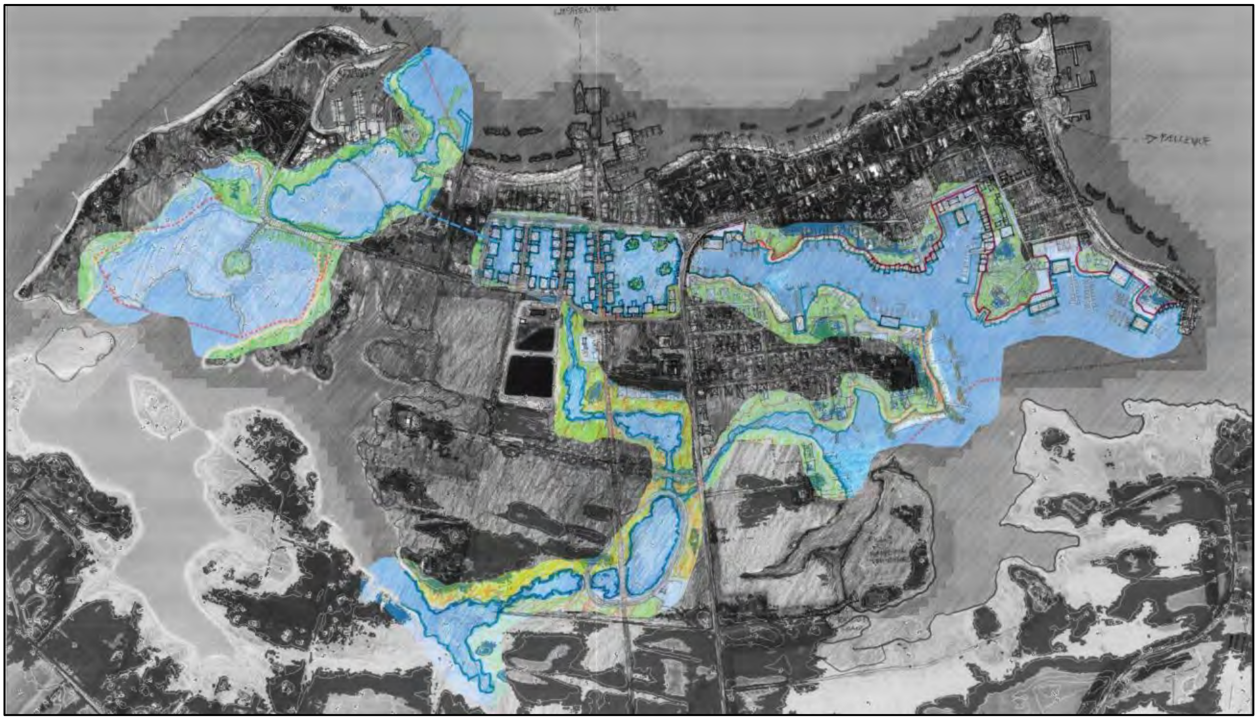

Fig. VII.2 *Visual of year 2100 - Tidal and Stormwater Management Aerial View*

MOSQUITO CONTROL CONCERNS:

Many of the proposed resiliency strategies discussed in this report are centered around the idea of coexisting with water. Designs like connected waterways and constructed wetlands have the potential to increase the presence of pests, particularly mosquitoes. It's likely that there will be nuisance-biting mosquito species in areas that support flooded habitats. However, this risk can be mitigated if flooded areas are regularly flushed by the tide (Medlock & Vaux, 2015). Given that Oxford's water is influenced by tides, there is a relatively low risk of increased nuisance mosquitoes as long as stagnant flooded areas are consistently drained and maintained. Ideally, before commencing construction, an Environmental Impact Assessment should consider the potential creation of mosquito habitats (Medlock & Vaux, 2015). Furthermore, any design proposals expanding the waterfront or inland flooding areas should integrate habitat for predator species to control mosquito larvae.

LEGAL CONSIDERATIONS / PRIVATE PROPERTY RIGHTS:

One of the challenges presented by the Strategic Vision is the potential alteration of the interface between private property and water. The construction of dunes and beaches will extend the current shoreline into the Tred Avon River or Town Creek. This will either create open, Town-owned lots that separate private property from the waterfront or provide additional land to individual private property owners. If public walkways are incorporated on top of proposed seawalls, this could allow public access behind homes where none currently exists. However, none of these options are currently feasible without obtaining consent from individual private property owners or involving government intervention. Securing consistent "buy-in" from individual private property owners, commercial entities, and public agencies will require special efforts and a commitment to collaboration.

COMMERCIAL VIABILITY / FEASIBILITY:

The Strategic Vision, as presented, will require significant investments from both public and private entities over the next 80 years. Larger infrastructure projects, such as dune placement, seawalls, and elevating the causeway, are expected to be funded with public investments through grants. The Town's adaptation will also require private support, particularly at the interface between the shoreline and private property. Dune and seawall placement will necessitate modifications to individual fee-simple lots. While the Strategic Vision presents a substantial opportunity to enhance the waterfront, including individual boathouses, extended dunes and beaches, and public spaces, executing the plan will be challenging without strong support from the Town's residents.

Additionally, the plan envisions a commercially thriving Oxford that embraces a potentially more water-dependent lifestyle, featuring multiple waterfront marinas, restaurants, and water-dependent transportation options. Justifying the cost/benefit ratio for proposed public infrastructure investments may prove difficult without the required private investments to make Oxford commercially viable in the future.

SOCIAL/ENVIRONMENTAL JUSTICE CONCERNS:

Environmental justice, as defined by the EPA, emphasizes fair treatment and meaningful participation of all individuals regardless of factors like race, color, national origin, or income in the development, implementation, and enforcement of environmental laws, regulations, and policies. The strategies outlined in this report entail significant alterations to Oxford's coastline and perimeter, which could inadvertently impact nearby communities in terms of habitat changes, transportation routes, access to resources, and local commerce. Nonetheless, given that many of the proposed designs incorporate environmentally friendly elements, disruptions to adjacent coastlines are expected to be minimal. Furthermore, distinct neighborhoods within Oxford necessitate tailored protection approaches, which have been meticulously considered to ensure equal importance across varying locations, income levels, and home values.

One recommendation that could contribute to advancing social and environmental justice in Oxford is the creation of a floating home community. Such communities can adhere to the previously outlined constructability guidelines, including the use of sustainable materials and renewable resources. This approach has the potential to enhance affordability within the Town by providing housing options across a range of prices, while also preserving the maritime character of the area.

When considering justice concerns, it's important to address various dimensions:

Distributive Justice:
Ensuring that the impact of changes is evenly distributed and doesn't disproportionately affect any specific group.

Capabilities Justice:
Paying attention to the different contexts in which individuals live and ensuring that their capabilities to adapt are supported.

Recognitional Justice:
Acknowledging and respecting diverse lifeways, cultures, and values in the planning process.

Procedural Justice:
Providing fair access to processes and decision-making related to the strategic vision.

The proposed multimodal linkages to Easton are expected to enhance accessibility from eastern communities to Oxford, contributing to distributive justice. Additionally, the strategies presented could serve as valuable reference points for other communities in their long-term planning efforts. The implementation of the Strategic Vision holds the potential to generate significant commercial opportunities for the entire region, further enhancing its appeal.

PROS AND CONS:

The Strategic Vision, as presented, offers scenarios for Oxford's adaptation into the future. However, this plan envisions significant change, and with change comes impact. While the strategies outlined in this report provide opportunities for resilience, it is crucial to consider the potential downsides. Below is a high-level discussion of the "cons":

Private Property Interface with Water / Private Property Rights:

As mentioned previously, the construction of dunes, beaches, and seawalls will alter how the shoreline currently interfaces with the Town and individual private property owners. Direct waterfront access from back decks and lawns will be affected. Achieving a consensus among property owners will be necessary to implement area-wide waterfront improvements without government intervention.

Maintenance:

Stabilization practices like dunes, seawalls, and other shoreline infrastructure will require ongoing maintenance from both the Town and individual private property owners. Depending on sediment transport patterns, dunes and beaches may also necessitate substantial investments in breakwaters and groins to preserve sand placement.

Tide Gate and Stormwater Pump Stations:

As repeatedly mentioned in this report, as sea levels continue to rise relative to adjacent land, gate systems and stormwater pump stations will become essential for draining the Town during wet weather events. These systems will also require regular maintenance and pose a potential risk if suitable backup strategies are not in place, such as standby generators and trained public works personnel.

Floating Home Community:

The report envisions a scenario where a section of the Town transforms into a floating home community. This represents a significant departure from the current landscape across Delmarva. Challenges associated with floating home communities include the potential for high utility costs due to unique living conditions and vulnerability to extreme events. In the proposed Strategic Vision, the floating home community would be situated "inside" the shoreline protection areas, which would provide a buffer against the impact of high-energy events.

Continued Climate Change and Sea-Level Rise:

The Strategic Vision proposes specific strategies based on current sea-level rise projections through 2100. However, without significant global changes, sea-level rise will continue beyond 2100. Many of the strategies outlined can be adapted over time. Dune systems and seawalls can be periodically raised, and gate systems and pump stations can be upgraded as needed. Flexibility and adaptability should be considered when implementing these strategies.

Catastrophic Events:

While much of the report focuses on resilience strategies to ensure Oxford's day-to-day vibrancy and thriving community, it's essential to consider how these strategies would function in catastrophic events. Design and implementation must consider the response to such events.

TRUST THE PROCESS:

The creation of the Strategic Vision document was achieved within a relatively short timeframe of about 12 weeks. However, the groundwork for addressing climate change and coastal resiliency in Oxford had been laid over several decades:

Cheryl Lewis, the Town Manager, played a pivotal role in the Eastern Shore Climate Adaptation Partnership (ESCAP) alongside Brent Jett, who is now associated with GMB. Ms. Lewis has been actively engaged in climate change issues specific to Oxford for over ten years. In the spirit of historic preservation and sustainability, in 2012, Philip Logan of Preservation Green LLC, in partnership with the Oxford Think Tank and the Water's Edge Museum, developed and constructed a compound as a template for sea level rise resiliency in an area of Oxford's Historic district which floods regularly. It currently accommodates the Environmental Justice Galleries of the Water's Edge Museum which addresses the many adaptive solutions presented in this report.

The Maryland Environmental Finance Center released a study in 2013, followed by a Shoreline and Drainage Inventory and Master Plan, contributing to the technical foundation. The involvement of graduate students from the University of Maryland further expanded the effort beyond technical analyses, introducing long-range planning and a vision for potential transformations in the built environment, land use, and community lifestyles. The final student design project served as a catalyst for launching the Oxford 2100 Strategic Visioning Project. A crucial element of the Vision was collaboration with local residents, Town officials, the Department of Natural Resources (DNR), and other stakeholders. The sketches and maps presented by the Preservation Green LLC team during public meetings played a critical role in visually depicting both vulnerable areas and opportunities for adaptation-based improvements. By juxtaposing real-world examples with section sketches from various points in the Town, the local community gained a comprehensive understanding of the challenges posed by climate change and the long-term impacts specific to Oxford.

This collaborative and illustrative process can be replicated in other projects and communities. The strategies outlined in the Strategic Vision can potentially serve as a model for addressing similar issues in many other waterfront communities across Maryland. By involving stakeholders, providing visual aids, and fostering collaboration, communities can develop effective plans to enhance resilience and address the challenges of climate change.

VIII. TIMELINE

IMMEDIATE (BY 2030):

- Monitor erosion at existing Town Park Beach in the North Morris/Tred Avon Bluff area. Develop "typical" sketches and sections. Initiate conversations with Maryland Department of the Environment (MDE) and Department of Natural Resources (DNR) about long-term practices. Engage adjacent landowners in discussions.

- Conduct a detailed topographic survey of the Tred Avon Yacht Club (TAYC) and Town Park to gather accurate elevation data.

- Complete the Strand Beach Enhancement Project. Conduct a comprehensive topographic survey of the entire area upon completion, including Norton and Stewart Streets.

- Replace tide gates and consider adding new ones where necessary to prevent tidal inundation. Conduct a full topographic survey of the affected areas.

- Initiate discussions with Maryland Department of Transportation (MDOT) and State Highway Administration (SHA) regarding the potential elevation of the causeway and the possibility of a future bridge. Address tide gate replacement to prevent backflow into Causeway Park.

- Begin the planning process for enhancing the resiliency of the treatment plant. Evaluate the public service area around the Public Works building and fire station for climate change adaptation needs. Identify additional public service equipment required for adaptation measures. Start long-term planning for protecting the critical public services area.

- Conduct a comprehensive topographic survey of the South Morris Beach area to gather essential elevation data for future planning and adaptation efforts.

SHORT TERM GOALS (BETWEEN 2025-2040):

- Conduct a comprehensive topographic survey of the entire North Morris Tred Avon Bluff area, capturing accurate elevation data. Simultaneously, explore various funding options to support forthcoming adaptation efforts. Develop a detailed plan specifically tailored to the Tred Avon Yacht Club (TAYC) for future resilience enhancements.

- Commence the planning process for enhancing the Strand Causeway to elevate its elevation, and also design temporary improvements for Norton, Mill, Tilghman and Stewart Streets. Develop a comprehensive strategy for a major protection project aimed at safeguarding the Town's V-zones against significant storm events.

- Evaluate the feasibility of raising sections of Mill, Tilghman, and Bank Streets to enhance their resilience against rising sea levels.

- Elevate the Causeway to a temporary higher elevation, without constructing a bridge at this stage.

- Develop plans for implementing Sylvan Sills and a breakwater system at Bachelors Point to counteract erosion. Begin the process of reinforcing Campbell’s Boatyard. Simultaneously, initiate the planning phase for a future boardwalk system in the area.

- Begin the initial stages of planning for an expanded marina and explore the potential for a ferry terminal around the South Morris Beach vicinity.

<u>MID TERM GOALS (BETWEEN 2040-2070):</u>

- Implement comprehensive resiliency upgrades at Tred Avon Yacht Club (TAYC) to enhance its ability to withstand climate-related challenges. Finalize the detailed design and initiate the construction of dunes to a temporary height along the North Morris Tred Avon Bluff area.

- Evaluate and plan for the extension of the dune system to the east and west of Strand Beach, connecting it to existing high ground and the sea wall. Simultaneously, install necessary drainage infrastructure and tide gates within this designated area.

- Construct a stormwater pump station and the initial phases of a sea wall in the North Morris Town Creek area. Replace existing piers and slips with floating infrastructure to accommodate rising sea levels.

- Install a stormwater pump station behind the causeway to maintain manageable water levels during various conditions.

- Initiate discussions with the Jacks Point neighborhood within the next two decades to prepare residents for upcoming resilient strategies. Although complete buy-in is not expected, garnering strong support for property alterations, enhanced access from both land and water, and adjustments to house positioning will be crucial.

- Commence the process of constructing dunes around Bachelors Point, including the incorporation of additional breakwaters. Simultaneously, initiate the development of a boardwalk system in the area.

- Continue the ongoing improvement and expansion of treatment plant facilities, focusing on pedestrian connectivity around public lands. Enhance the infrastructure of public service areas and acquire state-of-the-art equipment to ensure their effectiveness.

- Begin the construction of a revitalized marina and commercial zone at Morris Beach. Initiate the construction of a ferry terminal or commercial hub. Simultaneously, embark on the development of a dune system reinforced with breakwaters.

LONG TERM GOALS (BETWEEN 2070-2100):

- Finalize the construction of dunes along with the accompanying boardwalk and the relocation of docks and slips in the North Morris Tred Avon Bluff area. The ultimate height of the dunes will be determined in the future during the final concept, engineering design, and implementation phases. This determination will consider future FEMA flood maps, modeling software for sand transport, wind patterns, the offshore depth of the Tred Avon, additional shoreline protection measures, changes since the initial design, the fetch across open water, and any dredging activities. These factors will contribute to establishing the appropriate final elevation for effective protection and mitigation against storm-driven surges on river-facing properties.

- Complete the dune network to its final elevation, encompassing the area from Morris Avenue to the end of the Strand.

- Finalize the extension and expansion of the sea wall around the North Morris Town Creek area. Given the gradual nature of sea level rise relative to the lifecycle of infrastructure, the sea wall can be elevated through renovations and reconstruction after several decades of use. Each new construction phase can raise the top elevation for flood mitigation. The first iteration of the expansion should be studied within the next decade, considering location, potential construction challenges, permitting requirements, determining optimal top elevations, addressing drainage complexities when building a wall, and securing funding.

- Complete the dune system and associated elevated roadways and walkways around Bachelors Point.

- Achieve the completion of waterway connectivity and the ongoing development of public spaces and multi-modal connections.

- Finalize the dune system to prepare for its ultimate elevation and integrate it with the marina and adjacent resiliency measures for South Morris Beach.

IX. CONCLUSION

The strategies outlined in this report are intended to provide the Town with a roadmap for navigating the challenges posed by increased flooding due to climate change. Through this project, the community gains a visual representation of how Oxford might evolve by the year 2100. The final report encompasses the identification of potential climate mitigation measures, adjustments to both public and private infrastructure, and a range of approaches and alternatives required to attain the established goals. A prioritized timeline for implementing necessary adaptations is provided to ensure the community's resilience against climate-related impacts.

Oxford is poised to confront climate change, particularly rising sea levels, with deliberate consideration, extensive planning, and determined adaptation efforts. Embracing a harmonious coexistence with water will be pivotal for the Town's future success.

LIST OF FIGURES

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