

# **Society and Economy**

# Society and Economy

Properties with a tax-assessed value of nearly \$1.5 billion are located within areas potentially inundated by 1.5 meters of sea level rise (Laznik, 2012). The potential loss or devaluation of these properties will affect homeowners, businesses owners, communities, and tax revenues at all levels of government.

The Society and Economy Workgroup was formed to collaboratively investigate the potential effects of sea level rise on the residents, communities, and economy of Delaware. Its results are presented below and in the following sections. The socioeconomic effects of sea level rise issues are complex and interrelated; the Society and Economy Workgroup recognizes that the information that has been gathered and presented through this vulnerability assessment process is not complete in many cases; much more research will need to be conducted to answer many of the questions posed by the workgroup in its discussions.

## Assessing Exposure of Society & Economy Resources

The Society & Economy Workgroup was composed of members of the Sea Level Rise Advisory Committee and additional subject matter experts. A list of those who participated in this workgroup is available in Appendix C. The workgroup met seven times between February 2011 and March 2012 to identify, assess, and rank issues related to sea level rise, society, and the economy.

### Resources Considered

Specific resources that the Society and Economy Workgroup was initially concerned with included:

- Municipalities and future development areas
- Residences
- Businesses
- Tourism
- Real estate taxes
- Insurance claims
- Agriculture, including highly productive soils and easements
- Demographic information and vulnerable communities
- Historic resources
- Impermeable surfaces
- Hospitals
- Day care facilities
- fire and EMS stations
- Wastewater infrastructure
- Landfills

After discussion, initial data collection, and analysis by Delaware Coastal Programs staff, the workgroup narrowed their focus to the following topics:

- Businesses
- Industrial and manufacturing facilities
- Residences
- Future development areas
- Agriculture (acreage and structures)
- Tourism and coastal recreation
- Historic and cultural resources
- Socially vulnerable communities

Several resources of concern were initially identified by more than one workgroup, including agriculture, care facilities, wastewater, and landfills. Agriculture acreage and buildings were assessed in the Society and Economy Workgroup because of the strong economic implications of these resources. Conversely, the Natural Resources Workgroup assessed highly productive soils and agricultural preservation areas due to their stronger resource implications. Hospitals, day care facilities, emergency services, wastewater infrastructure, and landfills were assessed in the Public Safety and Infrastructure Workgroup.

## Assessing Exposure

As described in the Vulnerability Assessment Methods chapter, Delaware Coastal Programs staff worked with Workgroup and Committee members to collect data and information about each resource that the workgroup wished to assess. Using available data sets, tables were generated in ArcGIS that described the exposure of each resource to sea level rise under each of the three scenarios. Maps depicting location and density of this exposure were also generated in ArcGIS. Workgroup members filled out resource assessment templates based upon their own expertise and in collaboration with their colleagues. All of this information was compiled together into a comprehensive assessment for each resource, which was reviewed and edited by workgroup members. Full text of each one of these assessments follows this introduction.

## Data and Information Gaps

This vulnerability assessment relied on existing data and information to complete a statewide level screening of resources at risk to sea level rise. In many cases, data and information that would have provided a better picture of the economic and social ramifications of sea level rise impacts was not available at a scale that would be useful for analysis of sea level rise. For example, tourism data is available statewide, but not broken down by town or region, so definitive conclusions about inundation of certain areas of the state could not be made. This is also the case for employment, payroll, and sales revenue data which is not available at a site specific basis. Demographic information was also not available at a scale that would allow site specific assessments of very small areas of inundation due to sea level rise. These data gaps do limit our ability to provide specific economic losses and social ramifications for each resource assessed. However, they do not impede our ability to understand the range of potential impacts from sea level rise and make recommendations for future studies that would help improve our understanding of specific impacts.

## Property Tax Impact

As discussed above, data and information useful for understanding the wide range of interrelated economic impacts resulting from sea level rise was not available and additional studies are recommended. One readily available dataset is the tax assessment value. A study conducted by the University of Delaware indicated that the current tax assessed value for all parcels (regardless of use category) exposed to sea level rise in New Castle County is \$582 million and \$55.6 million in Kent County. The assessed “improved value” of parcels exposed to sea level rise in Sussex County is \$857.7 million (Laznik, 2012). Although tax rates per assessed value vary by county and some parcels have tax-exempt status, properties that are abandoned, de-valued or inundated could have an impact to local property tax revenues.

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## Assessing Vulnerability of Society & Economy Resources

As discussed in the Introduction, once the resource assessments were completed and maps were available, the Society and Economy Workgroup conducted an exercise to assess the state's vulnerability to the effects of sea level rise for each resource. Using standardized questions, the workgroup considered two primary factors: the geographic scope of impacts and whether the resource could continue to "function". For geographic scope, the workgroup considered both the discrete locations of impacts themselves and the extent to which impacts may be felt outside of those locations. For example, although the exposure of heavy industrial areas was limited primarily to New Castle County, the effects of exposure could be felt statewide through loss of job opportunities and revenues. For "function," the committee considered the extent to which a resource could continue to meet its intended purpose, whether that purpose is recreational opportunities, manufacturing items and/or revenue generation. As a result of this discussion, each resource was ranked as a High Concern, Moderate Concern, Low Concern, or Minimal Concern. Resources ranked as a high and moderate concern will likely become the starting point for adaptation strategy development in Delaware.

## High Concern Resources

Based upon the risk assessment conducted by the workgroup, the following resources are of the highest concern: Heavy Industrial Areas, Future Development Areas, and Tourism & Coastal Recreation. A high concern resource is generally a resource where inundation of a resource would cause it to no longer function and/or could cause impacts statewide, whether directly to the resource itself or indirectly through disruptions in jobs or revenue streams. Additional research and development of adaptation strategies for high concern resources is recommended.

**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, sea level rise impacts to heavy industrial areas in the state were 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.

**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 were ranked as a high concern.

## Moderate Concern Resources

Based upon the risk assessment conducted by the workgroup, only residential areas were categorized as having moderate concern. Resources are considered to be of moderate concern if there is some impact or loss of function and/or if the geographic extent of the impact is less than statewide.

**Residences:** Statewide, 1% to 5% of residences are within an area that could be inundated by sea level rise by 2100. The highest concentration of those at risk homes are in Sussex County along the barrier island south of Bethany Beach and around the Inland Bays. Although the majority of at-risk residences are in Sussex County, residences within small coastal towns in Kent County are at risk of inundation from sea level rise, as are homes in the cities of Wilmington, New Castle, and Delaware City. In already flood-prone areas, some of these homes may be elevated above the current 100-year flood zone or have other flood-proofing mechanisms installed which would limit structural damage from sea level rise. However, road access to homes subject to inundation may be limited whether the homes are flood-proofed or not. Several impacted residential areas are within socially vulnerable communities (see below) and may lack resources to repair flood damages, flood-proof, or relocate. Because potential impacts are concentrated in Sussex County but exist statewide, sea level rise impacts to residential addresses were ranked as a moderate concern.

## Low Concern Resources

Based upon the risk assessment conducted by the workgroup, the following resources were considered to be of lower concern at this time: Businesses and Commercial Areas, Agriculture (acreage and structures), Historic Resources, and Factories. A ranking of low concern does not necessarily mean that a resource is not important or that impacts from sea level rise will not be felt, rather that the impacts will not be significant in nature and/or will be isolated to several small geographic regions. Low concern resources should continue to be monitored and re-assessed in subsequent planning activities.

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**Businesses and Commercial Areas:** Between 1% and 5% of the state's commercial addresses are within an area that could be inundated by sea level rise by 2100. The effects to impacted businesses could include increased flood damage costs, increased insurance premiums, and reduced profitability; indirect impacts could include reduced employment opportunities and reduced goods and services for communities impacted. However, the business cycle may minimize these potential impacts as the life-span of most business ventures is much shorter than our planning horizon of 88 years and adequate commercially zoned land is likely to exist outside of the sea level rise inundation areas in the future should business owners need to relocate. While the overall impact to the state's businesses may be a small percentage, Delaware's commercial fishing and seafood industry may be particularly affected by loss of supporting infrastructure like docks and boat ramps and potential challenges to fish populations. In addition, individual business owners who rely upon waterfront access or proximity to the coast may be particularly impacted. Because of the small percentage of potentially impacted businesses and because the life-span of most commercial enterprises is less than our planning horizon, sea level rise impacts to businesses and commercial areas are of low concern at this time.

**Agriculture (acreage and structures):** Between 1% and 4% of currently farmed acreage in the state could be inundated by sea level rise by 2100. Inundation of agricultural land could result in decreased crop yields as a result of salt contamination and/or soils that are too wet to till. While the loss of a few thousand acres of tillable land is not likely to have a perceptible impact on the state's agricultural economy as a whole (residential development takes more land out of agricultural production), impacts to individual or regional agribusinesses could be significant. Because of the small percentage of potentially impacted land statewide, sea level rise impacts to agriculture are of low concern at this time.

**Factories:** Between 1% and 8% of industrial and manufacturing facilities in the state (as represented by sites listed on the toxic release inventory) are within areas that could be inundated by sea level rise. These facilities could experience repetitive flood damages, supply disruptions, and reduced production as a result of sea level rise. While facilities may experience effects of sea level rise, existing plants could become functionally obsolete during our planning horizon. Because of the small number and limited life-span of potentially impacted factories, sea level rise impacts to manufacturing and industrial facilities are of low concern at this time.

**Historic Resources:** Between 2% and 4% of the known historic sites (including up to 32 national historic register sites) in the state are within areas that could be inundated by sea level rise. Inundation could result in the permanent loss of these sites and their cultural value, including loss of historic information that could have been garnered from them. Because of the relatively small number of buildings at risk, historic resources are of low concern at this time.

## Social Vulnerability and Social Justice

Throughout the deliberations of the Society and Economy Workgroup, issues of social vulnerability and social justice were discussed and considered. Socially vulnerable communities are neighborhoods or groups that are less likely to have the resources to respond to environmental threats like sea level rise due to a variety of factors including educational level, economic standing, age, family status, and access to services. Citizens in areas identified as socially vulnerable may lack the resources to flood-proof their homes or relocate if sea level rise begins to affect their neighborhood. They may also lose access to transportation should bus routes or bus stops be relocated due to road flooding in the region; this could also affect their ability to travel to and from work. In addition, these communities are often near or within areas of already poor environmental quality and may disproportionately be affected by indirect impacts of sea level rise such as contaminant releases from underground storage tanks or contaminated sites.

A detailed sub-chapter on socially vulnerable populations is included within this document (pg. 2) but this issue was not ranked with the other resources analyzed in this document because assessment of these communities will need to be conducted at a more localized scale and with consideration of the interaction of numerous direct and indirect sea level rise impacts. Attention to and the fair treatment of socially vulnerable communities should be at the forefront in the minds of decision-makers as plans are made to adapt to the effects of sea level rise.

## Detailed Resource Assessments

The following sections contain a detailed exposure assessment for each resource and a description of the likely economic, social, and environmental impacts that could result. As discussed in the Introduction to this document, an exposure assessment describes how much of a particular resource is within each one of the three sea level rise scenarios; not whether that resource will be impacted. For example, a house that has been elevated above the floodplain is counted within the sea level rise inundation area, but that particular house may be unaffected by sea level rise because it has been flood-proofed. The potential effects to each resource are described within the text, along with the caveats of the analysis and data. These assessments are being used as the baseline data and information to formulate an adaptation strategy for the state, while recognizing the limitations of this method for site specific planning.

## Businesses and Commercial Areas

Commercial business enterprises form the backbone of Delaware's economy, communities, and sense of place. Many of Delaware's towns were established in waterfront locations to take advantage of shipping opportunities, and many business districts in Delaware remain in close proximity to tidal water.

Businesses within areas potentially inundated by sea level rise may experience increased operational costs as a result of repetitive flood damage and reduced access for customers and product shipments as a result of flooded roads. In addition, businesses dependent upon waterfront access may experience increased costs for dock and pier maintenance and upgrades as well as a lack of adequate space for operations as water encroaches inland. Although many businesses can relocate when lease terms end and so may be resilient to the effects of sea level rise, waterfront and water-dependent businesses, like commercial fishing operations and marinas, may not have as many choices when deciding how to respond to the effects of sea level rise.

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As demonstrated by several large coastal storms, temporary flooding causes little or no long term disruption to businesses if an area is economically viable. If more permanent inundation occurs as a result of sea level rise, history indicates that human populations have been able to adapt to these changes by moving to higher ground over a period of time. These potential impacts will depend greatly upon a business's ability to adapt to new conditions, the maintenance of supporting infrastructure and upon availability of suitably zoned areas to relocate if necessary.

**Exposure to Sea Level Rise:** In order to determine the potential vulnerability of Delaware's businesses to sea level rise, two data sources were used, the statewide 911 address database and the Delaware Division of Revenue's business license database. The 911 address database provides address information by type of address, including commercial. The state business license database provides an address for business licenses that are issued within the state. Both databases contain inherent errors and inaccuracies. For example, the commercial addresses from the 911 database include rental properties, which are also residences. The business license database contains addresses that were not able to be mapped in our computer system, which may underestimate the number addresses affected. Conversely, some addresses have multiple businesses licenses in one location, which may overestimate the number of addresses affected. Fixing the inherent data problems within these datasets was outside of the scope of this assessment; however, using both of these databases together provides a reasonable estimate of the extent and location of potential impacts to businesses resulting from sea level rise (see Table 26 and Table 27 below).

Statewide, over a thousand individual businesses are within an area that could be inundated by 1.0 meter of sea level rise, representing 2% - 3% of the total businesses in the state. Over two thousand businesses are within an area that could be inundated by 1.5 meters of sea level rise, representing about 5% of the total businesses in the State. Sussex County has both the highest number and highest percentage of businesses at risk, with between 9% - 11% of its businesses within a mapped sea level rise area.

At the 0.5 meter sea level rise scenario, the highest concentration of businesses with the potential to be inundated is found in South Wilmington, New Castle, Milton, and Fenwick Island. At higher levels of sea level rise, the geographic extent of businesses potentially inundated expands to include Delaware City, Dover, Milford and more areas along the Delaware Bay and Inland Bays (see maps in the Mapping Appendix).

Further evaluation of the types of businesses affected and their average life-spans, employment figures, and revenue figures are outside of the scope of this vulnerability assessment, but the Sea Level Rise Advisory Committee recognizes the importance of obtaining and analyzing this data for a more comprehensive understanding of potential business impacts from sea level rise.

**Table 26 - Number of Commercial Addresses**

County	Total Number of Addresses	Total Addresses Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	45,873	395	1,182	2,094	1%	3%	5%
New Castle	31,479	248	625	1,143	1%	2%	4%
Kent	4,714	21	73	93	< 1%	2%	2%
Sussex	9,680	126	484	858	1%	5%	9%

**Source:** University of Delaware CADSR 9-1-1 Address Database



**Table 27 - Number of Business Licenses within the Sea Level Rise Scenario Areas**

County	Total Number of Licenses	Total Bus. Licenses Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	51,302	237	1,072	2,556	0.5%	2%	5.0%
New Castle	29,258	120	349	777	0.4%	1%	3%
Kent	8,823	14	149	323	0.2%	2%	4%
Sussex	13,221	103	574	1,456	0.8%	4%	11.0%

**Source:** Delaware Division of Revenue and University of Delaware CADSR.

**Potential Economic Impact:** For property owners, sea level rise may result in increased costs of maintaining existing commercial structures whether from repetitive flood damages or flood-proofing measures. Other associated costs of doing business, like insurance premiums, may also rise. Costs for construction of a new business or redevelopment of an existing business could also rise as a result of decreased availability of coastal real estate or costs of complying with regulations.

On a regional scale, a reduced number of businesses or reduced profitability of businesses impacts business revenues, business reinvestment, and employment opportunities. It may also affect local and regional tax revenues.

The commercial fishing and seafood industry in Delaware may be particularly impacted by sea level rise. In 2009, this industry employed 407 people, creating \$57 million dollars in sales. The total economic impact of recreational fishing the same year as measured by fishing trips and durable equipment expenditures was 1,270 jobs and \$193 million in sales (National Marine Fisheries Service, 2010). The commercial fishing fleet is located primarily in small coastal towns and inlets in Kent County, with additional sites in Indian River and Cedar Creek (near Slaughter Beach). These places are within areas expected to experience inundation with 0.5 meters of sea level rise; additionally, salt-water intrusion could result in degradation of fish spawning grounds, leading to a reduction in the abundance of commercially important fish species.

**Potential Social Impact:** The potential social impact of commercial property exposed to sea level rise includes, but is not limited to: loss of employment centers and opportunities, loss of gathering locations for the public, potential reduction in local businesses and small town charm, and potential increase in travel distance for basic necessities. These potential social impacts will depend greatly upon the business’s rental or lease agreements and ability to adapt to new conditions.

**Potential Environmental Impact:** The potential environmental impacts associated with commercial properties and structures exposed to sea level rise primarily include release of contaminants, coastal debris, and loss of natural shorelines.

Pollution and release of contaminants may occur if commercial properties are abandoned without first removing underground or above ground storage tanks or remediating historic soil contaminants. Over time, storage tanks may leak, leaching their contents into the surrounding area. Certain contaminants in soil can also be released into the water column if repeatedly or permanently inundated. In addition, any structure left on a property that is subject to routine flooding may be transported off-site, and become a hazard or nuisance to surrounding landowners.

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The hardening of natural shorelines in response to increased inundation is a concern for both commercial and residential properties. Natural, vegetated shorelines provide fisheries habitat, bird foraging areas, and water quality improvements. Natural shorelines in commercial and residential areas can erode as a result of rising sea levels coupled with boat wakes and wave action and landowners may wish to build a stone revetment or bulkhead to avoid additional erosion. When natural shorelines are replaced by hard structures, habitat and water quality benefits decrease significantly.

## Industrial and Manufacturing

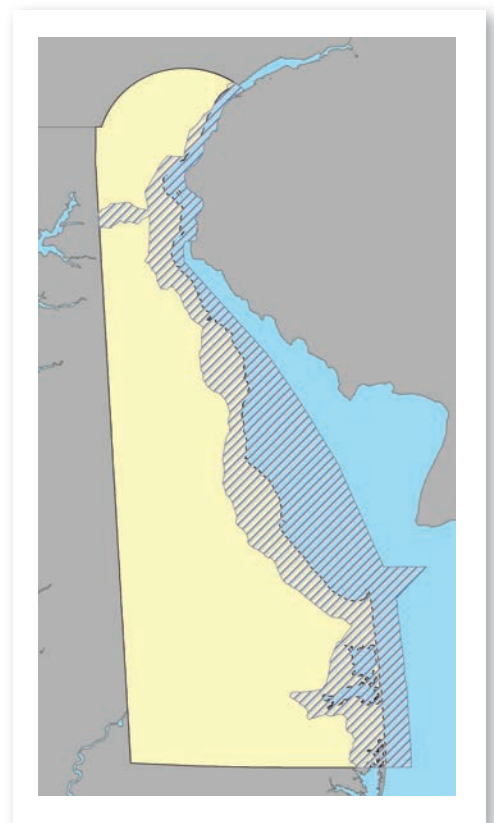
Delaware has a rich history of industrial and chemical manufacturing, beginning with the DuPont family who manufactured gunpowder along the banks of the Brandywine River in the 1800's. Since that time, Delaware's economy and quality of life have been closely tied to industrial and chemical manufacturing and processing. Industrial and manufacturing facilities provide jobs for Delaware residents, goods for the region, and tax revenue for state and local governments. The Bureau of Labor Statistics reports that production occupations (largely those from industrial and manufacturing facilities) accounted for 20,709 jobs in Delaware as of May, 2010. These jobs have a mean annual salary of \$32,810 (Bureau of Labor Statistics, 2010).

Many of Delaware's largest industrial and chemical manufacturing facilities are located along the Delaware River and generally require direct access to navigable water for docking of ships carrying materials and supplies, or export of manufactured products. Many also rely on the Delaware River for cooling water or to discharge treated effluent. These facilities are large economic drivers for Delaware; for example, a 2002 analysis of the Motiva Refinery in Delaware City (now Delaware City Refinery) found that the refinery had a wage and salary impact of \$186 million per year, and a total economic impact of \$379 million per year (Condliffe, 2002).

The location of waterfront heavy industry in Delaware is limited to areas that were already in industrial use prior to the passage of Delaware's Coastal Zone Act, which prohibited new industrial development in the Coastal Zone, a strip of land generally east of Route 13 in New Castle County, Route 9 in Kent County and Route 1 in Sussex County. It also includes land along the Chesapeake & Delaware Canal, and around Delaware's Inland Bays.

Sea level rise can affect Delaware's industrial and manufacturing facilities in several primary ways. Rising sea levels could permanently inundate facilities and supporting infrastructure like parking areas, wastewater lagoons and storm-water treatment areas. Temporary flooding from coastal storm events could also damage these structures. Increased rates of shoreline erosion could also occur, coupling with rising sea level to cause structural issues for associated docks and piers.

In addition, the structure and function of intake and discharge pipes could be impacted either through increased water levels, increased salinity, or a combination of both.



Map 1 - Delaware Coastal Zone Industrial Area.

**Exposure to Sea Level Rise:** To assess impacts to waterfront industrial areas, a database containing parcel information for permitted industrial facilities under the Coastal Zone Act was obtained from DNREC. This database contains the name, location, and property boundaries of each industrial facility within the areas regulated by the state’s Coastal Zone Act. All major waterfront industrial facilities are included in this database. This database was analyzed to determine the acreage and location of permitted industrial facilities within the three sea level rise scenarios (Table 28).

Statewide, approximately 20% of the land comprising the facilities permitted by the Coastal Zone Act is within an area potentially inundated by sea level rise of 1.0 meter, a total of 781 acres. However, although industrial land is exposed to sea level rise, it is important to note that there are no industrial facility buildings within the three future sea level rise inundation areas.

In New Castle County, approximately 19% of the acreage permitted under the Coastal Zone Act is exposed with a sea level rise of one meter. At this level of sea level rise, docking facilities at Sunoco, Ocean Port and DuPont Edgemoor are exposed, as is a limited area of shoreline. Intake and/or discharge pipes and channels could also be affected at these facilities, as well as the Delaware City Refinery and Croda/Atlas Point. The remainder of impacts to lands within these facilities is wetlands and in some cases, parking areas.

There is only one heavy industrial facility permitted under the Coastal Zone Act in Kent County; Delaware Storage and Pipeline, a dock and tank facility where jet fuel is delivered. In this case, the dock, pipeline and tank facility are almost entirely inundated under the 0.5 meter scenario, as is the road to the site.

The Indian River power plant is the only heavy industrial facility permitted by the Coastal Zone Act in Sussex County. This facility’s disposal area, shoreline, and intake structures are within areas that will be inundated by sea level rise, but the power plant itself is not within a potential inundation area.

**Table 28 - Coastal Zone Heavy Industrial Acreage Exposed to Sea Level Rise**

County	Total Acres of Industrial Land Permitted by CZA	Total Acres Inundated			Percent of Total Acres Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	4,141	676	863	1,041	16%	21%	25%
New Castle	3,861	583	746	913	15%	19%	24%
Kent	37	30	36	37	83%	97%	100%
Sussex	243	63	81	91	26%	33%	38%

**Source:** DNREC Office of the Secretary, Coastal Zone Heavy Industrial Facilities (20110321), unpublished

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To capture potential exposure from sea level rise at facilities that are not considered to be heavy industry in addition to those permitted through the Coastal Zone Act, a database containing names and locations of facilities which are required to report emissions to the state through the Toxic Release Inventory was obtained and overlaid with the sea level rise scenarios. Because the geographic location in this database is reported as a “point” instead of as a parcel, the results of the analysis more closely aligns with potential exposure to a facility or building (instead of to the parcel). This data also contains information for those facilities permitted through the Coastal Zone Act, but is more inclusive of smaller industrial and manufacturing facilities, and those not within the Coastal Zone Act area (such as facilities along the Nanticoke River).

Statewide, one facility is located in an area potentially inundated at 0.5 meters, six facilities are within an area inundated at 1.0 meter and twelve facilities are potentially inundated with a sea level rise of 1.5 meters (Table 29). The geographic extent of these potential impacts is limited to Wilmington and the surrounding area, Lewes, and Seaford (see map in the Mapping Appendix).

**Table 29** - Number of Factories (as represented by Toxic Release Inventory sites)

County	Total Number of Factories	Total Factories Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	145	1	6	12	1%	4%	8%
New Castle	85	1	4	8	1%	5%	9%
Kent	26	0	0	0	0%	0%	0%
Sussex	34	0	2	4	0%	6%	12%

**Source:** EPA, EPA Facilities Toxics Release Inventory, 20080212

**Potential Economic Impact:** Direct loss of land acreage zoned as industrial as a result of inundation from sea level rise or as a result of access or transportation issues resulting from sea level rise could constitute a significant economic issue for the state. Industrial facilities are an important component of Delaware’s statewide economy; moreover, land zoned as industrial with access to water and rail is a limited resource in the state. Should industrial acreage be inundated, there is limited potential for zoning new areas for industrial use within the state due to siting issues related to environmental, noise, and traffic concerns.

Operators of industrial and manufacturing facilities could experience increased costs from repetitive flood damage to buildings and associated structures, costs to relocate or elevate docking facilities, costs to relocate or raise intake/discharge pipes and increased insurance costs.

The Delaware Department of Labor reported 25,400 manufacturing jobs in the state as of March, 2012. If facilities were to shut down or reduce operations due to inundation and have no place to relocate, there could be a loss of employment and associated state and local tax revenues. Jobs within the industrial/manufacturing sector are often well paid, and have multiplier effects within the community and region.

From a regional perspective, it is also possible that a loss of one major sector or client to a railway company could result in a rail-line being financially unviable, resulting in the loss of that transportation network for other smaller users.

**Potential Social Impact:** Reduction in operational capacity of the industrial and manufacturing sector in Delaware from the effects of sea level rise could result in the loss of well-paying jobs in the affected communities listed above, and may also result in migration out of those locations as people search for new employment opportunities. Lack of local customers could also impact the surrounding local businesses and service providers in those communities.

**Potential Environmental Impact:** The potential environmental impacts associated with commercial properties and structures exposed to sea level rise primarily include release of contaminants and loss of natural shorelines.

As industrial land is inundated, there is the potential for contaminants contained within soil to be released into the water column. This is a concern for both existing facilities as well as for facilities that have been shut down or abandoned (see Public Safety and Infrastructure Section for additional details regarding brownfield and hazardous waste sites).

The hardening of natural shorelines in response to increased inundation may also occur in industrial or manufacturing areas. Natural, vegetated shorelines provide fisheries habitat, bird foraging areas and water quality improvements. Natural shorelines in industrial or manufacturing areas can erode as a result of rising sea levels coupled with boat wakes and wave action; facilities may wish to build a stone revetment or bulkhead to avoid additional erosion. When natural shorelines are replaced by hard structures, habitat and water quality benefits decrease significantly. However, industrial shorelines are often already severely degraded. The extent of habitat impact will vary dependent upon a facilities particular location and shoreline use.

## Residences

Delaware is home to nearly 900,000 people, living in 325,000 households, primarily owner-occupied (74%) (US Census Bureau, 2012). Between 2000 and 2010, Delaware's population increased by 15%, and many regions experienced unprecedented growth, particularly Southern New Castle County and Eastern Sussex County. Many of the residential construction projects that were planned during this time have stalled or have been abandoned due to the financial credit crises.

Sea level rise can affect housing units and residential communities through increased storm damage, permanent inundation of lots and through degradation of supporting infrastructure like roads, septic systems, and sewer systems (please see the Public Safety and Infrastructure Section of this document for more information on these impacts). Many newer subdivisions were established with community open spaces and stormwater facilities, managed and maintained by a maintenance corporation composed of residents. Sea level rise may also impact these community facilities in a similar way.

## Exposure to Sea Level Rise

In order to determine the number of homes located within a potential inundation area, the Delaware 911 database was used. This database provides a point for each residential address in the state, whether it is an apartment building, a townhouse, a manufactured home, or a single-family home. Although every point in the database does not necessarily fall exactly on a structure, this database provides a reasonable estimate of potentially affected structures at the state level.

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Results of this analysis (Table 30) indicate that 1% of the residential units in the state are within the 0.5 meter inundation area and that 5% are within the 1.5 meter scenario. Although this is a small percentage statewide, it represents potential impacts to between 4,000 and 20,000 residences within our state. Geographically, potential impacts to residences are clustered in developed areas, particularly coastal towns and the areas surrounding the Inland Bays (See maps in the Mapping Appendix).

In New Castle and Kent Counties, the potential number of housing units affected is very small (in most cases less than 1%), regardless of type (single-family, multi-unit or manufactured). A higher percentage of the total housing stock in Sussex County is within potential inundation areas than in either Kent or New Castle, largely due to the different development patterns in the resort areas which have resulted in high density residential development close to tidal water. Bethany Beach, South Bethany and Fenwick Island and the areas surrounding the Assawoman Bay have the highest concentration of potential residential impacts in both Sussex County and the state. The address data did not allow us to discern how many structures were second homes or seasonal rentals.

Table 30 Residential Addresses affected by sea level rise

County	Total Number of Addresses	Total Addresses Inundated			% of Total Addresses Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	346,574	3,571	9,988	17,095	1%	3%	5%
New Castle	166,569	131	409	923	< 1%	< 1%	1%
Kent	60,010	140	500	824	< 1%	1%	1%
Sussex	119,974	3,300	9,079	15,348	3%	8%	13%

Source: University of Delaware CADSR 9-1-1 Address Database, 2011

Table 31 Number of Residential Multi-Unit Addresses Exposed to Sea Level Rise

County	Total Number of Addresses	Total Addresses Inundated			% of Total Addresses Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	46,777	119	243	328	<1%	1%	1%
New Castle	37,022	0	0	12	0%	0%	<1%
Kent	1,770	0	0	0	0%	0%	0%
Sussex	7,985	119	243	316	1%	3%	5%

Source: University of Delaware CADSR 9-1-1 Address Database, 2011

Table 32 Number of Residential Manufactured Home Addresses Exposed to Sea Level Rise

County	Total Number of Addresses	Total Addresses Inundated			% of Total Addresses Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	18,526	350	2,201	3,318	2%	12%	18%
New Castle	3,772	0	0	0	0%	0%	0%
Kent	4,485	0	0	3	0%	0%	<1%
Sussex	10,269	350	2,201	3,315	3%	21%	32%

Source: University of Delaware CADSR 9-1-1 Address Database, 2011

**Potential Economic Impact:** Homeowners, property managers, and community associations could experience increased costs from repetitive flood damage to homes and associated structures and increased insurance costs. In some severely affected areas, property values could eventually decrease as structures become more difficult to access or experience frequent flooding and as surrounding homes are abandoned.

A study conducted by the University of Delaware indicated that the current tax assessed value for all parcels (regardless of use category) exposed to sea level rise in New Castle County is \$582 million and \$55.6 million in Kent County. The assessed “improved value” of parcels exposed to sea level rise in Sussex County is \$857.7 million (Laznik, 2012). Although tax rates per assessed value vary by county and some parcels have tax-exempt status, properties that are abandoned, de-valued or inundated could have an impact to local property tax revenues.

The availability and cost of flood insurance and homeowner’s insurance for residences in areas exposed to sea level rise is also a significant economic consideration. Forty-seven communities in Delaware participate in the National flood Insurance Program (NFIP), which makes federally-backed flood insurance available to their residents through the Federal Emergency Management Agency (FEMA). In order to participate, communities are required to adopt at least the minimum floodplain regulations and sign a resolution to adopt and enforce these regulations. Private (not federally-subsidized) flood insurance is also available to communities that do not participate in the program, and in coastal areas where the NFIP is prohibited from writing flood insurance policies by the Federal Coastal Barrier Resources Act. While sea level rise is not in itself a peril covered by the NFIP, the impacts of sea level rise related to higher flooding levels during storms may be felt by property owners and would be lessened by the continued availability of flood insurance.

Recently, the NFIP has been financially strained due to devastating storms, leading to speculation that fundamental changes are needed to make the NFIP financially solvent. At the same time, NFIP insurance premiums have increased annually by 10% each year, the maximum increase allowed by law. A few insurance companies have periodically stopped writing new homeowners’ insurance policies in coastal Delaware, but this is not due to flood risk; rather it is because their dense portfolio of policies in the region exposes them to unacceptable levels of payout in one weather event.

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**Potential Social Impact:** The potential social impact to residential structures and property exposed to sea level rise largely depends on the type of adaptation measure(s), if any, that are employed. A significant amount of the residential property exposed to sea level rise is in small coastal towns along the Delaware Bay and Inland Bays as well as in Delaware City, the town of New Castle, and South Wilmington. As a result of both an increase in existing residential development and future residential development land exposed to sea level rise, the quality of life, neighborhood fabric, and cultural character of Delaware's small coastal and bay towns may be significantly affected.

**Potential Environmental Impact:** The potential environmental impacts associated with residential properties and structures exposed to sea level rise include: introduction of contaminants from increased flooding and inundation of developed properties; coastal debris from the abandonment or loss of structures; pollution from residential septic systems and the inundation of community wastewater systems; and the loss of shoreline and wildlife habitat and the general reduction in habitat quality of the developed land that is inundated.

## Future Development Areas

The Delaware Population Consortium projects that by the year 2040, Delaware will be home to 1,120,523 residents – an increase of over 225,000 persons. These projections are routinely used by State, County and municipal governments to plan how and where future residential and commercial development will occur (Delaware Population Consortium, 2010).

Delaware encourages proactive planning for the state's future growth needs through a variety of mechanisms, including the Strategies for State Policy and Spending, implemented by the Office of State Planning Coordination. These strategies set forth guidelines and maps for where the state plans to make investments of public funds for roads, sewer, schools, and other infrastructure. It also outlines those areas where the state will direct funding for investments in agriculture and natural resource preservation. The strategies incorporate the zoning and future land use desires of county and municipal governments as outlined in their comprehensive development plans. The Strategies were first approved in 1999 and were updated in 2004 and 2010. Executive Order 26 states that "All state departments and agencies shall use the Strategies document and maps as a guide to making all decisions on policy, infrastructure and other investments, and resource management."

Inundation as a result of sea level rise could affect the availability and suitability of designated future growth areas for development. This could, in turn, drive the need for changes to development patterns in areas not subject to inundation from sea level rise to accommodate necessary growth.

**Exposure to Sea Level Rise:** Level 3 development areas, as designated by the Strategies for State Policy and Spending, were used to determine exposure of future growth areas to sea level rise. Level 3 areas are lands within the long-term growth plans (greater than five years) of county and municipal governments and/or are adjacent to already developed or developing areas. Some of these planned growth areas will be exposed to sea level rise under the three planning scenarios (See Table 33) and may be unsuitable for development to meet future growth needs.



Statewide, between 3% - 7% of Level 3 land is within an area that could be inundated by sea level rise. In New Castle County, these areas are generally in the areas surrounding the towns of New Castle, Delaware City and Port Penn as well as areas along the Christina River near the I-95 corridor. In Kent County, these areas are generally growth areas designated by coastal towns like Bowers Beach, Leipsic, and Little Creek for future growth. Fringes of land designated as Level 3 adjacent to the St. Jones River, Murderkill River and Mispillion River in Kent County are also exposed to future sea level rise under these scenarios (See maps in the Mapping Appendix).

In Sussex County, approximately 7 % of level 3 areas within the county would be inundated under the 1 meter sea level rise scenario. The coastal development patterns in Sussex County starkly contrast with Kent County's development patterns in large part because of the resort nature of coastal Sussex County. To meet the demand for homes and services near the Atlantic Coast and Inland Bays, future growth areas surround existing development around the Inland Bays. Many of these areas, particularly Angola Neck, Long Neck, and Fenwick along Route 54 will be exposed to future sea level rise. In addition, future growth zones in and around Rehoboth Beach, Lewes and Slaughter Beach will also be exposed.

**Table 33 - State Strategy Level 3 Areas Inundated by Sea Level Rise**

County	Total Acres of Level 3 Land	Total Acres of Land Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	152,001	3,907	7,777	11,178	3%	5%	7%
New Castle	43,480	428	783	1,107	1%	2%	3%
Kent	25,487	566	815	1,059	2%	3%	4%
Sussex	83,034	2,912	6,178	9,012	4%	7%	11%

**Source:** Delaware Office of State Planning Coordination, Investment Levels, Delaware State Strategies for State Policies and Spending (2010), 2010-10-01

**Potential Economic Impact:** Inundation of land within future growth zones could result in a reduction in potential tax base generated by new commercial and residential properties. In addition, development within future growth zones that have the potential to be inundated by sea level rise may be limited by the willingness of purchasers to assume risk, and it may be made more expensive if local communities enact stricter zoning or building codes.

New development in areas that may be exposed to sea level rise may create the expectation that government assistance for infrastructure improvements, flood control and/or buy-outs will be made available if necessary. The cost of these actions could have significant future cost to government entities. A recent report that assessed and proposed solutions for flooding problems in Bowers Beach estimated a total cost of over \$469,000 (KCI Technologies, 2011) for implementation of these solutions. This cost does not include the larger cost of state-provided sand for Bowers Beach for the past 50 years, a protective strategy necessitated by shoreline erosion and long term relative sea level rise, nor does it include costs for flood mitigation at an increased sea level.

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It is important to note that costs to individuals and government entities from flood mitigation projects and relocation or elevation of structures conducted as a response to sea level rise will vary depending on individual response to the rising tides. Many people residing or doing business within an inundation zone will accept a certain amount of risk and inconvenience and some may choose to relocate or raise their structures before inundation becomes problematic.

**Potential Social Impact:** Small coastal towns along the Delaware Bay like Bowers Beach, Leipsic, and Slaughter Beach may choose to limit the extent of their future growth areas, or change the location of their future growth areas based upon these sea level rise scenarios. If unable to find suitable areas to direct their growth, existing commercial and residential areas could fail to meet the needs of nearby residents.

Loss of land due to inundation without adequate planning or nearby land to rebuild could result in abandonment of properties within Delaware's small coastal towns and a reduction in the quality of life within them. In addition, the inundation scenarios indicate that both existing development and future development zones around Delaware's Inland Bays could be significantly affected by sea level rise. Quality of life in and around the Inland Bays may be reduced as a result, but it is important to note that the timeline for anticipated impacts is long and may allow adequate time for adjustments in development areas.

**Potential Environmental Impact:** Environmental impacts will vary depending upon how land use planners and developers choose to respond, and whether development is discouraged (whether by government action or personal risk tolerance) within potential future inundation zones. Development within these zones could result in a reduced opportunity for land preservation that would allow for tidal marshes to naturally migrate landward and could necessitate the hardening of natural shorelines, among others.

## Agriculture

Agriculture is a major component of the economic and social backbone of Delaware. The total economic contribution of the agriculture industry to the state is \$7.95 billion per year, supporting about 30,000 jobs. The overwhelming majority of the market sales are poultry (77.3%), followed by corn (6.3%), soybeans (2.9%), and milk and other dairy products (2.0%) (Awokuse, Ilvento, & Johnston, 2010).

According to the United States Department of Agriculture (2012), in 2007, 40% of the land mass in Delaware was classified as agricultural; many of these farms are located in coastal areas. Sea level rise can impact farming operations through permanent inundation of agricultural land, but it can also lead to salt contamination of soil from temporary flooding impacts during storms. Conversations with farmers at public meetings held in November, 2011 indicate that these impacts are already being seen in coastal agricultural areas. In addition, sea level rise can lead to saltwater intrusion into groundwater resources, contaminating irrigation wells with salt water unsuitable for irrigation of crops.

**Exposure to Sea Level Rise:** Exposure of the agriculture industry and community to sea level rise was assessed by using the State's Land Use/Land Cover maps. These maps outline areas that are used for specific types of land use, classified from aerial photographs. These maps were analyzed with respect to the sea level rise inundation areas to provide a gross indication of the extent and location of potential agricultural impacts.

Statewide, 1% - 4% of the 47,000 acres of mapped agricultural land is within areas that could be inundated by sea level rise (Table 34). Potential for the most concentrated impacts is in a region from southern New Castle County to Lewes, with coastal areas of northern Sussex seeing the most significant potential for concentrated impacts (see maps in the Mapping Appendix). While less than 5% of agricultural land could be potentially inundated from sea level rise, saltwater intrusion may present problems to a larger region; additional studies on saltwater intrusion are necessary before potential impacts can be characterized. It is also important to note that many of the farms within the sea level rise areas are also enrolled in agricultural conservation programs (additional discussion of these areas can be found in the natural resources section of this document).

**Table 34 - Acres of Actively Farmed Land Exposed to Sea Level Rise**

County	Total Acres of Farmed Land	Total Acres Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State		4,910	10,935	17,199	1%	2%	4%
New Castle	63,729	834	1,812	2,759	1%	3%	4%
Kent	166,506	1,248	3,747	6,511	1%	2%	4%
Sussex	243,562	2,828	5,376	7,928	1%	2%	3%

Source: Delaware Geographic Data Committee, 2007 Delaware Land Use and Land Cover, 2008-05-19

To understand potential impacts to farm structures, the Land Use/Land Cover maps were also analyzed with respect to the sea level rise scenarios to determine acreage and location of confined animal feeding facilities and farm buildings (Table 35 and Table 36). In general, less than 1% of Delaware's confined animal feeding operations are within areas that could be inundated by sea level rise. Up to 2% of farmsteads and related buildings could be inundated by sea level rise. The largest impact to farmsteads would be in Sussex County where 2% could be inundated at both the 1.0 meter and 1.5 meter scenarios. Due to the nature of the Land Use/Land Cover maps and the way in which structures are classified, the acreages reported in these tables are likely overestimated.

**Table 35 - Acres of Confined Animal Feeding Operations Exposed to Sea Level Rise**

County	Total Acres of Confined Feeding Operations	Total Acres Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	9,672	6	24	74	<1%	<1%	1%
New Castle	156	0	1	1	0%	<1%	<1%
Kent	1,554	1	4	11	<1%	<1%	1%
Sussex	7,964	5	20	62	<1%	<1%	1%

Source: Delaware Geographic Data Committee, 2007 Delaware Land Use and Land Cover, 2008-05-19

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**Table 36 - Acres of Farmsteads and Related Buildings Exposed to Sea Level Rise**

County	Total Acres of Farmsteads and Related Buildings	Total Acres Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	14,060	54	149	238	<1%	1%	2%
New Castle	2,781	6	23	36	<1%	<1%	1%
Kent	5,389	13	34	66	<1%	1%	1%
Sussex	5,890	35	92	136	1%	2%	2%

**Source:** Delaware Geographic Data Committee, 2007 Delaware Land Use and Land Cover, 2008 05 19

**Potential Economic Impact:** The loss of productive agricultural land to inundation and salt contamination decreases the profitability of individual farms and may make it increasingly difficult for family farmers to stay in business. It could also reduce the number of employment opportunities in the agricultural sector. The loss of local corn and soybean crops could also affect local feed sources and costs for the poultry industry. Landowners wishing to protect tillable acreage may also bear costs of shoreline protection strategies.

Specific studies to determine the economic impact of sea level rise to the agricultural industry are outside the scope of this assessment, but the workgroup acknowledges the importance of collecting this information.

**Potential Social Impact:** The potential loss of productive agricultural fields and resulting losses in employment may cause farmers and farm workers to move outside of the inundation zone, causing losses to the local agricultural heritage of a community. Delaware takes pride in having locally grown food sources; these sources have the potential to become lost as prime farmland becomes inundated with rising sea levels.

While the social impact may be significant in small geographic areas, the statewide exposure of agricultural acreage ranges from only 1-4% of the total agricultural area in the state. Based on this small statewide exposure, the farming community in Delaware is likely to be resilient to these changes.

**Potential Environmental Impact:** Agriculture in Delaware often relies on irrigation; groundwater withdrawals in coastal areas, combined with sea level rise, may increase saltwater intrusion into groundwater or aquifers and affect adjoining properties. Additional information about groundwater intrusion is available in the Natural Resources section of this document.

Inundation of agricultural land may also result in decreased areas for wildlife to forage or rest. Migratory geese in particular, utilize farm fields heavily during their winter stopover in Delaware.

As with residential and commercial areas, there is potential for loss of vegetated shorelines and their associated habitat, if landowners choose to protect the shoreline with rock or bulkheads to reduce flooding.

## Tourism and Coastal Recreation

Tourism is a critical part of the economy for the state of Delaware; tax-free shopping, family-friendly beaches, excellent restaurants, sporting events, and slot machines all draw non-Delawareans into the state to recreate and spend money. In 2010, the last year for which tourism data is available, 7.1 million people visited Delaware, generating \$400 million in state and local government taxes and fees and 39,000 jobs. Of those visiting Delaware from outside of the state, 24% dined in Delaware, 25% came here to shop, 16% to gamble, and 19% for beach activities (DEDO, 2012).

Coastal recreation opportunities in Delaware are a large component of the tourism industry, as well as a way of life for Delaware residents. A 2006 national survey of wildlife recreation found that 395,000 people who live in or visited Delaware fished, hunted, or watched wildlife in the state. Of the total number, 159,000 people fished, 30,000 people hunted and 285,000 participated in wildlife-watching activities, which includes observing, feeding, and photographing wildlife. During this time, state residents and nonresidents spent \$299 million on wildlife recreation in Delaware. Of that total, trip-related expenditures were \$75 million and equipment purchases totaled \$204 million. The remaining \$20 million was spent on licenses, contributions, land ownership and leasing, and other items (U.S. Department of the Interior, 2006).

Sea level rise will bring changes to many of the places and amenities that people visit and enjoy in Delaware. Waterfront restaurants and retail shops could experience increased frequency of flooding and eventual inundation. Scenic coastal routes like Delaware Route 9 may become difficult to travel on as a result of inundation or ground saturation may damage its structural integrity. Parks, natural areas and beaches may lose ground to inundation and erosional forces, and wildlife populations may relocate or shrink as a result of changing habitats. All of these changes may impact the tourism industry and recreational opportunities in the first state.

**Exposure to Sea Level Rise:** To assess the potential impact of sea level rise to tourist attractions in the state, the Society and Economy Workgroup attempted to obtain data that contained the locations of tourist attractions, including restaurants, shopping destinations, and hotels, and associated economic data. However, this data is not currently available statewide; therefore impacts to specific tourist attractions and tourist amenities could not be conducted. An analysis of impacts to the business sector in the state (inclusive of hotels and shops) was conducted as part of the statewide vulnerability assessment; those results are available in the Business chapter in this section.

Since gambling is a large component of tourism revenues in the state, the sea level rise scenario maps were compared to the locations of existing gambling sites; none of the three existing gambling sites are exposed to future sea level rise under the three planning scenarios.

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Delaware's State Parks provide visitors with many recreational and educational opportunities, from playing in the waves on the Atlantic Ocean to ghost tours at Fort Delaware. To assess potential impacts to these recreational opportunities, park boundary information was obtained from Delaware's Division of Parks and Recreation and used to determine the number and percentage of acres of parks within each of the three sea level rise planning scenarios (Table 37). Statewide, 25% of State Park land is within an area that could be inundated by sea level rise of 0.5 meters, up to 35% of State Park land is within areas that could be inundated by sea level rise of 1.5 meters. Potential inundation is most significant along the Atlantic Coast and Inland Bays in Sussex County; however, parks along the Delaware River in New Castle County could also be significantly affected. The Mapping Appendix indicates the state parks that could experience inundation, and provides a pie-graph indicating the extent of potential inundation at each scenario.

Additional resources that could impact outdoor recreational opportunities are discussed in the Natural Resources Section of this document.

**Table 37 - Acres of Delaware State Parks Exposed to Sea Level Rise**

County	Total Acres	Total Acres Inundated			Percent of Total Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	25,164	6,348	7,865	8,865	25%	31%	35%
New Castle	8,766	279	450	550	3%	5%	6%
Kent	1,601	0	0	0	0%	0%	0%
Sussex	14,796	6,069	7,415	8,316	41%	50%	56%

**Source:** Delaware Division of Parks and Recreation, 2011

**Potential Economic Impact:** Because many coastal resort areas contain land or amenities that could be inundated in the future and because many of the natural places that visitors seek out will experience inundation or habitat changes, alterations to tourism patterns could be expected as a result of sea level rise. If these patterns lead to decreased numbers of visits or decreased spending by visitors, tourism revenue will decrease, impacting business owners, employees of coastal businesses and tax revenues. However, should sea level rise result in entrepreneurial opportunities and expansion of amenities, tourism revenues may increase. For example, deeper water could allow some rivers, harbors, or marinas to accommodate boats with deeper DRAFTs, and could reduce the need for maintenance dredging of accumulated sediments.

In addition to changes in tourism revenue, sea level rise is expected to increase the costs of maintaining amenities and tourist destinations. For example, as sea level rises and flooding becomes more frequent, business owners may need to flood-proof or raise their buildings, parking lots, and docks. The cost to maintain sandy beaches may also increase. Delaware routinely partners with federal and local partners to replenish (or add sand to) its publically accessible Atlantic Ocean and Delaware Bay beaches, a strategy that has ensured that visitors and residents have space to enjoy a day at the beach while simultaneously protecting buildings, infrastructure and natural resources behind the dune from storm damage. Boardwalks, trails and viewing platforms that provide eco-tourism opportunities throughout the state may also require additional funding for maintenance or relocation to remain available and useful.

**Potential Social Impact:** The social fabric of many of Delaware's small coastal towns is based around fishing, boating, beach access, and the tourism that those activities bring. Reductions in the availability of these amenities as a result of sea level rise may affect tourism levels and local business revenues, leading to loss of business services and sense of community.

**Potential Environmental Impact:** Tourism and outdoor recreation contributes directly to environmental stewardship and natural resource conservation in the state of Delaware through financial contributions to restoration and through increased environmental awareness.

For example, one percent of the state's accommodation tax goes directly into the Beach Preservation Program of the Department of Natural Resources and Environmental Control, where it is used to help meet federal match requirements for beach replenishment projects. A reduction in the number of hotels and hotel guests could reduce this revenue stream, and thus the ability of the State to have the financial resources to conduct beach replenishment projects. However, seasonal rental homes are currently exempt from the accommodation tax; had seasonal home rental spending been subject to the tax, an additional \$72 million in state revenue would have been generated in one year (DEDO, 2012).

Similarly, many of the state's wildlife conservation programs are supported by a federal excise tax on hunting equipment and ammunition and by the Federal Duck Stamp, which migratory waterfowl hunters must purchase each year. Losses or changes to important wildlife habitat could reduce the number of hunting opportunities, and thus reduce the revenue stream for conservation programs.

## Historic and Cultural Resources

Historic resources are the physical places that embody Delaware's past, contain important information about the lives and history of our ancestors, and preserve the past for Delaware's future generations. Historic resources include buildings, structures, archaeological sites, landscapes, objects, and historic districts (areas with multiple numbers of individual resources) generally built before 1961. Historic resources can be found on land, in the water, and submerged on subaqueous lands.

Most historical resources are in private ownership. The public though, can enjoy the historic landscape around them as they drive, particularly on Delaware's Scenic and Historic Byways, and when they visit Delaware's historic towns, such as New Castle and Lewes, both of which have large historic districts. In addition, historians and researchers use and interpret these resources. Various historic museums are run by the state, as well as a number of private non-profits around the state, that provide historic interpretations and educational experiences for the public and for students at all grade levels. State parks also include many historic resources, for instance, the Fort Miles Historic District at Cape Henlopen State Park, and provide educational and recreational experiences for the public.

Sea level rise can affect historic and cultural resources in several ways. Damage to buried archaeological resources begins with a rise in the water table, leading to leaching of chemical and organic contents of the site. This results in loss of the information potential of the site to archeologists and historians. Inundation can cause structural damage or loss of historic buildings, historic vistas, and artifacts.

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## Exposure to Sea Level Rise

The Delaware State Division of Cultural and Historic Affairs' State Historic Preservation Office maintains a database of known historic and cultural sites in Delaware (State Historic Sites) and a database of National Historic Register Sites. The sea level rise scenario areas were overlaid with this database to determine the number and location of historic resources that are within areas potentially inundated by sea level rise. The Division of Cultural and Historic Affairs continually updates these databases, but not all areas in Delaware have been surveyed for historic resources and errors do exist in their data.

Table 38 and Table 39 below indicate the number of State Historic Sites and National Register Sites that could be inundated by sea level rise. Because of incomplete mapping, the summaries in the analysis table are likely an underrepresentation of the potential exposure of historic resources to sea level rise.

Between 2% - 4% of the 14,316 known historic sites in the state of Delaware are within areas that could be inundated by sea level rise. Between 2% - 5% of the state's 640 National Historic Register sites are within areas that could be inundated by sea level rise. Geographically, potentially impacted historic resources are widespread throughout the state (Map in the Mapping Appendix). Note that the maps show no impacts in northern and western Sussex County; this is due to lack of historic data collection in these areas and not necessarily because no historic resources exist in these areas.

**Table 38 - Number of State Historic Sites Exposed to Sea Level Rise**

County	Total Number of State Historic Sites	Total Number of Historic Sites Inundated			Percent of Historic Sites Inundated		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	14,316	244	441	634	2%	3%	4%
New Castle	6,645	79	137	181	1%	2%	3%
Kent	5,429	113	206	298	2%	4%	5%
Sussex	2,242	52	98	155	2%	4%	7%

**Source:** Delaware State Historic Preservation Office, CRS Inventory, 2011, unpublished.

**Table 39 - Number of National Register Sites Exposed to Sea Level Rise**

County	Total Number of National Register Sites	Total Number of National Register Sites Inundated			Percent of National Register Sites Inundateds		
		0.5 m	1.0 m	1.5 m	0.5 m	1.0 m	1.5 m
State	640	14	24	32	2%	4%	5%
New Castle	380	4	6	9	1%	2%	2%
Kent	141	5	10	14	4%	7%	10%
Sussex	119	5	8	9	4%	7%	8%

**Source:** Delaware State Historic Preservation Office, National Register of Historic Places for Delaware, 1997-12-01



**Potential Economic Impact:** Economic impacts of permanent inundation of historic resources include direct loss of buildings, structures, and landscapes as well as the revenues that are generated from them, whether home business, farms, or tourism. In addition, tax revenue to state and local governments could be affected by direct loss of property, although some of these properties may be tax-exempt.

In addition to direct losses, there are significant costs associated with moving historic buildings, structures, and cemeteries, raising historic buildings and structures above flood levels, providing flood protection for historic resources, repairing flood damage to historic resources, and/or conducting data recovery excavations of significant archaeological sites. In certain circumstances, some owners of historic resources may have a legal obligation to relocate or document the resource if loss is imminent, such as in the case of permanent inundation. Indirectly, loss of tidal marshes and other natural communities that provide natural flood mitigation to upland properties may exacerbate inundation impacts to inland historic resources.

**Potential Social Impact:** While not immediately visible to the public, the loss of archaeological sites means the irrecoverable loss of information that may be significant to understanding Delaware's past, representing a serious loss for researchers, archaeologists, historians, and even environmentalists interested in reconstructing past ecologies. Damage to archaeological sites begins with rises in the water table, leading to leaching of chemical and organic contents of the site, thereby damaging the information potential of the site well before a site is permanently inundated.

Additionally, property owners could experience loss of their historic homes and commercial properties such as stores and farms. Quality of life for all Delawareans could be impacted because historic resources are a large part of the community character of Delaware's towns as well as the look and feel of its rural areas, creating pleasing view-sheds, walkable neighborhoods, interesting streetscapes, and recreational and cultural opportunities.

**Potential Environmental Impact:** Some historic buildings may still contain lead-based paints and asbestos and there may be other chemicals and contaminants remaining in historic farms, mills, and industrial sites. Inundation of these sites could release hazardous materials into the water column. In addition, inundation of cemeteries may result in the release of lead and other toxins that are used in burial materials.

## Socially Vulnerable Populations

Socially vulnerable populations are neighborhoods or groups that are less likely to have the resources to respond to environmental threats like sea level rise due to a variety of factors including educational level, economic standing, age, family status, and access to services.

Citizens in areas identified as socially vulnerable may lack the ability or resources to adapt to sea level rise. They may not have the financial resources to flood-proof their homes or relocate if sea level rise begins to affect their neighborhood. They may also lack their own transportation or lose access to transportation should bus routes or bus stops be relocated due to road flooding in the region; this could also affect their ability to travel to and from work. In addition, these communities are often near or within areas of already poor environmental quality and may disproportionately be affected by indirect impacts of sea level rise such as contaminant releases from underground storage tanks or contaminated sites.

Socially vulnerable populations were discussed and considered throughout this document but were not ranked with the other resources analyzed because assessment of these communities will need to be conducted at a more localized scale and with consideration of the interaction of numerous direct and indirect sea level rise impacts. Attention to fair treatment of socially vulnerable communities should be forefront in the minds of decision-makers as plans are made to adapt to the effects of sea level rise. Strategies that are developed for sea level rise should seek to avoid disproportionate effects to socially vulnerable populations as described below.

# Society and Economy

**Exposure to Sea Level Rise:** To understand the location and extent of populations that could be particularly susceptible to the effects of sea level rise, two social vulnerability indicators were utilized: The Wilmington Planning Area Council's (WILMAPCO) Environmental Justice (EJ) areas and the Social Vulnerability Index (SoVI).

Environmental Justice entails the fair treatment and meaningful involvement of people from all races, cultures, and incomes regarding the development of environmental laws, regulations and policies. An outgrowth of Title VI of the Civil Rights Act of 1964, EJ is a policy to ensure the non-discriminatory distribution of federal funds in the U.S. During his terms, President Clinton issued a pair of Executive Orders (EO) which detailed the EJ responsibilities of federal agencies. EO 12898, signed in 1994, requires agencies to identify and avoid disproportionately high and adverse effects on low-income and minority populations. Six years later, EO 13166 called for outreach and involvement of persons with Limited English Proficiency (LEP). A decade later, President Obama reinvigorated the federal government's commitment to EJ. Strategies across federal agencies were revamped, with weight added to the following areas: public engagement, implementation of the National Environmental Policy Act (NEPA) and Title VI, the relationship of climate change to EJ, and the impacts of freight movement.

EJ areas in Delaware were identified by WILMAPCO for use in transportation planning projects. Using data from the 2000 Census, block groups were given points based on the percentage of low-income, black, Hispanic, and Asian persons. Based upon the number of points, block groups were scored as either having a Low, Moderate or Significant concentration of at-risk residents (WILMAPCO, 2009).

A Social Vulnerability Index is a quantitative measure of social vulnerability to environmental hazards. Social vulnerability focuses on demographic and socioeconomic factors that increase or attenuate the impact of environmental hazards (like sea level rise) on local populations. The Social Vulnerability Index (Cutter, Bryan, & Shirley, 2003) uses a similar strategy to identify block groups that are particularly susceptible to environmental hazards, but uses 32 variables to score each block group. These variables include race and income like the WILMAPCO method, but also includes percentage of elderly residents, percent female headed households, hospitals per capita, housing values, percent employment, education level, and others. Vulnerable block groups are identified as those whose scores are greater than one standard deviation above the mean (Cutter, Bryan, & Shirley, 2003). SoVI data at a block group level was obtained from the National Oceanic and Atmospheric Administration for use in this assessment.

Due to recent changes in the way in which demographic data is collected through the US Census, the most robust and useable dataset for social vulnerability analysis is the 2000 Census. This analysis should be updated as new demographic data is available.

Using these two methods, block groups whose boundaries were within any sea level rise scenario were identified; these block groups were further analyzed to determine if there were any residences that would be exposed to sea level rise. Block groups with at least one affected residence were included in the results below. It is important to note that in many cases, only a small sliver of each block group is exposed to sea level rise, and the remainder of the block group is outside of the area of concern. Additional analysis will be necessary to discern the social vulnerability within affected parcels.

Results of the two different techniques for identifying at-risk populations varied widely, likely as a result of the increased number of variables used by the SoVI versus the WILMACPO method. The SoVI, likely due to its inclusion of age and infrastructure factors, identified more rural and resort areas as vulnerable, but also included areas of dense development in Wilmington, Dover, and Milford. The Environmental Justice Areas, because of the focus on race and income, was more likely to identify urban areas in Wilmington, Milford, Dover, and Seaford. However, smaller towns and rural areas were also identified as vulnerable.

Block groups identified as environmental justice areas or socially vulnerable areas by this analysis are listed below. Block groups in italics indicate that the block group was identified by both methods.

#### WILMAPCO Environmental Justice Areas - Significant

- North of Wilmington, east of 13 (Tract 101700, Block Group 4)
- South Wilmington, East of Christina River and West of Heald Street (Tract 1900, Block Group 2)
- Milford, North of Mispillion River and west of 113 (Tract 042500, Block Group 2)

#### WILMAPCO Environmental Justice Areas – Moderate

- Wilmington, North of Brandywine River (Tract 000700 Block Group 2, Tract 000602 Block Group 2 & 3)
- City of Wilmington, northwest of Christina River (Tract 002700, Block Group 1)
- City of Wilmington, north of Christina River (Tract 002000, Block Group 1)
- North of Delaware City (Tract 0163303, Block Group 1)
- Bear, west of 7 (Tract 014902, Block Group 1)
- Southeast of Middletown (Tract 016802, Block Group 1)
- Eastern Kent County (Tract 040400, Block Group 1)
- East of Dover (Tract 041000, Block Group 1)
- Downtown Dover, along the upper St. Jones River and Silver Lake (Tract 040900, Block group 1)
- West Milford (Tract 050102, Block Group 3)
- Milton and vicinity (Tract 050801, Block Group 2)
- Seaford, North of Nanticoke River (Tract 050402, Block Group 2)
- Laurel and South of Laurel (Tract 051802, Block Group 2)

#### Social Vulnerability Index – High Vulnerability

- East of Christiana River (Tract 012900, Block group 2)
- Downtown Dover, along the upper St. Jones River and Silver Lake (Tract 040900, Block group 1)
- Lewes along the L&R Canal (Tract 050900, Block Group 3)
- Seaford, North of Nanticoke River (Tract 050402, Block Group 2)
- Millsboro, along Indian River (Tract 050602, Block Group 1)
- Sussex County along north side of Indian River (Tract 050702, Block Group 1)

#### Social Vulnerability Index – Moderate Vulnerability

- City of Wilmington, northwest of Christina River (Tract 002700, Block Group 1)
- West of Route 13 in Smyrna and Kent County (Tract 040203, Block Group 2)
- Milford west of Route 113 (Tract 042500 Block Group 2, Tract 050102, Block Group 1)
- Milton and vicinity (Tract 050801, Block Group 2)
- East of Millsboro, north side of Indian River (Tract 050702, Block Group 2)
- East and South of Dagsboro, including Frankford (Tract 051500, Block Group 2)
- East of Selbyville (Tract 051302, Block Group 1)

# Society and Economy

These results should be considered as a screening upon which to base additional investigations into the potential impact that sea level rise may have on communities. Americans have proven to be highly economically mobile throughout their lifetimes, and community composition is likely to change over our 88 year planning horizon. In addition, these methods identified some block groups as vulnerable based upon age and fixed incomes; these individuals may actually have sizeable assets and wealth to use as resources to adapt.

**Potential Economic Impact:** The potential economic impacts associated with exposure of socially vulnerable populations to sea level rise include costs associated with home maintenance, employment opportunities, and social services. Although it can be assumed that many socially vulnerable individuals rent their homes; flooding of residences may result in increased or unplanned costs for home repair or relocation. For homeowners, this may result in increased insurance costs or repairs after flood events. There could also be unanticipated costs for renters as well; including relocation costs (first and last month's rent, security deposits etc.) should this become necessary due to safety or structural issues. Alternate housing options may also be limited for those using subsidized housing programs.

In some neighborhoods, flooding of buildings could also result in loss of employment within the vicinity; those residents who do not have a car may lose employment opportunities within walking distance and may have difficulty with the costs associated with traveling by car. In addition, the nature of social services needed for residents of these areas may evolve in the future, requiring more government resources to help them respond, recover, or adapt to sea level rise.

**Potential Social Impact:** The potential social impact associated with the exposure of socially vulnerable populations to sea level rise includes the loss of housing, of 'local' identity, loss community structure, and character, loss of employment opportunities, and the loss of a social network. In many small communities, neighbors support neighbors through emergency babysitting, rides to work, and block watches. Any action that would result in the relocation of families could have an isolating affect, particularly in multi-generational communities or communities with long tenure. Increased flooding and structural damages will also impact quantity and quality of social service resources needed and available for these populations.

**Potential Environmental Impact:** The potential environmental impacts associated with the exposure of socially vulnerable populations to sea level rise include exposure to contaminants, water quality and health effects. Some socially vulnerable communities are located near industrial sites and brownfields (formerly industrial sites suspected of having contamination). Inundation of these sites may release contaminants (mercury, arsenic, PCBs etc.) into the water column, increasing the likelihood of these contaminants coming into contact with humans through a variety of means.

Sea level rise may also affect the function and safety of septic systems and drinking water wells; persons and communities unable to bear the costs of repair or replacement will be particularly affected. Increased water tables or inundation could cause septic systems to no longer drain properly or to back up into homes; this exposes humans and the water supply to bacteria, pathogens, and other pollutants. Increased water tables and inundation could also cause well-water to become salty affecting the quality and quantity of drinking water supplies.

Sea level rise may also increase the number of people at risk for health conditions related to standing water, wet building materials, and sustained high indoor humidity. Standing water can result in increased mosquito populations and exposure to mosquito borne disease. Wet or damp basements and high indoor humidity can result in increased mold spores and increased incidences of asthma and allergies.

