

Executive Summary

As a coastal state, Delaware's economy and quality of life have historically been linked to its shores, its vast expanses of protected tidal wetlands, and its fertile farm fields. Because of its location, low average elevation, and dependence on the coast, Delaware is particularly vulnerable to the effects of rising sea levels including loss of low-lying land and structures, saltwater intrusion into ground and surface waters, and increased coastal flooding from storm events.

Today, sea level rise is rarely, if ever, considered by governments, organizations, and individuals as they make decisions about where to develop, how to build, or what to preserve. However, changes in sea levels could impact the longevity, safety, and return-on-investment of projects that have long planning horizons or long life-spans. Accounting for changes in sea level that may be expected to occur over the lifetime of these projects will help lead to informed decisions for public and private investments by minimizing risk and potential for damage. Planning for the long-term effects of sea level rise may also help us better prepare in the short-term for flooding from coastal storms.

Delaware's Sea Level Rise Advisory Committee

Delaware's Sea Level Rise Advisory Committee (SLRAC) was established by invitation of Collin O'Mara, Secretary of the Department of Natural Resources and Environmental Control (DNREC), to help the state plan for sea level rise. The committee is composed of members from a wide variety of interest groups including state agencies, local governments, citizen organizations, business organizations, and environmental organizations. The goal of the Sea Level Rise Advisory Committee is to assess Delaware's vulnerability to current and future inundation problems that may be exacerbated by sea level rise and to develop a set of recommendations for state agencies, local governments, businesses, and citizens to enable them to adapt programs, policies, business practices and make informed decisions.

The committee's work has been split into two phases, a vulnerability assessment phase and an adaptation planning phase. This document is the culmination of the vulnerability assessment phase, during which the committee provided expert opinions to analyze and assess potential impacts of sea level rise to 79 statewide resources, ranging from roads to wetlands to tourism. This vulnerability assessment will be used as the basis for the next phase, adaptation planning. During the adaptation planning phase, the Advisory Committee will identify ways that government, businesses, and citizens can adapt their policies and business practices to reduce the impact of sea level rise on our state's citizens, economy, and natural resources. The final report of the Sea Level Rise Advisory Committee will contain recommendations to help governments, businesses and citizens prepare for sea level rise.

Results of the Sea Level Rise Vulnerability Assessment

Delaware's sea level rise vulnerability assessment demonstrates that inundation from sea level rise will occur in all three of Delaware's counties, affecting a range of resources. Although the direct impacts from sea level rise inundation will be felt primarily in areas near tidal waters, every Delawarean is likely to be affected by sea level rise whether through increased costs of maintaining public infrastructure, decreased tax base, loss of recreational opportunities and wildlife habitat, or loss of community character.

Statewide, between 8% and 11% of the state's land area (including wetlands) could be inundated by a sea level rise of 0.5 meters to 1.5 meters, respectively. Within those potentially inundated areas lie transportation and port infrastructure, historic fishing villages, resort towns, agricultural fields, wastewater treatment facilities and vast stretches of wetlands and wildlife habitat of hemispheric importance.

Peggy Schultz



The Delaware Sea Level Rise Advisory Committee discusses the issues.



The St. Jones River meeting the Delaware Bay, southeast of Dover, Delaware.

Eric Crossan

Executive Summary

Based upon the information in this vulnerability assessment, the Sea Level Rise Advisory Committee ranked each resource according to the potential impacts that could result from sea level rise and their relative statewide importance. Based upon this ranking, 16 resources emerged as being of high concern statewide:

Beaches and Dunes: Delaware's coastline is an important ecological resource—providing habitat for a variety of plants, animals, insects, migratory birds, and a multitude of other terrestrial and aquatic wildlife. Shorelines naturally shift and retreat in response to wind, waves, tides, storms and rising seas. However, natural shoreline processes are interrupted by people's desire to live and recreate near the shore. Delaware's 381 miles of shoreline, including 24 miles that front the Atlantic Ocean, provides economic benefits from tourism, coveted high-value space for commercial and residential development, and many forms of recreation, including boating, fishing, and beach-going. When combined with wind-driven waves, sea level rise can exacerbate shoreline erosion that damages dune habitat and leaves infrastructure along the coastline vulnerable to storm damage. Beach replenishment has been the predominant means to offset sand loss and protect structures to which the state has contributed considerable funding. Due to the economic value, natural resource value and significant state investment in sand replenishment, this resource was ranked as a high concern.

Coastal Impoundments: Coastal impoundments are vital resources that serve to provide important breeding, migration, and wintering habitat for a variety of birds, serve as nurseries for fish, help to control mosquitoes, and provide important recreational opportunities. Impoundments in each county are at risk from sea level rise. A sea level rise of 0.5 meters would result in the potential inundation of 81% of the state's acreage of impounded wetlands. Up to 99% of all the state's acreage of impounded wetlands could be inundated at both 1.0 and 1.5 meters of sea level rise. The impacts will be relatively local; however the areas that are affected show high levels of inundation and complete loss of function. Since the majority of the resource within the state may be affected, this resource was ranked as a high concern.

Dams, Dikes & Levees: Between 39% and 78% of the state's 50 miles of dams, dikes and levees could be inundated by sea level rise by 2100. The highest concentration of potential impact is focused in Kent County, whose dikes primarily protect wildlife areas. The majority of the dikes in New Castle County protect people, property, and, in one case, a contaminated site. These structures were built to provide a certain level of containment or protection. If a breach or structural failure were to occur, the resultant flooding could affect a large area inland of the structure. Due to these considerations, inundation of dams, dikes, and levees in the state was ranked as a high concern.

Evacuation Routes: Between 1% and 6% of the state's evacuation routes are within an area that could be inundated by sea level rise by 2100. Interstates and arterial roads tend to serve as the major evacuation routes for emergencies; substantial reliance on a single mode of transportation for evacuations may endanger many people if the highway infrastructure is made inaccessible because of sea level rise. All three counties experience exposure but the highest concentration is found in Sussex County. Because evacuations rely on automobile transportation and because flooded roadways can prevent or slow evacuation by car, inundation of evacuation routes was ranked as a high concern.



Delaware Coastal Programs

Freshwater Tidal Wetlands: Freshwater tidal wetlands occur at the upper reaches of estuaries where the water is no longer salty, but is still influenced by the rise and fall of the ocean tides. These wetlands are home to unique plant and animal communities and are known for their high species diversity. Sea level rise, over time, may introduce salinity to freshwater areas, replacing freshwater tidal marshes with brackish marshes or open water, which in turn will cause major shifts in species composition. For freshwater tidal marshes affected by sea level rise, a wetland system may still exist with increased salinity, but its unique habitat value will be lost. Sea level rise could impact between 84% and 98% of the total freshwater tidal wetland acreage statewide by the year 2100. Because of the unique habitats contained within freshwater tidal wetlands and because the majority of the resource within the state could be affected, this resource was ranked as a high concern.

Future Development Areas: Between 3% and 7% of land designated as future development areas by Delaware's Strategies for State Policies and Spending are within an area that could be inundated by sea level rise by 2100. These areas are typically rural or suburban in nature and are adjacent to the actively growing zones of Delaware's municipalities. Four-fifths of these potentially inundated areas are located in Sussex County and could be developed to meet the future demand for residential and commercial development in and around the resort areas. Careful consideration must be given to determine whether directing new development to potential inundation areas will place citizens and infrastructure at risk in the future and whether creating new building restrictions will impact citizens' freedom of choice and the regional economy. Due to the significant potential effects for development in Sussex County coupled with the potential need for state funding of infrastructure repairs and legal concerns, sea level rise within future development areas was ranked as a high concern.

Habitats of Conservation Concern: The Delaware Wildlife Action Plan, the framework for conserving the state's native wildlife, identified 27 Habitats of Conservation Concern (HCC). These habitats are rare, have special significance in Delaware, are particularly sensitive to disturbance, and/or have a high diversity of rare plants. Of these 27 unique habitat types, 15 were determined to be vulnerable to sea level rise and were analyzed to determine the extent of possible exposure. Between 55% and 65% of the total acreage of the 15 HCCs analyzed could be inundated by sea level rise by 2100. Because these exceptional habitat types often harbor rare plant and animal species and are sensitive to environmental stresses, including sea level rise, this resource was ranked as a high concern.



A driver navigates across a flooded road during a nor'easter in October 2009.

Executive Summary

Heavy Industrial Areas: Between 16% and 25% of the acreage of heavy industrial lands in the coastal area (as permitted by Delaware's Coastal Zone Act) are within an area that could be inundated by sea level rise by 2100; the majority of these areas are in New Castle County. While the inundation model shows that inundation risk to the facility buildings themselves is low, many associated structures like docks, piers, and lagoons could be affected. Because these facilities are a large economic driver for the state, reduced operational capacity could impact both the economies of the towns surrounding these facilities and the state's economy as a whole. If the lands currently zoned for heavy industry become unsuitable for industrial operations, retaining these businesses within the state could prove difficult due to lack of suitable industrially zoned land and the difficulties of rezoning land to industrial uses. Due to the significant potential statewide effects resulting from sea level rise, heavy industrial areas were ranked as a high concern.

Port of Wilmington: Between 36% and 73% of the Port of Wilmington's property is within an area that could be inundated by sea level rise by 2100. The port is based in northern New Castle County; however, the economic value to Delaware and the entire Northeast Region makes exposure to sea level rise a state and regional issue. Due to these considerations, inundation of the Port of Wilmington was ranked as a high concern.

Protected Lands Statewide: Protected lands encompass a variety of lands owned by state, local and municipal governments, conservation groups and individuals. These lands include state wildlife areas, state parks, state forests, boat ramps, nature preserves, historical sites, national wildlife refuges, municipal parks, open space, and recreational facilities and public and private conservation easements. Collectively, these properties represent a variety of habitat types and extensive opportunities for outdoor recreation. Statewide, between 37% and 44% of protected lands statewide are exposed to sea level rise under the three scenarios. Because these lands represent a significant investment to protect natural habitats and recreational use and because sea level rise could impact their intended use, protected lands were ranked as a high concern.

Roads & Bridges: Between 1% and 5% of the state's roads and bridges are within an area that could be inundated by sea level rise by 2100. Inundation of an individual segment of road could cause regional transportation disruptions, particularly if no alternative routes are available. The highest concentration of roadway exposure to sea level rise was found in Sussex County; however, potential exposure was found throughout the state. Due to the potential regional impacts, inundation of roads and bridges from sea level rise was ranked as a high concern.

Railroad Lines: Between 2% and 6% of the state's railroad lines are within an area that could be inundated by sea level rise by 2100. The highest concentration of impact is focused in New Castle County. Even with smaller amounts of exposure in Kent and Sussex Counties, it should be noted that if a single rail line segment becomes inundated, the entire functionality of the line could be lost. This may impact industries served by rail such as power plants and the Delaware City refinery. Passenger travel is also a concern; disruptions and possible restrictions to the Amtrak rail line could impact travel throughout the northeast corridor. Because disruption of rail service in Delaware could have impacts throughout the state and region, inundation of railroad lines as a result of sea level rise was ranked as a high concern.

Tidal Wetlands: Tidal wetlands are among the most productive ecosystems in the world and provide habitat, food and breeding grounds for many species of plants and animals. Delaware's tidal wetlands are an intricate part of the local, regional, national, and international ecosystems. Tidal wetlands act as sponges by soaking up floodwaters and buffering storm impacts and also act as filters by trapping sediments and removing contaminants. The potential impacts to tidal wetlands as a result of sea level rise are striking in their extensiveness, affecting the vast majority of tidal wetlands in all three counties. The exposure assessment found that 97% of the state's tidal wetlands may be impacted at the 0.5 meter scenario, and 99% at both the 1.0 and 1.5 meter scenarios. Since the majority of the resource within the state may be affected, impacts to tidal wetlands as a result of sea level rise was ranked as a high concern.

Tourism and Coastal Recreation: Tourism and coastal recreation are important components of Delaware's economy and quality of life. Significant portions of Delaware's resort areas, coastal historic sites, and natural resources could be inundated or significantly altered by sea level rise. Of specific concern is the maintenance of Delaware's beaches, which are currently replenished on a routine basis with federal and state funding. Accelerated rates of sea level rise may necessitate larger or more frequent beach replenishment projects to preserve recreational beach uses. Due to the potential for revenue losses statewide, coupled with the potential increased funding needs for maintenance or repair of tourist destinations, sea level rise impacts to tourism and coastal recreation was ranked as a high concern.

U.S. Fish and Wildlife Service Refuges: Prime Hook National Wildlife Refuge (NWR) is located in Sussex County near the town of Milton. Bombay Hook NWR is located in Kent County near the towns of Smyrna and Dover. Area residents and tourists use the refuges for passive outdoor recreation activities such as birding, wildlife watching, and photography, as well as for hunting and fishing. Refuge wetlands provide habitat for overwintering and migrating waterfowl and shorebirds, wading birds, secretive marsh birds and wetland passerines. Reduction or loss of wetland habitats within the protected boundaries of the refuges can impact populations of these species. Species may be forced to redistribute if refuge wetlands no longer meet their needs, and may relocate in wetlands that are not afforded the same protection and management that is provided by the NWR designation. Between 85% and 95% of refuge acreage could be inundated under the three scenarios. While the impacts are localized, the acreage affected (21,354 to 24,120 acres) represents a significant loss of protected habitat and was ranked as a high concern.

Wells: Residents and businesses in Kent and Sussex Counties rely on groundwater resources for drinking, irrigation and industrial purposes. Operation of wells that extract groundwater can be compromised by inundation from sea level rise, and the quality of groundwater can be compromised by saltwater intrusion resulting from sea level rise. Statewide, between 3% and 7% of domestic wells, 3% and 7% of industrial wells, 1% and 2% of irrigation wells, and 2% and 10% of public wells are within an area that could be inundated by sea level rise by 2100. Potential exposure of wells to sea level rise is focused along the coast; however, reduction in availability of groundwater in the coastal areas may increase demand on inland public wells. Because access to clean water is a necessity and because demand on inland wells may increase, sea level rise impacts to wells was ranked as a high concern.



The Sea Level Rise Advisory Committee will use the results of the Vulnerability Assessment to inform and focus efforts during the next phase of their work, the development of adaptation options.

Executive Summary

Use of this Document

This document and its appendices provides an exhaustive accounting of resources vulnerable to sea level rise of up to 1.5 meters in Delaware. It includes background information, a description of the process used to assess vulnerability, exposure assessment tables, and risk assessments for 79 resources. A comprehensive set of vulnerability maps and information on how to use them is also included as the Mapping Appendix. The vulnerabilities and risk assessment described in this document should be considered as a starting point for more detailed localized or resource-based assessments and as a starting point for prioritizing adaptation strategies.

This document is the first of its kind to provide detailed estimates of numbers or acres of resources at risk from sea level rise at a state level. It represents a significant accomplishment and positions the state well to develop and implement specific adaptation strategies for resources most important to Delaware's continued sense of community, economic well-being, and natural resource diversity.

Tony Pratt



Homes and wildlife habitat at Broadkill Beach, along the Delaware Bay.

