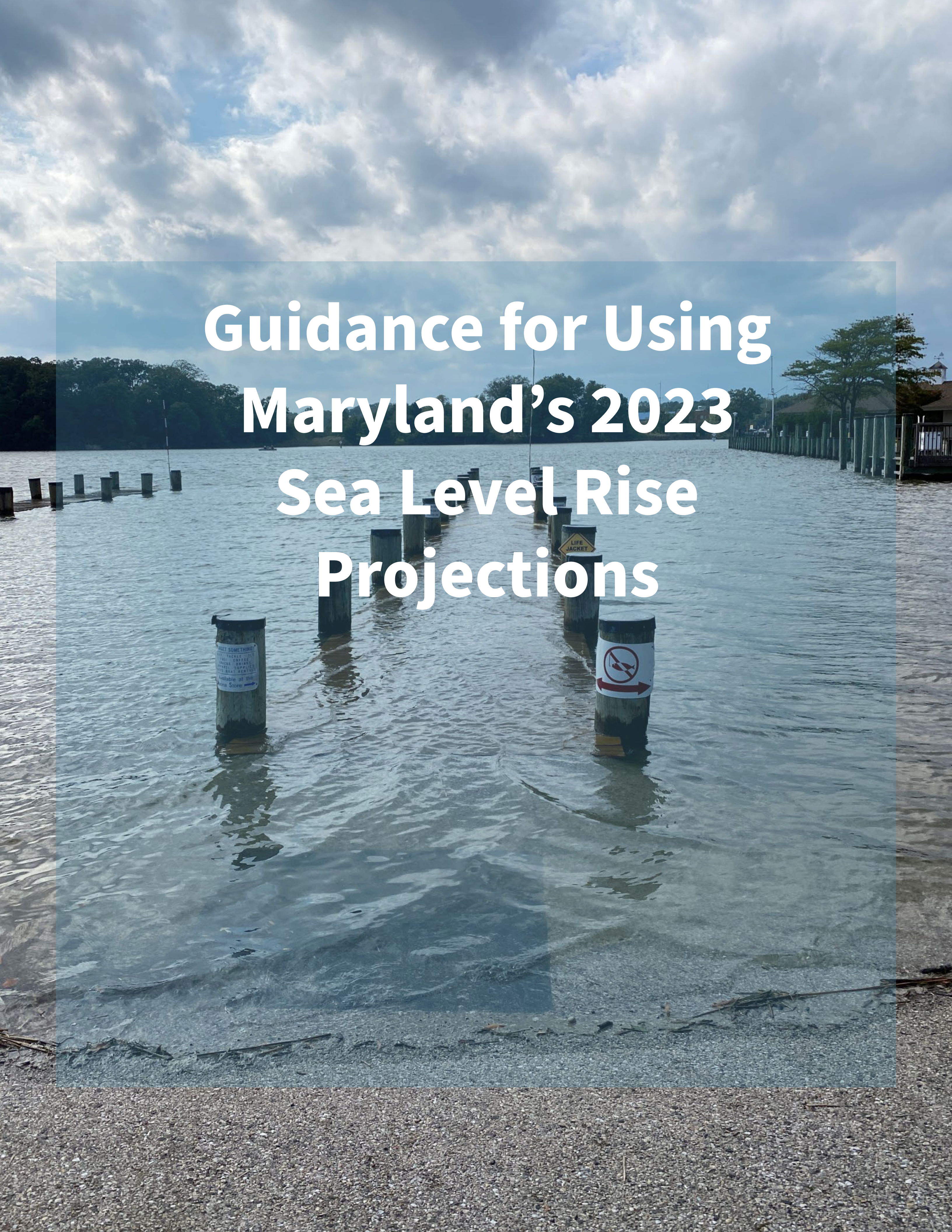
Guidance for Using Maryland's 2023 Sea Level Rise Projections



Guidance for Using Maryland's 2023 Sea Level Rise Projections

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***words that are bolded and underlined are defined in the glossary.**

Introduction and Purpose

Rising seas and coastal flooding already impact communities, infrastructure, and natural and historic resources in Maryland. These impacts are expected to increase in the future as sea levels continue to rise, putting more Maryland communities, ecosystems, economies, and livelihoods at risk. However, science-based projections of sea level rise can inform decisions and help reduce the impact of future sea level rise. This document is intended to facilitate the use of the 2023 Maryland sea level rise projections in planning, regulatory, and site-specific projects to increase **resilience** to changing sea levels in the Chesapeake Bay and the Atlantic Coast.

For the purposes of this guidance, the term **"project"** refers to any private, local, state, and federal planning, regulatory, or site-specific efforts that should consider and incorporate sea level rise projections.

The Maryland Commission on Climate Change Act of 2015 requires the University of Maryland Center for Environmental Science (UMCES) to produce a report every five years with updated sea level rise projections for Maryland to facilitate the use of the latest sea level rise science. In 2018 and 2023 UMCES convened a group of sea level rise experts from the Mid-Atlantic region that produced reports with updated projections for the state [1, 2]. The 2023 report, *Sea-Level Rise Projections for Maryland 2023* [2], provides the most up-to-date sea level rise science and relative sea level rise (RSLR) projections.

Relative sea level rise (RSLR) is the change in the level of the ocean relative to the land at a particular location. RSLR includes both global and local factors. Globally, sea level is rising due to climate change as warmer temperatures cause the thermal expansion of ocean water and the melting of land ice. On a regional scale, sea level is influenced by gravitational and oceanic processes. Locally, sea level change is also affected by vertical land motion, or the movement of land up or down. In the Mid-Atlantic region, the land is slowly subsiding, or sinking, leading to RSLR rates greater than the average global rate [2]. Since local factors influence RSLR, locally-adjusted projections of RSLR are more appropriate for projects in Maryland than national or global projections.

Projections in the 2023 report are probabilistic projections derived by the Intergovernmental Panel on Climate Change (IPCC) [3] with localized estimates provided by the NASA AR6 Sea Level Rise Projection Tool [4]. The projections include factors such as thermal expansion, glacier and polar ice sheet melting, winds and currents, and vertical land motion. These probabilistic RSLR projections provide both central estimates and probabilities that RSLR will meet or exceed certain values. Projections are available in the 2023 SLR report for seven tide gauge locations in Maryland and DC based on the three most plausible greenhouse gas emissions scenarios (Increasing Emissions (SSP3-7.0), Current Commitments (SSP2-4.5), and Paris Agreement (SSP1-2.6)). The expert group convened by UMCES recommends that decision-makers use the Current Commitments scenario (SSP2-4.5) and corresponding sea level rise projections because it represents the most realistic future scenario. Based on that recommendation, this document focuses on the Current Commitments emission scenario. To accommodate the possibility of an earlier-than-projected loss of polar ice sheets, the 2023 updated projections also include estimated levels of RSLR with a low probability of exceedance which incorporate additional ice loss processes that are more uncertain, but cannot be ruled out. These RSLR estimates are based on the judgment of the UMCES expert group and fall between the 83rd and 95th percentile. For the complete methodology and relation to national assessments, refer to the Sea-Level Rise Projections for Maryland 2023 [2].

What's different in the 2023 Maryland sea level rise report versus the 2018 report?

- The baseline year changed from 2000 to 2005 to be consistent with the IPCC's projections.
- Projections are provided for three of the five emissions scenarios designated by the IPCC. These emissions scenarios are called Shared Socioeconomic Pathways (SSPs) in the IPCC's Sixth Assessment, which replace the Representative Concentration Pathways (RCPs) used in the IPCC Fifth Assessment.
- Different percentiles are now recommended for each level of risk tolerance to reflect changes in the data provided by the IPCC and the UMCES expert group and to better account for natural and nature-based projects (see step 5).

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The purpose of the guidance document is to:

- Assist decision-makers in Maryland with incorporating probabilistic RSLR projections into planning, regulatory, and site-specific projects at the private, local, state, and federal levels through a step-by-step approach
- Provide guiding principles to consider when planning for sea level rise
- Highlight examples of how RSLR could be applied in projects

The document provides a step-by-step broad approach to incorporate RSLR into projects, but the guidance does not specifically instruct on adaptation strategies or actions that could be taken to lessen the impact of future sea level rise. The intended users of this document include decision-makers involved in developing, providing input on, and implementing private, local, state, or federal, planning, regulatory, or site-specific projects within Maryland's coastal communities. "Decision makers" may include, but are not limited to, government officials and staff, volunteer board or commission members, professional consultants, technical assistance providers, private property owners, businesses, and affected stakeholders.

This document is an update to *Guidance for Using Maryland's 2018 Sea Level Rise Projections* (2022) [4] and incorporates input from reviewers from local, state, and federal government, non-governmental organizations (NGOs), the private sector, and academic institutions with expertise in using RSLR projections. The guidance provided is advisory and nonmandatory. The intent is for this guidance document to be updated every five years on the same schedule as the state's SLR projections.

Guiding Principles for Incorporating Sea Level Rise Projections into Projects

These guiding principles provide an overarching framework to apply throughout the **decision-making process**.

1. Protect, enhance, and ensure resilience of natural, recreational, and critical infrastructure, and cultural and historic resources by accounting for sea level rise in project planning.
2. Use the most up-to-date sea level rise projections for Maryland from University of Maryland Center for Environmental Science (UMCES) to inform decisions.
3. Plan for at least the most plausible greenhouse gas emissions scenario (SSP2-4.5) as identified by the expert panel for sea level rise projections in Maryland.
4. Prioritize **equity** and **justice** in the project planning and decision-making process.
5. Adopt transparent and inclusive processes that enable underserved and overburdened communities to directly shape the design and implementation of sea level rise adaptation strategies.
6. Approach the project holistically and build **adaptive capacity** into the project to maximize benefits and ensure the project's longevity.
7. Reduce greenhouse gas emissions during a project's design and implementation phases and avoid contributing to more extreme, long-term climate change impacts.
8. Support and coordinate adaptation efforts within and across jurisdictions using a "whole-of-government" approach to minimize the burden on local governments, reduce redundancies, leverage resources, and ensure consistency in RSLR estimates used for cross-jurisdictional projects.
9. Consider the financial, social, and ecological costs and legal liability of all possible options to manage flood risk including avoidance, no action, accommodation, resistance, and relocation (see Step 7).
10. Establish criteria in grant solicitations and request for proposals that direct applicants to address RSLR to ensure that proposed projects will appropriately reduce the impacts of RSLR.

Photo from: MyCoast MD

Community Involvement & Input:

Engaging community members and ensuring equity is essential for project success. Project scoping should include development of a timeline that allows for meaningful community involvement and input that results in outcomes representative of the community.
Community participation should be included during all project phases, scoping through implementation, with the understanding that who is involved and methods of engagement are specific to each project and community. Thought should be given on the best methods to gain understanding of various perspectives, gather input, and solicit feedback. For example, updating comprehensive plans and zoning ordinances to incorporate sea level rise projections should include input and discussions of flood risk tolerance from both residents and businesses in the community. Multiple projects may be seeking input from the same community members, so collaboration on engagement activities across projects can help achieve meaningful involvement in an efficient manner. Below are resources for how to meaningfully engage community members, receive and integrate input into decision making processes.

Suggested climate adaptation resources:

Urban Sustainability Directors Network (USDN) Guide to Equitable, Community-Driven Climate Preparedness Planning (May 2017)

National Association for the Advancement of Colored People (NAACP) Equity in Building Resilience in Adaptation Planning

A Seat at the Table: Integrating the Needs and Challenges of Underrepresented and Socially Vulnerable Populations into Coastal Hazards Planning in New Jersey

San Francisco Bay Conservation and Development Commission's Adapting to Rising Tides (ART) Program

National Association of Climate Resilience Planners: Resource Library

Approaches for Incorporating Sea Level Rise Projections into Projects

Several different approaches can be used to effectively plan for and adapt to future sea level rise impacts. This guidance details two strategies: identifying risk tolerance or following an adaptation pathways approach.

The risk tolerance approach uses **tolerance for flood risk**, or the willingness of decision-makers and stakeholders to accept possible consequences of flooding, to select an RSLR estimate from a range of probabilistic projections (see Step 4 for further information about flood risk tolerance). This approach is especially appropriate for regulatory or site-specific projects that require a single RSLR value, but can potentially lead to over-investment or over-design.

Flexible adaptation pathways are an emerging approach for evaluating and selecting adaptation strategies to allow for uncertainty. This approach involves assessing the efficacy of potential adaptation actions and identifying thresholds when those actions will no longer be effective (ie. when sea level has risen a certain amount or when a road is flooded a certain number of times per year) in order to identify a series of sequential adaptation strategies in response to rising waters. Adaptation pathways allow decision-makers to plan for a range of uncertain futures while only investing in adaptation strategies when the identified thresholds are reached. This approach is particularly appropriate for long-range community-level planning efforts with a planning window of greater than 50 years, but can be highly time and labor intensive.

Both approaches have advantages and disadvantages, and there is no one "right" way to plan for sea level rise. Decision-makers can refer to the Interagency Application Guide [5] for a more detailed discussion of various approaches for incorporating sea level rise projections into planning, along with each option's strengths and weaknesses.

The guidance provided in this document can help inform projects that employ either a risk tolerance approach or an adaptation pathways approach. The following step-by-step process can be used to select one RSLR estimate for a project based on decision-makers' tolerance for flood risk or to determine a range of RSLR to consider if using a flexible adaptation pathways approach:

Step 1: Define the project type, goal, and area
Step 2: Determine the project's timeframe
Step 3: Select a tide gauge
Step 4: Determine tolerance for flood risk
Step 5: Select an RSLR estimate for the project
Step 6: Assess extent of flood impacts
Step 7: Consider adaptation options

The remainder of this document provides more detailed information on each step. The worksheet in **Appendix A** guides users through the first five steps of the process for selecting an RSLR estimate for a project using a risk tolerance approach.

Step 1: Define the Project Type, Goal, and Area

For the purposes of this guidance, the term "project" refers to any private, local, state, and federal planning, regulatory, or site-specific effort that should consider and incorporate sea level rise projections. Table 1 provides a list of planning, regulatory, and site-specific projects that should consider RSLR.

A **planning project** typically has an impact at a community scale and often has planning horizons and update cycles of five or more years. This guidance can be used to help prioritize action and build resilience into planning projects.

A **regulatory project** refers to regulations, ordinances, codes, and designations that are updated and/or adopted by local or state governing bodies. This type of project should consider future RSLR conditions that may impact what is being regulated in order to inform the development of regulatory standards.

A **site-specific project** is one that is done in a specific location or parcel. This guidance can be used to inform where the project is sited, as well as how it is designed and implemented.

Table 1: Examples of planning, regulatory, and site-specific projects that should consider RSLR.

Planning Projects	Regulatory Projects	Site Specific Projects
Vulnerability or risk assessments	Zoning ordinances (new development in vulnerable or coastal areas)	New construction
Hazard or flood mitigation plans	Site plans or subdivision	Redevelopment and substantial improvements
Nuisance flood plans	Wetland and shoreline regulations	Roads, bridges, & culverts
Comprehensive plans	Critical area regulations	Shoreline stabilization
Pre-disaster recovery plans	Floodplain ordinances	Wetland restoration
Capital improvement plans	Freeboard requirements	Coastal resilience easements
Sustainable Communities Action Plans	Updated building codes	Land preservation
Land preservation & recreation plans	Historic district designation	Waterway improvement & infrastructure
Green infrastructure plans		Natural & nature based infrastructure
Asset management plans		Erosion management/Sediment control
Transportation plans		Critical infrastructure
Continuity of operations plans		Location of resilience hubs
Economic development plans		Land acquisition
Historical/cultural resources assessments and plans		Beneficial use of dredge material
Resilience plans		Ditch restoration
		Nuisance flooding mitigation

Begin with the following actions when initiating a project:

- Identify the project type (planning, regulatory, or site-specific), define the goal of the project, and project outcomes.
- Determine the primary planning area, or the regulatory or site location, by considering project goals and community needs. Refer to page 6 for resources to guide community engagement. Identify areas currently vulnerable to high tide and/or coastal storm flooding.
- Identify who and what will benefit from or be impacted by the project, keeping in mind that individuals outside of the project area may also be affected. Develop a community engagement process that ensures impacted residents, property owners, community leaders, community based organizations, and business owners are included in the decision making process. Keep in mind that all residents in a community may be impacted by a project, even if some individuals do not live within or near the project area.
- Conduct an inventory of natural, recreational, and critical infrastructure and cultural and historic resources in the project area to determine if the project should be separated into smaller sub-areas that may have different flood risk tolerances (see Step 4 for guidance on determining tolerance for flood risk).

Photo from: MyCoast MD

Step 2: Determine the project's timeframe

Since sea level will increase over time, RSLR estimates should be considered for the project's full duration whether using a risk tolerance or adaptation pathways approach. In general, the project's timeframe will be the **ultimate lifespan** of the project, or the maximum number of years it is likely to remain in use or effect. Identify the decade that is closest to the end of the project's timeframe (ie. 2030, 2040, 2050, etc.).

Consider opportunities to adapt the project throughout its lifespan and identify **action points** when adaptation will be feasible due to anticipated updates or maintenance. Opportunities for adaptation are especially important for projects with long timeframes due to increasing uncertainty in sea level rise projections towards the end of the century. Adaptation action points can be defined based on certain time points or intervals in the future (ie. a plan that will be updated every five years) or triggered by project specific metrics.

For projects with a timeframe of greater than 50 years, decision-makers should particularly consider using the adaptation pathway approach as a strategy for planning for a range of uncertain futures while investing in adaptation actions when identified thresholds are met. As part of the adaptation pathways approach, thresholds must be determined when specific adaptation actions will no longer be effective (ie. when high tide flooding occurs on a road more than 10 times a year).

Table 2: Guidelines and examples for determining a project's timeframe.

	Planning Project	Regulatory Project	Site Specific Project
Guidelines for Determining Project Timeframe	Consider the time horizon of the plan, the timeframe that is relevant for decisions made under the plan, and how often the plan is updated.	Consider the timeframe relevant to the regulation, the regulatory standard, and incremental updates.	Consider the ultimate lifespan of the project and identify any action points, thresholds or adaptation opportunities over the course of the project.
Example	The planning horizon for a comprehensive plan may be 30 years, with required updates every 10 years. Decision-makers may choose to use 30 years as the timeframe for the project but should consider that landuse and other decisions made under the plan may extend beyond that timeframe. Action points could occur every 10 years when the plan is updated.	Local floodplain ordinances regulate the construction of residential and commercial buildings. When updating the regulatory standards in the floodplain ordinance, decision-makers may choose to use the ultimate lifespan of residential and commercial buildings as the timeframe to account for future risk. An action point could occur every five years as new RSLR projections become available and the floodplain ordinance is updated to account for that projected risk.	The ultimate lifespan of a business park may be 60 years. Action points could occur when HVAC or other building systems require maintenance and upgrade.

Step 3: Select a tide gauge

RSLR rates and projections vary slightly within Maryland due to variation in vertical land motion (the movement of land up or down). Localized RSLR projections have been calculated based on sea level trends measured by seven tide gauges in or near Maryland. RSLR projections are available for Annapolis, MD; Baltimore, MD; Cambridge, MD; Ocean City, MD; Solomons Island, MD; Tolchester Beach, MD; and Washington, DC (Fig. 1). RSLR estimates differ among the tide gauges by only a few inches by the year 2100 (SSP2-4.5).

Decision-makers may choose to select the tide gauge that best represents or is the closest to the project area. In most cases, RSLR projections based on the closest tide gauge should be used for the project. However, in some instances, a further tide gauge may be more representative of the project area. For example, Hoopers Island in Dorchester County is closest to the Solomons Island tide gauge, but would be better represented by the Cambridge tide gauge because it is on the same side of the Bay and more representative of the local rate of land subsidence.

For regional or statewide projects, consider selecting a tide gauge with a median rate of RSLR (Annapolis or Cambridge) to be representative of the whole project area or selecting the Baltimore tide gauge due to it having the most complete historical record.

Fig. 1: A map indicating the locations of the NOAA tide gauges in or near Maryland for which RSLR projections are available.

Step 4: Determine tolerance for flood risk

Tolerance for flood risk is the willingness of decision-makers and stakeholders to accept possible consequences of flooding. Tolerance for flood risk can be categorized as high, medium, or low. Determining tolerance for flood risk can inform appropriate adaptation actions and be used to select a RSLR estimate from a range of probabilistic projections.

Determining flood risk tolerance is not a necessary step for selecting a RSLR estimate when using an adaptation pathways approach, but can help identify thresholds for adaptation actions. Flood risk tolerance is also different from a project's **sensitivity to inundation**, which is the degree of damage or loss of function a project may experience during a flood event or repeated flood events.

Stakeholder knowledge, perspectives, and project characteristics all contribute to the determination of flood risk tolerance. Given different geographies, perspectives, and tolerance to living with water, the determination of flood risk tolerance is subjective. Diverse perspectives should be considered when choosing a tolerance level. Community members, including underserved and overburdened populations should have representation within the decision-making group.

Consider the following for a project or project area when determining the appropriate level of flood risk tolerance:

- Is the project area currently impacted by flooding? If so, how often?
- What are the public function and safety implications?
- What is the cultural, recreational and historic value of the area?
- What is the sensitivity to inundation?
- For site specific projects:
    - Is replacement an option?
    - What are the associated costs or implications if the site is impacted by flood waters?
    - Upon completion, how easily can this project be modified to withstand future water levels?

When determining how easily the project can be adapted, consider the potential action points identified in Step 2. If a project area experiences frequent flooding and detrimental impacts now, an increasing risk of damage may influence the willingness of decision-makers and stakeholders to accept the risk of potential future flooding.


Photo from: MyCoast MD

Table 3: Project characteristics to consider when determining the level of tolerance for flood risk (Adapted from New Hampshire Coastal Flood Risk Summary, Part II [6]).

	High tolerance for flood risk	Medium tolerance for flood risk	Low tolerance for flood risk
Description	Flooding is expected and has minimal impact	Some flooding can be tolerated and impacts can be variable	Flooding has detrimental impacts
Possible Project Characteristics	Low impact, importance or consequence to the community and/or replacement cost	Medium impact, importance or consequence to the community and/or replacement cost	High impact, importance or consequence to the community and/or replacement cost
	Easy or likely to adapt	Moderately easy or somewhat likely to adapt	Difficult or unlikely to adapt
	Little to no implications for public function and/or safety	Moderate implications for public function and/or safety	Substantial implications for public function and/or safety
	Low sensitivity to frequency and exposure to inundation	Moderate sensitivity to frequency and exposure inundation	High sensitivity to frequency and exposure to inundation

Examples of high, medium, and low tolerance for flood risk:

High tolerance for flood risk: Projects determined to have a high tolerance for flood risk should have low impact, importance or consequence to the community, a low replacement cost, and little to no implications for public safety or the ability of the community to carry on day-to-day functions. The project should have low sensitivity to frequency and exposure to inundation (meaning it is acceptable for this area to flood intermittently) and have the capacity to be adapted to account for future flooding. The project's objectives or design should consider accommodating water or taking no action to address flood impacts (see Step 6). For structures, a high tolerance to flood risk would equate to the American Society of Civil Engineers (ASCE) 24-14 flood design class 1. This is "buildings and structures that normally are unoccupied and pose minimal risk to the public or minimal disruption to the community should they be damaged or fail due to flooding [8]."

One project example is a coastal resilience easement or other land conservation project that maintains an area as open space or natural areas and can be designed to temporarily accommodate flood waters. Another example is a Natural and Nature Based Features (NNBF) project such as a living shoreline or marsh restoration/creation. These types of projects typically allow natural features to stay or expand on the landscape to act as a buffer and lower community flood risk, and, if given sufficient space, can adapt to changing water levels over time.

Medium tolerance for flood risk: Projects determined to have a medium tolerance for flood risk should be able to tolerate some flooding and subsequent impacts. Community day-to-day functions may be affected, but the impacts are likely concentrated to a specific area and critical functions are not compromised. These projects should have the potential to adapt over time. For structures, medium tolerance to flood risk would equate to ASCE 24-24 flood design classes 2 and 3: “buildings and structures that pose a high risk to the public or significant disruption to the community should they be damaged, be unable to perform their intended functions after flooding or fail due to flooding. Includes most residential, commercial and industrial buildings [8].”

An example of a regulatory project that could be assigned a medium tolerance for flood risk is a floodplain ordinance that includes a higher **freeboard** requirement or extends the regulatory floodplain beyond the 100-year floodplain to account for future sea level rise and high tide flooding. In this case, there is an understanding that flood impacts to buildings are undesirable, costly, and disruptive for the community, but most commercial and residential buildings can experience some flood impacts without compromising critical community functions.

Low tolerance for flood risk: Projects determined to have a low tolerance for flood risk should be highly important to the community or irreplaceable. These projects are highly sensitive to inundation, and public safety and/or community day-to-day functions would be substantially impacted if flooding occurs. The likelihood or capacity to replace or adapt the project is low. This category often pertains to community assets or facilities such as emergency shelters, hospitals, power stations, water treatment plants, other critical infrastructure, or places of high community importance as defined by community members. For structures, a low tolerance to flood risk equates to ASCE 24-14 flood design classes 4: “Buildings and structures that contain essential facilities and services necessary for emergency response and recovery, or that pose a substantial risk to the community at large in the event of failure, disruption of function, or damage by flooding [8].”

Certain projects and project areas may have more than one identified level of flood risk tolerance. In such cases, flood risk tolerances can be assigned to each sub-area or structure included in the project. For example, a community updating its comprehensive plan may assign a high flood risk tolerance to recreational, natural, or open space areas and a medium or low flood risk tolerance to residential areas. Alternatively, one flood risk tolerance could be selected for the entire project area, which should be the lowest tolerance level selected for a sub-area. This should be determined in coordination with the inventory of assets conducted in Step 1.

Photo from: MyCoast MD

Step 5: Select an RSLR estimate for the project

Maryland's 2023 RSLR projections provide probabilities that RSLR will reach or exceed certain values at future timepoints relative to the mean sea level in 2005 (average of sea level measurements between 1995 and 2014).

If using the risk tolerance approach, decision-makers' tolerance for flood risk can be used to select one RSLR value to plan for within the range of available estimates. Projects with low tolerance for flood risk should consider RSLR estimates that are unlikely to be exceeded during the project's lifespan to avoid potentially severe consequences of inundation (i.e., high repair or replacement costs, substantial implications for public safety, etc.). Projects with high or medium tolerance for flood risk may consider RSLR estimates that are more likely to be realized during the project's lifespan because the consequences of flood impacts are less severe or there can be adaptations during the project's ultimate lifespan to minimize the impact. It may be relevant to divide the project area into sub areas to evaluate what is at risk and whether the sub area(s) has a high, moderate or low flood risk tolerance.

High Flood Risk Tolerance	Medium Flood Risk Tolerance	Low Flood Risk Tolerance
50th percentile (median)	83rd percentile (upper end of likely range)	83rd-93rd percentile (low probability of exceedance)

If using the adaptation pathways planning approach, a range of RSLR should be identified that encompasses the high and low values possible during the project's timeframe. Fifth percentile RSLR values should be used to determine the minimum amount of sea level rise considered. RSLR values with a low probability of exceedance (between the 83rd and 95th percentiles) that incorporate additional ice loss processes should be used to determine the maximum amount of sea level rise.

The following table (Table 4) is a representative table for Maryland based on the Baltimore tide gauge and the Current Commitments (SSP2-4.5) emissions pathway. Tables for all Maryland tide gauges (Annapolis, Baltimore, Cambridge, Ocean City, Solomons Island, Tolchester Beach, and Washington, DC) are available in **Appendix B**.

Photo from: MyCoast MD

To select the RSLR for a project, find the table in Appendix B of RSLR estimates for the tide gauge identified in Step 3. Then find the row for the year corresponding to the timeframe identified in Step 2.

- If using the risk tolerance approach, find the column for the risk tolerance level identified in Step 4. The value where that row (year) and column (tolerance) intersect is the projected RSLR estimate that should be used for the project. If the project has multiple timeframes or categories of flood risk tolerance for different aspects of the project, decision-makers may choose a range of RSLR estimates or consider the most protective estimate (i.e., the lowest tolerance for flood risk) for the entire project.

- If using the adaptation pathways approach, identify the low (5th percentile) and high (83rd-95th percentile with additional ice loss) values. These values define the minimum range of RSLR that should be considered.

Table 4: RSLR estimates above 2005 levels in feet based on the Baltimore, MD tide gauge and the Current Commitments emissions pathway (SSP2-4.5).

Tide Gauge: Baltimore, MD
Emissions Pathway: SSP2-4.5

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.46	0.89	1.16	1.3
2050	0.72	1.18	1.52	1.6
2060	0.97	1.47	1.86	2.3
2070	1.20	1.79	2.27	3.0
2080	1.42	2.09	2.65	3.6
2090	1.60	2.37	3.06	4.3
2100	1.68	2.69	3.54	4.9
2110	1.72	2.97	4.02	5.9
2120	1.90	3.29	4.48	6.9

Risk Tolerance Example: A shoreline stabilization project near Baltimore, MD with a 30 year timeframe and high tolerance for flood risk should consider 1.2 feet of RSLR (i.e., the intersection of the row "2050" and the column "High tolerance for flood risk" on the table of RSLR estimates for the Baltimore tide gauge).

Adaptation Pathways Example: A project near Baltimore with a 100 year timeframe that is using the adaptation pathways approach, at least a minimum of 1.9 ft of RSLR (i.e., the intersection of the row "2120" and the column "5th percentile on the table for the Baltimore tide gauge) and a maximum of 6.9 feet (i.e., the intersection of the row "2120" and the column "low tolerance for flood risk" on the table for the Baltimore tide gauge).

Photo from: MyCoast MD

Step 6: Assess extent of flood impacts

RSLR & Coastal Flooding Impacts:

As sea levels rise, coastal flooding, including high tide flooding and storm surge, will occur more frequently and impact areas further inland. At the Baltimore tide gauge, high tide flooding is projected to occur at least 65 days per year in 2050 (NOAA Annual High Tide Flooding Outlook, NASA Flooding Analysis Tool). This prediction is similar across all the Maryland tide gauges. In order to plan for and address increased high tide flooding, coastal counties are required to update their Nuisance Flood Plans every five years to document where high tide flooding is occurring and how they are responding to those impacts.

Higher sea levels will also cause the impacts of coastal storms to be more severe, with water reaching further inland and increasing coastal erosion. Stormwater management systems may be compromised due to higher sea levels, and longer durations of flooding when there is both tidal flooding and precipitation. Groundwater levels may rise with sea levels, leading to prolonged flooding in low-lying coastal areas with shallow water tables that could cause land to be permanently soggy. For more information, see Maryland's Plan to Adapt to Saltwater Intrusion and Salinization [7].

Now that an RSLR value or range of values has been selected for the project or project area, there needs to be an evaluation of the extent and depth of present-day and future inundation. This assessment should include the impact on natural, cultural, historic, and human resources, critical infrastructure, businesses, and residents, including underserved and overburdened populations.

Begin the assessment in the project area by:

1. Visualizing and/or understanding the current coastal flooding, including high tide and storm surge flooding. Use the visualizations to engage community members in the identification of flood-prone areas and the associated impacts. If able, update the maps to include the qualitative information obtained from the community.
2. Next, visualize future water levels with the RSLR value selected in Step 5.
3. Also visualize future water levels with RSLR combined with high tide and/or storm surge flooding to consider expanded impact areas.

The Platforms in Table 5 are a starting point for assessing current and future inundation with the selected sea level rise estimate in mind (there may be others that are not listed that can be used as well). In most cases, more in-depth analysis will be needed to more accurately visualize flood impact areas, and surveyed site plans may be necessary for site-specific projects.

Table 5: Tools for visualizing present-day coastal flooding and projected sea levels (to correspond to note below).

Name	Web Address	Details
MyCoast MD	MyCoast.org/md	• MyCoast MD is a platform for the state of MD that allows users to upload pictures of flood impacts. • The photos are shown on a map, linked with information detailing water levels, rain and wind at the time the photo was taken. • An assessment of present-day coastal flooding could include looking at existing reports of high tide flooding and storm events. • Community members could also be engaged to take photos before, during, and after floods to demonstrate the extent and impact of the flooding.
NOAA Coastal Flood Exposure Mapper	https://coast.noaa.gov/digitalcoast/tools/flood-exposure.html	• Provides a flood hazard composite layer for both near and long term flood hazards. • Visualizes sea level rise relative to Mean Higher High Water (MHHW) at one foot increments to allow flexibility in selecting a SLR projection. • Visualizes areas prone to current high tide nuisance flooding and storm surge flooding as individual layers. • Includes FEMA 100-year and 500-year floodplains (1% and 0.2% annual chance of flooding, respectively). • Includes layers for societal, infrastructure, ecosystem exposure. • Intended to be used as a screening-level tool and allow for maps to be saved.
MDOT SHA Climate Change Vulnerability Viewer	https://www.arcgis.com/apps/webappviewer/index.html?id=8659332d3e45ee8b9d8a5f03a7030c	• Visualizes water levels relative to Mean Sea Level (MSL) and Mean Higher High Water (MHHW). • Provides flood depth grids for 0 feet of RSLR (referred to as 2015 water levels), 2 feet of RSLR (referred to as 2050 water and 6 feet of RSLR (referred to as 2100 water levels) combined with 10%, 4%, 2%, 1%, 0.2%, and 0% annual chance storms. • Provides nuisance tidal inundation layers. • Intended to be used as a screening tool and uses the 2013 ACOE SLR projection.
Climate Central Coastal Risk Screening Tool Water Level Map	https://coastal.climatecentral.org/	• Visualizes water levels relative to Mean Higher High Water (MHHW) at 0.1 foot increments. • Intended to be used as a screening-level level tool.
MD Climate Ready Action Boundary (CS-CRAB)	https://mdfloodmaps.net/crab/	• **Visualizes** water levels up to 3 feet (vertical and horizontal) beyond the floodplain and provides flood depth grids. • Includes FEMA 100-year and 500-year floodplains (1% and 0.2% annual chance of flooding, respectively). • Indicates area considered by the Maryland **Coast Smart Council** to be especially vulnerable to current storm surge flooding and future sea level rise. • If state or local capital projects have a cost over $500,000 and that uses at least 50% state funds is located with in this boundary, then the Coast Smart Construction Program Siting and Design Guidelines apply.

**Note: Some tools, including the NOAA Annual High Tide Flooding Outlook, NASA Flooding Analysis Tool, and the Climate Central Coastal Risk Screening Tool, use sea level rise scenarios developed by the U.S. Sea Level Rise and Coastal Flood Hazard Scenarios and Tools Interagency Task Force [8]. These scenarios differ from the projections recommended in the 2023 UMCES sea level rise report. However, if you need or want to use the Interagency Task Force's sea level rise scenarios, the Intermediate-Low Interagency scenario is most consistent with the sea level rise projections based on the Current Commitments (SSP2-4.5) emissions pathway recommended by the UMCES expert group (refer to UMCES report p. 17 for a more detailed comparison with the Interagency Task Force's scenarios).*

Once the current and future flood risk for the project or project area has been visualized, determine how the project team would like to move forward to quantify and assess impacts. How the team proceeds will depend on the outcome and goal of the project. This can take the form of a vulnerability assessment, a flood and SLR action plan, a flood mitigation, plan or other relevant planning mechanisms. Trainings, tools, and other resources related to adapting to rising waters are available on NOAA's Digital Coast.

Other Considerations: Tidal Datums and RSLR:
For some projects, tidal datums other than mean sea level may be relevant (e.g. mean higher high water, mean lower low water, etc.). For example, mean lower low water, the average height of the lowest low tide, may be relevant for a boat ramp or waterway improvement project where the lowest possible water level needs to be considered, or you may wish to consider mean higher high water (the average height of the highest high tide) if flooding during high tide is a concern.

Tidal datums are calculated at individual tide gauges by averaging water level measurements over a 19-year period known as an epoch (available from NOAA Tides & Currents for each tide gauge). The current epoch is 1983-2001, which has a midpoint of 1992. This epoch is in the process of being updated to the 2002-2020 version. However, the sea level rise estimates in *Sea Level Rise Projections for Maryland 2023* are relative to mean sea level in 2005. In order to understand how future water levels relate to tidal datums, the baseline years must be aligned. To shift a RSLR estimate's baseline from 2005 to 1992, 0.16 ft (5 cm) should be added to the value to account for the change in sea level between 2005 and 1992. The adjusted RSLR estimate can then be added to tidal datums found on NOAA Tides & Currents (based on the 1983-2001 epoch) and used to determine future MHHW, MLLW, or other datums with projected sea level rise.

Example: Estimating mean higher high water (MHHW) in 2050 for a project in Baltimore, MD with high tolerance for flood risk.

RSLR estimate in 2050 from 2005 mean sea level baseline: 1.18 ft (30-yr timeframe & high tolerance for flood risk)
RSLR estimate in 2050 from 1992 mean sea level baseline: 1.18 ft + 0.16 ft = 1.34 ft

Mean higher high water (MHHW) from 1983-2001 epoch: 0.82 ft above NAVD88 (from NOAA Tides & Currents)
Mean higher high water (MHHW) in 2050: 0.82 ft above NAVD88 + 1.34 ft RSLR = 2.16 ft above NAVD88

Step 7: Consider Adaptation Options

After assessing the RSLR impacts to the project and what's at risk, the project team should evaluate and/or consider adaptation options. Adaptation options typically fall within a framework of five categories: avoid, no action, accommodate, resist, or relocate.

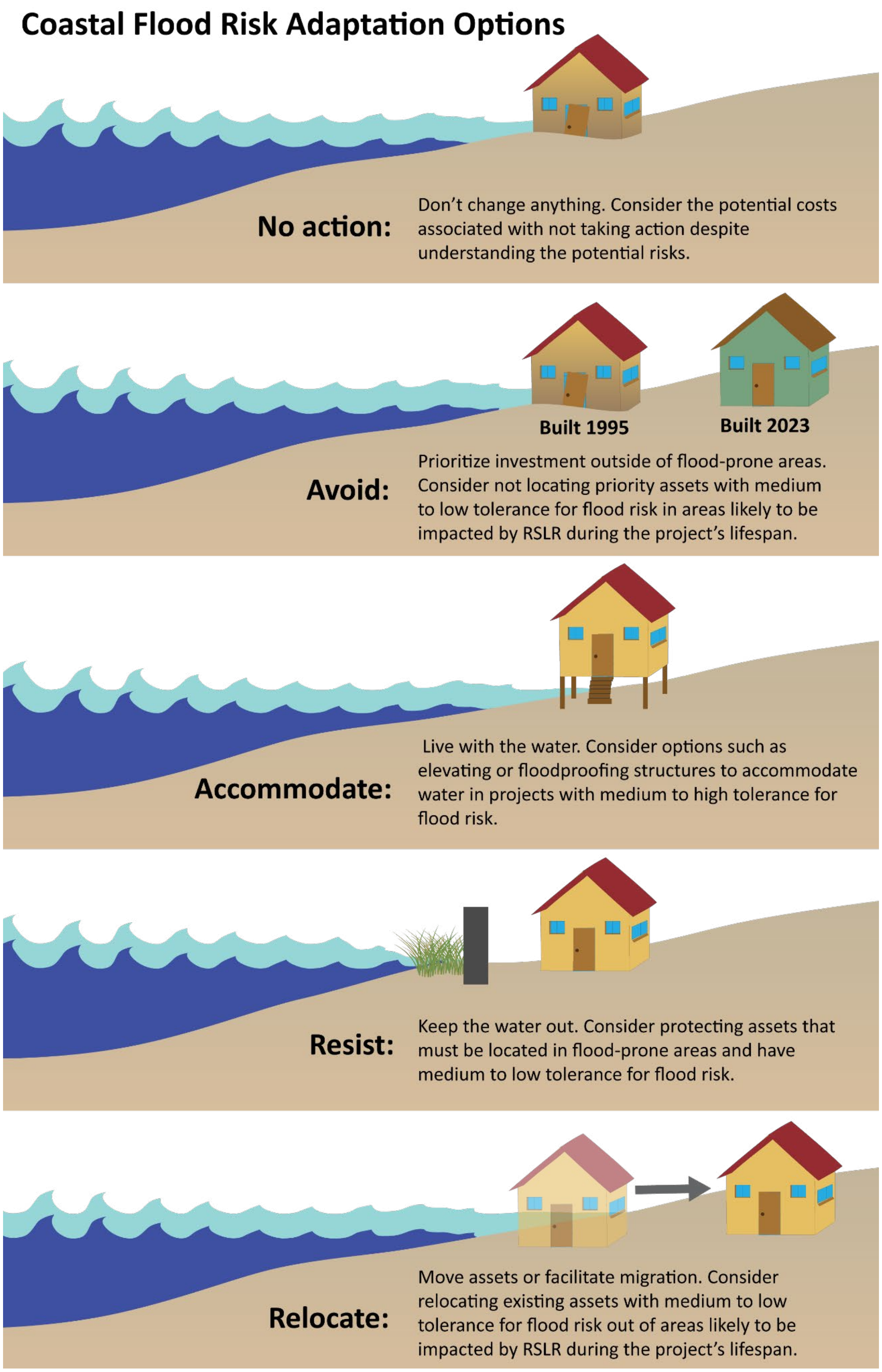

Fig. 2: The five categories of adaptation options

Determining which adaptation option or suite of options is acceptable for your project area will be dependent on input by the community, project team and what the goals and outcomes are. The use of an adaptation pathway approach (discussed below) may help determine which option is appropriate for your project.

Using Adaptation Pathways to Plan Under Uncertainty:
Adaptation pathways allow decision-makers to consider multiple possible outcomes in the face of uncertainty instead of planning for just one predicted amount of sea level rise. This approach links potential adaptation actions with predetermined thresholds and decision points that indicate when the adaptation action will no longer be effective and it is time to switch to another. Thresholds can be based on the amount of RSLR, frequency of flooding, severity of flood damage, or any other parameter that is relevant to the community's goals and objectives. After identifying adaptation actions appropriate for near-term conditions and the range of potential futures and identifying corresponding thresholds and decision points, decision-makers can create pathways that map out potential sequences of adaptation actions. This approach allows decision-makers to plan for a range of uncertain futures while only investing in adaptation strategies when the identified thresholds are reached.

Adaptation pathways resources:

- South West Climate Change Portal: Adaptation Pathways (Australia)
- CoastAdapt: What is a pathways approach to adaptation? (Australia)
- ResilientCA.org: Adaptation Pathways (California)

Table 6: Climate adaptation resources

Name	Web Address	Details
U.S. Climate Resilience Toolkit	https://toolkit.climate.gov/	Step-by-step framework for building climate resilience and resources including decision-support tools, case studies, and training courses
NOAA Digital Coast: Coastal Adaptation Strategies	https://coast.noaa.gov/digitalcoast/topics/climate-adaptation.html	Trainings, reference guides, and case studies related to adaptation in coastal communities
Planning for Climate Change on Maryland's Public Lands	https://sites.google.com/umich.edu/marylandclimatechange/home	A framework for planning for climate impacts to natural, recreational, human, cultural and historical resources and impacts to built infrastructure. Includes tools, case studies, example plans, funding ideas.
Georgetown Climate Center Adaptation Clearinghouse	https://www.adaptationclearinghouse.org/	Searchable database of climate adaptation resources
Nature-based Solutions Funding Database	https://fundingnaturebasedsolutions.nwf.org/	Interactive database for communities interested in pursuing federal funding and/or technical assistance for nature-based solutions.
EcoAdapt Climate Adaptation Knowledge Exchange (CAKE)	https://www.cakex.org/	Shared knowledge base to enhance climate adaptation action: Provide accurate timely information; increase awareness of adaptation project, options, and resources.

Other Considerations: Determine Design Flood Elevation to account for Combined RSLR and Coastal Storm Impacts for structures:

RSLR and coastal storm impacts can be incorporated into a project by determining the design flood elevation (DFE). FEMA flood maps identify a **Base Flood Elevation (BFE)** where water levels are expected to inundate during a 1% annual chance storm today. To consider the impact of RSLR, add the RSLR estimate selected for the project to the BFE in the project area. If your jurisdiction has a freeboard requirement, the design flood elevation should be the sum of either the RSLR estimate selected in Step 5, the current BFE provided by FEMA, or the freeboard if higher than the RSLR. This is an example of an "accommodation" type adaptation option.

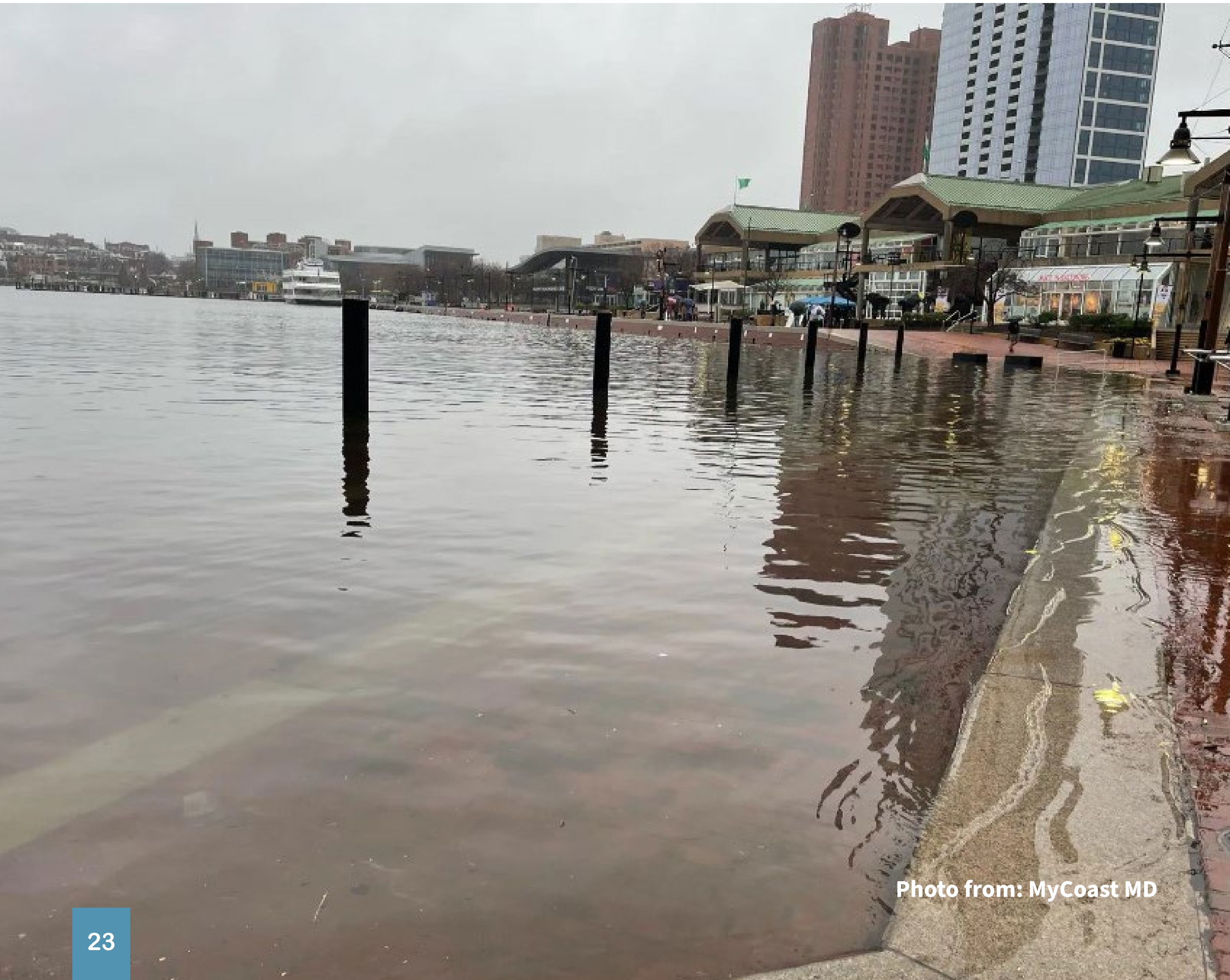

Photo from: MyCoast MD

In Summary

Planning for future sea level rise and the associated impacts is a key component of planning, regulatory, and site-specific projects in Maryland's coastal zone. Incorporating the most up-to-date and locally-specific sea level rise projections, and authentically engaging impacted community members, are essential for robust and equitable planning. There is no one correct method to incorporate sea level rise in projects, and multiple approaches can be employed to effectively plan for and adapt to future sea level rise impacts. Identifying risk tolerance can provide project decision makers with a specific number to plan for throughout project design and implementation. Considering multiple potential adaptation pathways across a range of possible RSLR values promotes flexibility and allows communities to plan for a range of uncertain futures while only investing in adaptation strategies as necessary. Regardless of the approach used, incorporating sea level rise projections into projects demonstrates a commitment to ensuring the vibrant future of Maryland.

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Photo from: MyCoast MD

Glossary

Adaptive capacity:
the ability to adapt a project to reduce the impacts of relative sea level rise or other hazards

Base Flood Elevation (BFE):
elevation of surface water resulting from a flood that has a 1% chance of equaling or exceeding that level in any given year [9]

Decision-making process:
process that includes all steps required to make decisions for projects. This includes project idea inception, consideration of options, stakeholder and community involvement, to decision-making, and implementation of decisions

Equity:
equity is the guarantee of just and fair treatment, advancement, opportunity, inclusion, and access for all individuals. It strives to eliminate barriers and dismantle the systems of oppression that have historically prevented the full participation of some groups. Equity ensures that all community members have access to the environments, resources, and opportunities to reach their full potential and to experience optimal well-being and quality of life [10]

Flexible adaptation pathways:
an emerging approach for evaluating and selecting adaptation strategies to allow for uncertainty

Freeboard:
height above the Base Flood Elevation at which a structure's lowest floor must be elevated or floodproofed as a factor of safety

Action point:
points throughout the lifespan of a project after the initial phase that allow adaptation actions to be taken if community identified thresholds are reached or there are updated climate projections.

Justice:
the realized ability of all individuals to live a full and dignified life. Achieving justice requires directly dismantling barriers to resources and opportunities in society

Planning project:
development of a community-scale plan, such as a comprehensive plan or hazard mitigation plan

Project:
any private, local, state, or federal planning, regulatory or site-specific effort that should consider and incorporate relative sea level rise projections [6]

Regulatory project:
regulations, ordinances, codes, and designations that are updated and/or adopted by local or state governing bodies

Relative sea level rise (RSLR):
the change of the height of the ocean relative to land at a certain location

Resilience:
the ability of a system to recover from a disturbance, adapting a complex network of interactions to maintain productivity and fundamental identity

Sensitivity to inundation:
capacity to sustain damage or loss of function during a flood event or repeated flooding events

Site-specific project:
a project that is done in a specific location or parcel

Tolerance for flood risk:
the willingness of decision-makers and stakeholders to accept possible consequences of flooding

Ultimate lifespan:
the number of years a structure or asset is likely to remain in use, inclusive of major renovations

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Appendix A: Worksheet for Selecting a RSLR Estimate

This worksheet walks you through the steps of selecting a RSLR estimate for your project, as described in Guidance for Using Maryland's 2023 Sea Level Rise Projections. Remember to consider the Guiding Principles (p. 3) when answering the questions included in the worksheet.

If using an adaptation pathway approach for your project, we recommend not using this worksheet, but instead refer to the federal Interagency Application Guide for the 2022 Sea Level Rise Technical Report (section 4.4 pp. 29-31). The Town of Falmouth, MA on pp 33 has been identified as using an Adaptation Pathways Approach and can be used as an example.

Step 1: Define the project type, goal, and area	pp. 8-9
Project type and goal/outcomes: (include all short and long-term outcomes)	
Think about the project location or area, who does this project impact? Describe who will be impacted by the project and included in the decision-making process. How will you engage with those impacted and during which phases of the project?	

Step 2: Determine the project's timeframe	p. 10
Project timeframe in years: _________	Project end year (round to the nearest decade):_________

Identify incremental action point(s): Provide the approx year of the action point and give a short description of each action point and the intended outcome.

Year or Event	Description of Actions:
Start Year	
End Year	

Step 3: Select a tide gauge		p. 11
Annapolis, MD	Ocean City, MD	Washington, DC
Baltimore, MD	Solomons Island, MD	Cambridge, MD
Tolchester Beach, MD		

Step 4: Determine the project's tolerance for flood risk (2 parts) Parts A & B should repeated for each of the projects sub-area if the characteristics are different	pp. 12-14

Characteristic	**High**	**Medium**	**Low**	**Explanation**
Community Value				
Replacement Cost				
Likelihood to adapt				
Adverse Implications for public function and/or safety				
Sensitivity to frequency and exposure to inundation				
Other: ______________				

Part B: Selection of Flood Risk Tolerance based on characteristics: Evaluate the characteristics above, note where the majority of the answers fall and align them with the definitions given for the associated flood risk tolerance.

	High Tolerance	**Medium Tolerance**	**Low Tolerance**	**Explanation**
Determine tolerance for flood risk	Flooding is expected and has minimal impact	Some flooding can be tolerated and impacts can be variable	Flooding had detrimental impacts	

Step 5: Select an RSLR estimate for the project: In step 3 you identified the representative tide gauge for your project. Go to Appendix B to find the SLR estimates for the selected tide gauge	pp. 15-17

The project should plan to, regulate for, or design for ________ feet RSLR by year ________

Incremental action point(s) (year) (From Step 2)	RSLR (feet)

Great job, you have selected a RSLR estimate for your project and project sub-areas.

You can now determine how that number can be applied to your project. Steps 6 and 7 of the Guidance provide additional information to consider how RSLR interacts with coastal flooding and where to begin when considering possible adaptation options. Both steps will provide guidance as you continue in your project planning. Refer to pages 16-21.

Appendix B: Sea Level Rise Projections

The following tables provide RSLR estimates in feet above 2005 levels for seven tide gauges (Annapolis, Baltimore, Cambridge, Ocean City, Solomons Island, Tolchester Beach, and Washington, DC) based on the Current Commitments (SSP2-4.5) emissions pathways.

Tide Gauge: Annapolis, MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.50	0.92	1.20	1.3
2050	0.76	1.23	1.56	1.6
2060	1.02	1.52	1.92	2.3
2070	1.26	1.85	2.33	3.0
2080	1.49	2.16	2.73	3.6
2090	1.68	2.45	3.14	4.3
2100	1.77	2.78	3.63	4.9
2110	1.82	3.06	4.12	5.9
2120	2.00	3.40	4.59	6.9

Tide Gauge: Baltimore MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.46	0.89	1.16	1.3
2050	0.72	1.18	1.52	1.6
2060	0.97	1.47	1.86	2.3
2070	1.20	1.79	2.27	3.0
2080	1.42	2.09	2.65	3.6
2090	1.60	2.37	3.06	4.3
2100	1.68	2.69	3.54	4.9
2110	1.72	2.97	4.02	5.9
2120	1.90	3.29	4.48	6.9

Tide Gauge: Cambridge MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.50	0.92	1.20	1.3
2050	0.76	1.23	1.57	1.6
2060	1.02	1.53	1.92	2.3
2070	1.26	1.85	2.33	3.0
2080	1.49	2.16	2.74	3.6
2090	1.68	2.45	3.15	4.3
2100	1.78	2.79	3.65	4.9
2110	1.82	3.07	4.13	5.9
2120	2.01	3.41	4.60	6.9

Tide Gauge: Ocean City MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.56	0.98	1.26	1.3
2050	0.84	1.31	1.65	1.6
2060	1.11	1.63	2.02	2.6
2070	1.37	1.97	2.46	3.3
2080	1.62	2.30	2.88	3.9
2090	1.83	2.61	3.31	4.6
2100	1.94	2.97	3.83	5.2
2110	2.01	3.27	4.34	6.2
2120	2.21	3.62	4.83	7.2

Tide Gauge: Solomons Island MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.53	0.94	1.22	1.3
2050	0.80	1.26	1.59	1.6
2060	1.06	1.57	1.96	2.6
2070	1.31	1.90	2.38	3.0
2080	1.55	2.21	2.79	3.6
2090	1.74	2.51	3.20	4.3
2100	1.85	2.85	3.70	5.2
2110	1.90	3.14	4.20	5.9
2120	2.10	3.48	4.68	7.2

Tide Gauge: Tolchester Beach MD
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.47	0.90	1.18	1.3
2050	0.73	1.20	1.54	1.6
2060	0.98	1.50	1.89	2.3
2070	1.22	1.81	2.29	3.0
2080	1.44	2.11	2.69	3.6
2090	1.63	2.40	3.09	4.3
2100	1.72	2.73	3.58	4.9
2110	1.76	3.01	4.07	5.9
2120	1.94	3.33	4.53	6.9

Tide Gauge: Washington, DC
Emissions Pathway: SSP2-4.5 (ft)

Year	5th percentile	50th percentile (High tolerance for flood risk)	83rd percentile (Medium tolerance for flood risk)	83rd-95th percentile with additional ice loss (Low tolerance for flood risk)
2040	0.47	0.89	1.17	1.3
2050	0.72	1.19	1.52	1.6
2060	0.97	1.48	1.87	2.3
2070	1.21	1.80	2.27	3.0
2080	1.43	2.09	2.66	3.6
2090	1.61	2.38	3.06	4.3
2100	1.69	2.70	3.55	4.9
2110	1.73	2.97	4.03	5.9
2120	1.92	3.30	4.49	6.9


Photo by: MyCoast: Maryland