ABSTRACT

Title of Thesis:	CHRONIC INUNDATION: DEVELOPING AN OUTDOOR EDUCATION CENTER FOR THREATENED COMMUNITIES
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Effects of climate change, like sea level rise, extreme weather and chronic inundation are damaging historic cultural resources and landscapes along the Chesapeake Bay watershed. Maryland's Eastern Shore is highly susceptible to these effects due to its naturally low-lying topography and its abundance of historic towns and heritage resources. Historic coastal communities are struggling to address the vulnerability of their historic assets due to the fragility of the resources and current preservation methods. This evolving landscape is not only reshaping the way people live, but how tangible heritage is being preserved for the community, the region's identity and future generations. Adaptation of historic communities to climate change is more urgent than ever as the severity of climate pollution projections increase with every climate pollution report and analysis.

This thesis aims to explore structural resiliency techniques and public education and awareness strategies to protect Maryland's historic and cultural resources, specifically focusing on chronic inundation. It will examine Cambridge, Maryland, a historic coastal city on the Eastern shore, to develop an outdoor education center to service the region and support resiliency efforts and exploration.

CHRONIC INUNDATION: DEVELOPING AN OUTDOOR EDUCATION CENTER FOR THREATENED COMMUNITIES

by

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Chapter 1: Introduction

Humanity is facing an environmental crisis. The impacts of climate change (e.g. extreme weather, sea level rise, chronic inundation, shoreline erosion, increased precipitation in shorter time frames, and degradation of ecosystems) are not distant threats or isolated instances anymore. For the last half century, coastal cities and communities across the globe faced great difficulty in adapting to unprecedented inundation, whether it is caused by hurricanes, heavy rainstorms, sea level rise or higher tide levels. Chronic inundation is reshaping people's everyday life and many communities are not fully prepared to adapt. Disappearing islands, sinking cities and evolving shorelines are the present reality, but people often do not sense the urgency of the environmental crisis because it is difficult to imagine. Increased flooding of a local road or large puddles in the backyard after a rainstorm is not always seen as a product of climate change. These frequent, subtle disturbances to normal routines and activities are foreshadowing greater problems to come in fifty or a hundred years.

When approaching the challenges of chronic inundation in coastal communities, historic resources are one of the greatest assets at risk, arguably greater than most modern construction or infrastructure. The intrinsic significance of a nation, region or community's heritage is invaluable. Additionally, historic buildings or structures are often fragile due to its age, type of construction material and current condition. These conditions increase its vulnerability, particularly to floods. Coastal cities often have an abundance of these historic resources because these communities were often established early in civilization due to the reliance on water as a source of

agriculture, transportation and trade. Without historic resources, many cities would lose the rich character people value and love about those locations. People cannot live without their past, consequently, careful regarding the future of people's past is equally important.

Fig.1 Flooding in historic Downtown Annapolis, Maryland in 2012. Source: Forsaken Fotos/ flickr

However, people often regard historic resources as "old buildings" that do not matter and is frequently sacrificed due to the complexity of preserving the structure's historic features while addressing present needs. Can current preservation methods and policies be re-evaluated to reshape the way historic coastal communities engage with the evolving landscape? As Carl Elefante, former AIA President and sustainability advocate, once stated, the greenest building is the one that is already built. If preserving historic resources is a sustainable effort, how can these resources be adaptively reused and address the gravity and urgency of chronic inundation? How

can a small-town heritage resiliency masterplan empower and sustain a historic community rather than stunt its growth? Coastal cities and the historic preservation communities around the globe are challenged with these questions and concerns for the survival of humanity's heritage, history and culture.

Fig.2 Flight of Thielens, painting by artist, Thomas H. Benton, illustrating the chaos and danger of surging tides from the 1938 hurricane in Massachusetts. Source: JSTOR

For the United States of America (U.S.), Union of Concerned Scientists (UCS) stated within twenty years, by 2035, about 170 coastal U.S. communities will be chronically inundated. This projection is roughly twice as many inundated communities today.[1] Locally in Maryland, there are numerous historic communities facing chronic inundation currently. Annapolis and Ellicott City may be more well-

[1] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).

known communities due to recent inundation events, however, many of the extremely threatened coastal communities are located on Maryland's Eastern Shore. Characterized by low-lying wetlands, the region is extremely vulnerable to the growing severity of chronic inundation. These historic communities are often colonial settlements from the 1600s to 1700s and have a rich heritage around the watermen and seafood industry of Maryland. Often these communities have a socially vulnerable, declining population that is struggling at adapting to chronic inundation.

City of Cambridge is one of those historic communities on Maryland's Eastern Shore. Cambridge is a small city in northern Dorchester County, right on the Choptank river. Its rich colonial history, ties to the Underground Railroad and Maryland's watermen and seafood industry makes it a valuable community illustrating Maryland's history. This history draws visitors to stop in their museums and experience the landscape. However, many of the heritage experiences are scattered throughout the community. Most of its historic resources are along Choptank river or Cambridge Creek, which is the forefront of inundated land in Cambridge. This thesis aims to explore Cambridge's waterfront heritage at risk from chronic inundation through public awareness and education facility design. By developing an outdoor education center, this thesis will explore how an environment focused facility located in a more urban context can serve to support the region and community in addressing and streamlining flood resiliency projects.

Fig.3 Eastward looking Aerial View of Cambridge, Maryland. Source: Cruisemapper

Chapter 2: Understanding Chronic Inundation and Its Impacts

Sea level rise, nuisance flooding, extreme weather events and increased intensity of precipitation in shorter time frames all contribute to the overarching problem of chronic inundation in U.S. coastal cities. The Union of Concerned Scientist defines chronically inundated land floods twenty-six or more times per year annually.[2] This calculation equates to flooding, on average, once every other week. This frequency and level of intensity is worsening as climate pollution scenarios are projecting sea level to rise higher and faster than previously estimated. Numerous cities are addressing present and future inundation events in various ways across the country.

Frequent events of flooding will alter the livability and lives of people in coastal communities. Chronic inundation can be an unbiased force of destruction

[2] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).

when it comes to impacts on infrastructure and human lives. Chronic and disruptive inundation can destroy roads, homes, businesses, schools and ultimately degrade the quality of life in an area. It is one of the costliest disastrous events a city will face, particularly for communities that choose not to address chronic inundation at all. An example about be Ellicott City's historic 2016 flood, which caused an estimated $22 million in damages and $42 million in lost economic activity.[3] Multiplying this damage cost by the 90 chronically inundated communities in the U.S. today[4] equates to a minimum of $2 billion worth of damages. However, in NOAA's studies below, these disaster events are much more costly and have been increasing since 1980. Out of these billion-dollar disaster events 54 percent are severe storm or flooding related.[5] Consequently, damages from chronic inundation will only increase in the future, yet not all communities are fully prepared to address this inevitable problem.

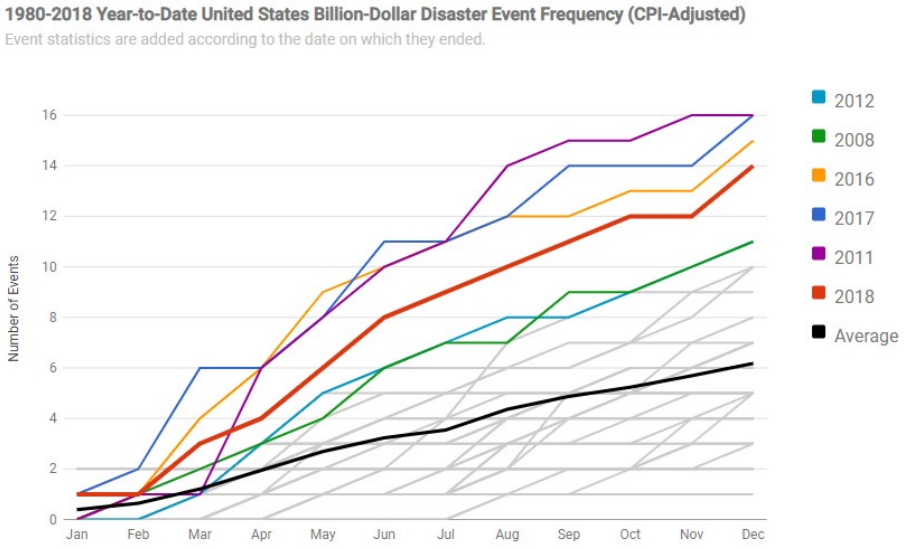

Fig.4 Billion-Dollar Disaster Events are increasing every year in the U.S. Source: NOAA

[3] Yeager, Amanda, *State, local leaders detail financial impact of Ellicott City flood.* (Jan. 19, 2017)
[4] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).
[5] Smith, Adam. *2018's Billion Dollar Disasters in Context.* (Feb. 7, 2019).

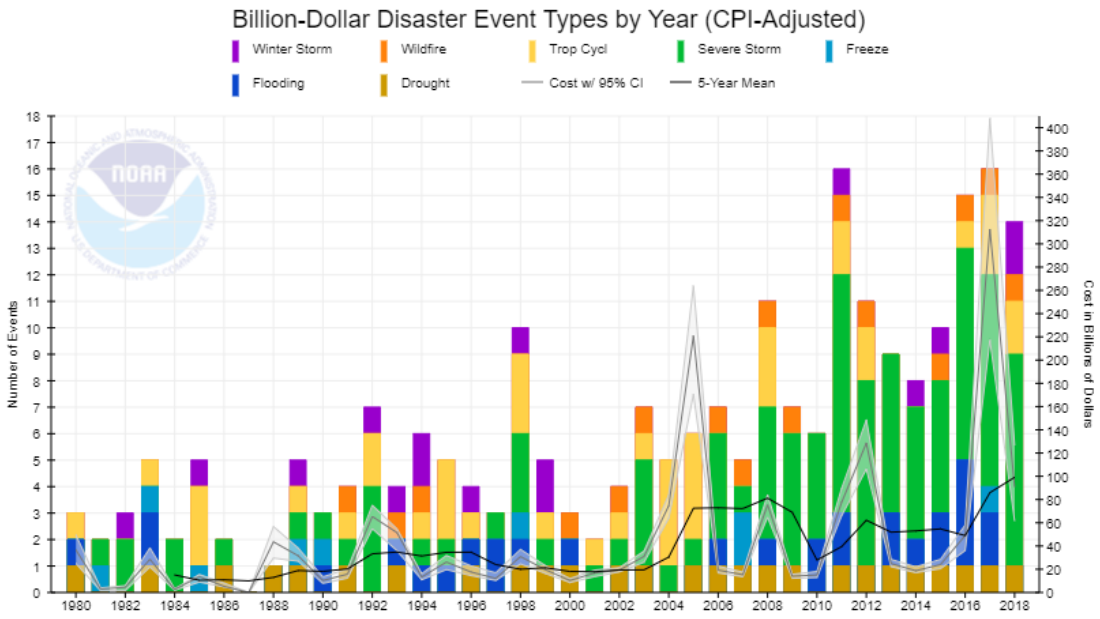

Fig.5 Inland flooding (blue) and Severe storms (green) are increasingly contributing to the number of U.S. billion-dollar disasters from 1980 to 2018. Source: NOAA

Billion-dollar events to affect the U.S. from 1980 to 2018 (CPI-Adjusted)

DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	CPI-ADJUSTED LOSSES *(BILLIONS OF DOLLARS)*	PERCENT OF TOTAL LOSSES	AVERAGE EVENT COST *(BILLIONS OF DOLLARS)*	DEATHS
Drought	26	10.8%	$244.3 CI	14.6%	$9.4	2,993†
Flooding	29	12.0%	$123.5§ CI	7.4%§	$4.3§	543
Freeze	9	3.7%	$30.0 CI	1.8%	$3.3	162
Severe Storm	103	42.7%	$226.9 CI	13.6%	$2.2	1,615
Tropical Cyclone	42	17.4%	$919.7 CI	55.1%	$21.9	6,487
Wildfire	16	6.6%	$78.8 CI	4.7%	$4.9	344
Winter Storm	16	6.6%	$47.3 CI	2.8%	$3.0	1,044
All Disasters	**241**	**100.0%**	**$1,670.5 CI**	**100.0%**	**$6.9**	**13,188**

†Deaths associated with drought are the result of heat waves. (Not all droughts are accompanied by extreme heat waves.)
§Flooding statistics do not include inland flood damage caused by tropical cyclone events.
The confidence interval (CI) probabilities (75%, 90% and 95%) represent the uncertainty associated with the disaster cost estimates. Monte Carlo simulations were used to produce upper and lower bounds at these confidence levels (Smith and Matthews, 2015).

Fig.6 Severe Storm and Flooding contributes to over 54% of the billion-dollar disaster events from 1980 to 2018. Source: NOAA

Severity of Chronic Inundation on Maryland's Eastern Shore

The Eastern Shore is ground zero for the effects of climate change in Maryland. Many populated cities east of the Chesapeake Bay are located along the water and on low-lying land. Encroaching tide waters and flooding are not recent issues to these communities; chronic inundation has been occurring decades ago. Holland Island is an example of a coastal community that is crushed by the inevitable force of climate change and chronic inundation from sea level rise. Occupied since the 1600s, Holland Island became a small fishing community up until the 1900s. Erosion on the western shores, where most people lived, forced the community to move away to the mainland. Stone walls built to protect the island failed and only a few former residents visit the island during the fishing season. All of the history and community is gone when the last remaining house on Holland Island collapsed in October of 2010.[6] As one of the early victims of rising waters, Holland Island is a stark reminder of the devastation climate change and chronic inundation creates to the local history, heritage and community.

[6] Invanov, Bojan, *Holland Island That Sank into Chesapeake Bay* (April 21, 2017).

Fig.7 Last remaining and historic house on Holland Island before its collapse in 2010.

Source: baldeaglebluff/ flickr

Chestertown, Stevensville, St. Michaels and Smith Island are additional Eastern Shore cities facing chronic inundation today. Not quite completely erased of the history and life of the community like Holland Island, the fear of chronic inundation and the livability of their community is at the forefront of their minds. These four communities showcase the varying degrees of proactiveness, detail and planning when it comes to addressing the inevitable rising tides in their communities.

Located in Kent County, Chestertown, Maryland, is a historic coastal community of 5,054 people, according to the 2018 census.[7] In 2019, Chestertown

[7] U.S. Census Bureau, Quick Facts Chestertown Town, Maryland (May 1, 2019).

released the *Strategic Guidance for the Chestertown Environmental Committee* planning exercise document. This planning exercise showcases how Chestertown is aware of the rising tides and environmental issues. There is a clear sense of direction from the four breakout teams: Administration, Energy, River and Habitat, and Waste System Management. The Chestertown Environmental Committee (CEC) and these individual teams have laid out next step action items and goals. These action items range from policy changes to infrastructure improvements to gathering funding sources, and re-envisioning service operations. The 2019 planning exercise priorities what the organization and town can do to become a "sustainable, resilient Chestertown."[8] In the brief document, Chestertown's main street and historic district are mentioned briefly in terms of energy use of businesses and lead paint for environmental concerns. The historic waterfront was also mentioned for beautification and the construction of an improved boardwalk experience. Chestertown's strategic guidance fails to mention resiliency approaches of their historic resources. Chestertown does not address the inherent cultural and heritage draw to their community, which is under threat from rising waters.

Stevensville, one of the cities on Kent island, is a historic coastal community of 6, 803, according to the 2010 census.[9] Located in Queen Anne's County, it is the largest island in the Chesapeake Bay. However, despite the threat of sea level rise, there is only a *Sea Level Rise and Coastal Vulnerability Assessment and Implementation Plan* available at the county level from 2016. The document is a

[8] Chestertown Town Hall, Strategic Guidance for the Chestertown Environmental Committee (January 17. 2019)
[9] U.S. Census Bureau, Quick Facts Stevensville CDP, Maryland (May 1, 2019).

broad adaptation strategy and implementation plan to conduct studies, monitor coastal conditions and adjusting zoning laws. However, the main problem for the county staff seems to be funding and capacity of the staff force to put this framework into action.[10] This might be why the Queen Anne's County plan lacked a clear timeline and direction in their most current document.

St. Michaels is a coastal town located in Talbot County, Maryland with a population of 1,029 people, according to the 2010 census.[11] The town's most recent climate related plan is their *St. Michaels Comprehensive Plan 2015*. The plan focuses on the town's development with sensitivity to the area's historic resources. The attention to St. Michaels' invaluable heritage assets extends from zoning regulations to environmental impacts, future growth and most importantly preservation strategies. Chapter 14 specifically focuses on ways St. Michaels plans on implementing climate resiliency strategies within their community. The main strategy is updating their flood maps from agencies like FEMA and NOAA, encourage residents to invest and retrofit their property and improve the town's infrastructure. It is important to note that despite the wholistic and detailed vision and implementation strategies, the document did not set a timeline for execution. A vague outline of tasks without a timeline is a reoccurring concern in these Eastern Shore community comprehensive plans.

Smith Island is an island in the Chesapeake Bay within Somerset County, Maryland. Much like Holland Island, the land area has been shrinking due to its low elevation and erosion from storms. There are only three communities left on the

[10] Queen Anne's County, Sea Level Rise and Coastal Vulnerability Assessment and Implementation Plan (March 2016).
[11] U.S. Census Bureau, Quick Facts St. Michaels, Maryland (May 1, 2019).

island: Ewell, Tylerton and Rhodes Point, with a total population of 276 from the 2010 census.[12] The community's most recent planning document is the *Smith Island Vision Plan* released in 2015. The plan focuses on the island's watermen heritage, tourism, accessibility, infrastructure and long-term residents as the goals for the future when addressing climate impacts. Each vision goal is analyzed in detail on the strengths, challenges, opportunities and strategies. In the end, the vision plan has a chart detailing the goal, strategies to execute and a proposed timeframe ranging from near term (in 2 years), midterm (2-5 years) and long term (5-10 years). While providing a timeframe makes Smith Island distinctive in its vision and planning compared to Stevensville and St. Michaels, the strategies could be more detailed and defined. For example, "address the problem of vacant housing"[13] is one of the strategies, but it lacks clarity in how this will be address as a strategy to support more yearlong residents.

Not all Eastern Shore communities are equally prepared to handle or address the evolving landscape, infrastructural impacts and livelihoods of their residents. Compared to towns and cities west of the Chesapeake Bay and in other states, the resources, time and planning efforts are truly incomparable. These historic coastal towns on Maryland's Eastern Shore should not be undermined in their importance to Maryland's state history and heritage. More detailed and immediate action plans need to be created for these historic coastal communities than what is available today.

Dorchester County

[12] U.S. Census Bureau, Quick Facts (May 1, 2019).
[13] Smith Island Community Vision Steering Committee, Smith Island Vision Plan (August 2015)

As "The Heart of the Chesapeake," Dorchester County is the fourth largest county in Maryland and largest county on the Eastern Shore. As a county full of national and local history and heritage, it is a county that will be devastated by chronic inundation and sea level rise in this century. In a low scenario, sea level rise is projected to rise 2 feet in 2050 and 4.3 feet by 2100[14]. Low scenario is the current rate of global sea level rise (GSLR) to 2100[15]. This will inundate over a third of Dorchester County. Most of the inundation will occur in southern Dorchester County, where the Blackwater National Wildlife Refuge is located. Numerous of hamlets or communities of about 30 to 50 people, are in this impact zone. These hamlets are rural agricultural farms or small marina communities. However, in an extreme scenario, sea level rise is projected to rise 11.6 feet by 2100[16]. Extreme scenario refers to the Antarctica ice sheet melts even more rapidly while greenhouse gas pollution remains high. Over 10 feet of sea level rise will nearly inundate over half of Dorchester County. In conjunction with worsening tidal floods, Dorchester County is at the forefront of climate change impacts on the Eastern Shore. Brian Soper, Environmental Planner of Dorchester County, described Dorchester as being twenty years ahead of many other [neighboring Eastern Shore] counties in terms climate

[14] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).
[15] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).
[16] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).

change impact urgency[17].

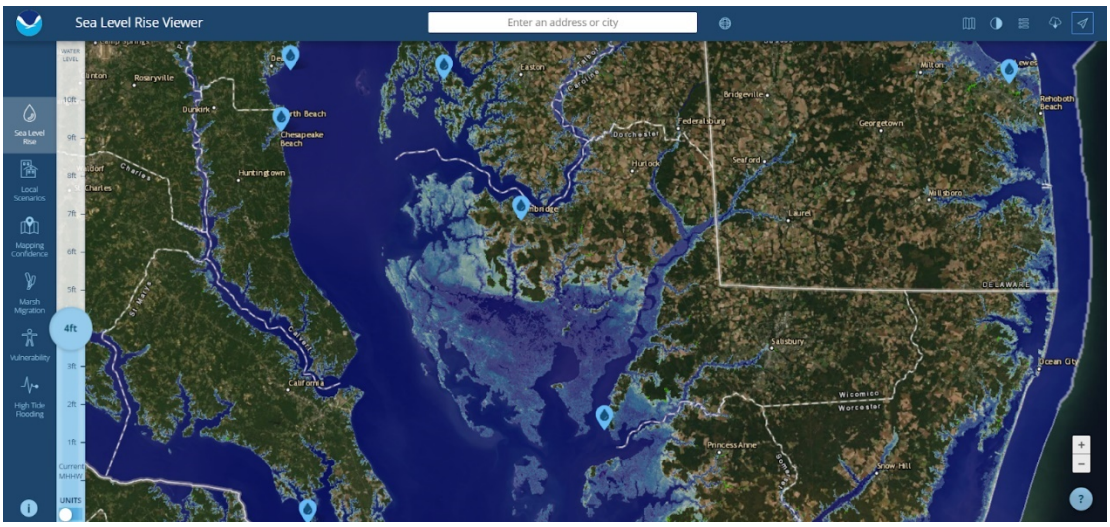

Fig.8 Sea Level Rise Projection at 4 feet in Dorchester County. Source: NOAA

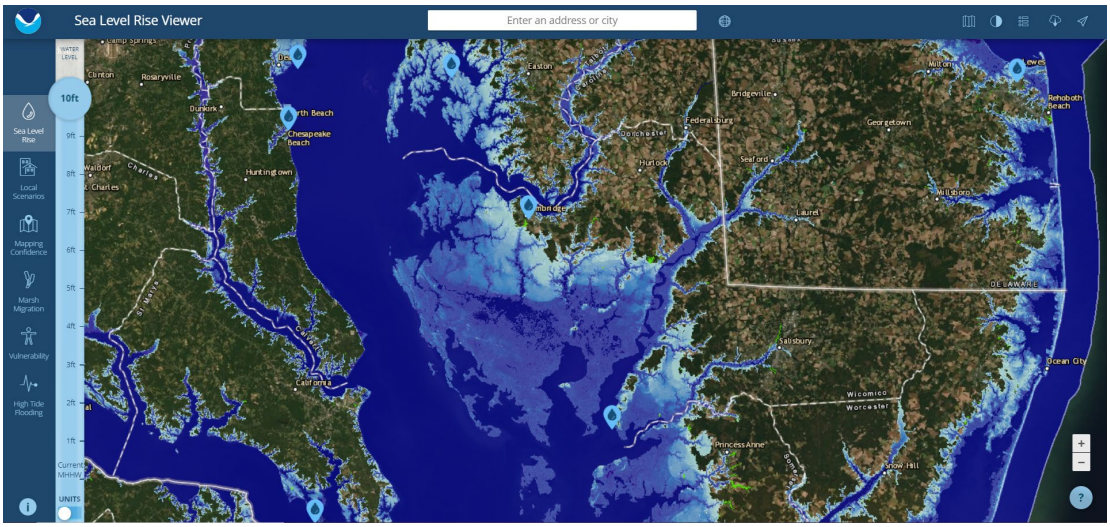

Fig.9 Sea Level Rise Projection at 10 feet in Dorchester County. Source: NOAA

As a mostly rural and sparsely populated county in Maryland, there are few sizeable communities. Cambridge, the county seat of Dorchester, is the only city with a population of 12,346 as of the 2010 census[18]. Compared to the population of

[17] Soper, Brian. Interview by Amy Duan. (December 18, 2019)
[18] U.S. Census Bureau, Quick Facts Cambridge City, Maryland (May 1, 2019).

Annapolis at 38, 394 in 2010[19], Cambridge is barely a third of Annapolis' population size. Eight towns (Brookview, Church Creek, East New Market, Eldoraldo, Galestown, Hurlock, Secretary and Vienna) and five census designated places (Algonquin, Elliott, Fishing Creek, Madison, and Taylors Island) within the county make up the remaining communities. However, it is important to note the numerous of hamlets scattered throughout the county as well. The rest of Dorchester county is mainly marshland, forests and farmland. With 541 square miles of land area, farmland and Blackwater National Wildlife Refuge makes up over 50% of the county's land. Surrounded by water and low-lying natural environments, Dorchester is perfect for the rising tides to creep rapidly inland.

Dorchester County is not only environmentally vulnerable; it is socially vulnerable as well. An older population with a mean age of 44.5 years old, this figure is 20 percent higher both state and national averages[20]. In conjunction with a poverty rate of 15.8 percent, this figure is 1.5 times higher than Maryland's rate and 10 percent higher nationally[21]. Characteristic of Eastern Shore communities, rural communities with a low income, aging population increase the difficult and risk of these communities at adapting to chronic inundation and other climate change impacts. Minority communities like Cambridge with 27 percent of the community is African American[22], often lack a voice in the decision-making process. Equity of climate resiliency preparedness is not evident on the Eastern Shore compared to the west shore.

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[19] U.S. Census Bureau, Quick Facts Annapolis, Maryland (May 1, 2020).
[20] Census Reporter, Dorchester County, Maryland (May 1, 2020)
[21] Census Reporter, Dorchester County, Maryland (May 1, 2020)
[22] Census Reporter, Dorchester County, Maryland (May 1, 2020)

Rich in local history and heritage, tourism makes up at least a fifth of the county's workforce, according to Amanda Fenstermaker, Director of Dorchester County Tourism[23]. Flanked by the Chesapeake Bay and Choptank River, visitors come to Dorchester to experience both the natural environment, colonial history, watermen heritage and significant African American heritage sites. There are two major Maryland scenic byways that pass-through Dorchester County: Harriet Tubman Underground Railroad and Chesapeake Country. Located in southern Dorchester County, Blackwater National Wildlife Refuge is a refuge for migratory birds with 28,000 acres of rich marsh, hardwood and loblolly pine forests, wetlands and cropland[24]. Cambridge and Vienna are the two main historic communities with local historic resources, museums, walking tours and businesses available to visit.

In addition to its heritage, sporting events like the Ironman 70.3 Eagleman and Ironman Maryland are held within Dorchester county. The course traverses throughout the rural landscape of fields, forests, small towns and marshlands. Large events like the Ironman brings in thousands of people into Cambridge increasing foot traffic in the city's downtown business area. Without the environmental and heritage tourism draw for the county, communities like Cambridge would depopulate and cease to exist, particularly in face of inevitable inundation from the rising tides. Dorchester County contains invaluable Maryland history and heritage at risk from the changing landscape from climate change. Chronic inundation in the next 30 years in Dorchester County will permanently alter the changing marshlands, historic

[23] Lu, Amy, *Maryland Sees Steady Growth in Tourism* (November 16, 2018).
[24] NASA Earth Observation, Blackwater National Wildlife Refuge (May 1, 2020).

communities and resources. Numerous historic resources will be permanently altered or inaccessible by the next century. The motto for Dorchester County's waterfront villages of "Life on the water" will soon become "Living with water" instead.

Consequently, City of Cambridge is an ideal thesis exploration site to address the challenges and impacts sea level rise has on historic structures. Cambridge sits at the entrance of Dorchester County for many visitors and contain a vast collection of historic resources at risk from its historic district to its downtown and Cambridge Creek waterfront. As part of an inevitable future, Cambridge can become a precedent for other Eastern Shore communities on how a community's invaluable historic resources can be preserved for the future. Eastern Shore communities rely heavily on heritage tourism and the "shoreness" character and aesthetic to sustain and strengthen their growth. Equity in climate resiliency not only applies to all communities but also in our infrastructure as well to include historic resources.

Chapter 3: Climate Resiliency Strategies

To better understand what cities, towns and communities have executed to address climate change impacts, an analysis of climate resiliency masterplans as well as specific resiliency strategies were conducted. Size of community, scale of climate change impacts and consequences of various strategies highlight the complexity of existing infrastructure interacting with water. In the end, "we can't save every single house" as stated by Heather Carruthers, mayor of Monroe County in Florida[25].

[25] Flavelle, Christopher and Mazzei, Patricia, *Florida Keys Deliver a Hard Message: As Seas Rise, Some Places Can't Be Saved* (December 5, 2019).

Comparing strengths and weaknesses of various climate resiliency approaches provides the reasoning for choices and decisions each community made to save and sacrifice for the greater whole.

Precedent Climate Resiliency Masterplans

Fig.10 View of Historic Downtown Annapolis from the water. Source: Steven Frame/ Shutterstock

Annapolis is the capital of Maryland located on the Chesapeake Bay and at the mouth of the Severn River. As a historic waterfront community, the city has numerous historic landmarks at risk from climate change impacts like sea level rise and chronic inundation. Consequently, Annapolis created a first in the nation Cultural Resources Hazard Mitigation Plan in 2018[26]. The three key finds are the need for resilience financing, leadership needed to implement and finance efforts and lastly, combining efforts in mitigation and resilience. The key recommendation was to create

[26] University of Maryland School of Public Policy, Annapolis, Maryland Resilience Financing Assessment (December 2018).

a Director of Resilience and Resilience Finance Committee that could create an action plan and modify current procurement and regulatory policies to expedite resilience investment projects.

A notable aspect of the mitigation plan is a list of 48 actionable ideas compiled from over 75 public events, which engaged the public, civic and private organizations, government agencies, and city departments. Appendix B lists action items that could be immediately or in course of current planning direction. Appendix H lists actionable ideas that require additional resources and budget[27]. Many actionable ideas like ideas 27, and 31, are about aiding local businesses and property owners with technical support for developing plans in flood risk areas. Another common theme in the actionable items like ideas 21 and 36, is education and resources for the region of what is considered model adaptation projects and awareness of potential flood hazard risks and considerations when planning future development and growth. Public awareness and education is a reoccurring priority in their immediately actionable ideas.

[27] City of Annapolis, WEATHER IT TOGETHER: A Cultural Resource Hazard Mitigation Plan (April 2018)

Fig.11 Timetable depicting the priority and timing of recommended projects. Source: City of Annapolis

Annapolis' Weather It Together Team in the document has cost estimated 9 recommended projects deemed doable in the next five years[28]. In Figure 11, larger boxes such as City Initiative for Flood Adaptation and Risk Management, are considered higher priority or extensive public work projects requiring more action in changing city codes, intergovernmental coordination and feasibility studies. The other four recommended projects like public awareness and education and tools and practices for flood preparedness and adaptation, are low cost activities that can be implemented as ongoing projects in conjunction with long term high priority projects. However, the document noted that these implementation projects rely heavily on public awareness and education. Education of flood resiliency also extends beyond the public and individual private businesses into city departments and their decision-

[28] City of Annapolis, WEATHER IT TOGETHER: A Cultural Resource Hazard Mitigation Plan (April 2018)

making process as well. Overall, Annapolis is collaborating with the community and within the government to support the city's future in face of sea level rise and hazardous flooding.

Fig.11 Rendering of proposed open area from removal of select historic structures and widening of the channel. Source: Mahan Rykiel Associates Inc.

Ellicott City Watershed Master Plan was created after the second disastrous flood event in the historic downtown of Ellicott City in 2018. Both 2016 and 2018 flood events were having a one in a thousand chance of occurring each year, that occurred nearly back to back. Historic buildings, businesses, homes and roads were severely damaged after both flood events. Ellicott City's 2016 flood caused an estimated $22 million in damages[29] and $42 million in lost economic activity[30]. The

[29] Hayes, Christal, *In flood-hammered Ellicott City, Md., the question lingers: Do you rebuild once more?* (May 29, 2018).
[30] Yeager, Amanda, *State, local leaders detail financial impact of Ellicott City flood* (January, 19, 2017).

2018 flood devasted the rebuilding efforts, thus triggering a sense of urgency and need to develop a better long-term approach to protecting the people, businesses and historic character of Ellicott City.

Mahan Rykiel Associates Inc.'s Ellicott City Watershed Master Plan was ultimately selected by Howard County Executive, Calvin Bell to protect the flood prone Main Street in Ellicott City. This is a five-year, $140 million-dollar effort involving tearing down and gutting nine historic structures on Main Street and building a tunnel to carry floodwater away[31]. In the community presentation, there are three main concepts used in the master plan for future flood mitigate. The first concept is placemaking[32]. Designing architecture, streetscape and construction materials based on site context. Encouraging the way people design to the site rather than working the site to fit the program. This extends from introducing more permeable materials in paving to building houses with the topography rather than completely altering the drainage path in a new development. Second concept is limiting hard surfaces and introducing more naturalized environments. Increasing permeability of land area can reduce flash floods events.

Lastly, the most important concept of the master plan is increasing visibility of the waterway. Throughout the main street corridor, the masterplan focuses on creating public plaza experiences around the waterway. Building a naturalized buffer on the water channel and improving pedestrian access heightens the awareness and increase protection of people and infrastructure to potential flood risks. Stringing

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[31] Amara, Kate, *Flood mitigation plan chosen for future of Ellicott City* (May 14, 2019).
[32] Rykiel, Mahan, Muldrow, Arnett, RK&K, Land Studies, SouthCoast Consulting, and Preservation Consulting, *Ellicott City Watershed Master Plan* (October 15, 2019).

together public areas of respite facing the water channel enhances the city and surroundings. Increasing the setback of historic buildings and businesses from the widened water channel offers an infrastructural improvement that includes greater public experience and awareness. These plazas, terraces, ramps and parks also benefit local businesses by improving the pedestrian experience while protecting their properties.

Fig.12 Cover page for Miami Beach Rise Above Resiliency Strategic Plan. Source: Miami Beach Rise Above

Miami Beach is one of the top U.S. cities under threat from sea level rise for the last few decades. Located in the low-lying region of southern Florida, the waterfront community of 91, 718 people[33] is at the forefront of the rising tides and

[33] U.S. Census Bureau, Quick Facts Miami Beach City, Florida (May 1, 2019).

chronic inundation. A partnership of Miami-Dade County, the City of Miami and the City of Miami Beach formed Greater Miami & Beaches (GM&B) to develop *Resilient305*, a collaborative resiliency strategy under the 100 Resilient Cities Network by the Rockefeller Foundation. *Resilient305* is intended to guide planning, collaboration and responsiveness of the community to current stresses, such as coastal erosion, storms, aging infrastructure, sea level rise and flooding. This study estimates $21 billion in assets at risk and 53, 000 homes are located less than 3 feet above high tide making them vulnerable to the projected 3-7 feet of sea level rise estimated in 2030 in southeast Florida[34]. One of the strategies is developing more natural based systems to mitigate the impacts of flooding like wetland and living shoreline projects. This extends to acquiring land in the floodplain to actively prepare and anticipate devastating coastal floods. Understanding current land use and distressed communities is another aspect of the plan to strengthen resiliency planning and pinpoint vulnerable areas.

A bold proposal in *Resilient305* is combining resiliency with transportation and mobility. A more human centric public transportation system is proposed to improve pedestrian and cyclist safety. The Strategic Miami Area Rapid Transit (SMART), bus rapid transit (BRT) and the Underline, a 10-mile linear park, serve to connect communities as well as restore and create natural habitats. This helps alleviate environmental impacts car centric transportation creates, but also promotes a better lifestyle and protects community resources from climate impacts. At the macro level, the Building Efficiency 305 program will be introduced as a *Resilient305*

[34] Resilient Greater Miami & The Beaches, Resilient 305 (2019).

strategy to guide communities towards solar energy and obtain Gold SolSmart status[35]. SolSmart is a U.S. Department of Energy funded recognition program to advise and assist communities looking to go solar by reducing cost barriers and accelerating the process.

Housing is another aspect *Resilient305* is addressing due to the 53,000 homes at risk from the estimated 3 to 7 feet sea level rise projects in 2030. Parking garages are being studied for as potential future housing due to the decline in garage utilization and increase in car share systems like Uber and Lyft. Apart from unique housing types, Miami-Dade County is looking to create resilient public housing. Over 9,000 public housing units will be required to meet the County's Sustainable Buildings ordinance[36]. This ordinance includes hardening structures, elevating back up generators, utilizing solar power when feasible and minimize water and utility burdens. Many of these improvements seek to make current and future housing more resilient to sea level rise and protect current residents from climate related disparity and equity.

Education is large component of the *Resilient305* strategic plan, which makes up most of the action steps within the three goals: Places, People and Pathways. In Pathways, the goal and actions aim to educate and communicate the concept of resiliency. Increasing understanding of resiliency on a government and community level can streamline government process in implementation as well as enhance community action. Preplanning efforts by developing a recovery toolkit, strategize

[35] Resilient Greater Miami & The Beaches, Resilient 305 (2019).
[36] Resilient Greater Miami & The Beaches, Resilient 305 (2019).

innovative recovery financing, and training government leadership and employees about resiliency are a few of their action items. Collaborating with universities and non-profits in workshops like the Brickell Bay Drive Accelerator, helps connect government officials, professionals, local leaders and the community in developing and designing more resilient waterfront standards.

Resilient305 is a stronger and more plausible strategic plan due to its ability to address how the goals and actions will be addressed and financed. The City of Miami is looking to explore parametric insurance for its tourism revenue due to its volatility to sudden weather and economic shocks. Timeframes are also clearly established under each action item in what can be immediately (0 to 1 year), short term (1 to 5 years) and mid term (5 or more years). The strategy implementation team, or Progress, Innovation, and Vision for Our Tomorrow (PIVOT) team is clearly laid out to support municipalities and organizations implementing these actions on the ground[37]. Overall, *Resilient305* is a wholistic resilience plan at an urban waterfront scale that seeks to address the diverse and complex impacts of sea level rise in the region.

[37] Resilient Greater Miami & The Beaches, Resilient 305 (2019).

Fig.13 Rendering of proposed Battery Park berms in the Big U, proposed resiliency plan, for New York City by BIG Team. Source: Bjarke Ingels Group

New York City is one of the most populated cities in the U.S. under threat from sea level rise. The impact and aftermath of Hurricane Sandy in New York City made the community and government aware of the severity and urgency of climate change. In the low-lying area of Lower Manhattan, the storm devastated the financial district and around 95,000 low-income, elderly, and disabled residents[38]. The infrastructural damage, shutdown of transportation and communication as well as thousands of people without power and running water was an example of how unprepared New York City was to storm events and other effects of climate change.

In collaboration with New York City, Bjarke Ingels Group (BIG) created The Big U proposal to protect Lower Manhattan from floods, storms and other climate change impacts. The proposal is a continuous 10 miles long protection system divided

[38] Rebuild by Design, The Big U (May 1, 2019).

into three parts: East River Park, Two Bridges and Chinatown, and Brooklyn Bridge to The Battery. The community and stakeholder workshops focus on how these resilient strategies can be envisioned beyond its protective purpose. Integrating social and community planning into the decision making process allows opportunities to simultaneously protect and enhance the city.

A bridging berm is proposed in the East River Park that not only protects the community from storm surges and flooding but also beautifies the waterfront and maintain river vistas. The naturalized waterfront offers human centric waterfront access, while acting as a resilient urban green space for future storm surges and floods. Creating new topography and introducing salt resilient trees and plants plays a large role in revisioning typical concrete sea walls into a beautiful park for the community.

Fig.14 Bridging berm proposal in East River Park as part of the BIG U proposal. Source: Bjarke Ingels Group

Deployable walls attached to the underside of FDR Drive is proposed in the Two Bridges and Chinatown area of the BIG U proposal. The panels on these deployable walls will be lighted and decorated to increase safety and excitement in a once harsh waterfront experience. An alternative flood resilient strategy is the Big Bench underneath of FDR. The 4-foot-high bench creates pockets of program spaces and allows waterfront views while protecting communities from low level storms. While not providing protection from the worst storms, the Big Bench provides an opportunity to benefit local communities and offer some level of climate resilient protection.

Fig.15 Deployable wall and big bench proposal in Two Bridges and Chinatown area as part of the BIG U proposal. Source: Bjarke Ingels Group

Lastly, Battery Berm is the most ambitious area of the proposal. This resilient proposal is set to protect the low-lying area of the City's most critical financial assets. This section of the BIG U provides protective infrastructure for tourists, local workers and residents to engage with the waterfront. Deployable barriers, protective waterfront furniture, pavilions and altered topography of Battery park serves to

support commercial and tourist activities while maintaining views and accessibility to the waterfront. The Harbor Berm proposal to create a reverse aquarium experience for visitors to engage with climate change is a bold program proposal. Acting beyond a flood barrier, the Reverse Aquarium educates visitors and provides an optimistic hope of living with sea level rise and climate change.

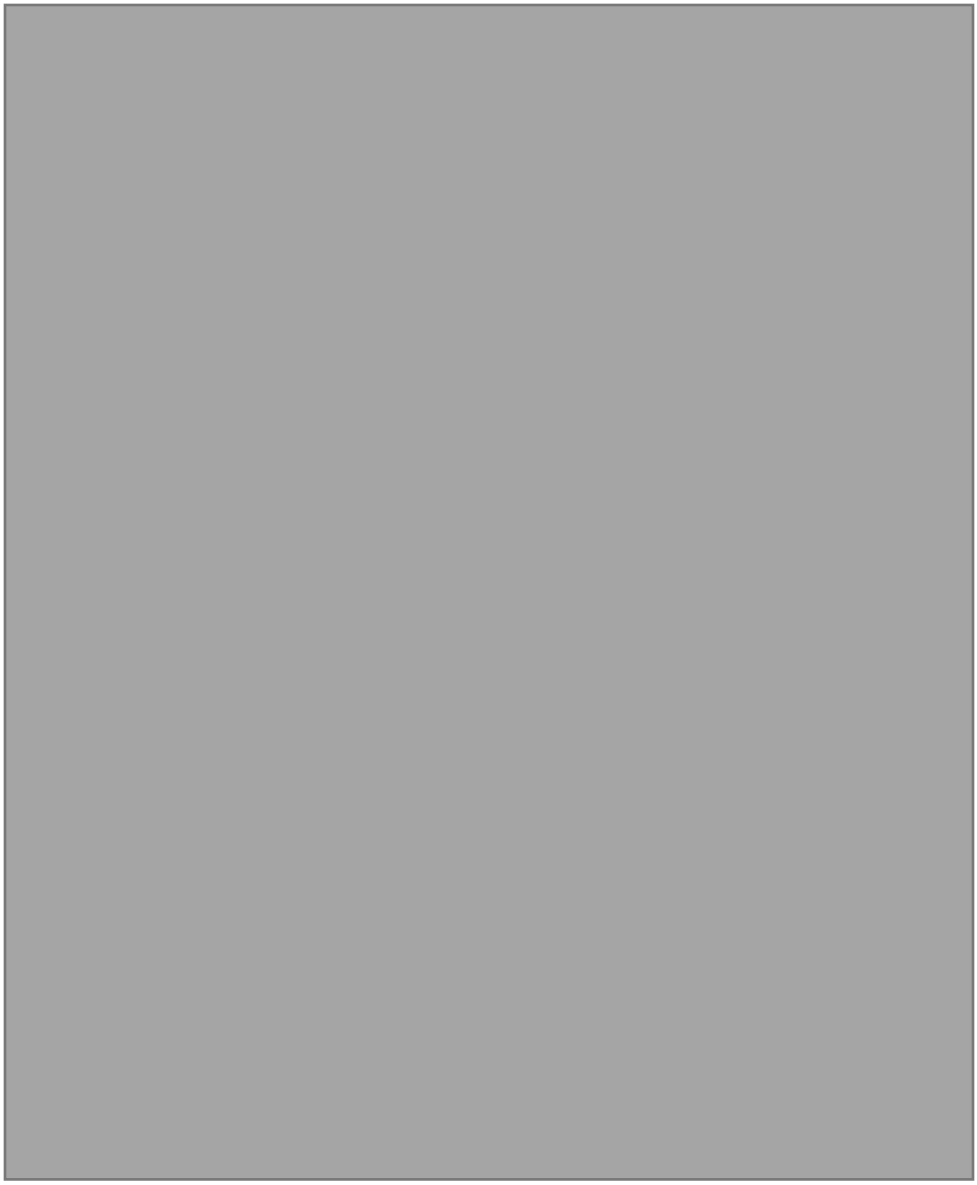


Fig.13 Battery park berm transforms existing Coast Guard building to new maritime museum as part of the BIG U proposal. Source: Bjarke Ingels Group

Analyzing the resiliency master plans for various cities along the East Coast provided some perspective on how climate resiliency is tackled on an urban scale and within city government planning. Despite the scale of implementation, there are similar concepts and agreements across these cities and communities. Education is the most repeated theme, whether it is providing technical assistance to the public, local businesses or creating a museum to educate visitors on the dire situation of sea level rise and storm surges. A public amenity component is part of every master plan as well. Public access to the waterfront allows physical and visual engagement with the water increasing continual awareness. Lastly, landscaping the flood risk zones to create berm parks or incorporating more vegetation to soften impacts of future flood events is set forth in every precedent. The scale of increasing green space within the city differs, however, the concept of beautifying resilient strategies and introducing more permeable land area is cohesive in every plan. It is evident cities share similar ideology and methodology in climate resiliency, but the greatest challenge still occurs at implementing the strategies locally to its respective context.

Strategies and Approaches to Addressing Chronic Inundation

Chronic inundation is an increasing relevant issue to numerous cities across the globe. Consequently, there is a diverse set of existing strategies and approaches implemented today. These climate resiliency approaches can be categorized into these three broad groups: construction, landscape, and infrastructure. Construction approaches focus on the buildings and structures, such as construction methods, materials and housing types. Landscape approaches focus on environmental interventions relating to nature or public space at an urban scale. Lastly, infrastructure

approaches focus on the grey infrastructure of a community such as sewer and septic systems. Each of these broad approaches highlights climate related problems that are occurring at various scales and details in a community.

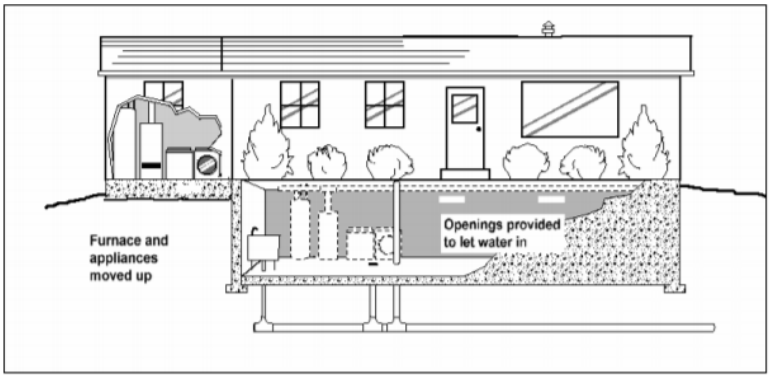


Fig.14 Diagram of two main retrofit methods for wet floodproofing the basement. Source: FEMA

Wet floodproofing is a "permanent or contingent measures applied to a structure or its contents that prevent or provide resistance to damage from flooding while allowing floodwaters to enter the structure or area." [39] This typical involves creating vent opening in the basement level of a structure allowing water to enter during a flood and drain out when water recedes. Electrical equipment and appliances are usually removed from the basement up to a higher floor above the flood elevation. The main advantage of wet floodproofing is reducing likelihood of structural damage. Same level of water within the house as flood waters outside reduced effects of hydrostatic pressure.

However, this resiliency strategy is limited in application and has numerous of concerns. The area flooded within the house is usually below grade basements or crawl space, living areas are not suitable for wet floodproofing. It is also not

[39] FEMA, Wet floodproofing (May 23, 2019).

recommended to use this strategy if the flooding will exceed 24 hours in duration[40]. Flooding of the basement can also damage existing finishes and the cleaning process is usually done with harsh chemicals and power washing, which adds to potential material removal. The drying process can also make the area unhabitable for extended periods of time. Consequently, this resiliency strategy is not usually recommended for historic buildings due to the elevated risk of damaging historically significant elements of the structure.

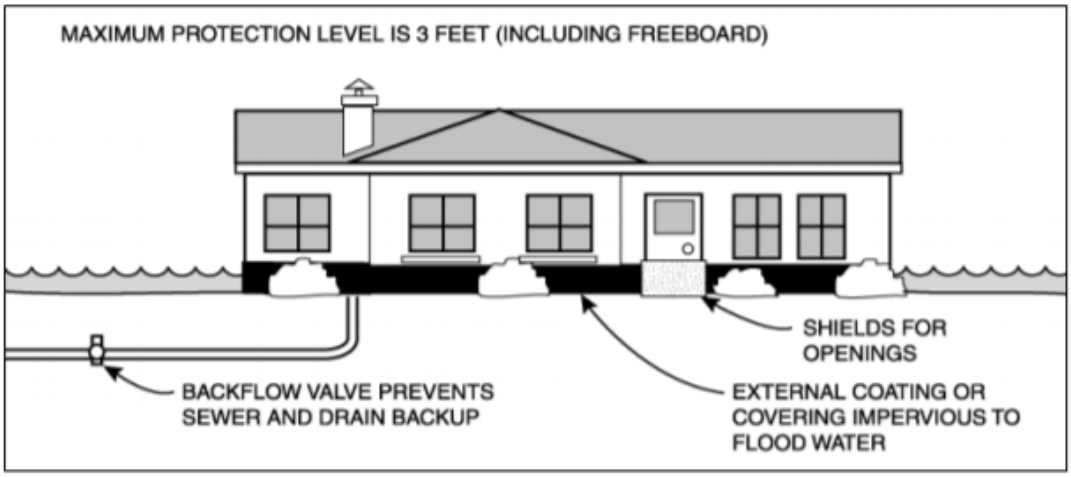


Fig.15 Typical dry floodproof structure. Source: FEMA

Dry floodproofing is to make the structure "watertight below the level that needs flood protection to prevent flood waters from entering."[41] This process typical involves installing a waterproof membrane around the exterior walls, covering any openings (i.e. doors and windows) with watertight shields and some type of sewer

[40] Eggleston, Jenifer, Parker, Jennifer, and Wellock, Jennifer, Guidelines on Flood Adaptation For Rehabilitating Historic Buildings (November 2019).
[41] FEMA, Guidelines on Flood Adaptation for Rehabilitating Historic Buildings- Chapter 7 Dry Floodproofing (May 1, 2020).

backup protection. The main advantage of dry floodproofing is the lower cost than other resiliency strategies and can be funded by FEMA's mitigation grant program.

While the attractive low cost is enticing, dry floodproofing cannot be used to bring structures up to the community's floodplain management ordinance or law. The waterproof membrane and watertight shields can be unsightly and require ongoing maintenance. Flood depth can also influence the appropriateness of dry floodproofing due to hydrostatic pressure. Typical masonry and masonry veneer walls can withstand 3 feet of flood water, but over 3 feet can cause unreinforced masonry or masonry veneer walls to crack or collapse[42]. Long flood duration and flow velocity can cause the watertight sealants to fail and shift structures off their foundation breaking any dry floodproofing measures. Dry floodproofing may have a low upfront cost and quick installation, however, the maintenance and risk suggest it may not be cost effective strategy in certain flood conditions.

[42] FEMA, Guidelines on Flood Adaptation for Rehabilitating Historic Buildings- Chapter 7 Dry Floodproofing (May 1, 2020).

Fig.16 Section diagram illustrating how the Thames Amphibious House designed by Baca Architects float during a flood event. Source: Construction21 International

Amphibious housing or floating houses is a structure that rests on the ground, but whenever a flood occurs the entire building would rise and buoyed by the floodwater. This type of resilient building construction involves creating a fixed foundation that can be flooded in a flood event. Guideposts and slide gears are built into the structure to buoy the building up to the dock. The main advantage of amphibious housing is the flexibility it offers, allowing minimal disruption to the structure's functionality in flood events.

Floating houses are not fully embraced as a mass response to climate resiliency due to its inherent limitation. Amphibious housing is typically new construction due to the engineering required to design and implement the buoy system involving a designed foundation to accommodate guideposts and slide gears to elevate the structure beyond the projected flood height. This system is not easily implemented on existing structures. As a new building type, there are few precedents in the world currently. Floating houses Ijburg in Amsterdam by Marlies Rohmer Architects & Urbanists is one of few examples of a waterfront community of floating homes. Additionally, amphibious housing construction is not standardized, thus the financial cost of this type of resiliency is uncertain. In Floating houses Ijburg, the modular design of the homes could potentially be an affordable solution for this type of resilient strategy.

Fig.17 Porchdog House is a elevated residential home designed to be protected from a potential Category 4 storm surge event. Source: Marlon Blackwell Architects

Elevating structures is one of the most traditional approaches to addressing chronic inundation. There are various ways to elevate an existing building by lifting the structure up with piers, raising slab foundation, or raising the interior floors above base flood elevation (BFE). While it is a practical resiliency approach, there are some scenarios that benefit more from each type of elevation method. Extending foundation walls works best as a technique for houses originally built with basements and crawlspace than houses with slab on grade foundation[43]. An alternative method for

[43] FEMA, Homeowner's Guide to Retrofitting- Chapter 5 Elevating Your House (2014).

masonry slab on grade foundation houses is to elevate by extending walls of the house and building new elevated floor above old slab.

Other techniques of elevation include abandoning the lower level all together, but it is better suited for masonry houses with slab on grade foundations. Elevating with an open foundation through piers, post or columns, or piles works well for a variety of housing types. The two major considerations would be the type of soil condition and potential retrofitting of the supports to handle new forces once elevated.

There are many considerations to understand prior to elevating a building for resiliency. One of the main challenges is aesthetic. Elevating a building higher than four feet alters the façade and streetscape to a point in which landscaping cannot hide the alteration. This can completely alter a community's urban fabric and is usually unacceptable in historic districts and structures. Another challenge is accessibility since living spaces are above the original ground floor access. Alternative accessways like stairs must be built and ADA access will be challenging in a non-residential building. Lastly, the foundation of the elevated structure must withstand new forces and hazards like high winds, earthquakes, hydrostatic and hydrodynamic pressure and debris impact[44]. Based on location and these forces, the structure will need to be retrofitted beyond simply elevation to become resilient. Although elevating structures is a practical resilient strategy, careful analysis of site condition and building type is required to select the most appropriate elevation technique.

[44] FEMA, Homeowner's Guide to Retrofitting- Chapter 5 Elevating Your House (2014).

Fig.18 Galloway Mansion, a 250-year-old home, is transported down Tred Avon River by barge to its new location in Queenstown from Easton, Maryland. Source: Jerry Jackson/ Baltimore Sun

Moving the building is arguably another resiliency approach. This involves shoring the structure to be raised onto a dolly, then depending on distance, the structure will be transferred onto a flatbed truck to be driven to its final location. A high level of coordination and cost is required to safely move a structure. This is often a costly and risky decision for modern buildings and a last resort for historic structures due to potential structural damage that could occur during the moving process. An example would be the relocation of Galloway Mansion from Easton to Queenstown, Maryland, which took two years of planning, four nights to travel six miles through town. This did not include the barge ride and transportation needed in Queenstown. This relocation costed just under $1 million dollars[45], a sum not

[45] Pacella, Rachael, *Family moves historic house to new home in Queenstown by boat* (September 25, 2019).

possible to invest in every structure at risk from sea level rise and chronic inundation. The main advantage of completely moving the building to a higher elevation is the integrity of the building being spared from intrusive resiliency implementations.

Fig.19 Axonometric diagram of a new temporary disaster housing to meet the realistic needs of these vulnerable families displaced due to severe weather disaster events like Hurricane Dolly. Source: buildingcommunity Workshop

Flexible housing is generally describing structure that can adjust to the changing needs of the user and accommodate new technologies as they emerge. In the climate resiliency lens, this can be defined as a structure designed to be easily altered and transformed to meet flood resiliency needs. This type of flexible housing occurs most often in disaster recovery housing models. Rapid Recovery Housing, RAPIDO, by buildingcommunity Workshop, envision a way to produce more durable

“temporary” housing, which often becomes permanent housing for victims of natural disasters. Components of the housing like elevated construction, flexible wall assemblies, “safe house” rigid shear walls and connections allow the structure to transform to its site. Increasing flexibility in adapting in place or moving the structure due to its component driven construction. Like amphibious housing, flexible housing is not fully explored in mass due to the “nomadic” nature of this type of housing type. It is completely different from many current resilient housing strategies and has limited precedents.

Fig.20 MOSE flood gates lifted in the Venetian lagoon during a test in 2013. Source: Luigi Constantini/ Associated Press

Gray and green infrastructure refers to both man-made and natural resiliency defenses against sea level rise, storm surges and flood events. Gray infrastructure can include sea walls, flood walls, tide gates, dikes and canals. These “hard” techniques

create an immediate out of sight out of mind solution. However, Venice's flood gate proposal, the MOSE project, reveals many concerns related to gray infrastructure for resiliency. The cost of building flood gates in the lagoon has amounted to 5.5 billion euros[46], a significant upfront investment. However, the flood gates are designed to block tides up to 180 centimeters (nearly six feet), but with higher sea level rise projections MOSE at best would give Venice another 100 years and at worst 50 years[47]. Currently, the flood levels are reaching up to 180 centimeters already in Venice. Gray infrastructure strategies are significant community investments that are quickly out speed in viability by worsening climate change impacts.

Fig.21 Salt Marsh is a type of natural, green infrastructure to mitigate sea level rise and flooding.

Source: NOAA

[46] Stancati, Margherita, and Sylvers, Eric, *The Wall That Would Save Venice From Drowning Is Underwater* (November 21, 2019).
[47] Stancati, Margherita, and Sylvers, Eric, *The Wall That Would Save Venice From Drowning Is Underwater* (November 21, 2019).

Green infrastructure are more environmental implementations involving restoring or creating a natural buffer through salt marshes, berms, or "living shorelines." Introducing more vegetation and riprap softens tidal waves, flooding and rate of coastal erosion. However, natural buffers do not stop rising waters from creeping further inland. Consequently, a hybrid infrastructure proposal combining gray and green infrastructure are more common. The BIG U is an example where a hybrid system maximizes the utility of land area within the floodplain beyond a natural buffer to contain community spaces and program.

Fig.22 Waterplein in Rotterdam, Netherlands functions as a public plaza and rainwater collection ponds for the city. Source: Public Space/ Centre de Cultura Contemporània de Barcelona

Water plazas or water squares is an urban flood resilient strategy utilizing and diversifying usage of public spaces within the urban infrastructure as opportunities. "Waterplein" in Benthemplein located in Rotterdam, Netherlands is an example of a

water plaza. This 4 million-euro project transformed an impermeable plaza into an urban recreational space for sports and rainwater collection and regulation system during heavy rainstorms[48]. When empty, the pools served as public seating, performance space, playing areas for basketball, volleyball and soccer, as well as skate boarding. In heavy rain, these pools' hydraulic function would alleviate stormwater runoff. Creating multiple purposes in public facilities is a common trend in resiliency at an urban scale.

As an urban infrastructure project, water plazas require designing and implementing a hydraulic system that is compatible with existing sewer and septic systems. This type of resiliency is also specific to urban settings with lots of impermeable surfaces, which can overload urban infrastructure due to excessive rainwater runoff. Conceptually, the idea of utilizing resilient strategies beyond flood protection is a repeated technique used in many masterplan precedents.

Fig.23 Before and after transformation of Waterplein in Rotterdam, Netherlands. Source: Public Space/ Centre de Cultura Contemporània de Barcelona

[48] De Urbanisten, *Water Square Benthemplein* (May 1, 2020).

Fig.24 Vision of the blue corridor along the Elysian Fields at Prentiss Avenue in Gentilly, New Orleans. Source: Gentilly Resilience District

Blue and Green corridors are another resilient urban infrastructure strategy to transform once impervious streetscapes into canals and green infrastructure throughout flood impact areas. The City of New Orleans is implementing this strategy through the Blue and Green Corridors project in 2020[49]. In the Gentilly Resilience District plan, blue and green corridors involve improving major boulevards to slow and storm stormwater, while still providing safe and comfortable spaces to travel. Copenhagen's Strategic Flood Masterplan in 2013[50], shares a similar concept at a much larger scale. Several iterations of urban streets and parks designed to become flood pathways while creating safe zones for people to still traverse through the city. The implementation requires changing the topography of public parks and street sections in order to create green canals or basins to contain stormwater and floods. It is unclear how much of the masterplan is implemented today.

[49] City of New Orleans, Blue & Green Corridors Project (May 2019).
[50] Landezine, *Copenhagen Strategic Flood Masterplan* (May 29, 2015).

While building canals to regulate water is not new, the implementation of blue and green corridors is not widely used in urban settings in the U.S. The most common variant of blue and green corridor strategies is the type of flood control used in Carroll Creek Park in downtown Fredrick, Maryland. Carroll Creek Park channels the waterway with culverts into Carroll Creek park, which serves as a water basin for water overflow. This method is different from blue and green streets in that it is not a widespread urban implementation, nor does it allow people to "live with water." Carroll Creek Park moves the flooding away from the community rather than allowing it to coincide with the urban fabric. Blue and green corridors are still new in application with few precedents. It is worth observing and analyzing New Orleans' Blue and Green Corridors Project in the coming decade on its effectiveness.

Fig.25 Vision of blue and green streetscape in the Copenhagen Strategic Flood Masterplan to accommodate flood capacity and protect safe space to travel. Source: Ramboll Studio Dreiseitl

Updating and improving existing community infrastructure systems like sewer and septic pipes is the most common strategy proposed in resiliency masterplans. As

a natural response to increased floods events and intensity per flood, the city's current infrastructure cannot meet the needed flood capacity. The most common improvement is increasing the carrying capacity of the systems by enlarging pipes and drainage systems to handle more water during severe storms or flood events. Despite the simple approach, the strategy of upgrading undersized city infrastructure can be costly and lengthy due to the scale of implementation.

Selecting a climate resilient strategy to implement is not simple. Financial cost is always a point of contention, particularly when discussing the value of what is protected. In many of the strategies discussed, climate resiliency is a significant individual, community or regional effort. Another challenge is the longevity of a climate resilient strategy. Impacts of climate change has been a moving target within the scientific community with projections worsening as recent studies show[51]. Thus, certain resilient strategies, like wet floodproofing and dry floodproofing, might not be an option anymore for some buildings.

[51] Lindsey, Rebecca, *Climate Change: Global Sea Level* (November 19, 2019).

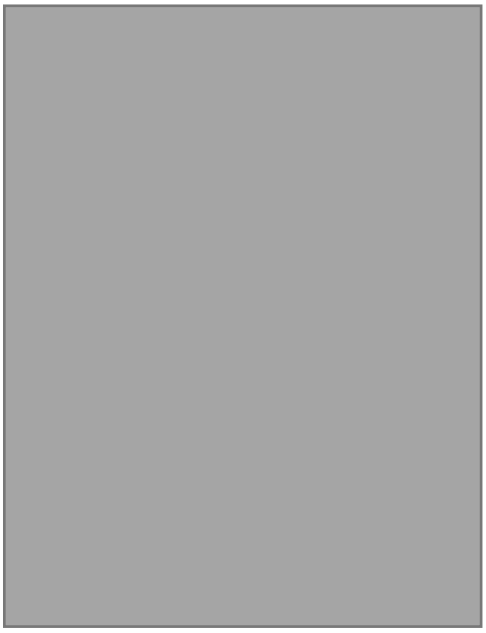
Chapter 4: History and Heritage of Cambridge, Maryland

Fig.26 Bird's Eye View of Cambridge, Maryland postcard dating between 1930 to 1945. Source: Boston Public Library/ The Tichnor Brothers Collection

Cambridge is one of the oldest towns in Maryland with history dating back to its founding in the early 15th century. The city was founded in 1684, as a colonial trade port, due to its deep port, second only to Baltimore in the state of Maryland[52]. Like many colonial towns, tobacco plantations and use of slave labor powered the local economy until the late 1700s. By the revolutionary war, the local economy shifted from tobacco to grain, making Cambridge an agricultural hub. Flour, lumber and shipbuilding operations were constructed on Cambridge Creek around this time.

[52] Henry, Christine, *Valuing Historic Preservation: Cambridge, Maryland a case study* (December 18, 2010).

Prior to the start of the civil war, in 1849, Harriet Tubman made her first escape from the Dorchester County plantation she worked at towards the North[53]. This was the start of the Underground Railroad, a network or safe houses and secret routes used by enslaved African Americans to escape into free states and Canada. As a sizable town, Cambridge's local newspaper, Cambridge Democrat, posted a runaway notice of Tubman offering $100 for her capture. After her initial escape, Tubman made 13 additional trips back to the Eastern Shore to rescue at least 70 family members and friends from slavery.[54] In Cambridge, some 30 slaves escaped through the Underground Railroad.[55] Tubman's efforts continued throughout the civil war.



[53] Henry, David, *A Timeline of Historical Events about the African American Community of Cambridge-Dorchester County, Maryland 1699-2018* (2018).
[54] Henry, David, *A Timeline of Historical Events about the African American Community of Cambridge-Dorchester County, Maryland 1699-2018* (2018).
[55] Henry, David, *A Timeline of Historical Events about the African American Community of Cambridge-Dorchester County, Maryland 1699-2018* (2018).

Fig.27 1849 Slave runaway notice in the Cambridge Democrat offering $100 for the capture of Harriet Tubman, who was also referred as Minty. Source: Cambridge Democrat

Booming Oyster Industry in Cambridge After the Civil War

After the civil war, Cambridge's oyster industry boomed with more than a million bushels of oysters shucked each year, only second to Baltimore[56]. This rise in industry meant prosperity within Cambridge. Soon, oysters were being packed and canned in Cambridge and sold to markets in Baltimore and as far north as New York City. While J.M. Clayton, located in Cambridge, was the first company in Dorchester County to start picking crab and shucking and canning oysters, Cambridge experienced the greatest growth when Philips Packing Company opened in its business in 1902. The packing and canning seafood industry employed many African Americans in the Cambridge. In 1917, Philips Packing Company won a government contract for the U.S. Army to produce C-rations, individual canned and pre-cooked meals, during World War I and II.[57] This employed about a quarter of Cambridge's residents at the time.

[56] Choptank River Heritage, Cambridge (2011).
[57] Intern, Waxter, *Made in Maryland: The Phillips Packing and Seafood Company* (June 25, 2017).

Fig.28 A. Philips & Co. oyster house on the Cambridge Creek waterfront established in 1907. Source: J. Watson Thompson/ Morley Jull Collection

Decline of Oysters and the Civil Rights Movement

Prosperity in Cambridge declined in the late 1950s from depleted oyster beds and the closure of Philips Packing Company, the largest employer in the city at the time. Widespread unemployment and civil unrest from the Civil Rights Movement in the U.S. escalated racial tensions in Cambridge. Riots erupted in Cambridge in 1963 and 1967, causing the National Guard to be deployed to maintain peace. A fire broke out at Pine Street Elementary School that spread quickly destroying the school, local businesses, a motel, billiard parlor, and Zion Baptist Church.[58] With the passage of the Civil Rights Act of 1964, public segregation officially ended in Cambridge.

[58] ArcGIS Story Map, Revitalizing Cambridge - One Step at a Time (May 1, 2020).

Fig.29 Peaceful demonstration outside of businesses in Cambridge in 1963. Source: Tomlinson/ Baltimore News American

Fig.30 National Guard at the intersection of Dunn's Court and Pine Street receiving instructions during the riots in Cambridge. Source: Kilmartin/ Baltimore News American

21st Century Cambridge

In the early 2000s, Cambridge began to revitalize as a community. The Hyatt Regency resort built in 2002 created more attention, visitor traffic and economy into Cambridge again. Soon after, in 2003, Cambridge was designated a Maryland Main Street community bring attention and support to revitalize local businesses and the downtown area.[59] In the last decade, Cambridge was certified as a Maryland Sustainable community, conducted city wide road improvements and blight housing studies. The Harriet Tubman visitor center opened in 2017, which supported the Harriet Tubman Underground Railroad byway that creates heritage tourism traffic through the city. In 2018, the city invested money to reconstruct the deteriorating wharf at Governors Hall, the local multi-purpose facility center. Today, Cambridge is undergoing a rise from more business growth and foot traffic in its downtown area as well as both heritage and environmental tourism. Vacant downtown storefronts, RAR Brewing, and its Chesapeake Mural trail has improved the area in the last few years. This improvement is slowly impacting the city's attention on its local infrastructure like roads, blight housing condition and neighborhoods. The racial tension since the late 1900s and housing condition of African Americans in Cambridge is still an issue plaguing the cohesiveness of the city today.

Cambridge's Historic Building Stock today

Most historic resources in Cambridge are located within the Cambridge Historic District and Pine Street Neighborhood Historic District. Both districts are incredibly large nearly encompassing most of west Cambridge right across the

[59] ArcGIS Story Map, Revitalizing Cambridge - One Step at a Time (May 1, 2020).

Cambridge Bridge. In the Cambridge Historic District, there are 672 contributing historic properties. Over two thirds of the historic properties are large detached single-family housing from the early to mid-20th century. There are some select historic properties from the mid to late 19th century throughout the historic district as well. Many of the waterfront historic homes were houses of ship captains, who operated their ships out of the Cambridge Creek port transporting local resources like lumber, tobacco and agricultural produce to other markets.

Fig.31 View of contributing historic buildings down High Street walking towards Choptank River. Source: Author

Pine Street Historic District has historic resources from the same time period, but most were modest. In the Pine Street Historic District, there are 571 contributing historic resources. Most of the contributing historic homes are two story, two bay frame houses with gable roofs. The vernacular architecture in the district are largely reflective of worker housing during Cambridge's canning boom and inhabited by the free African American community in the area during the late 18th and early 19th

century. Devastating fires of 1892 and 1910 and fire from the 1960s riots caused significant damage to the historic Cambridge community. Many significant historic homes, businesses, churches, schools were destroyed leading many buildings to be rebuilt in brick afterwards. This impacted buildings on High Street, Race Street and Pine Street. Only a few survived these fire events during the late 18th and 19th century in Cambridge like the Dail Brick Storehouse, a three-story commercial building built around the 1850s.

Fig.32 Historic Dail Brick Storehouse today with a commercial storefront and apartment housing on the upper floors. Source: Author

Nonresidential historic structures range from railway depot to churches to downtown business buildings makes up the rest of existing historic resources. Much

of the historic business structures are the most often visited places in Cambridge due to its location and recent downtown revitalization. The existing historic building stock represented the flourishing development of Cambridge when the watermen and packing and canning industry brought wealth into the area. Cambridge's 19th century boom and railway connection attracted people to stay and businesses to grow.

Fig.33 View down High Street from the historic Nathan's Furniture Building (now, Dorchester Center for the Arts) to the Christ Episcopal Church. Source: Author

Fig.34 Historic Johnson Building, one of the surviving 19th century commercial buildings in downtown Cambridge. Source: Author

Fig.35 Historic Catholic Church (now called Anchored Church) adjacent to the historic Cambridge Academy School on the corner of Mill and William Street. Source: Author

Fig.36 Historic Christ Episcopal Church is an important religious building in Cambridge because of its late Victorian Gothic Revival architecture style, its architect, Charles Cassell and its ties to five Maryland governors and local Revolutionary War heroes, whom were buried in the church's cemetery. Source: Author

Fig.37 Historic Delaware and Dorchester Railway Depot built in 1891 is currently occupied as a real estate office. Source: Author

Chapter 5: Choptank River and Cambridge Creek Waterfront

Based on the NOAA Sea Level Rise Viewer and Climate Central's Surging Seas Risk Zone Map, the City of Cambridge will be impacted by the rising tide regardless of whether it is a low, intermediate or high sea level rise scenario. With a minimum global two feet sea level rise prediction by 2050, the rising water will flood the existing marina and extend to Hambrooks Boulevard and Water Street from the Choptank River, which is north of Cambridge. However, the flooding will also reach the city boundaries from the West and South as well. From the West, flooding from Jenkins Creek will barely touch western Cambridge. From the South, flooding of the Blackwater National Wildlife Refuge will reach the southern tip of Cambridge through the Little Blackwater River. City of Cambridge is in a unique predicament where chronic inundation from sea level rise is encroaching towards the city from all sides. The main intrusion into the city will occur on the Choptank River and Cambridge Creek waterfront.

Fig.38 View of Cambridge Yacht Basin located right on the Choptank River, parts of the historic district can be seen beyond the trees in Long Wharf Park. Source: Author

Fig.39 View of Cambridge Creek from the Cambridge Bridge, J. M. Clayton Company can be seen in the background. Source: Author

Timeline of Chronic Inundation in Cambridge

Tidal flooding is a palpable problem in Cambridge today. Residents living on the Choptank River experience flooding in their lawns, yards and roads at high tide. In an interview with local resident, Mary Ann McNamara, she accounts rising waters reaching up to porches and completely submerging the docks and piers on Choptank River from a combination of a severe storm and high tide.[60] Cambridge is expected to be chronically inundated by 2100. The only factor is whether chronic inundation will come sooner and how much more land area it will impact. The lowest projections expect at least two feet of sea level rise by 2050 and four feet of sea level rise in 2100

[60] McNamara, Mary Ann. Interviewed by Amy Duan (June 4, 2020).

in Cambridge. Flooding within the city may impact limited areas, but will severely devastate the rural communities, residents and landscape in southern Dorchester County.

However, in the most extreme scenario with unchecked pollution, Cambridge will experience 11.6 feet of sea level rise by 2100.[61] This level of inundation impacts much of Cambridge Creek's working port and nearly half of the Cambridge Historic District. In 80 years, the community of Cambridge will be forever altered by the flooding from sea level rise. In UCS's When Rising Seas Hit report, the raw data by state indicates in Maryland, Cambridge will be 16 percent inundated in a low scenario in 2100.[62] In an intermediate scenario, Cambridge will be 16 percent inundated by 2060 and 26 percent inundated by 2100. Projections in a high scenario indicates Cambridge will reach nearly 16 percent inundated in 2045 and be 49 percent inundated in 2100.[63] Chronic inundation is not a distant problem in Cambridge's projected sea level rise timeline. Cambridge could be a chronically inundated community in 25 years.

[61] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).
[62] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).
[63] Union of Concerned Scientists, When the Rising Seas Hit Home (2017).

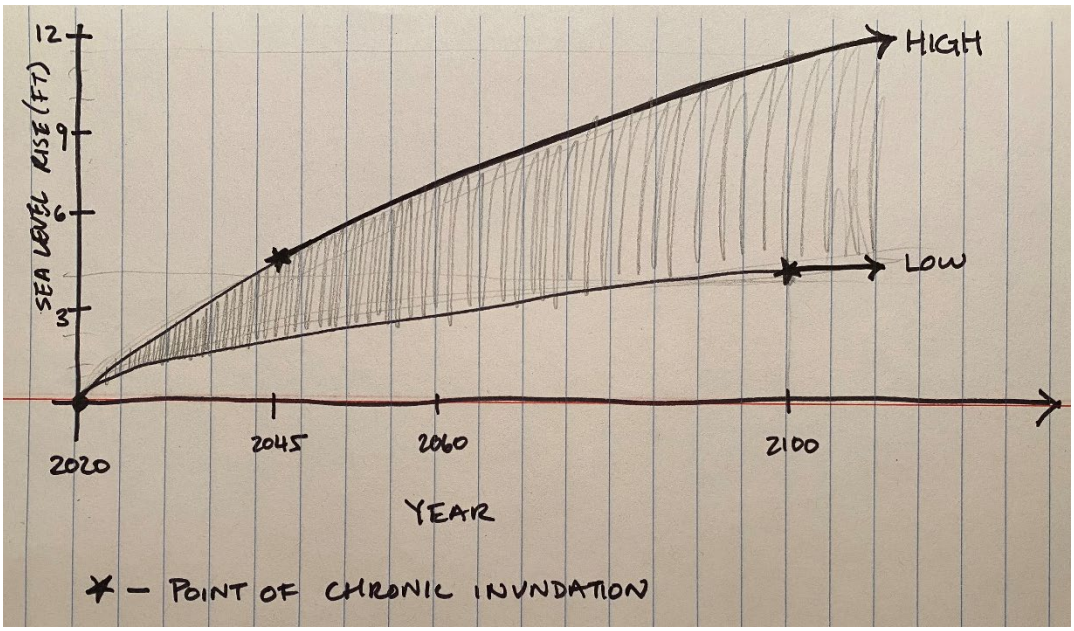


Fig.40 Timeline of Cambridge's projected point of chronic inundation and sea level rise height based on low and high climate scenarios. Source: Author

Infrastructure at Risk

In 80 years, the potential of over 49 percent of Cambridge's usable land area being inundated will put numerous of infrastructure at risk. This will change the way people live, build and experience the city. Sea level rise will reach roughly 850 feet inland into the historic district from the current shoreline on Choptank River, this equates to the water reaching three residential blocks into the city. This extent of inundation will also affect the active working port and businesses on Cambridge Creek as well as most of the Sailwinds Park redevelopment area by the visitor center.

Both historic resources as well as recent development and infrastructure will be impacted. Dorchester County studies show Cambridge is extremely vulnerable to hurricane storm surge inundation with hundreds of buildings within storm surge categories: 132 buildings in Category 1, 197 buildings in Category 2, 304 buildings in

Category 3 and 1,194 buildings in Category 4.[64] In FEMA's National Flood Insurance Report (NFIP), Cambridge has the highest number of flood insurance policy holders and claims within the county.[65] This further confirms the current risk and implies the devastation future inundation risks can have on the community.

Recent and modern construction at risk range from waterfront multifamily housing to detached single family housing to marinas to restaurants and small businesses. The Dorchester County Visitor Center, Governors Hall and the Dorchester General Hospital properties will be affected as well. Historic resources at risk within the city limits are mostly the on High, Mill and Oakley Street, which are large single-family detached housing from the late 19th century to 20th century. The inundation is set to affect a variety of non-residential historic resources on the Cambridge Creek waterfront. A few of these historic resources are still active today like the J.M. Clayton Company, Dorchester and Delaware Railway Depot (now Powell Realtor), Cambridge Bridge, and Cambridge Cemetery. Although the impact on historic resources are limited to certain areas, overall, the City will face increased need by residents, local business owners and developers to plan and complete flood resiliency projects. Flood adaptation needs will increase in the next 80 years and the city government needs to find ways to streamline the implementation across the community, particularly since Cambridge does not have the financial power of west shore cities like Annapolis and Baltimore.

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[64] Dorchester County Emergency Management Agency, Dorchester County 2017 Flood Mitigation Plan (2017).
[65] Dorchester County Emergency Management Agency, Dorchester County 2017 Flood Mitigation Plan (2017).

Demographic and Socioeconomic Condition of Cambridge

Cambridge is not only a physically vulnerable city to sea level rise, storm surges and severe tidal flooding, which will ultimately make the community chronically inundated potentially as early as 2045. The community also suffers from a socially vulnerable population with limited funds to address flood risks. Based on census data from 2000, over half of Cambridge's family households are single parent households — these families find it harder to earn income levels higher than poverty level.[66] Comparing to the 2018 national poverty rate in the U.S., Cambridge is double the percentage at 23.6 percent with the national rate is 11.8 percent.[67] The owner and renter occupied ratio of properties is also imbalanced with more renter occupied properties.[68] Low ownership, vacant houses and some seasonal properties indicate the accessibility and mobility available within Cambridge for lower income families to stay and for wealthier residents from the west shore to buy and own extra property in the city.

Fig.41 Breakdown of Household type in Cambridge according to U.S. Census Bureau data from 2000. Source: City of Cambridge

[66] U.S. Census Bureau, QuickFacts Cambridge City, Maryland (May 1, 2020).
[67] U.S. Census Bureau, QuickFacts Cambridge City, Maryland (May 1, 2020).
[68] U.S. Census Bureau, QuickFacts Cambridge City, Maryland (May 1, 2020).

Limited economic opportunities are another reasoning for Cambridge's socially vulnerable population. Most of the base local economy stems from manufacturing and transportation. Agriculture, hospitality, and retail are slowly growing over the last few decades from the Hyatt Regency resort and revitalization of downtown Cambridge. These dominating sectors provide a disproportionate share of low wage jobs and high wage sectors like professional, technical and scientific services are underrepresented in the City. In addition to the predominately African American community making up 47.6 percent of Cambridge[69], these factors make climate resiliency equity a major concern.

Fig.42 Breakdown of occupied and unoccupied housing in Cambridge according to U.S. Census Bureau data from 2000. Source: City of Cambridge

[69] U.S. Census Bureau, QuickFacts Cambridge City, Maryland (May 1, 2020).

Plans for the Future

Fig.43 Most recent Dorchester County and City of Cambridge plans. Source: Dorchester County/ City of Cambridge

Cambridge's most current city comprehensive plan was released in 2011. Based on the city's studies, the government anticipates urban development up to 2030 will occur within the city boundaries and less in the surrounding farmland and woodland areas. It will be vital to update the city's sewer and water service to accommodate the growth as well as collaborating with the county to discourage growth beyond the boundaries. This extends to future land use development across the city and street and pathways improvements. For example, the plan sets to "encourage development strategies within 1,000 feet of the Choptank River that promote water quality improvements and to promote environmentally sound

development practice in all new developments."[70] Although the strategy is vague, the City mentions examples like Environmental Site Design as a potential principle to follow, which mimic hydrologic runoff and minimize impacts on local waterways. For roadways, the City plans to improve pedestrian and bicycle access and accommodate more landscape medians to serve as bio-retention for city wide storm water management.

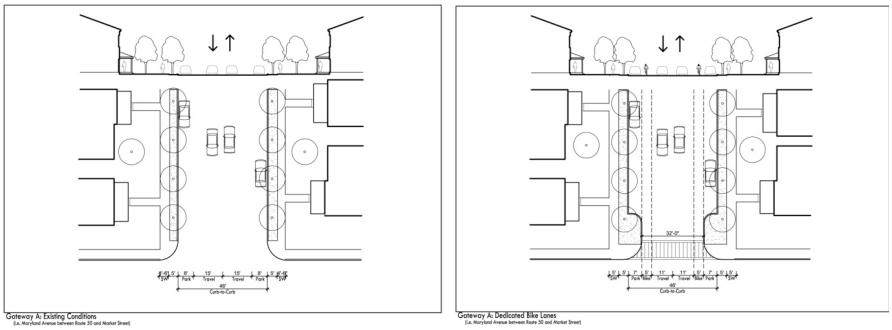

Fig.44 Existing and Proposed street modification for bike lanes and medians. Source: City of Cambridge

The most important section of the City's Comprehensive plan is Chapter 6 and 7, where the city discusses how Cambridge's comparative advantages and ways to implement the strategies and proposals. Downtown/ Waterfront Development District is the largest planned proposal for the future because it investigates the current zoning, development pattern and land use surrounding Cambridge Creek. It captures the need to densify the city downtown, improve access and nodes, and create a unified sense of place with future development in mind. This document includes limited plans for historic resources apart from the cohesiveness of new development with the historic aesthetic of the city through building design standards. Other

[70] Cambridge City Council, City of Cambridge Comprehensive Plan (March 28, 2011).

heritage and historic goals focus on heritage tourism trails from the visitor center to Cambridge Creek Bridge.

However, Cambridge's Comprehensive plan does suggest some strategies for local economic development that optimizes current land use pattern and infrastructure. This includes a medical campus district, downtown/ waterfront development district, U.S. Route 50 Office and Technology Park, Dorchester Avenue Business District, Natural Resource Park and Environmental Science Center and the waterfront. The Natural Resource Park and Environmental Science Center is interesting because it is building from current partnership with University of Maryland Center for Environmental Science at Horn Point to bring more professional and scientific employment base, which will provide future job opportunities within the city. More environmental research in the area can also benefit Cambridge in addressing chronic inundation in the future.

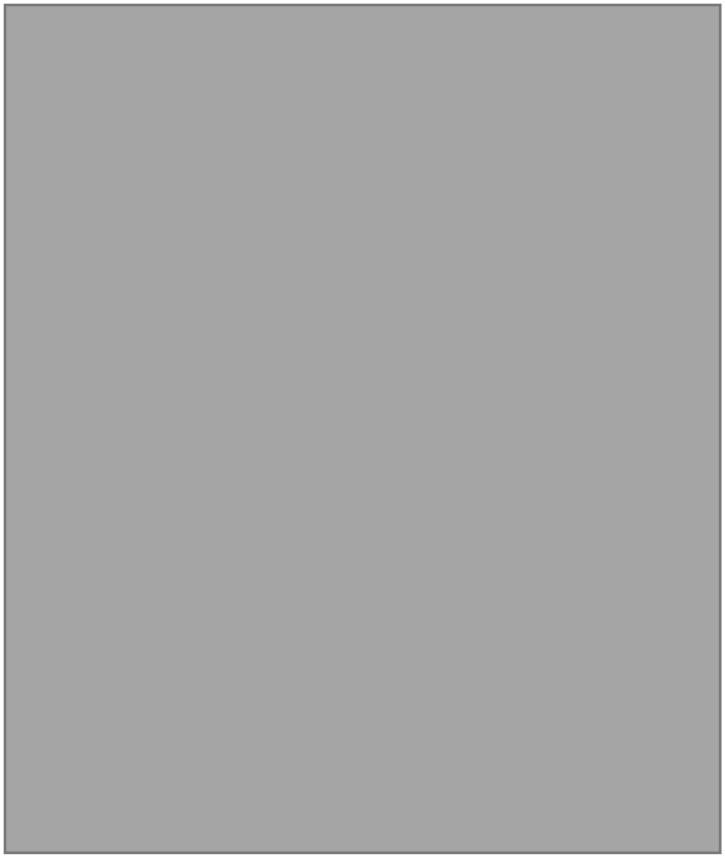

Fig.45 Cambridge Waterfront Concept Plan diagram. Source: City of Cambridge

As part of Dorchester County, the 2017 Hazard Mitigation Plan is the only available document addressing how the City will plan and implement strategies to decrease vulnerability and risk from flood hazards. The document developed 13 mitigation implementation action items and some initiatives to assist Dorchester County flood vulnerability and risk reduction efforts. Some of the initiatives include continuing partnership efforts with local organizations like Eastern Shore Land Conservancy in facilitating public awareness and education efforts and working with Department of Natural Resources in obtaining coastal hazard data and collaborate on waterfront development plans. Thirteen action items from the Hazard Mitigation Plan includes,

- Encourage property owners to elevate structures
- Black mold remediation outreach
- Water infrastructure best practices
- Prioritize flood prone vacant property for hazard mitigation
- Prioritize and upgrade flooded roadway infrastructure
- Potential acquisition and open space
- Taylors Island flood and sea level rise mitigation
- Private sector integration plan program
- Sea level rise vulnerability study
- Modify floodplain ordinance
- Municipal participation in CRS (Community Rating System)
- Bestpitch Ferry Road bridge replacement
- Organize roadway and drainage easements

The three priority action items are encouraging property owners to elevate structures, acquire open space and conduct sea level rise vulnerability studies. Each item has a clear goal, strategy, measurable outcome, funding source and responsible agency assigned to implement the item. It is evident based on the thirteen items the concern of how existing infrastructure will combat inundation from black mold to elevating structures to vacant properties and the city's grey infrastructure systems.

Chapter 6: Site Selection

Three potentials sites were initially explored for this thesis: Governors Hall at Sailwinds Park and Dorchester General Hospital property, Herbert Hearm Hardware

Company building and the Cambridge Academy Public School, also known as the Academy School. All three properties are at potential risk from future sea level rise and inundation due to the city's low-lying topography and location on the Choptank River. The structures are all currently underutilized or vacant, thus offering adaptive reuse potential for the city and community. Ranging from around 12,000 gross square feet to 30,000 gross square feet of potential program space, each site has significant potential to become a new community asset.

Fig.46 Governors Hall Property at Sailwinds Park is a major part of Waterfront 2020, a citizen led planning and design effort on Cambridge's waterfront. Source: City of Cambridge

Fig.47 Governors Hall located near the opening of Cambridge Creek. Source: Governors Hall at Sailwinds Park

Fig. 48 View of Dorchester General Hospital from Dorchester County Visitor Center. Governors Hall can be seen in the background. Source: Author

Governors Hall at Sailwinds Park and Dorchester General Hospital is located the Choptank River right off Route 50 and near the mouth of Cambridge Creek. Governors Hall is an underutilized multipurpose rental venue used for weddings, festivals, music events, parties and most large local gatherings. The wharf on the Governors Hall property was recently reconstructed from its previous deteriorating

state in 2018.[71] Dorchester General Hospital is a full-service medical facility for residents in the city and surrounding areas. The medical service is slated to relocate in 2021 to a new freestanding facility a mile away from its current location.[72] The city is working to acquire and develop the 25-acre property for mixed use development right on Choptank River. Currently, both structures occupy valuable waterfront real estate for the city. The development plan is still a work in progress for the city and is a very controversial topic for many residents.

Fig. 49 Riprap and stone rubble used on the Sailwinds Park shoreline to protect the land from erosion.

Source: Author

[71] ArcGIS Story Map, Revitalizing Cambridge - One Step at a Time (May 1, 2020).
[72] ArcGIS Story Map, Revitalizing Cambridge - One Step at a Time (May 1, 2020).

Since this large stretch of waterfront is planned by the city for future development, it makes the property an interesting potential thesis site. Located on Choptank River, it will be within the flood risk zone despite the riprap and stone rubble implemented on the shoreline today. The site offers the opportunity to explore building resiliency on the coast while providing more businesses and economic drivers into the city. The site does not offer the potential to address the historic resources at risk within Cambridge, which support its strong tourism industry.

Fig. 50 Recently stabilized and partially restored Herbert Hearm Hardware Company building sits unfinished and vacant today. Source: Author

Herbert Hearm Hardware Company building is a historic commercial block built around 1914 on Race Street in historic downtown Cambridge. It is a three story four by twelve bay stretcher and common bond brick structure. Recessed double door entrances on the first floor and segmented brick jack arches span the double window

units on the upper floors. The overall building design is similar in style to other early 20th century commercial buildings in Cambridge. This building is likely designed by local architect, J. Benjamin Brown, who also designed many buildings in Cambridge.[73] Awarded a Maryland Historic Trust Tax Credit award in 2016, the Herbert Hearm Hardware Company building was able to restore the failing exterior walls. The restoration work on the building has stopped for at least a year based on interviews with local business owners in downtown Cambridge, thus the historic building still sits vacant today.

The 1914 historic commercial building offers an opportunity to explore ways historic resources within Cambridge can be adaptively reused for other purposes supporting local economic growth such as mixed-use housing, office building, art studios and makerspaces. The site does not provide flood resiliency exploration potential in historic resources due to its location. Inundation projections in Cambridge does not extend to the Herbert Hearm Hardware Company building site boundary.

Fig. 51 Original Victorian Wood Structure of the Cambridge Academy Public School. Source: C.L. Moore, Maryland National Historical Trust

[73] Touart, Paul B., "Herbert Hearn Hardware Company," Maryland Inventory of Historic Properties (February 25, 2010).

Cambridge Academy Public School is a historic school located in the middle of Cambridge's historic district on the corner of Mill Street and School Street. The original school was built in 1865 was a rectangular two- and one-half story building with a gable roof, a tower at each corner, and another tower over the center (see Fig. 50).[74] However, the original school was burnt down in 1902 when workers were attempting to thaw frozen pipes. A new school was built in 1903 out of brick as a result of that fire by local architect, J. Benjamin Brown. Additions for an auditorium and more classrooms were added in 1936 and 1954.[75] The Academy School closed in 1970 and was purchased by the Golden Shore Christian School. The property was sold to Cambridge School House Associates, LLC in 2006 and the 1936 and 1954 additions were demolished in 2008 for future development plans.[76]

Fig. 52 East façade of Cambridge Academy Public School in 1976. Source: C.L. Moore, Maryland National Historical Trust

[74] Touart, Paul B., "Academy School," Maryland Inventory of Historic Properties (February 24, 2010).
[75] Touart, Paul B., "Academy School," Maryland Inventory of Historic Properties (February 24, 2010).
[76] Touart, Paul B., "Academy School," Maryland Inventory of Historic Properties (February 24, 2010).

The Academy School was originally planned for adaptive reuse into an apartment complex by Crosby + Associates, LLC, a local architecture firm. The historic building was planned in the schematic design to contain 8 units and a new two-story building will be built on the northwestern corner of the site containing 15 more units and amenity spaces like a theater, library and computer room.[77] Apart from the demolition of the mid-20th century additions, the Academy School building still sits vacant and is currently surrounded by chain link fencing today. This roughly 8,000 gross square foot historic school offers a unique setting for adaptive reuse beyond more residential housing in Cambridge's historic district.

Fig. 53 Vacant Cambridge Academy Public School currently surrounded by a chain link fence. Source: Author

[77] Crosby, Tim. Interviewed by Amy Duan (January 16, 2020).

As a contributing structure to Cambridge's historic district, the Academy School will be one of numerous historic properties threated by 11.6 feet of sea level rise in 2100. Based on NOAA projections of sea level rise in Cambridge at 10 feet, high tide will push water right onto the steps of the Academy School. The Academy school offers an opportunity to explore how the city can build flood resiliency in historic resources, but also be adaptively reused to service impending flood resiliency needs within the local community. Numerous homeowners and businesses will be within the flood risk zone that will need to address inundation concerns through various resiliency strategies. Instead of adapting the historic school into more residential housing, the Academy School can maintain its original institutional program and serve as a resource center for city officials, local researchers, and the public to educate each other on flood risk concerns and streamline resiliency projects within the city.

Site Analysis of the Academy School

Compared to the other two potential thesis sites in Cambridge, the Academy School offers the most potential to address the thesis question of how rural coastal communities can approach inevitable chronic inundation. Adaptively reusing the Academy School to address resiliency in historic resource can also provide an additive value for the local community. The roughly 1.8-acre property offers generous setback from the street and surrounding residential housing to design an addition to supplement the programmatic needs of the thesis proposal. A light tree line behind the residential housing on the block buffers private residential space from the property. The historic building faces Mill Street, which is the busier residential

street carrying the most foot and car traffic. Meanwhile, School Street is a narrower one-way street that can provide a different public approach to the site. Despite the generous setback and the nearly 2 acreage property, the surrounding properties are mostly residential homes except for the Anchored Church adjacent from the site. One of the greatest challenges will be designing sensitively to the private residents that envelope the surrounding site.

Fig. 54 Property Boundary of the Academy School. Source: Author

Chapter 7: Concept Proposal

As a historic resource at risk from future inundation from sea level rise and storm surges, Cambridge Academy Public School has the potential to become a precedent in building resiliency in the area. Located in the center of Cambridge's historic district, the Academy School is easily accessible for residents, business owners, city officials and visitors. The physical renovation and adaptive reuse of the structure to withstand flooding can serve as an example of potential building

resiliency methods in Cambridge. Specifically, it can serve to educate the hundreds of contributing historic property owners within the historic district on ways to build resiliency in the next few decades.

In turn, this new resilient structure can serve as a public awareness and education center for climate resiliency in the area. Near Cambridge's Department of Planning and Zoning, city officials can utilize the Academy School to bridge the gap between the public and current regulations. University of Maryland's Center for Environmental Science at Horn Point can also partner with the City to use the Academy School to educate the public on their local research and findings related to climate resiliency. As a result, this thesis proposes to adaptively reuse the early 20th century school building and property into an outdoor education center campus.

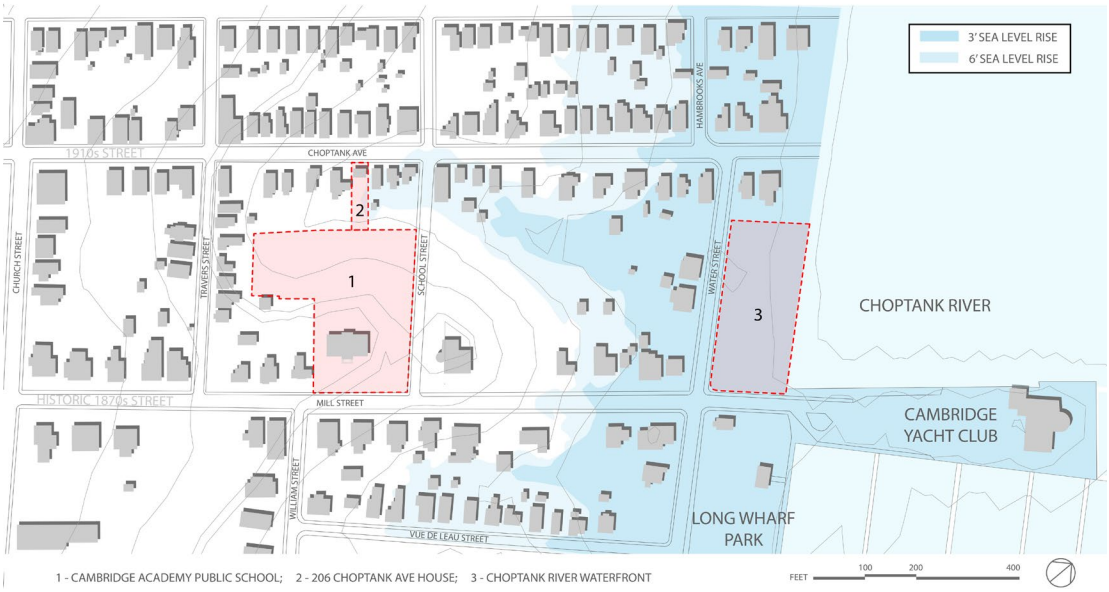

Fig. 55 Selected sites for thesis proposal. Source: Author

In addition to the historic school, the opposing historic residential house on the block on Choptank Avenue will be adaptively reused and made flood resilient to demonstrate ways local homeowners can address flood risks in the future. The third

site on Choptank River waterfront is an open public green that can serve as a location for the outdoor education center campus to access the local waterways to teach and restore the environment operating out of a designed waterfront pavilion. The pavilion serves as both a new community space but also a demonstrative project in terms of a new construction project in a flood risk zone. The open public green will be envisioned without the existing bulkhead into a living shoreline providing the historic district a soft edge buffering impending tidal flood waters.

Fig. 56 Historic residential house typical of 1900s workers housing on Choptank Avenue. Source: Author

Fig. 57 Choptank River waterfront at the end of Mill Street viewing from the yacht club parking lot. Source: Author

Designing within a historic district or a historic structure is always a complex process and project. The main concern is renovating and adapting the historic structure to fit current and future needs without compromising its historic integrity. Consequently, it is important to define what resiliency and success means for this thesis exploration. Resilience means reduction in a building's flood risk by adapting the property to flood hazards. Successful resiliency and flood adaptation mean protection of building from potential damages to none or a negligible state such as structural stability, building systems, access to spaces and water damage in living spaces. This also includes health, safety and welfare of the users within the building during and after a storm event. The less disturbance to the access and function of the building from flood events is a form of successful resiliency as well.

For historic buildings, resiliency and success includes the impact on historically significant materials, features and spaces. As a result, achieving flood resiliency in a historic building is both an opportunistic and challenging adaptation project. Considerations regarding the historic building's architectural features, its setting and streetscape as well as any new additions onto the building or on the

property are the three supplementary elements in conjunction with resiliency strategies.

Historic Architecture Considerations

When adaptively reusing a historic building, the main concern is preserving historically significant elements. The Secretary of Interior's Standards for rehabilitation requires the historic structure to be minimally altered to fit new program while maintaining the historic defining features of the property. Alterations and new additions should be easily differentiated and not damage historic materials. For the historic school, some historic defining features is the hipped roof, nine bay four stretcher bond brick structure, overall symmetry of building and window opens as well as the rusticated sills. These exterior features make the historic Cambridge Academy Public School historically significant as an example of early 20th century education facilities.

The setting is also another important feature of the school, where it traditional sat uninterrupted within the historic residential district. The visual connection from Mill Street, the historic entry is important. The view of the school from School Street is less important due to the location and alley nature of School Street. However, the historic school should still feel like a landmark building on the landscape. Consequently, the architectural proposal of an outdoor education center involves very little alterations to the physical building appearance in the rehabilitation of the school itself. The new building cluster behind the school also is set back away to allow the school to sit as a dominant building surrounded by open green space. The new

buildings also are scaled down from the historic school to respect and not destroy the civic importance of its presence within the historic district.

New Construction in Historic Context Considerations

New construction in a historic district requires a delicate balance of blending into the landscape while not competing with existing historic structures. Materiality, form and location are the three main factors that influenced the ultimate architectural proposal. Usage of natural material like wood and selectively choosing an unpainted gray, weathered wood to dominate the exterior aesthetic along with a metal roof draws a lot of influence from local vernacular agricultural buildings. This consideration ties to a broader tobacco plantation history within Dorchester County and throughout the Eastern Shore. The gable roof form of the Outdoor Education Center structures draws from both vernacular traditions and local context. Lastly, location of the facility is important when introducing new construction within a historic district. Locating the building cluster behind the historic school off of School Street, an alley within the historic district allows the buildings to diverge from the immediate context and embrace a different style while not glaringly stand out in the historic district experience.

Adaptive Reuse Precedents of Historic Schools

Fig. 58 Historic Marie Reed Elementary School renovated to modernize the school facility as well as provide more community services and spaces like health clinic, pool and daycare. Source: Century 21 Redwood Realty

Marie Reed Community Learning Center is a historic brutalist elementary school located in Washington D.C. Built in 1891, Marie Reed Elementary School educated the African American students in the community during an extremely segregated time period in the city.[78] The building was in disrepair and needed an upgrade, which led DC Public Schools to commit funding for its updating efforts. It was modernized by local architecture firm, Quinn Evans to transform the open floor plan into compartmentalized classrooms for the elementary school and provide more services to the local community like a health clinic, daycare and pool.

[78] Marie Reed Elementary School, History (May 1, 2020).

Fig. 59 Historic Fremont High School adaptively reused into senior apartment housing in Fremont, Michigan. Source: Quinn Evans

The Gateway Senior Housing is another Quinn Evans adaptive reuse project that transformed the former historic Fremont High School into senior apartment housing. Columbus School Apartments is a similar adaptive reuse project in Baltimore where Quinn Evans transformed the historic Columbus School 99 into affordable apartment units. Both projects offer precedent in how historic schools can be adaptively reused to provide housing and management office spaces.

Fig. 60 Historic Columbus School 99 adaptively reused into affordable apartment housing in Baltimore, Maryland. Source: Quinn Evans

Programmatic Precedents of Education Centers

Two environmental education center precedents greatly influenced the thesis design process. Arlington Echo Outdoor Education Center in Anne Arundel County, Maryland and the Leopold Legacy Center in Wisconsin, both are evaluated as successful due to their impact on the local community, region and user experience. These facilities focus on public awareness and education to induce change and action within their community starting with the architectural design themselves. Arlington Echo Outdoor Education Center is designed to bring students onto the campus into a main hall and then disperse the students to various support facilities across the landscape of the property for various educational activities all the way towards the

Severn River. This design creates a constant physical and visual connection to nature and the goal of the facility. The Leopold Legacy Center is a center dedicated to Aldo Leopold an environmental ethics and wildlife conservation pioneer, uses architectural form, material usage, orientation and circulation to sit respectfully on the landscape. The most important design takeaway was the visitor circulation experience through and between the buildings surrounding the central demonstration green. The continual visual and physical connection to the outdoors creates a powerful experience to the user of the beauty and importance of our environment.

Both precedents have a main hall, offices, meeting rooms, workshop, pavilion and an outdoor classroom. These programs support education and collaboration efforts and events to connect various stakeholders together. Experts can connect and share their knowledge to visitors, students and residents. These moments provide spaces to interact and foster a sense of environmental stewardship in the landscape and community. However, these facilities are often situated in a natural landscape isolated away from a local community. The environmental education and issues are thus detached from the community and how it is changing resident's daily life. This thesis challenges that standard setting of an outdoor education center by situating the facility right within a vulnerable community.

Program Analysis of Academy School Site

The existing 8,000 gross square foot historic school does not offer enough space to accommodate the program needed in an outdoor education center. Based on programmatic precedent studies, the EEC will require the following spaces:

Library

Exhibit

Offices

Meeting rooms

Bathrooms

Storage

Outdoor Demonstration Green

Main Hall

Wet and Dry Laboratory Classrooms

Workshop

Consequently, early in the architectural proposal process the historic school was going to become a part of a larger campus. Smaller new construction structures were envisioned to house most of the educational and collaboration spaces supporting the main resource and administration spaces within the historic school.

Fig. 61 Cambridge Academy Public School condition in 1906. Source: Sanborn Insurance Map

Chapter 8: Design Proposal and Principles

Based on a combination of site research, interviews with residents and business owners, government officials, city partnership organizations, and site visits, this thesis proposes to adaptively reuse the Cambridge Academy Public School into Dorchester County Outdoor Education Center. The historic school building will house a specialized research library, office, and meeting rooms. The rehabilitated historic residential house will house the campus facilities manager and functions as a flood resiliency demonstration house for residents. A campus of three new buildings will situate between the historic school and house. The main hall will center the cluster of buildings with the workshop and laboratory classroom building flank the sides. The cluster is organized around a central outdoor classroom. This outdoor learning space is populated with native plants where visitors can learn about what is native to the region as well as a functional outdoor demonstration space where students or residents can sit on the steps or elevated walkway around the buildings.

The Outdoor Education Center buildings on the main campus is designed to be reminiscent of agricultural buildings found throughout Dorchester County and the Eastern Shore region. While it is not brick or clapboard like the immediate surrounding context, the tobacco barn form of the main hall and shed like forms of the workshop and laboratory classroom building does not make the facility seem out of place. It is a familiar architectural style that is introduced in the historic district because of its more discreet location within the urban block. The facility also serves to support the whole region beyond Cambridge thus the more regional vernacular architectural style was chosen.

Fig. 62 Overall site plan. Source: Author

Fig. 63 Campus Entry from School Street looking into the outdoor classroom. Source: Author

Fig. 64 View looking towards Discovery Lab. Source: Author

Fig. 65 Main campus floor plan. Source: Author

Fig. 66 Organization of Outdoor Education Center campus and program relationship. Source: Author

The new waterfront pavilion will be added onto the open public green at the end of Mill Street. This elevated waterfront building protrudes out into Choptank River to bring visitors straight into the heart of chronic inundation. The building form is reminiscent of canning facilities that are important to Cambridge's historic development. This pavilion not only serves as a waterfront restoration program facility but also a community building. The multipurpose room overlooking the water is designed to be flexible in altering from educational classroom to support community events like local meet ups, seminars and temporary art galleries. It's location right on the corner of Mill and Water Street makes the pavilion visible from the main campus and for visitors explore historic Cambridge. It provides a new landmark within the district while making the chronic inundation issue at hand visible and accessible.

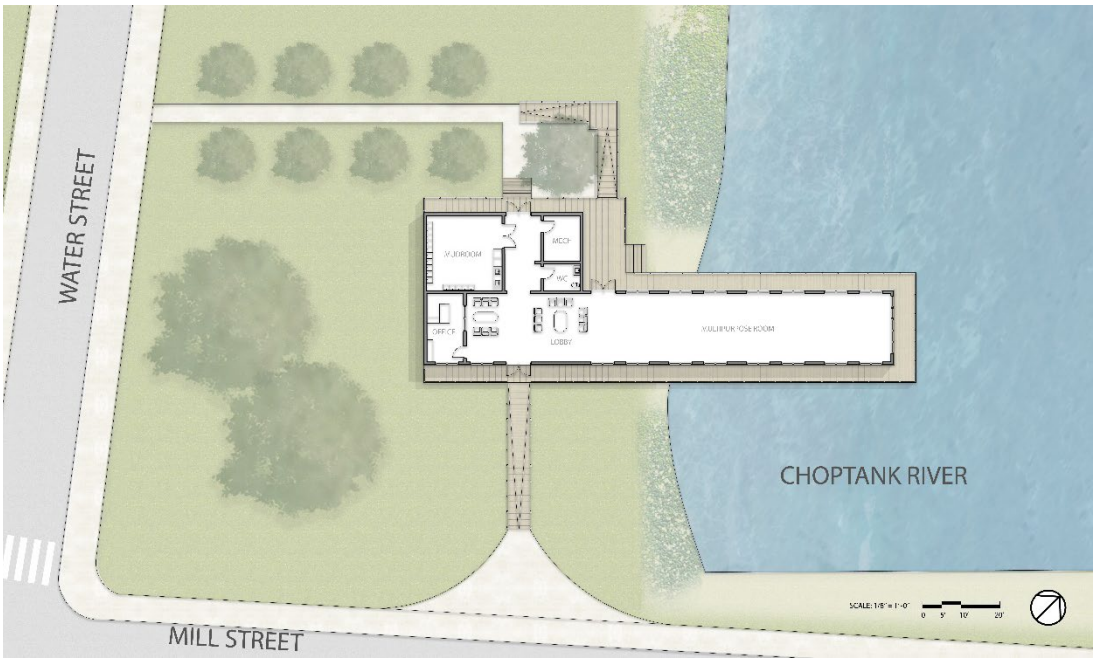

Fig. 67 Floor plan of Waterfront Pavilion. Source: Author

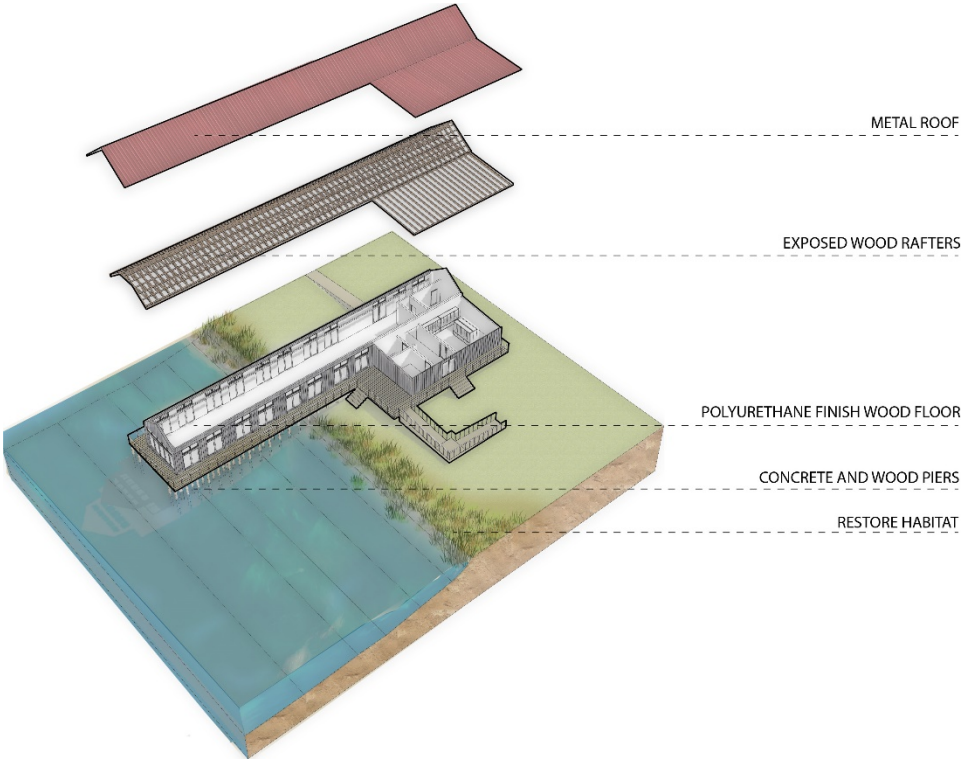

Fig. 68 Axon of Waterfront Pavilion. Source: Author

Fig. 69 Interior view of multipurpose room in the Waterfront Pavilion. Source: Author

Fig. 70 Exterior view of Waterfront Pavilion and restored living shoreline on Choptank River. Source: Author

In order to establish a design framework, four goals were established to guide design decisions in this process, which are preserving historic defining elements, accessibility, floodproofing, and educational use programming requirements. Within each goal, guiding principles are created to define the goal, strategy and measurable outcome.

Protecting Historic Defining Elements

Goal: Preserving historically significant elements on the Academy School to maintain its historic integrity as a contributing structure of the Cambridge Historic District

Strategy: Identifying exterior and interior historically significant features and their condition. Analyze and evaluate higher priority features to preserve and best flood adaptation method to limit flood risk.

Measurable Outcome: Maintain maximum historic materials and historically significant elements identifiable from the exterior and interior. Minimize flood infiltration into historic building based on the high projection scenario in 2100.

Accessibility

Goal: Renovating the Academy School to modern standards of accessibility (ADA). The buildings and property should be accessible during flood conditions projected in 2100.

Strategy: The buildings and site should be transitional in its development over the next 80 years to accommodate sea level rise infiltration that creeps closer to the site

and buildings. This includes entry and cross access between buildings as well as site landscaping design.

Measurable Outcome: The facility should be accessible and functional in both dry and flooded conditions.

Floodproofing

Goal: Reduce damage of building from potential flood hazards such as structural stability, building systems, access to spaces and water damage in living spaces.

Strategy: Elevate living spaces above projected flood height and dry floodproofing property to create watertight conditions.

Measurable Outcome: The living spaces should be accessible and functional under dry and flood conditions. Damage to the property is minimal and controlled.

Educational Use

Goal: Provide a public community center as a platform for various stakeholders, decisionmakers and policymakers to communicate with one another on flood adaption and flood risk reduction strategies.

Strategy: Offer a variety of programs supporting various levels of educational exploration from exhibits to presentation rooms to research library. Diversifying the educational experience to attract the attention of visitors from all backgrounds.

Measurable Outcome: Connecting educational spaces to encourage continual development and participation in flood adaptation and future community planning.

Fig. 71 Aerial of Main Outdoor Education Center Campus. Source: Author

Conclusions

This thesis is about exploring chronic inundation and its impact on historic resources within a historic coastal community. The inevitable flooding and sea level rise are changing the landscape of historic coastal communities. The city's historic architecture, streetscape and accessibility to these resources are impacted. Historic character and aesthetic of a historic city like Cambridge will be at risk, thus impacting its cultural and heritage value. The thesis explores ways architecture can address chronic inundation. Developing an outdoor education center in the heart of a threatened community like Cambridge, Maryland allows the environmental issue at hand to become visible and accessible. Architecturally, the facility becomes demonstrative as a potential strategy for further discussion within the community. Drawing inspiration from Eastern shore vernacular architecture forms, usage of natural materials and elevated circulation experience, all demonstrate ways

architecture can address the severity and impact of chronic inundation to the various users.

In the final presentation, the jurors commented on the strengths in referencing the vernacular context as well as the concept of public awareness and education within a community rather than an isolated environment. The jurors noted the design proposal could be strengthened with a stronger and visible connection between the in-land campus and the waterfront pavilion through a path or re-envisioned urban block situated between the two sites. The design and flood mitigation approach of the demonstration house on Choptank Avenue was critiqued as a potential aspect of the design to explore further. Overall, the jurors were satisfied with the vision and overall execution of the outdoor education center.

Across the nation, thousands of historic resources and communities are in flood zones. Impending sea level change often creates a distant feeling from the immense danger and impacts chronic inundation can create within a community. These communities often take decades to recover and face a drastically different cityscape. But by, exploring building resiliency design in historic structures to exist within impending flood events; architects and city government officials can become educated and proactive about implementing resiliency design in these invaluable heritage and cultural resources. Strong public awareness and education is needed for historic resources to survive inundation for future generations to experience and learn about their own history.

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