

SEA LEVEL RISE AND COASTAL VULNERABILITY ASSESSMENT AND IMPLEMENTATION PLAN

QUEEN ANNE'S COUNTY, MARYLAND



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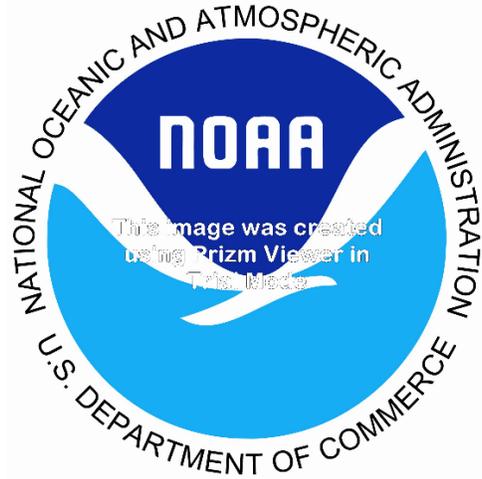
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ACRONYMS

CCG	CoastSmart Communities Grant
CFR	Code of Federal Regulations
CRS	Community Rating System
DC	District of Columbia
DETF	DelMarVa Emergency Task Force
DNR	(Maryland) Department of Natural Resources
EMS	Emergency Medical Services
ESRGC	Eastern Shore Regional GIS Cooperative
FEMA	Federal Emergency Management Agency
FIS	Flood Insurance Study
GIS	Geographic Information System
GMSL	Global Mean Sea Level
HIRA	Hazard Identification and Risk Assessment
HPA	Habitat Protection Area
HUD	(U.S.) Department of Urban Development
IDA	Intense Development Area
IPCC	Intergovernmental Panel on Climate Change
KNSG	Kent Narrows/Stevensville/Grasonville
LDA	Limited Development Area
LIDAR	Light Detection and Ranging
MD	Maryland
MES	Maryland Environmental Service
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MSRSW	Mid-Shore Regional Solid Waste
NAVD88	North American Vertical Datum of 1988
NESDIS	National Environmental Satellite, Data, and Information Services
NFIP	National Flood Insurance Program
NGO	Non-Government Organizations
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRCS	Natural Resource Conservation Service
NWI	National Wetlands Inventory
PFA	Priority Funding Area
QACO	Queen Anne’s County
RCA	Resource Conservation Area
RK&K	Rummel, Klepper and Kahl, LLP
SFHA	Special Flood Hazard Area
SHA	(Maryland) State Highway Administration
SKI	Southern Kent Island

SLR	Sea Level Rise
STWG	(Maryland Commission on Climate Change) Scientific and Technical Working Group
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USNCA	U.S. National Climate Assessment
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

As a County with over 400 miles of coastline, Queen Anne’s County’s (QACO, County) economy and quality of life have historically been linked to its shores, tidal wetlands, farm fields, and the resources of the Chesapeake Bay. Because of its location, low elevations, and dependence on the coast, QACO is particularly vulnerable to the effects of Sea Level Rise (SLR), loss of low-lying land and structures, saltwater intrusion into surface water and ground water, and increased flooding from storm events. Changes in sea levels have the potential to impact existing infrastructure and natural resources in the short-term and also the durability of future development with long-term design life. Long-range planning and accounting for changes in sea level that may be expected in the County will help lead to informed decisions for public and private investments by minimizing risk and potential for damage to both existing and future resources. This study was prepared using widely-accepted methods and science in Maryland.

In July, 2014, the Maryland Smart Growth Sub Cabinet granted QACO a Priority Funding Area (PFA) exception to extend sewer service to nine communities located on Southern Kent Island (SKI). The project will provide public sewer to more than 1,200 existing homes and more than 600 vacant lots to alleviate the significant public health and environmental concern caused by the existing/failing septic systems penetrating groundwater. As a condition of the SKI project, the Maryland Smart Growth Sub Cabinet is requiring a sea level rise and coastal vulnerability assessment to be prepared. This assessment is being prepared through the CoastSmart Communities Grant (CCG) administered by the Maryland Department of Natural Resources (DNR). The objective of this assessment is to identify the impacts of SLR and coastal flooding, as well as build and/or plan the resiliency of the County to withstand sea level rise and future storms.

Results of the SLR and Coastal Vulnerability Assessment indicate that inundation from SLR will affect a range of resources, including infrastructure, land use, and natural resources, as well as increase the risk to public safety. Three SLR and storm surge scenarios have been mapped to identify areas of vulnerability and risk in the County:

1. SLR of 2 feet plus Mean Higher High Water (MHHW)
2. SLR of 4 feet plus MHHW
3. SLR of 2 feet plus MHHW plus coastal storm surge

Between 2.6% and 4.1% of the County’s land area could be impacted by a SLR of two feet (2’) to four feet (4’), respectively and 6.3% of the County’s land area could see increased temporary impacts by two feet of SLR plus coastal storm surge. Within those potentially inundated areas lie transportation infrastructure, critical facilities, commercial properties, utilities, existing homes, agricultural fields, and expansive stretches of wetlands and wildlife habitat. Figure 1 shows the vulnerable areas of the County for the three scenarios. A comprehensive list of assessed countywide resources and their associated impacts is provided in Table 1.

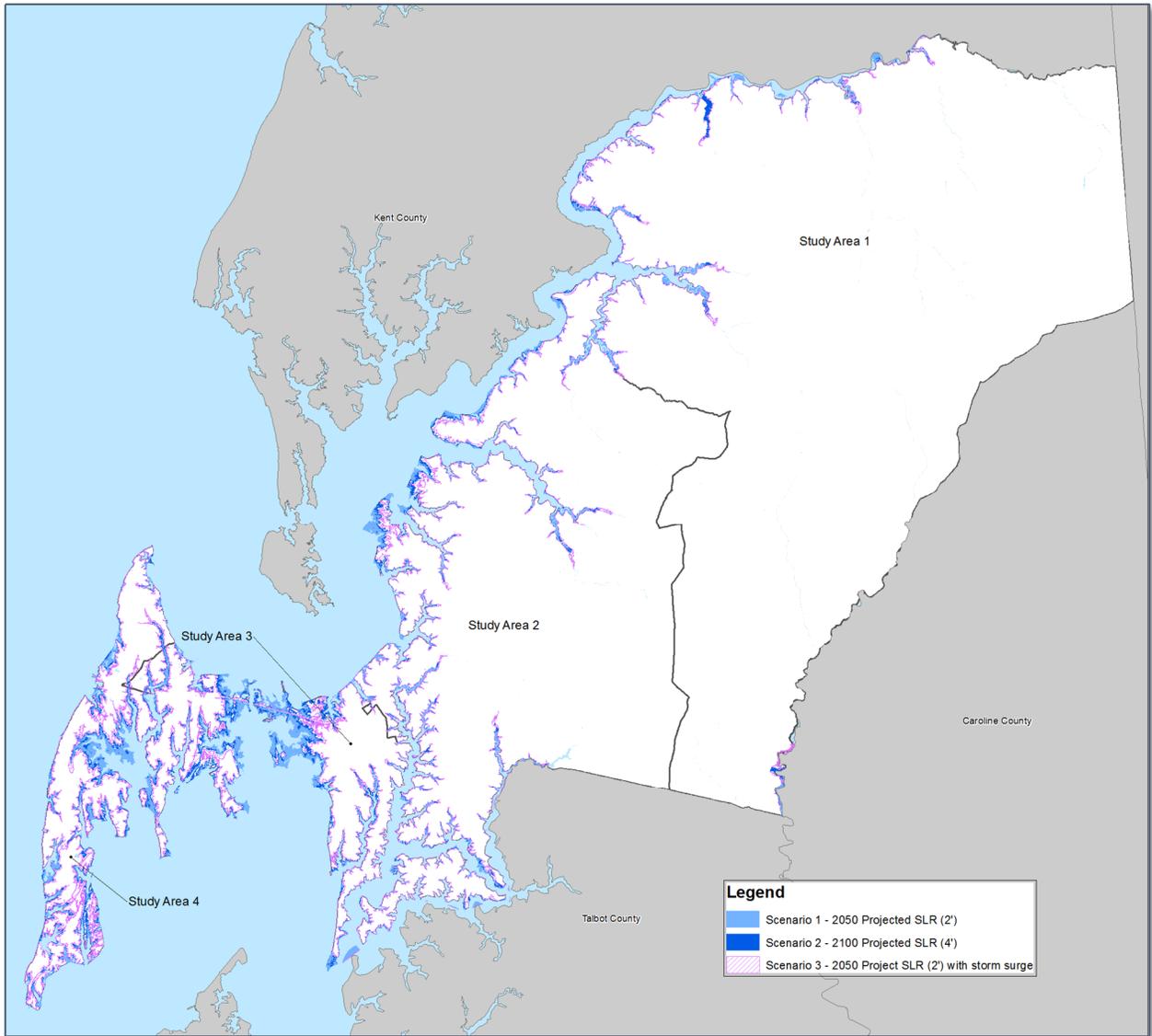


FIGURE 1: QUEEN ANNE'S COUNTY'S VULNERABLE AREAS

TABLE 1: ASSESSED RESOURCES AND COUNTYWIDE IMPACTS

Resource	Units	Total Number Countywide	Number Impacted by Coastal Vulnerability Scenarios			Concern
			Scenario 1	Scenario 2	Scenario 3 ²	
Emergency Service Facilities	Properties ¹	52	5	9	18	High
Emergency Service Facilities	Buildings	52	0	1	5	High
Evacuation Routes	Miles	258.3	1.4	4.2	8.1	High
Roadways	Miles	1,077.4	3.6	22.7	62.0	Moderate
Schools	Properties ¹	38	1	4	9	Low
Schools	Buildings	38	0	0	0	Low
Wastewater Treatment Plants	Properties ¹	5	3	4	4	High
Sewer Stations	Stations	31	2	13	16	High
Water Treatment Plants	Properties ¹	11	1	3	3	Moderate
Fire Hydrants	Each	393	8	30	68	Low
Dams	Each	19	0	0	2	Low
Catch Basins	Each	652	18	56	113	High
Culverts	Each	784	76	142	272	High
Concrete Drains	Each	17,710	430	1,337	2,902	High
Storm Drains	Segment	345	8	17	51	High
Drop Inlets	Each	524	30	96	143	High
Manholes	Each	1,112	12	71	173	High
Pipes	Segment	117	4	11	28	High
Stormwater Ponds	Each	415	27	60	90	Moderate

Resource	Units	Total Number Countywide	Number Impacted by Coastal Vulnerability Scenarios			Concern
			Scenario 1	Scenario 2	Scenario 3 ²	
Sub Stations	Each	8	0	0	0	Low
Transformers	Each	8	0	0	0	Low
Lamp Posts	Each	1269	18	132	304	Moderate
Light Poles	Each	2625	76	214	423	Moderate
Traffic Signal Poles	Each	21	0	0	0	Low
Utility Poles	Each	18,303	277	807	1,589	Moderate
Utility Boxes	Each	378	2	22	63	Moderate
Telecommunication Towers	Each	47	2	3	4	High
Private Residential Property	Properties ¹	21,316	1,412	4,732	6,538	High
Private Residential Property	Buildings	19,553	64	990	2,785	High
Commercial Development	Properties ¹	2,429	709	854	1,064	High
Commercial Development	Buildings	1,642	36	96	192	High
NWI Wetlands	Acres	27,337	3,606	4,211	4,780	High
DNR Wetlands	Acres	55,446	6,794	8,351	9,601	High
Critical Area	Acres	4,034	507	822	1,256	High
Agricultural Land	Acres	181,040	2,998	4,739	7,258	High

¹ Property impacts may only represent a portion of the property

² Scenario 3 may only represent a temporary impact of certain resources without long-term impacts

Adaptation Strategies

Adaptation strategies have been grouped into categories as shown in Table 2.

TABLE 2: ADAPTATION STRATEGIES

Adaptation Strategy	Description
Avoid	Avoidance strategies seek to limit new development or infrastructure in vulnerable areas.
Accommodate	Accommodate strategies acknowledge the long-term effects of SLR, while implementing short-term measures to maintain the existing use of a resource. These strategies decrease the risks of SLR without using potentially more costly protection strategies.
Protect	Protection adaptation strategies focus on protecting land from inundation or storm-induced flooding through construction of larger, longer-lasting projects such as building levees or raising elevations of roadways and other utilities.
Retreat	Retreat adaptation strategies allow for natural shore migration through land conservation and planned relocation of structures and other infrastructure.
Build Adaptive Capacity	The strategy of building adaptive capacity is not a solution in itself but is critically important to provide the data and knowledge to inform the aforementioned adaptation strategies. Communities with more capacity to adapt to SLR and coastal flooding are able to react quickly and make informed decisions.
No Action	The no-action strategy is the default strategy for communities that do not proactively plan for SLR and coastal flooding. This un-planned retreat results in loss of habitat and infrastructure that are imminent or have already occurred, leaving few viable options for adaptation. This adaptation strategy is not discussed in this document and is not recommended herein for any identified vulnerable resources.

Short-term, medium-term, and long-term adaptation strategies are recommended in Table ES-3. Short-term action strategies address the immediate needs of the County to build resiliency and protect against SLR and coastal flooding. These are typically strategies to either provide temporary protection of resources or planning activities for more permanent protection. Medium-term action strategies begin to implement short-term planning studies and increase the level of protection in the County. Long-term strategies aim to create more permanent solutions and resiliency to achieve lasting protection throughout the County.

TABLE 3: SHORT –TERM, MEDIUM-TERM, AND LONG-TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
Short-Term Adaptation Strategies				
<ul style="list-style-type: none"> • Increase building set-back distances • Identify opportunities for voluntary conservation easements • Create elevated County review procedures for projects in vulnerable areas • Evaluate process for transfer of development rights • Coordinate with private utility companies to incorporate SLR • Encourage FEMA to update Flood Insurance Rate Maps (FIRMs) to include SLR and re-map riverine flooding with SLR effects • Encourage FEMA to update FIRMs to include impacts to storm surge modeling based on SLR • Identify opportunities for voluntary conservation easements • Evaluate changes to zoning 	<ul style="list-style-type: none"> • Improve emergency evacuation plans based on SLR projections • Evaluate boat transportation emergency routes to areas isolated by inundation • Flood-proof at-risk structures • Evaluate regulatory incentives that encourage SLR and coastal flooding adaptation • Evaluate mobile capabilities and mutual aid backup of emergency services • Install salinity observation stations to monitor changes to freshwater resources over time • Evaluate potential crop changes for agricultural areas such as aquaculture 	<ul style="list-style-type: none"> • Evaluate feasibility of levees and other structural measures to protect vulnerable areas • Identify targeted areas to be protected • Evaluate and determine regulatory elevations for vulnerable areas • Coordinate SLR adaptation with SHA • Evaluate elevation of critical component elevations of wastewater and water treatment/ transmission facilities • Coordinate development and Capital Improvement plans to address as many affected resources as possible • Identify beaches with high erosion rates • Evaluate living shoreline protection • Identify potential wetland migration areas 	<ul style="list-style-type: none"> • Identify areas of high vulnerability • Evaluate relocation potential of structures and infrastructure in vulnerable areas • Evaluate feasibility of land acquisition of vulnerable parcels • Purchase frequently flooded areas and remove structures • Identify areas of high vulnerability • Identify land conservation areas and protect with easements 	<ul style="list-style-type: none"> • Improve coordination with Federal, State, and Local officials • Create new partnerships to increase resources for research and development of adaptation options • Conduct comprehensive inventory of funding mechanisms, regulations, and policies to remove barriers to SLR adaptation • Provide technical assistance to local governments, business owners, and residents • Develop a prioritization plan of adaptation actions • Evaluate socio-economic impact of SLR • Participate in FEMA’s Community Rating System and employ CRS activities • Develop framework for decision making regarding land protection and restoration strategies

AVOID	ACCOMMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
Medium-Term Adaptation Strategies				
<ul style="list-style-type: none"> • Implement conservation easements • Monitor set-back requirements • Limit or prohibit new infrastructure in vulnerable areas • Implement transfer of development rights • Require private utilities to build new infrastructure outside of vulnerable areas • Implement conservation easements • Allow coastal wetlands to migrate landward 	<ul style="list-style-type: none"> • Develop plans for mobilization of emergency management services • Require additional freeboard of new homes above the base flood elevation • Incorporate regulatory incentives for innovative projects that adapt to SLR and coastal flooding • Improve boat access for emergency evacuation services • Monitor conversion of freshwater wetlands and agricultural land to salt water wetland 	<ul style="list-style-type: none"> • Require roads to be elevated to provide access to new development and targeted protection areas • Require new development to protect against regulatory elevations in vulnerable areas • Evaluate impacts to adjacent properties from adaptation actions • Coordinate elevation of evacuation routes/ bridges with SHA • Retrofit wastewater and water treatment/ transmission facilities as needed • Elevate wastewater manholes above anticipated SLR and flood elevations to prevent inundation • Replenish beaches • Preserve wetland migration areas • Coordinate sand supply from State or Federal dredging projects for reuse 	<ul style="list-style-type: none"> • Create a special funding mechanism for purchase of frequently flooded structures • Purchase frequently flooded areas and remove structures • Implement rolling easements • Create new land conservation areas 	<ul style="list-style-type: none"> • Engage public participation in adaptation decisions • Implement cost-sharing projects with State and Federal agencies • Update Multi-Jurisdictional Hazard Mitigation Plan, Floodplain Management Plan, Zoning Ordinance, Comprehensive Plan, and Capital Improvement Plan to address SLR • Continue FEMA’s CRS program and employ CRS activities • Identify grant opportunities to incorporate SLR adaptation projects • Encourage DNR to continually evaluate and update Critical Area

AVOID	ACCOMMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
Long-Term Adaptation Strategies				
<ul style="list-style-type: none"> • Continue monitoring set-back compliance • Monitor conservation easements • Continue limiting or prohibiting new resources in vulnerable areas • Monitor transfer of development rights procedures and adjust as needed • Monitor coastal wetlands and enhance as needed • Monitor conservation easements 	<ul style="list-style-type: none"> • Construct new infrastructure projects above the vulnerable elevation • Monitor SLR and coastal flooding effects on infrastructure and adjust regulatory requirements • Continue monitoring regulatory incentives for projects incorporating SLR • Enhance conversion of freshwater wetlands and agricultural lands to saltwater wetlands 	<ul style="list-style-type: none"> • Elevate roadways in targeted protection areas • Retrofit wastewater and water treatment facilities as needed for protection against inundation • Adjust adaptation actions to protect adjacent properties • Monitor wetland migration and identify/ preserve additional wetland migration areas • Coordinate elevation of evacuation routes/ bridges with SHA 	<ul style="list-style-type: none"> • Purchase frequently flooded areas and remove structures • Monitor rolling easement compliance • Remove structures that prevent shoreline movement • Monitor land conservation areas and reassess as needed 	<ul style="list-style-type: none"> • Evaluate adaptive capacity and adapt as necessary • Employ CRS activities

Implementation Plan

Implementation of the recommended adaptation strategies can best be achieved at the County level through more stringent regulatory requirements and revision of planning documents to incorporate the impacts of SLR and coastal flooding scenarios. The recommended adaptation strategies are intended to be somewhat broad in nature so that they were not unnecessarily prescriptive. However, since specific actions are not proposed herein the County will need to decide which strategies may work best in the County based on funding, political support, socio-economics, regulatory environment, and County agency organization and objectives. For example, the recommendation to “identify targeted protection areas” is an important recommendation since protection of all County resources is not economically feasible, but will require the County to determine how to best allocate funding to protect those areas most critical to the livelihood of the County residents.

Implementation opportunities to incorporate SLR and coastal flooding scenarios into county planning and regulatory documents include:

- Updates to the County’s Multi-Jurisdictional Hazard Mitigation Plan to incorporate hazard identification and risk, identify mitigation goals and prepare execution and maintenance plans for flooding, hurricanes, and other hazards in the County. This will also permit access to federal funding for SLR related projects.
- Updated to the County’s Floodplain Management Ordinance to add more-stringent requirements to the minimal requirements of FEMA. This will also help the County with FEMA’s Community Rating System (CRS) rating. Protecting against future SLR will also build resiliency in today’s storm events.
- Updates to Zoning and Subdivision Regulations through the evaluation of zoning districts, potential creation of a special district for vulnerable areas, changes to permitted uses by district, and changes to minimum lot sizes and/or setback distances.
- Updates to the Comprehensive Plan to incorporate SLR and related coastal hazards. This may include changes to ultimate land uses to account for SLR and coastal flooding. Goals for sensitive areas, water resources, priority preservation areas, historic and cultural preservation, County/Town planning framework, economic development and tourism, and community facilities and transportation should be updated accordingly.
- Updates to Capital Improvement Plan to incorporate SLR and coastal hazards into capital projects. Identification of funding options to build resiliency in the County should also be considered with this plan.

In addition to these planning documents, the County should consider the prioritization of adaptive management strategies. Due to the magnitude of the recommendations, the diversity in vulnerabilities, the diversity of resources that are vulnerable, and the realization of funding limitations and capacity – a prioritization strategy should be developed for implementation opportunities.

As Capital Improvement Plan funds are limited and there is extensive competition for the funds. Strategies to pursue these funds and position for high potential for reward should be part of an implementation plan. The need to generate additional funding resources is evident and a strategy to develop those alternative programs is vital to an implementation plan. The County should continue to look for creative fee structures, taxes, public/private partnerships, incentive programs, and the like for needed funding.

Use of this Document: This document and its appendices provides a planning-level accounting of resources vulnerable to SLR of up to four feet in QACO. It includes background information and a description of the process used to assess vulnerability based on the best available science and data at this time. It should be noted that SLR predictions and storm surge studies will change over time. This document has been prepared as a planning tool to prioritize adaptation strategies and provide information and guidance to help the County and its residents to make informed decisions when considering future impacts, actions, and investments in areas that may be at risk from the effects of SLR and coastal flooding. It should not be considered a regulatory document of any kind. Any recommended adaptation action that would require a change in legislation of regulations would go through the normal legislative and public processes.

1. INTRODUCTION

Queen Anne’s County (QACO, County) contains more than 400 miles of shoreline with a significant portion of the County located in low-lying coastal areas. Because of its location, portions of QACO are particularly vulnerable to the effects of rising sea levels and coastal flooding (Figure 2 shows a location map of QACO). Other natural processes such as storm events, wave action, erosion, and sediment deposition are also affected by changes in sea level to change the size and makeup of shorelines, wetlands, and streams. However, as the rates of sea level rise (SLR) accelerate, SLR may increasingly become the driving force in coastal changes. Accelerated rates of SLR could cause inundation of low-lying land, allow greater saltwater intrusion into groundwater and streams, and promote an increased extent and severity of coastal and riverine flooding. Inundation of low-lying land and structures can occur when the sea level rises faster than natural processes can build up land. This can cause dry land to become flooded and can cause wetlands to convert to open water. Structures, including homes, roads, critical infrastructure, businesses, and utilities, that have been constructed in low-lying areas can become difficult to access and can become inundated or structurally unstable.

The population of QACO as determined by the 2000 Census was 40,563, and the 2010 Census was 47,798, an increase of 17.8% (Reference 1). The vision for the future of QACO has remained constant with emphasis on maintaining and enhancing a “predominately rural county with small towns connected by creeks and county roads through fields and forest – a great place to live; a county that encourages agriculture, seafood and maritime industries, tourism and outdoor sports, small business and high tech enterprise – a good place to work; a county that is a faithful steward of its natural and cultural heritage – a good neighbor for the Bay and other Eastern Shore counties; a county in which development by some does not impair the quality of life enjoyed by all – a good community that protects the expectations and opportunities of all its citizens.” (Reference 2). Many goals included in this vision have the potential to become impacted by SLR and coastal storm events.

In July, 2014, the Maryland Smart Growth Sub Cabinet granted QACO a Priority Funding Area (PFA) exception to extend sewer service to nine communities located on Southern Kent Island (SKI). The project will provide public sewer to more than 1,200 existing homes and more than 600 vacant lots to alleviate the significant public health and environmental concern caused by the failing septic systems penetrating groundwater. As a condition of the SKI project, the Maryland Smart Growth Sub Cabinet is requiring a sea level rise and coastal vulnerability assessment to be prepared. This assessment is being prepared through the CoastSmart Communities Grant (CCG) administered by the Maryland Department of Natural Resources (DNR). The objective of this assessment is to identify the impacts of SLR and coastal flooding, as well as potential ways, means, approaches, and strategies to build the resiliency of the County to withstand sea level rise and future storms.

This document assesses the vulnerability of the County’s infrastructure, private property, and natural resources; identifies potential action strategies; recommends the most feasible short-term, medium-term, and long-term strategies; and identifies implementation plan recommendations and timeline to build resiliency in the County.

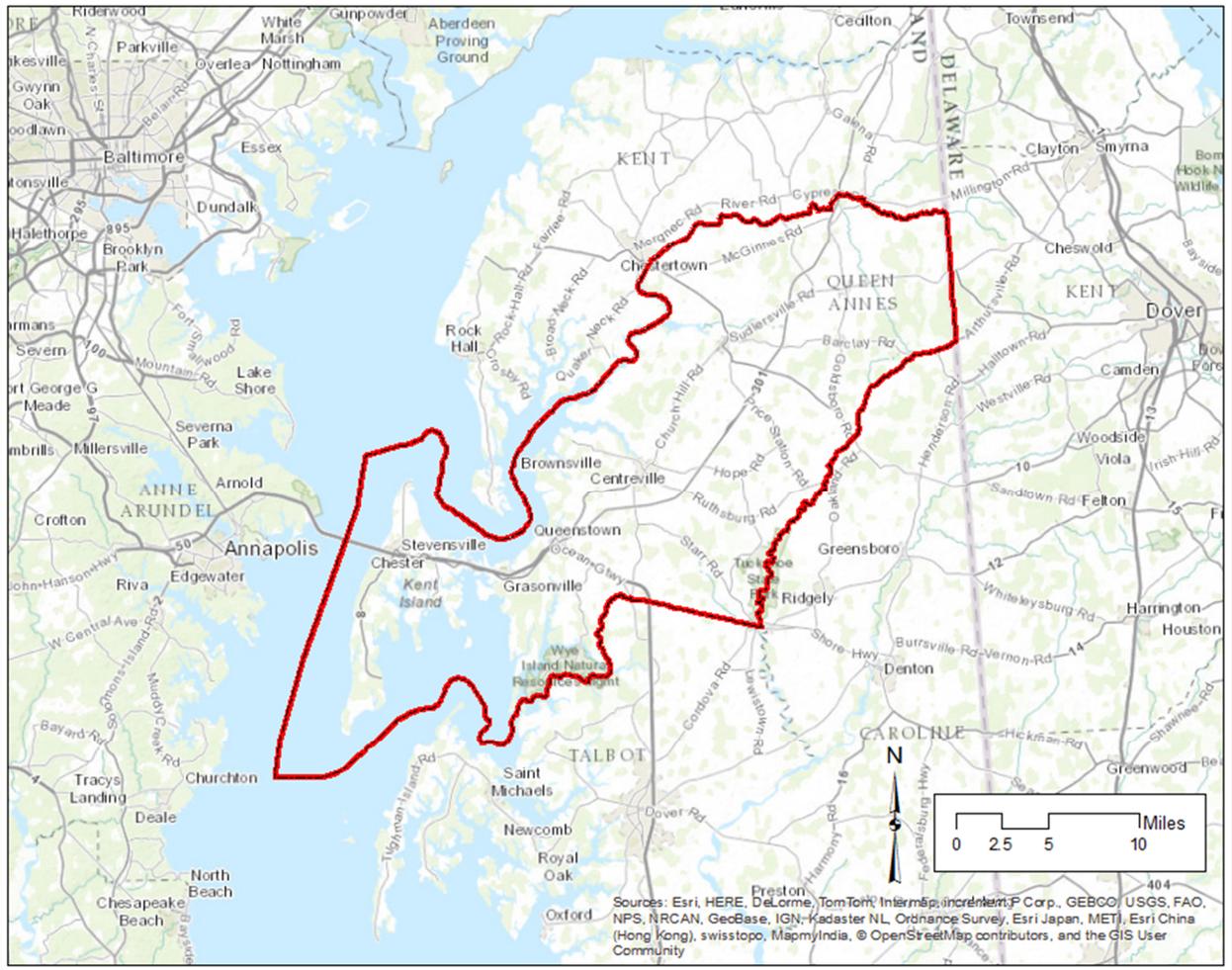


FIGURE 2: QUEEN ANNE’S COUNTY LOCATION MAP

Coastal Flooding in Queen Anne’s County

The low lying, relatively undisturbed topography, high seasonal water tables, poor drainage, and high runoff characteristics of the soils in QACO combine to provide a high flooding potential. When heavy rainfall and high river discharge combine with storm tides, low lying areas adjacent to rivers and estuaries become inundated with saltwater. Major floods in QACO have occurred in 1933, 1954, 1955, 1960, 1972, 1999, 2003, 2008 and 2011 (Reference 3). The following are detailed records of documented historical coastal flood damage:

- In late October 1954, Hurricane Hazel caused extensive damage to QACO. Damage estimates were placed at approximately \$500,000. One hundred people were evacuated from Kent Narrows as a result of high storm tides. The storm tides in the Towns of Centreville and Queenstown were reported as the highest in history. The storm tide flooded the office of Valiants Fertilizer in Centreville. Two 18,000-gallon, empty oil tanks were overturned at the Thocar Oil Company by the high tide. Many boats were washed ashore by the high winds and tide (Reference 4).

- During August 1955, Hurricane Connie struck QACO. Advance warning made it possible for residents to prepare their property against high water, drastically reducing property damages in comparison with Hurricane Hazel (Reference 4).
- On September 18, 2003, Hurricane Isabel caused a record-breaking tide and storm surge up the Chesapeake Bay, heavy rain and strong power outage producing winds. In QACO, public and private damage was estimated at 27 million dollars. Thirty-seven homes were destroyed, 151 suffered major damage and 192 suffered minor damage. Most of the damage was caused by tidal flooding, although four homes were damaged by fallen trees. The heavy rain did not coincide with the tidal flooding and there were no reports of stream related flooding (Reference 5). The maximum observed water level was 1.262 meters (4.14 feet) higher than the mean higher high water tide elevation in Cambridge, Maryland (Reference 6).
- Coastal flooding occurred on January 25, 2010 in QACO as strong south winds up the Chesapeake Bay produced a high tide. Flooding occurred in the Kent Narrows area and along Maryland State Route 18 near Dundee Avenue and Love Point causing closure of the road in both locations (Reference 5).



FLOODING OF STREETS DURING HURRICANE ISABEL.

In addition to coastal flooding due to storm surges, several other significant rainfall and storm related wind events have occurred in the County which caused riverine flooding, property damage, emergency evacuations, road closures, and loss of life. Although none of the significant rainfall events coincided with elevated storm tides, future SLR will only exacerbate the effects of rainfall-induced storm events.

Sea Level Rise

SLR is not a new problem, but its historic rate is rapidly increasing according to multiple sources (References 7-9). Sea level trends have been recorded by tide stations, which measure the height of water referenced to a stable point on land with a known elevation (benchmark). Tide stations are primarily installed for navigational purposes and their data are used to make tide predictions. Long term data sets from these tide stations have also been used to understand local and global sea level trends. Globally, sea level rises for two primary reasons: expansion of saltwater as it warms and loss of ice on land (Reference 7). Other local phenomena, conditions, and processes can also contribute to SLR. As the ocean absorbs solar radiation in excess of what it emits, the water warms. When water warms, it expands and causes the average level of the water to rise. In addition, as the Earth becomes warmer, land-based glaciers and ice-caps melt and slide into the sea. This melt-water and ice empties into oceans and causes the average level of the water to rise. In combination, these two forces constitute the global rate of SLR. The global sea level rate during the twentieth century, as determined by tide gauge measurements, was about 0.07 inches per year (or about 7 inches over 100 years) (Reference 7). Tide gauges indicate that the change in the local mean sea level in Maryland is greater than the global sea level rate. The rate of change recorded at the tide gauge in Annapolis, Maryland is 0.14 inches per year (or 14 inches over 100 years), as compared to global rate of 0.07 inches per year. This difference is due to the vertical movement of the Earth's crust, which is causing the land in the Mid-Atlantic to slowly sink. This combined motion of the

land and the sea is recorded by tide stations. Figure 3 shows the mean sea level trend at a tide station in Annapolis, Maryland. Other tide stations throughout the Mid-Atlantic show similar trends.

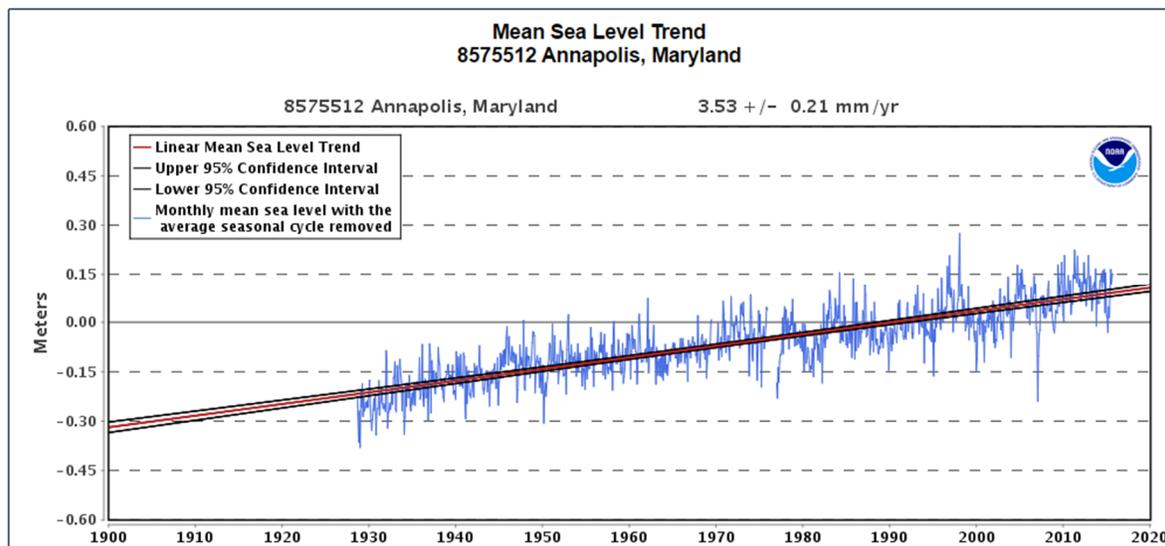


FIGURE 3: MEAN SEA LEVEL TREND AT ANNAPOLIS, MARYLAND

In 2007 the Intergovernmental Panel of Climate Change (IPCC) indicated that the rise in global mean sea level (GMSL) would not likely exceed 0.52 m (1.7 ft) by the end of the century. However, the IPCC explicitly excluded future changes in flows from polar ice sheets that, at that time, could not be confidently modeled based on the peer-reviewed literature (Reference 8).

Since 2008, there has been additional scientific literature to indicate that sea level is likely to rise more than estimated by the IPCC 2007 assessment (Reference 8). In 2011, the U.S. Army Corps of Engineers (USACE) issued guidance for USACE projects specifying three SLR scenarios – low (0.5 m, 1.6 ft), medium (1.0 m, 3.3 ft) and high (1.5 m, 4.9 ft) of GMSL and an adjustment based on the local rate of vertical land movement (Reference 9), shown in Figure 4.

Governor Martin O’Malley issued an Executive Order on Climate Change and “Coast Smart” Construction in December 2012. The order directed that “The Scientific and Technical Working Group (STWG) shall review the sea-level rise projections in the Maryland Climate Action Plan (2008) and shall provide updated projections based on an assessment of the latest climate change science and federal guidance.” The STWG

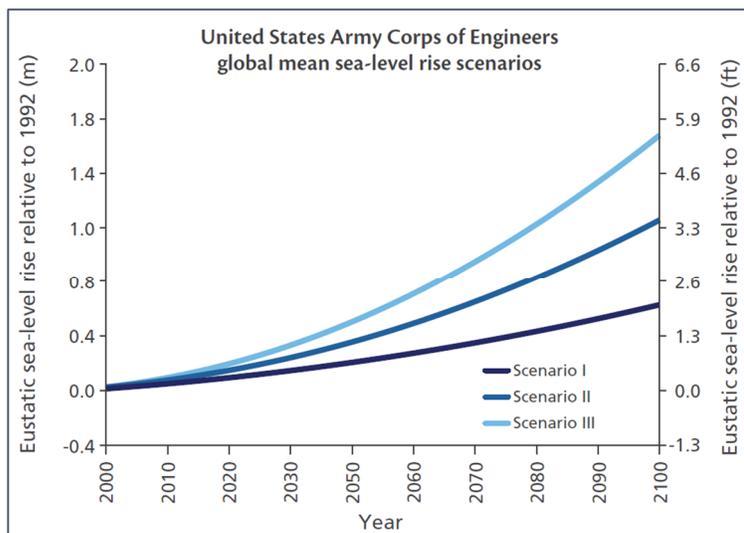


FIGURE 4: USACE GLOBAL MEAN SLR SCENARIOS

reviewed several assessments and studies to narrow the probable range of relative SLR based on the latest science including two important assessments of projected SLR by the National Research Council (Reference 10) and the U. S. National Climate Assessment (Reference 11).

Several recent papers provide a detailed analysis of SLR trends as measured by tide gauges along the Mid-Atlantic coast. The STWG report notes that these papers consistently show that sea level has been rising faster in the Mid-Atlantic region than elsewhere along the Atlantic coast and that the rate of SLR began to increase in the late 1980s. Figure 5 shows trends in relative sea level at tide gauges around the Chesapeake Bay (from STWG, 2013).

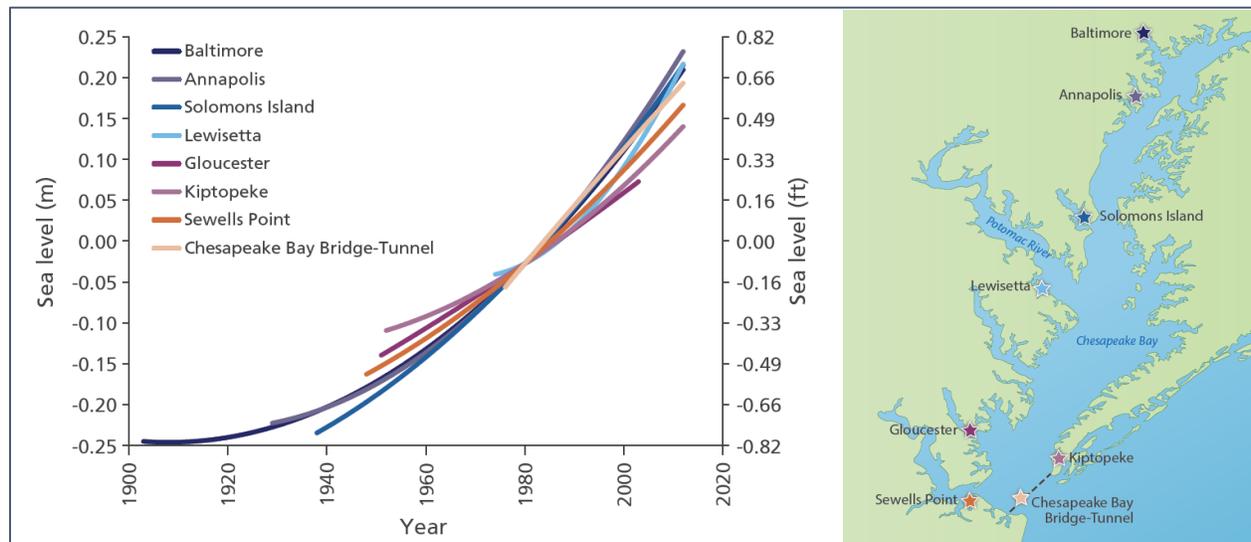


FIGURE 5: TRENDS IN RELATIVE SEA LEVEL AT TIDE GAUGES AROUND THE CHESAPEAKE BAY

The 2013 STWG assessment resulted in providing the best, low, and high projections of relative SLR in Maryland for 2050 and 2100 based on contributions of thermal expansion of the ocean, land-ice loss in glaciers and polar ice caps, vertical land movement (land subsidence) in the Mid-Atlantic, and regional ocean dynamics of the Chesapeake Bay. These projections are as shown in Table 4.

TABLE 4: SCIENTIFIC AND TECHNICAL WORKING GROUP MARYLAND RELATIVE SEA LEVEL RISE PROJECTIONS

Maryland Relative SLR	Relative SLR (meters)	Relative SLR (feet)
2050 Best	0.4	1.4
2050 Low	0.3	0.9
2050 High	0.7	2.1
2100 Best	1.1	3.7
2100 Low	0.7	2.1
2100 High	1.7	5.7

The STWG also provided the following practical advice for adaptive planning:

1. It is prudent to plan for relative sea-level rise of 2.1 feet by 2050 in order to accommodate the high end of the National Research Council (NRC) projections as adjusted for regional factors particular to Maryland. Based on the various methodologies available today, it is very unlikely to rise more than that within that timeframe. This would essentially constitute an increase in mean sea level, on top of which storm surge would have to be factored in, to judge the risks to land-based facilities.
2. Providing planning advice for the end of the century is more challenging, both because the actual greenhouse gas emissions trajectory is unknown and because of greater uncertainties in the models of sea-level response, particularly regarding the rate of loss of the mass of polar ice sheets. How one should use the guidance provided by our projections depends both on the longevity of investments at risk and the acceptance of risk. For example, if one were concerned about an investment in facilities or public infrastructure the useful life of which is not intended to extend beyond this century or which could tolerate very occasional inundation, one might find it acceptable to use our Best projection of sea-level rise of 3.7 feet for adaptation planning. If, on the other hand, one is concerned about facilities and infrastructure intended to be useful well into the next century or for which any risk of inundation is unacceptable, it might be prudent to use our High projection of relative sea-level rise of 5.7 feet. Furthermore, planners and engineers should also take into consideration anticipated changes in storm surge heights and tidal flood levels as a result of future sea-level rise, a subject deserving further research.
3. The projections presented here are improvements on those used in the 2008 Maryland Assessment because they are based on the recent process-based projections by the National Research Council and include a range of possibilities that reflect uncertainties about greenhouse gas emissions and the responses of climate and land ice. In contrast with the scenario-based approaches used in the U.S. Army Corps of Engineers guidance, the National Climate Assessment, and adaptation planning in the neighboring states of Delaware and Virginia, these new projections also narrow the range of possibilities and define probabilities based on current scientific evidence. Because our scientific understanding will continue to improve and the trajectories of greenhouse gas emissions will become clearer over time, periodic updating of these sea-level rise projections should be undertaken. Certainly, the new sea-level rise projections in the forthcoming Intergovernmental Panel on Climate Change (IPCC) should be considered.
4. Maryland's Climate Action Plan addresses both actions taken to limit the magnitude of climate change (commonly referred to as mitigation) and those taken to adapt to climate change. This is appropriate as they are two sides of the same coin: adaptation is required even if aggressive mitigation is undertaken, but without mitigation adaptation becomes increasingly daunting. This is particularly evident with regard to sea-level rise, which will continue to occur through this century and into the next as a result of the global warming that has already occurred. Furthermore, global warming will be substantially greater in subsequent centuries, unless greenhouse gas emissions are substantially reduced during this one.

Based on this advice for adaptive planning and discussions with QACO representatives at the project kickoff meeting, this study uses 2.0 feet and 4.0 feet as relative SLR projections for 2050 and 2100 respectively, to identify vulnerable coastal areas, and to enable planning for building resiliency of the identified areas.

Storm Surge

As sea levels rise, temporary flooding from coastal storm events may become more widespread. As sea levels increase, so do the storm surge heights generated by a given storm. An increased storm surge height, combined with resulting loss of tidal wetlands that provide natural flood protection may result in increased flood depths and erosive forces in already flood-prone areas. It may also cause flooding in areas further inland that have not previously been flood-prone.

While increased storm surge heights and flooding is an important consideration for understanding the potential range of effects caused by SLR, modeling specific storm surge impacts countywide is a complicated and resource-intensive undertaking that was outside the scope of this assessment. For this reason, the 100-year storm surge elevation for QACO as reported by FEMA in their 2014 Flood Insurance Study (FIS), averaged Countywide, is used in this assessment to assess the vulnerability of several resources discussed in Section 4 of this report. Table 5 summarizes the range of storm surge stillwater elevations for the 10-Percent-Annual-Chance (10-Year), 2-Percent-Annual-Chance (50-year), 1-Percent-Annual-Chance (100-Year), and 0.2-Percent-Annual-Chance (500-Year) floods from the FEMA FIS based on tidal and wind setup effects. It is important to note that the 100-Year storm event does not imply that this magnitude of storm will only occur once every one hundred years but that it is a storm that statistically has a one-percent chance of occurring in any given year. All elevations are reported in feet and reference the North American Vertical Datum of 1988 (NAVD88).

TABLE 5: FEMA COASTAL STORM SURGE STILLWATER ELEVATIONS

Flooding Source and Location	10-Year	50-Year	100-Year	500-Year
<u>CHESTER RIVER</u>				
From the mouth of the Corsica River to Kent Narrows	3.8-4.2	4.4-4.9	4.6-5.1	5.5-6.2
<u>CHESAPEAKE BAY</u>				
From Kent Narrows to William Preston Lane, Jr. Memorial Bridge	3.7-3.9	4.2-4.5	4.4-4.7	5.4-5.7
From William Preston Lane, Jr. Memorial Bridge to the mouth of the Eastern Bay	3.5-3.7	4.0-4.2	4.3-4.4	5.1-5.4
<u>CRAB ALLEY</u>				
Entire Shoreline	3.7-3.9	4.2-4.4	4.4-4.6	5.6-6.0
<u>EASTERN BAY</u>				
From the mouth to the mouth of Crab Alley Bay	3.5-3.9	4.1-4.2	4.4-4.6	5.6-6.0
From the mouth of Prospect Bay to Bennett Point	3.7-3.8	4.2-4.3	4.4-4.5	5.4-5.8
<u>PROSPECT BAY</u>				
Entire Shoreline	3.8-3.9	4.3-4.5	4.5-4.8	5.5-6.4

For the purposes of this study an average 100-year storm surge elevation of 4.6 feet is used to represent the storm surge countywide.

It should also be noted that the effects of wave heights associated with coastal storm surge flooding are not represented in this study. FEMA’s FIS indicates a range of significant wave heights from 0.5 feet in the upper portions of the Chester River and Cox Creek to 4.7 feet along the western shore of Eastern Bay. Generally within the County, greater wave heights are expected where water depth is greater and fetch length is longer such as in the Chesapeake Bay and Eastern Bay where the coastline is more prone to damaging wave action during high wind events due to the significant fetch over which winds can operate. From the mouth of the Chester River further upstream, the fetch considerably shortens to be within the river channel, therefore lower wave heights are anticipated. Although not mapped herein, wave prone areas should be considered in future resiliency planning.

Tidal Datums

With any coastal study it is important to understand tidal datums relative to land-based topographic data. For this study, the National Oceanic and Atmospheric Administration’s (NOAA’s) Tide Station 8571892 was used to determine tidal datums. Station 8571892 is located in Cambridge, Maryland on the Choptank River just downstream of US 50 and was established in October 1980. Tidal datums from NOAA for this station are shown in Table 6, referencing Mean Lower Low Water (MLLW). A datum adjustment is also shown to reference NAVD88 datum for comparison to LiDAR-based topographic data provided by QACO.

TABLE 6: TIDAL DATUM SUMMARY – TIDE STATION 8571892

Datum	Elevation (ft, MLLW)	Elevation (ft, NAVD88)
Highest Observed Water Level (09/19/2003)	6.18	5.08
Mean Higher High Water (MHHW)	2.04	0.94
Mean High Water (MHW)	1.83	0.73
North American Vertical Datum (NAVD88)	1.11	0.00
Mean Tide Level (MTL)	1.02	-0.09
Mean Sea Level (MSL)	1.01	-0.09
Mean Low Water (MLW)	0.21	-0.90
Mean Lower Low Water (MLLW)	0.00	-1.11
Lowest Observed Water Level (01/17/1982)	-2.88	-3.99

For this study, coastal vulnerability area maps and resource impact maps were produced to depict potentially vulnerable areas due to sea levels at mean higher high water. In QACO, there are two high tides per day. Of those two high tides, one rises slightly higher than the other. Mean higher high water is calculated by taking the average of the higher of the two high tides each day, observed over a nineteen year period called the Tidal Datum Epoch. When compared to the topographic data used in this study to prepare mapping, the MHHW occurs at elevation 0.94 feet. Any reference to “high tide” in this document refers to MHHW.

2. VULNERABILITY ASSESSMENT METHODS

This vulnerability assessment was conducted to understand the effects of SLR and coastal flooding in QACO, identify locations of increased risk and vulnerability, and map the extents of potentially vulnerable areas within the County. This assessment provides detailed information regarding which resources will be impacted, where the impacts will occur, and provides information for resiliency planning. The methodology used in the assessment included data collection and mapping using GIS tools and geospatial data. Findings of the vulnerability assessment, including identifying impacts is discussed in Section 3.

Data Collection

To prepare an in-depth vulnerability assessment, it is necessary to have accurate geospatial datasets that include both tabular data to identify specifics of the information and spatial data that can be presented on a map. QACO maintains a robust Geographic Information System (GIS) database with many datasets of the County's resources. County staff provided many datasets and other datasets were retrieved from publically available sources. A total of 34 datasets were obtained and utilized as part of this assessment. In most cases, existing data was used for this assessment. Creating, improving, editing, and/or updating datasets was outside of the scope of this assessment, however, a few datasets were generated based on other data, information, and/or maps from the County. Appendix D lists all datasets used in this assessment and the source of the data.

SLR and Coastal Vulnerability Scenarios

The 1-foot contour interval County LiDAR data was used to develop a three-dimensional terrain model of the existing ground Countywide. Three scenarios were developed using a "bathtub" model that floods all land below a specified elevation. A map was produced showing inundation limits of each scenario. The following three scenarios were modeled and mapped to assess coastal vulnerability areas:

Scenario 1 – 2050 projected SLR plus MHHW: This scenario uses two feet of SLR plus MHHW of 0.94' to assess risk and potential impacts to all land Countywide below elevation 2.94'.

Scenario 2 – 2100 projected SLR plus MHHW: This scenario uses four feet of SLR plus MHHW of 0.94' to assess risk and potential impacts to all land Countywide below elevation 4.94'.

Scenario 3 – 2050 projected SLR plus MHHW plus storm surge: This scenario uses two feet of SLR plus MHHW of 0.94' plus 4.6' (FEMA storm surge) to assess risk and potential impacts to all land Countywide below elevation 7.54'. It should be noted that Scenario 3 models the temporary impact of storm surge in addition to the permanent effects of SLR.

Additional scenario combinations using different SLR projections, various tidal datum, varying storm surge depths, and/or wave heights could all be modeled, however additional scenario modeling is not a part of this scope. These three scenarios were selected as the best representative scenarios for preparation of short-term and long-term adaptation strategies. As sea level rises, storm surge and wave heights will change based on changes in bathymetric depths, potential for increased fetch lengths and wind energy input, and changes in vegetation and other structures that dissipate wave energy. For this reason, 2100 SLR projections have not been coupled with the storm surge for this assessment.

Coastal vulnerability areas have been mapped for each scenario and corresponding maps are included in Appendix A. Each of the resource datasets were intersected with the coastal vulnerability areas using ArcGIS to identify and quantify impacted resources for each scenario. The impact results of each assessed resource is presented in Section 3 of this report. Public safety and infrastructure resource impact maps are included in Appendix B and natural resource and land use impact maps are included in Appendix C.

3. SEA LEVEL RISE VULNERABILITY ASSESSMENT FINDINGS

This vulnerability assessment indicates that permanent inundation from SLR will impact a number of resources within the County. This section identifies areas vulnerable to SLR by Study Area and quantifies vulnerable resources by Public Safety and Infrastructure, as well as by Natural Resources and Land Use, both by Study Area and Countywide. Temporary impacts due to storm surge are described in Section 4 of this report.

Study Areas

Four study areas have been included for mapping purposes. The four study areas match the County’s Commissioner Districts (CCD) for ease of mapping (ie., CCD 1 = Study Area 1, etc.). Figure 6 shows a map of the County’s Commissioner Districts (from QACO Comprehensive Plan) and Table 7 shows potential land inundation (including wetlands) by acreage and percent of land area for the County as a whole and for each Study Area. Countywide, 2.6% and 4.1% of land is inundated by SLR Scenarios 1 and 2 respectively. In Study Areas 3 and 4 these values increase substantially, emphasizing the importance of short- and long-term resiliency planning. As shown in Table 7, the vulnerability to SLR varies throughout the County. The resources at risk in the County vary from loss of homes to utility disruption to loss of natural resources and habitat.

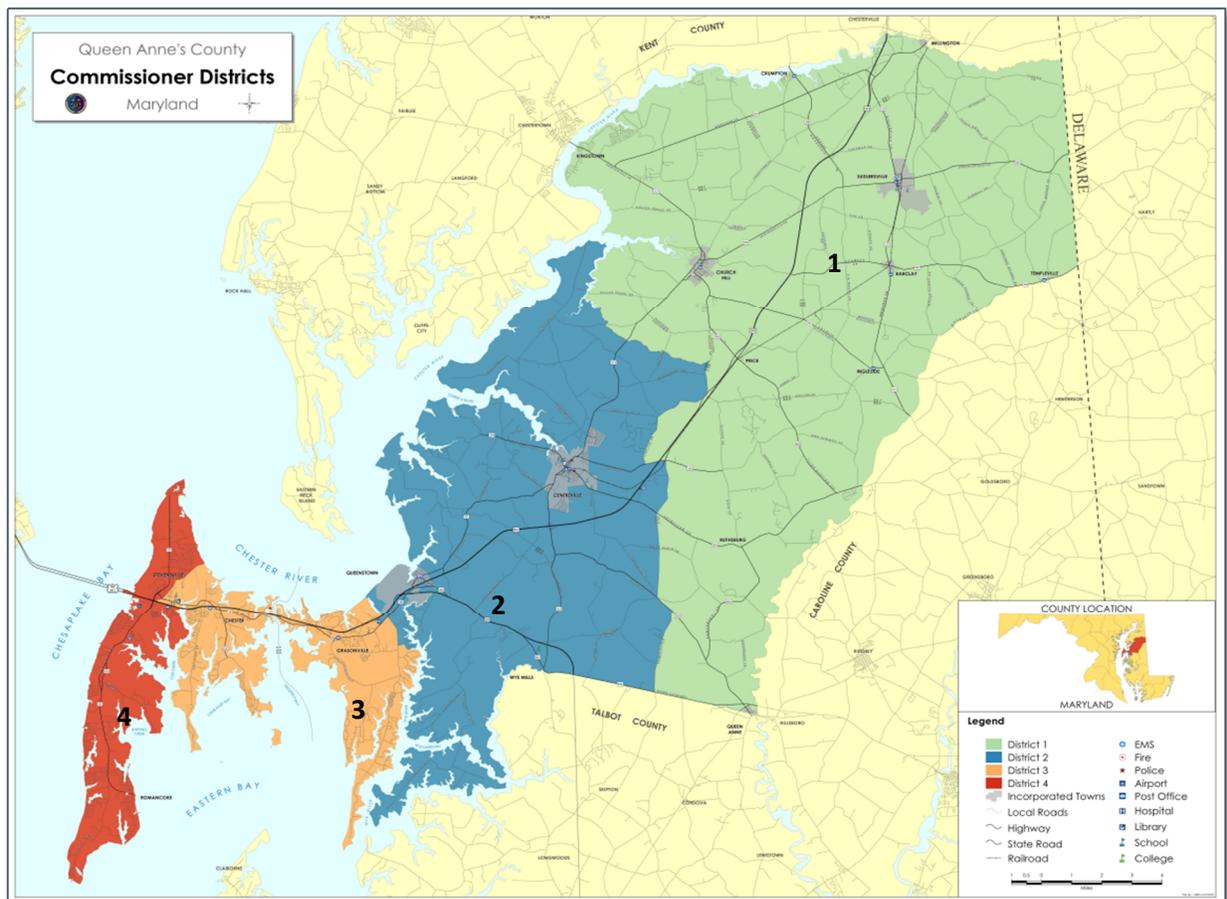


FIGURE 6: QUEEN ANNE’S COUNTY COMMISSIONER DISTRICT MAP

TABLE 7: TOTAL ACREAGE VULNERABLE TO SEA LEVEL RISE

Study Area	Total Land Area Acres	Area Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	136,345	700	1,061	0.5%	0.8%
2	72,382	1,800	2,662	2.5%	3.7%
3	15,445	2,114	3,520	13.7%	22.8%
4	13,145	1,463	2,479	11.1%	18.9%
Countywide	237,318	6,077	9,722	2.6%	4.1%

Study Area 1

Study Area 1 is located in the north and east portions of the County covering approximately 213 square miles. Although this portion of the County is generally higher in elevation, tidally-influenced coastline exists along reaches the Chester River, Island Creek, Southeast Creek, and Tuckahoe Creek. Of the total land area in Study Area 1, 0.5% and 0.8% is vulnerable to SLR of 2 feet and 4 feet respectively.

Study Area 2

Study Area 2 is located in the central portion of the County covering approximately 113 square miles. Tidally-influenced coastline exists along reaches of the Chester River, Wye River and their tributaries. Of the total land area in Study Area 2, 2.5% and 3.7% is vulnerable to SLR of 2 feet and 4 feet respectively.

Study Area 3

Study Area 3 is located generally in the western portion of the County covering approximately 24 square miles. Tidally-influenced coastline exists along reaches of the Chester River, Wye River, Eastern Bay, Prospect Bay, Crab Alley Bay, and their tributaries. Of the total land area in Study Area 3, 13.7% and 22.8% is vulnerable to SLR of 2 feet and 4 feet respectively.

Study Area 4

Study Area 4 is located in the far west portion of the County. It includes the western portion of Kent Island and covers approximately 21 square miles. Tidally-influenced coastline exists along reaches of the Chesapeake Bay, Chester River, Eastern Bay and their tributaries. Of the total land area in Study Area 4, 11.1% and 18.9% is vulnerable to SLR of 2 feet and 4 feet respectively.

Public Safety and Infrastructure

The effects of SLR and coastal flooding on infrastructure is relatively straightforward as SLR and coastal flooding result in damage or reduced usefulness of a resource. Public safety is more complex and subjective when social and health aspects are factored in to the assessment. For the purposes of this study, public safety is assumed to be relevant when public and private infrastructure resources are impacted and is not discussed herein independently.

QACO is home to nearly 50,000 people, living in approximately 17,300 households of which 84.5% are owner-occupied (Reference 1). The County's sustainable smart growth management strategy aims to direct growth to existing population centers positioned around existing towns with the intent of providing cost-effective public facilities, reducing impacts of traffic, providing employment opportunities, reducing impacts on the environment, and reducing development encroachment in the rural agricultural areas (Reference 2). Understanding the coastal vulnerability of these "planning areas" will facilitate long-term resiliency during the planning, design, and development of these areas.

Based upon available public and private infrastructure data, tables were generated in ArcGIS that described the vulnerable areas under each of the three SLR and storm surge scenarios. Specific public infrastructure resources assessed include:

- Emergency service facilities
- Evacuation routes
- Roads and bridges
- Schools
- Wastewater facilities
- Water supply
- Other utilities

Specific private infrastructure resources assessed include:

- Private residential property
- Commercial development

Other resources considered for which data was not available include boat ramps, underground pipeline utilities, contaminated sites, underground storage tanks, private septic systems, and a comprehensive list of piers. Additionally, solid waste facility data was not available. In May of 1986, QACO entered into a Memorandum of Understanding with Maryland Environmental Service (MES) to develop the Mid-Shore Regional Solid Waste (MSRSW) facilities to serve Queen Anne's, Caroline, Kent, and Talbot Counties with each hosting an operating landfill for a period of twenty years (Reference 2). The County currently oversees the operation of five County transfer stations but QACO is not scheduled to host a Mid-Shore Regional Solid Waste Facility until possibly 2030 (Reference 2).

It is important to consider that impacts to infrastructure occur at discrete locations but the overall impact may be far reaching. For example, if a bridge loses function during a storm surge event, the impacts may include losing emergency access to a large geographical area. Impacts to infrastructure are quantified based on an appropriate unit but may not convey the overall impact.

The assessed resources that contain buildings associated with a property have been divided into two distinct impact tables – one to show impacts to property and the other to show impacts to the structure itself. Note that the structure impacts are based on GIS lateral coverage and not by elevation. Structures may have finished floors elevated above the flooding elevation. Impacted properties may only affect a portion of the property that are lower in elevation but may not impact the access or use of the building. In addition, there are many vacant parcels that have impacts.

Emergency Service Facilities

This resource includes critical facilities such as emergency medical services (EMS) stations, fire stations, police stations, emergency shelters and hospitals. QACO has seven (7) EMS stations, ten (10) volunteer fire stations five (5) police stations, one (1) department headquarters, twenty-four (24) emergency shelters and five (5) medical centers. For the purposed of this report these 52 facilities were combined into a single emergency service facility resource. Please note that the majority of the emergency shelters are also schools and therefore these impacts are also tabulated in the School section.

Emergency service facility data was obtained from QACO. There are no impacts to emergency service facility buildings or properties in Study Area 1.

In Study Area 2, the following facilities are affected:

- The Wye Research and Education Center property, which is designated as a temporary emergency shelter, is impacted by Scenarios 1 and 2; however, the building itself is not impacted by either SLR scenario.
- The Agriculture Center UMD Research property, which is also designated as a temporary emergency shelter, is impacted by Scenarios 1 and 2; however, the impacts are located in a wooded section of the property. The building itself is not impacted by either SLR scenario.

In Study Area 3, the following facilities are affected:

- QACO Sherriff Kent Narrows Substation property is impacted by Scenarios 1 and 2; however, the building itself is not impacted by either SLR scenario.
- EMS Station 200 property will be impacted by Scenarios 1 and 2 and the building will be impacted by Scenario 2. In addition, the entrance to the facility and several surrounding roads are impacted.
- The Stevensville Middle School property, which is designated as a temporary emergency shelter, is impacted by Scenarios 1 and 2; however, the building itself is not impacted by either SLR scenario.
- The Bayside School and Grasonville Senior Center properties, which are designated as temporary emergency shelters, are impacted by Scenario 2; however, the buildings are not impacted by either SLR scenario.

In Study Area 4, the following facilities are affected:

- EMS Station 100 property is impacted by Scenario 2; however, the station is located on a large, County-owned parcel and the impacts are not in the proximity of the building.
- The Matapeake Elementary School and Middle School properties, which are designated as emergency shelters, are impacted by Scenario 2; however, the building itself is not impacted by either SLR scenario and the property impacts are limited to the northern periphery of the property.

Table 8 and Table 9 summarize the number and percent of emergency service facility property and buildings vulnerable to SLR using all scenarios respectively.

It is important to note that building impacts noted herein are based on lateral extents of the topography and building footprint. Finished floor elevations have not been determined as a part of this study. It is possible that while an impact is determined by lateral extents on the mapping, the usable portions of the

buildings may not be inundated by elevation. Also note that the property impacts listed in Table 8 can vary from minor impacts limited to the periphery of the property to significant impacts that limit or block access to the property buildings.

TABLE 8: EMERGENCY SERVICE FACILITY PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	10	0	0	0.0	0.0
2	22	2	2	9.1	9.1
3	14	3	5	21.4	35.7
4	6	0	2	0.0	33.3
Countywide	52	5	9	9.6	17.3

¹ Note that impacts may only represent a portion of the property

TABLE 9: EMERGENCY SERVICE FACILITY BUILDING IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	10	0	0	0.0	0.0
2	22	0	0	0.0	0.0
3	14	0	1	0.0	7.1
4	6	0	0	0.0	0.0
Countywide	52	0	1	0.0	1.9

Evacuation Routes

Evacuation routes have been identified throughout the County for the immediate and urgent movement of residents away from the threat or occurrence of a hazard such as an approaching weather system. The Delmarva Emergency Task Force (DETF) has determined primary and secondary emergency evacuation routes for the Delmarva Peninsula, including QACO. The identified routes within the County include Routes 8, 18, 19, 50, 213, 290, 300, 301, 302, 304, 309, 313, 405, 481, 544, and various connected local roads. The evacuation route dataset was obtained from the Maryland State Highway Administration (SHA).

Table 10 summarizes the impacted evacuation routes (both primary and secondary combined) by miles of roadway and percent of total resource.

Evacuation route impacts are primarily located at bridges adjacent to tributaries of the Chester River as well as coastal waters of the Chesapeake Bay. It is difficult to determine the actual impacts to the bridge structures and roadway as the LiDAR data does not include bridge deck elevations. A portion of the total impacts shown in

Table 10 may not be actual impacts due to the presence of high-level bridge decks. The following paragraphs describe known impacts to evacuation routes based on roadway elevations not associated with bridges.

In Study Area 2 roadway impacts occur at MD 213 in the Town of Centreville where Scenario 2 inundates a portion of the roadway near the Mill Stream Branch crossing. MD 18 is inundated by both SLR scenarios in the Town of Queenstown near Thompson Avenue.

In Study Area 3 portions of MD 18 are impacted near Gravel Run Road in Scenario 2 and much of the roadway near the Kent Narrows and Cox Creek areas to varying stages in both Scenarios 1 and 2.

In Study Area 4 significant impacts to MD 8 occur in Scenario 2 near Broad Creek, effectively cutting off transportation to the southern portion of Kent Island. Route 8 is also impacted at Carter Creek and Holligans Snooze Inlet in Scenario 2.

TABLE 10: EVACUATION ROUTE IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Miles	Miles Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	139.6	0.22	0.25	0.16	0.18
2	69.7	0.02	0.14	0.03	0.20
3	27.8	1.02	3.06	3.67	11.02
4	21.3	0.12	0.73	0.56	3.43
Countywide	258.3	1.38	4.18	0.53	1.62

Piers

Digital data was not available for pier locations, however, the County requested that two piers in particular be considered: the Matapeake Pier and the Romancoke Pier. These piers are county-owned and could be used for a boat-based evacuation during an emergency.

Pier elevations are unknown, therefore an analysis was done based on the ground elevations surrounding the pier at the shoreline. If the area around the beginning of the pier is inundated then it was assumed that the pier would be overtopped or not accessible during an event.

The Romancock Pier has the following impacts:

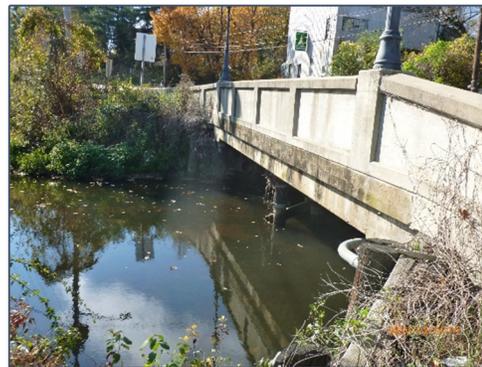
- The eastern portion of the parking area is impacted by Scenario 1.
- Scenario 2 appears to overtop the pier based on the ground elevations where the pier meets the shoreline.

The Matapeake Pier has the following impacts:

- Scenario 1 appears only to impact the boat ramp.
- Scenario 2 appears to be close to overtopping the pier.

Roads and Bridges

Roads and bridges are essential infrastructure that act as the major source of transportation in QACO. Typically, in this location, roadways are lower than adjacent land so that land can drain into the streets. As such, roads typically flood before adjacent land. Even minor flooding on major roads can cause widespread transportation impacts. SLR can affect flooding frequency on roads as well as increased nuisance flooding as floodwater will evacuate low lying roadways at a higher elevation. SLR will also reduce clearances of bridges resulting in less flood flow conveyance and causing roadways to overtop due to storm events.



**TIDALLY-INFLUENCED BRIDGE IN
CENTREVILLE OVER MILL STREAM BRANCH.**

Per the County road data, there are approximately 1080 miles of road in QACO. Approximately 270 miles of the roads in the County are maintained by SHA based on roadway data from SHA. QACO Public Works County Roads Division maintains approximately 547 miles of roads and 32 bridges.

Road centerline data was obtained from QACO. A comprehensive bridge dataset was not available. Due to the complex nature of assessing vulnerability to bridges, impacts are not quantified in this study. However, it is important to identify potential bridge-specific impacts for future transportation planning efforts.

Impacts to roadways in Study Area 1 are located primarily adjacent to the Chester River. Impacts to roadways in Study Area 2 are located primarily adjacent to the Corsica River and Reed Creek. Impacts to roadways are significant in Study Area 3, impacting several roads in the Kent Narrows, Prospect Bay, and Cox Creek areas. MD 18 through the Kent Narrows area is inundated by both SLR scenarios. Long Point Road, Narrows Pointe Drive and Swan Cove Lane are blocked by Scenario 2, cutting off access to homes off of those roads. Significant roadway impacts are also seen in the Prospect Bay area with Dominion Road and Parson Island Road being blocked by Scenario 2, cutting off access to homes located on the southern tip of the peninsula. Cox Neck Road is also blocked by Scenario 2, cutting off access to homes on the southern portion of that peninsula. Roadway impacts in Study Area 4 are also significant with several roads being blocked in the Broad Creek area and the Romancock area by Scenario 2. In addition, MD 8 is blocked in several locations by Scenario 2, cutting off access to the homes located on southern Kent Island.

Table 11 summarizes the total road miles (including the evacuation routes) and percent of road miles vulnerable to SLR.

TABLE 11: ROADWAY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Miles	Miles Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	477.0	0.1	0.5	0.0	0.1
2	311.8	0.2	1.0	0.1	0.3
3	157.8	2.8	14.9	1.8	9.5
4	130.8	0.5	6.3	0.4	4.8
Countywide	1077.4	3.6	22.7	0.3	2.1

Schools

Schools were located using the QACO address point dataset. This data indicates 38 address points for schools. This includes multiple buildings for Chesapeake College and the Gunston Day School. For the purposes of this study this resource was assessed based on the building associated with each address point.

There are no impacts to the school buildings for either of the SLR scenarios, however there are noted impacts to four of the school properties. In Study Area 3, the Stevensville Middle School parcel will be impacted by both scenarios. The Bayside Elementary School parcel will also be impacted by Scenario 2. In Study Area 4, a small area on the northern edge of the Matapeake Elementary and Middle School property will be impacted by Scenario 2. The impacts are small and are primarily limited to wooded floodplain portions of the parcels and would likely not impact day-to-day activities. Table 12 summarizes the total number and percent of resource property that is vulnerable to SLR using all scenarios.

TABLE 12: SCHOOL PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	4	0	0	0	0
2	26	0	0	0	0
3	5	1	2	20	40
4	3	0	2	0	66.6
Countywide	38	1	4	2.6	10.5

¹ Note that impacts may only represent a portion of the property

Wastewater Facilities

Wastewater facilities are a critical infrastructure to maintaining quality of life and environmental quality. Infrastructure used for wastewater treatment include treatment facilities, pumping stations, and wastewater piping systems. Wastewater facilities are often located in low-lying areas to allow wastewater to drain via piping systems by gravity to the collection and treatment plants. Where flow by gravity is not possible, pump stations are used to move wastewater to treatment plants.

There are five wastewater treatment plants (WWTP) located within QACO: Kent Narrows/ Stevensville/ Grasonville (KNSG) WWTP, Queenstown WWTP, Centreville WWTP, Church Hill WWTP, and Sudlersville/ Barclay WWTP (Reference 10). Additionally, the Town of Millington has a collection/treatment system, Prospect Bay has a private system, several institutional and private facilities have private systems, and residents use individual septic tanks in Crumpton, Barclay, Queen Anne, and Templeville. The Queen Anne’s Sanitary Sewer Service Areas Map in the 2010 Comprehensive Plan indicates 14 pumping stations throughout the County.

Wastewater treatment plants were located using the QACO address point dataset. The dataset indicates five Municipal facilities, plus the Town of Millington Facility, which matches the Comprehensive Plan map. Addresses were provided for 14 vacuum collection stations, 10 sewage pumping stations and seven (7) sewage lift stations that are associated with the KNSG facility. These addresses were digitized for inclusion in this analysis. Sewer piping was not available in digital format and has not been used in this assessment.

It is important to note that this simple assessment tells us whether a facility is within an area that is potentially vulnerable to SLR and/or coastal flooding based on the existing ground elevation adjacent to the treatment plants. To fully assess the impact on treatment plants, critical equipment elevations would be required. Impacts generally occur on low-lying portions of the sewage treatment plant parcels. There are no direct building impacts in SLR Scenarios 1 or 2. Table 13 summarizes the number and percent of the resource vulnerable to SLR using all scenarios. Note that parcel impacts could potentially impact the functionality and/or operations of the sewage treatment plant or other assets. The parcel impacts should be considered in more detail with consideration given to outfall elevations in order to determine the severity of the impacts.

TABLE 13: WASTEWATER TREATMENT PLANT PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	3	1	1	33	33
2	2	2	2	100	100
3	0	0	0	0	0
4	1	0	1	0	100
Countywide	5	3	4	60	80

¹ Note that impacts may only represent a portion of the property

TABLE 14: SEWER STATION IMPACTS DUE TO SEA LEVEL RISE

Sewer Station	Total Number	Number Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2
Vacuum Stations	14	2	11
Pumping Stations	10	0	2
Lift Stations	7	0	0

Water Supply

Water supply in QACO primarily is derived from groundwater extraction wells, stored in water towers, and distributed through pressure piping systems. Wells in QACO extract water from the Aquia aquifer, Magothy aquifer, and Lower Patapsco aquifer (Reference 10). MDE prohibits additional withdrawal from the Aquia on Kent Island due to saltwater intrusion (Reference 10). Saltwater intrusion is anticipated to increase as sea level increases.

The County has 11 water treatment plants and there are an additional four (4) town systems located throughout the County (Reference 10). Additional private and/or institutional systems are located within the County, along with individual private wells owned and maintained by County residents.

The County also has one (1) well house, two (2) water booster pump stations, nine (9) water towers and six (6) in-ground storage tanks. One in-ground storage tank is located at each of the following water treatment plants: Bridge Pointe, Grasonville, Stevensville and Thomson Creek. Oyster Cove has two in-ground storage tanks.

There are several impacts to water treatment plant properties, however no water treatment plant buildings are impacted under SLR Scenarios 1 or 2. The property of Oyster Cove is impacted by both SLR scenarios and the property of Thomson Creek is impacted by Scenario 2. The property of Riverside, located in Study Area 3, is also impacted by Scenario 2.

The well house, which is inactive, along with the water booster pump stations are not impacted by any of the SLR scenarios. The water towers are not impacted by either scenario. Since Oyster Cove water treatment plant is impacted by both SLR scenarios it is possible that the underground water storage tanks at this location could also be impacted. Similarly, since Thompson Creek water treatment plant property is impacted by Scenario 2, the in-ground storage tank at this location could potentially be impacted. Depending on the original design and construction of the storage tanks, the impacts could be minor to significant.

Table 15 below summarizes the number and percent of water treatment plant properties that are vulnerable to SLR using both scenarios.

TABLE 15: WATER TREATMENT PLANT PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	0	0	0	0	0
2	0	0	0	0	0
3	2	1	2	50.0	100.0
4	9	0	1	0	11.1
Countywide	11	1	3	9.1	27.3

¹ Note that impacts may only represent a portion of the property

Other Utilities

Two utility datasets were received from the County’s GIS database: Utility Points and Utility Lines. The datasets contain some duplicate layers and both contain unique layers. Layers contained in both datasets are noted below. The following are layers within the datasets that were included in the SLR impact analysis:

- Fire hydrants (both datasets)
- Dams
- Water towers (included under Water Supply Impacts)
- Catch basins (both datasets)
- Culverts
- Concrete drains (typically driveway culverts)
- Storm drain
- Drop inlets (both datasets)
- Manholes (both datasets)
- Pipes (both datasets)
- Stormwater Ponds
- Sub-stations
- Transformers
- Lamp posts
- Light poles
- Traffic Signal Pole
- Utility poles
- Utility boxes

The following are layers within the Utility datasets that were not included in the SLR impact analysis:

- Channel markers
- Concrete
- Guide wire
- Metal covers (both datasets)
- Signs (both datasets)
- Towers
- Traffic signals (both datasets)
- Valves (both datasets)

Data gaps include electrical generation and distribution, cable television lines, and telephone lines. Telecommunication towers were also downloaded from the QACO GIS website and are also assessed with the utility layers. Impacts are determined using the available data and each point or line are counted based on the datasets. Layers in multiple datasets are only counted once using the line dataset. Channel markers are not included in the impact summary due to their existing location in waterways. Elevation data is not included with the channel marker dataset but could be important planning information in the future as the sea level increases, potentially inundating the markers. Table 22 summarizes the number and percent of resource vulnerable to SLR using both scenarios. Note, some utilities are located in two study areas and therefore some impacts are counted twice.

TABLE 16: UTILITY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	13,846	24	56	0.2	0.4
2	10,653	55	131	0.5	1.2
3	10,062	611	1838	6.1	18.3
4	9,439	273	950	2.9	10.1
Countywide	43,943	988	2998	2.2	6.7

It is important to note that the impacts shown are based on lateral extents of the utilities and SLR inundation scenarios. Vertical elevations have not been evaluated which could lead to additional impacts. For example, storm drain systems are located underground and SLR can cause a backwater effect into the storm drain, decreasing the conveyance capacity during frequent storm events. It is also important to note that although electrical lines have not been mapped by the County, inundation of light poles or other utilities can potentially lead to power outages.

Table 17 lists the number of utilities impacted by each scenario Countywide by utility type.

TABLE 17: IMPACTS BY UTILITY DUE TO SEA LEVEL RISE

Utility	Total Number	Number Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2
Fire Hydrants	393	8	30
Dams	19	0	0
Catch Basins	652	18	56
Culverts	784	76	142
Concrete Drains	17,710	430	1,337
Storm Drains	345	8	17
Drop Inlets	524	30	96
Manholes	1,112	12	71
Pipes	117	4	11
Stormwater Ponds	415	27	60
Sub-stations	8	0	0
Transformers	8	0	0
Lamp Posts	1269	18	132
Light Poles	2625	76	214
Traffic Signal Poles	21	0	0
Utility Poles	18,303	277	807
Utility Boxes	378	2	22
Telecommunication Towers	47	2	3

Private Residential Property

This resource includes privately-owned property associated with QACO Address Point and Parcel datasets.

Table 18 summarizes the number and percent of private residential properties vulnerable to SLR and Table 19 summarizes the number and percent of private residential buildings vulnerable to SLR under both scenarios. Note that the buildings dataset includes detached garages, sheds, and other out-buildings and multiple buildings may pertain to one parcel. Impacts to detached garages or other out buildings were

not considered to be residential impacts, only building that intersected address points with a residential classification were considered for residential building impacts. Additionally, the impacts shown in Table 19 are based on lateral extents of the buildings and SLR and storm surge inundation scenarios to show vulnerability. Elevations of the first floor of the buildings are not available and have not been evaluated. Buildings built on piers, or otherwise elevated, may not be impacted by the SLR and coastal storm surge scenarios. Note that the impacts shown in Table 18 range from significant property impacts that decrease functionality to minor impacts of low-lying areas that would not decrease functionality.

TABLE 18: PRIVATE RESIDENTIAL PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	5,082	407	438	8.0	8.6
2	4,304	398	454	9.2	10.5
3	5,688	1,509	1,839	25.2	30.7
4	45,942	1,412	2,001	23.8	33.7
Countywide	21,316	1,412	4,732	16.3	22.2

¹ Note that impacts may only represent a portion of the property

TABLE 19: PRIVATE RESIDENTIAL BUILDING IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	5,013	5	44	0.1	0.9
2	4,422	1	35	0.0	0.8
3	5,459	41	517	0.8	9.5
4	4,659	17	394	0.4	8.5
Countywide	19,553	64	990	0.3	5.1

Commercial Development

This resource includes commercially-owned property associated with QACO Address Point and Parcel datasets. Table 20 summarizes the number and percent of commercial properties vulnerable to SLR and Table 21 summarizes the number and percent of commercial buildings vulnerable to SLR using both scenarios. The impacts shown in Table 21 are based on lateral extents of the buildings and SLR and storm surge inundation scenarios to show vulnerability. Elevations of the first floor of the buildings are not

available and have not been evaluated. Buildings built on piers, or otherwise elevated, may not be impacted by the SLR and coastal storm surge scenarios.

TABLE 20: COMMERCIAL PROPERTY IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios		Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	378	13	14	3.4	3.7
2	497	39	48	7.8	9.7
3	790	245	350	31.0	44.3
4	261	54	74	20.7	28.4
Countywide	1,926	351	486	18.2	25.2

¹ Note that impacts may only represent a portion of the property

TABLE 21: COMMERCIAL BUILDING IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	198	2	5	1.0	2.5
2	474	2	4	0.4	0.8
3	534	32	82	6.0	15.4
4	436	0	5	0.0	1.1
Countywide	1,642	36	96	2.2	5.8

Natural Resources and Land Use

Based upon available natural resource data, tables were generated in ArcGIS that described the vulnerable areas under each of the two SLR scenarios. Specific natural resources assessed include:

- Wetlands
- Critical areas
- Agriculture

This vulnerability assessment relied on existing data and information to screen resources at risk to SLR and coastal hazards. In some cases, data and information that would have provided useful planning information was not readily available. For example, GIS datasets were not available to assess and quantify

the potential for loss of beaches and dunes. Additionally, salinity changes in freshwater and groundwater are difficult to assess given the unknowns about the complex hydrologic and hydrogeological interactions involved. Although the assessment of these resources is not in the scope of this analysis, it is important for the County to understand the potential impacts of saltwater intrusion into surface and ground water.

Wetlands

Wetlands provide habitat, food, and breeding grounds for many species of plants and animals. They contain unique plant and animal communities and are known for their high species diversity. They also act to attenuate floodwaters, buffer storm impacts, and act as filters by trapping sediment and removing contaminants. Tidal marshes, in particular, are an important buffer to protect against shoreline erosion and reduce wave energy during storm events. They provide vital food and habitat for clams, crabs, and juvenile fish, as well as offering shelter and nesting sites for several species of migratory waterfowl.

Tidal and non-tidal wetland impacts are combined in this analysis to give a total wetland impact using two wetland datasets. Wetland data was obtained from the U.S. Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) dataset as well as the DNR wetland dataset, which are DNR identified wetlands that supplement the NWI dataset.

Impacts generally occur along the Chesapeake Bay in Study Areas 3 and 4 with over 50 percent of the wetlands in these study areas impacted by acreage in SLR Scenarios 1 and 2. Table 22 summarizes the acreage and percent of the NWI wetlands and Table 23 summarizes DNR wetlands vulnerable to SLR using Scenarios 1 and 2.

It is important to note that the wetland data is not easily sortable to distinguish between freshwater and saltwater wetlands. Effects of saltwater inundation of freshwater wetlands have not been evaluated. Permanent saltwater intrusion of freshwater wetlands resulting from Scenarios 1 and 2 could cause significant alteration of habitat.

TABLE 22: NWI WETLAND IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	17,766	506	629	2.8	3.5
2	6,383	1,054	1,253	16.5	19.6
3	2,067	1,281	1,455	62.0	70.4
4	1,121	765	873	68.3	77.9
Countywide	27,337	3,606	4,211	13.2	15.4

TABLE 23: DNR WETLAND IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	35,496	1,073	1,457	3.0	4.1
2	13,483	2,492	3,004	18.5	22.3
3	3,468	1,760	2,085	50.8	60.1
4	3,000	1,469	1,805	49.0	60.2
Countywide	55,447	6,794	8,351	12.3	15.1

Critical Areas

The Critical Area is a resource protection program that governs land use within 1,000 feet of high tide or tidal wetlands. Additionally, Habitat Protection Areas (HPA) include a minimum 100-foot buffer from tidal wetlands and waterways, historic waterfowl staging and concentration areas, colonial water bird nesting sites, threatened and endangered species and species in need of conservation, anadromous fish spawning areas, existing riparian buffers, forest areas used by forest interior dwelling birds, non-tidal wetlands, National Heritage Areas, and other areas of local significance.

Three categories of land development within the Critical Area were based on existing development and public services available as of December 1, 1985. These include Intense Development Areas (IDA), Limited Development Areas (LDA), and Resource Conservation Areas (RCA). For the purposes of this study, impacts to each of these land development categories are summed to include one value of Critical Area impacts.

TABLE 24: CRITICAL AREA IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	608	60	84	7.6	10.6
2	1,608	153	229	9.5	14.2
3	1,030	180	308	17.5	29.9
4	789	115	201	14.6	25.5
Countywide	4,034	507	822	12.6	20.4

Critical Area data was received from the Eastern Shore Regional GIS Cooperative (ESRGC) at Salisbury University with permission from DNR. The dataset is currently in draft status as DNR is currently updating the Critical Area maps to reflect updated shoreline and wetland conditions. Impacts are highest in Study Area 3, however, there are significant impacts in all four study areas. The impacts are primarily along the Chesapeake Bay shoreline. Table 24 summarizes the acreage and percent of the resource vulnerable to SLR for each scenario.

Agriculture

Agriculture plays an important role in QACO’s economic strategy. The County’s Comprehensive Plan’s primary focus is to preserve and maintain the County as a quintessential rural community with agriculture as a viable industry, ranking first in the State of Maryland for the production of corn, soybeans, and wheat for grain (Reference 2).

Agricultural land was identified using the Parcel dataset provided by QACO. The percent of total agricultural land impacted in Study Areas 3 and 4 ranges from 11 to 22% in SLR Scenarios 1 and 2. Table 25 summarizes the acreage and percent of agricultural land resource vulnerable to SLR for both SLR scenarios.

TABLE 25: AGRICULTURAL LAND IMPACTS DUE TO SEA LEVEL RISE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios		Percent of Total Impacted by Coastal Vulnerability Scenarios	
		Scenario 1	Scenario 2	Scenario 1	Scenario 2
1	114,795	455	700	0.4	0.6
2	55,053	1,117	1,712	2.0	3.1
3	5,470	623	1,057	11.4	19.3
4	5,721	803	1,269	14.0	22.2
Countywide	181,040	2,998	4,739	1.7	2.6

4. STORM SURGE IMPACTS

As sea levels continue to rise, storm surge impacts will also increase. While these impacts can be temporary, the extent of coastal flooding due to storm surge will increase due to elevated base water surface levels and loss of wetland buffer systems at or near mean sea level. Impacts to resources such as roads or utilities will be temporary in nature and the resource is likely to recover following the storm. However, impacts to other resources such as residential/commercial buildings or agricultural lands can have a more severe effect if flooded or affected by saltwater intrusion. Table 26 shows potential temporary land inundation by acreage and percent of land area for the County as a whole and for each Study Area. The resources at risk vary from temporary roadway closures to potential loss of homes from coastal storm flooding.

TABLE 26: TOTAL ACREAGE VULNERABLE TO STORM SURGE

Study Area	Total Land Area Acres	Area Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	136,345	1,488	1.1%
2	72,382	4,061	5.6%
3	15,445	5,287	34.2%
4	13,145	4,200	31.9%
Countywide	237,318	15,036	6.3%

Of the total land area Countywide, 1.1%, 5.6%, 34.2%, and 31.9% of Study Areas 1, 2, 3, and 4 is vulnerable to 2 feet of SLR plus storm surge respectively. Impacts due to storm surge coastal flooding can be of a temporary nature, affecting resources while the water levels are elevated as a result of atmospheric pressure changes and wind associated with a coastal storm.

Public Safety and Infrastructure

The following tables and discussions presents quantitative and qualitative results of Scenario 3 (impacts due to SLR plus storm surge) for each of the public safety and infrastructure resources discussed in Section 3 of this report.

Emergency Service Facilities

The following facilities are temporarily affected by coastal flooding due to storm surge:

- The Wye Research and Education Center property and building are temporarily impacted by Scenario 3.

- The Agriculture Center UMD Research property, which is also designated as a temporary emergency shelter, is temporarily impacted by Scenario 3; however, the impacts are located in a wooded section of the property. The building itself is not impacted.
- The Chesapeake Community College, Centreville Elementary School and the Kennard Elementary School properties are all temporarily impacted by Scenario 3. All three schools are designated as temporary emergency shelters. There are no building impacts.
- The Centreville Police Department property will be temporarily impacted by Scenario 3, however, the building and entrance roads will not be affected.
- QACO Sherriff Kent Narrows Substation property and building is temporarily impacted by Scenario 3. In addition, several roads in the immediate area are impacted.
- EMS Station 200 property and building will be temporarily impacted by Scenario 3. In addition, the entrance to the facility and several surrounding roads are impacted.
- Grasonville EMS property will be temporarily impacted by Scenario 3. Inundation from Scenario 3 does approach but does not inundate the building, however, inundation does block some roads in the area, possibly reducing response times.
- Both the building and property of the Grasonville Fire Department are temporarily impacted by Scenario 3. In addition, the entrance to the facility and several of the surrounding roads are impacted.
- The Stevensville Middle School property, which is designated as a temporary emergency shelter, is temporarily impacted by Scenario 3.
- The Bayside School and Grasonville Senior Center properties, which are designated as temporary emergency shelters, are temporarily impacted by Scenario 3. The building itself is not impacted.
- The Kent Island Elementary School property, which is designated as an emergency shelter, is temporarily impacted by Scenario 3. The building itself is not impacted.
- EMS Station 100 property is temporarily impacted by Scenario 3, however, the station is located on a large, County-owned parcel and the impact is not in the proximity of the EMS station.
- The property and building of the United Communities VFD are impacted by Scenario 3. In addition, the entrance to the fire house and several of the surrounding roads are impacted by Scenario 3.
- The Matapeake Elementary School and Middle School properties, which are designated as emergency shelters, are impacted by Scenario 3. The buildings are not impacted.
- The Kent Island High School property, which is designated as an emergency shelter, is impacted by Scenario 3. The building is not impacted.

Table 27 and Table 28 summarize the number and percent of emergency service facility properties and buildings vulnerable to temporary impacts due to storm surge coastal flooding.

It is important to note that building impacts noted herein are based on lateral extents of the topography and building footprint. Finished floor elevations have not been determined as a part of this study. It is possible that while an impact is determined by lateral extents on the mapping, the usable portions of the buildings may not be inundated by elevation. In addition property impacts can vary from minor impacts to the property periphery to significant impacts that affect functionality of the property and associated structures.

TABLE 27: EMERGENCY SERVICE FACILITY PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	10	0	0.0
2	22	6	27.3
3	14	8	57.1
4	6	4	66.7
Countywide	52	18	34.6

¹ Note that impacts may only represent a portion of the property

TABLE 28: EMERGENCY SERVICE FACILITY BUILDING IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	10	0	0.0
2	22	1	4.5
3	14	3	21.4
4	6	1	16.7
Countywide	52	5	9.6

Evacuation Routes

Table 29 summarizes the impacted evacuation routes (both primary and secondary combined) by miles of roadway and percent of total resource for Scenario 3 (storm surge).

In Study Area 1 a portion of roadway along MD 290 is inundated in Scenario 3 in the northern portion of the Town of Crumpton just south of the bridge crossing the Chester River. Additionally, the bridge approach of MD 213 crossing the Chester River in the Town of Kingstown is inundated in Scenario 3.

In Study Area 2 roadway impacts occur at MD 213 in the Town of Centreville where Scenario 3 inundates a portion of the roadway near the Mill Stream Branch crossing. MD 18 is also temporarily inundated by Scenario 3 in the Town of Queenstown near Thompson Avenue.

In Study Area 3 portions of MD 18 are temporarily impacted near Gravel Run Road, Chester River Beach Road, and much of the roadway near the Kent Narrows and Cox Creek areas in Scenario 3.

In Study Area 4 portions of MD 18 are impacted in Scenario 3 near Love Point. Significant impacts to MD 8 occur near Broad Creek, temporarily cutting off transportation to the southern portion of Kent Island. Route 8 is also impacted at Warehouse Creek, Carter Creek, Chews Creek, and Holligans Snooze Inlet under the storm surge scenario.

TABLE 29: TEMPORARY EVACUATION ROUTE IMPACTS DUE TO STORM SURGE

Study Area	Total Miles	Miles Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	139.6	0.48	0.34
2	69.7	0.35	0.50
3	27.8	5.25	18.90
4	21.3	1.97	9.25
Countywide	258.3	8.05	3.12

Piers

Digital data was not available for pier locations, however, the County requested that two piers in particular be considered: the Matapeake Pier and the Romancoke Pier. These piers are county-owned and could be used for a boat-based evacuation during an emergency.

Pier elevations are unknown, therefore an analysis was done based on the ground elevations surrounding the pier at the shoreline. If the area around the beginning of the pier is inundated then it was assumed that the pier would be overtopped or not accessible during an event.

The Romancoke Pier appears to be temporarily inundated during Scenario 3. Romancoke Road is also temporarily inundated for the 300 feet leading to the pier. The Matapeake Pier and the 50 feet of access leading to the pier is temporarily inundated in Scenario 3.

Roads and Bridges

During coastal storm surges, low lying roads will be vulnerable to temporary flooding that may temporarily cutoff emergency service access.

Temporary impacts to roadways in Study Area 1 are located primarily adjacent to the Chester River. Temporary impacts to roadways in Study Area 2 are located primarily adjacent to the Corsica River and Reed Creek. Temporary impacts to roadways are significant in Study Area 3, impacting several roads in the Kent Narrows, Prospect Bay, and Cox Creek areas. MD 18 through the Kent Narrows area is temporarily inundated by Scenario 3. Long Point Road, Narrows Pointe Drive and Swan Cove Lane are

blocked by Scenario 3, cutting off access to homes off of those roads. Significant temporary roadway impacts are also seen in the Prospect Bay area with Dominion Road and Parson Island Road being blocked by Scenario 3, temporarily cutting off access to homes located on the southern tip of the peninsula. Cox Neck Road is also blocked by Scenario 3, temporarily cutting off access to homes on the southern portion of that peninsula. Roadway impacts in Study Area 4 are also significant with several roads being temporarily blocked in the Broad Creek area and the Romancoke area by Scenario 3. In addition, MD 8 is blocked in several locations by Scenario 3, temporarily cutting off access to the homes located on southern Kent Island. Table 30 summarizes the total road miles (including the evacuation routes) and percent of road miles vulnerable to coastal storm surge.

TABLE 30: TEMPORARY ROADWAY IMPACTS DUE TO STORM SURGE

Study Area	Total Miles	Miles Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	477.0	2.5	0.5
2	311.8	3.7	1.2
3	157.8	33.8	21.4
4	130.8	22.0	16.8
Countywide	1077.4	62.0	5.8

Schools

There are no impacts to the school buildings during the storm surge scenario, however there are noted impacts to nine of the school properties. In Study Area 2, three school properties are impacted by Scenario 3: Chesapeake Community College, Centreville Elementary School, and Kennard Elementary School. In Study Area 3, the Stevensville Middle School, Bayside Elementary School, and a small portion of the Kent Island Elementary School parcel are temporarily impacted by Scenario 3. In Study Area 4, a small area on the northern edge of the Matapeake Elementary and Middle School property, as well as the wooded portion of the Kent Island High School parcel will also be temporarily impacted by Scenario 3. The impacts are small and are primarily limited to wooded floodplain portions of the parcels and would likely not impact day-to-day activities. Table 31 summarizes the total number and percent of resource property that is vulnerable to SLR using all scenarios.

TABLE 31: TEMPORARY SCHOOL PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	4	0	0
2	26	3	11.5
3	5	3	60
4	3	3	100
Countywide	38	9	23.7

¹ Note that impacts may only represent a portion of the property

Wastewater Facilities

Temporary impacts to wastewater facilities generally occur on low-lying portions of the sewage treatment plant parcels. The only building impact is for an out building associated with the KNSG Sewage Treatment Plant during Scenario 3. The building appears to be used as a garage. Table 32 summarizes the number and percent of the resource vulnerable to SLR using Scenario 3. Note that parcel impacts could potentially impact the functionality and/or operations of the sewage treatment plant or other assets. The parcel impacts should be considered in more detail with consideration given to outfall elevations in order to determine the severity of the impacts.

TABLE 32: WASTEWATER TREATMENT PLANT PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	3	1	33
2	2	2	100
3	0	0	0
4	1	1	100
Countywide	5	4	80

¹ Note that impacts may only represent a portion of the property

TABLE 33: SEWER STATION IMPACTS DUE TO STORM SURGE

Sewer Station	Total Number	Number Impacted by Coastal Vulnerability Scenarios
		Scenario 3
Vacuum Stations	14	12
Pumping Stations	10	4
Lift Stations	7	2

Water Supply

Saltwater intrusion is anticipated to increase as sea level increases and coastal storm surge flooding becomes more prevalent which may negatively impact water supply to portions of the County. There are three temporary impacts to water treatment plant properties, as well as two (2) water treatment plant buildings that are impacted. Oyster Cove, located in Study Area 3, and Thompson Creek, located in Study Area 4, both have building impacts from Scenario 3. The properties of Oyster Cove, Thomson Creek, and Riverside are temporarily impacted by Scenario 3.

Since Oyster Cove and Thompson Creek water treatment plants are impacted by Scenario 3 there is potential that the underground water storage tanks at these location may also be impacted during coastal storm surges due to saltwater intrusion. Depending on the original design and construction of the storage tanks, the impacts may be minor to significant.

Table 34 below summarizes the number and percent of water treatment plant properties that are vulnerable to storm surge.

TABLE 34: WATER TREATMENT PLANT PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	0	0	0
2	0	0	0
3	2	2	100.0
4	9	1	11.1
Countywide	11	3	27.3

¹ Note that impacts may only represent a portion of the property

Other Utilities

Table 35 summarizes the number and percent of resource vulnerable to SLR using all scenarios. Note, some utilities are located in two study areas and therefore some impacts are counted twice.

TABLE 35: UTILITY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	13,846	106	0.8
2	10,653	279	2.6
3	10,062	3403	33.8
4	9,439	2,415	25.6
Countywide	43,943	6225	13.9

It is important to note that the impacts shown are based on lateral extents of the utilities and storm surge inundation scenarios. Vertical elevations have not been evaluated which could lead to additional impacts. For example, storm drain systems are located underground and SLR can cause a backwater effect into the storm drain, temporarily decreasing the conveyance capacity during storm surge events. Table 36 lists the number of utilities impacted by Scenario 3 Countywide by utility type.

TABLE 36: IMPACTS BY UTILITY DUE TO STORM SURGE

Utility	Total Number	Number Impacted by Coastal Vulnerability Scenarios
		Scenario 3
Fire Hydrants	393	68
Dams	19	2
Catch Basins	652	113
Culverts	784	272
Concrete Drains	17,710	2,902
Storm Drains	345	51
Drop Inlets	524	143
Manholes	1,112	173

Utility	Total Number	Number Impacted by Coastal Vulnerability Scenarios
		Scenario 3
Pipes	117	28
Stormwater Ponds	415	90
Sub-stations	8	0
Transformers	8	0
Lamp Posts	1269	304
Light Poles	2625	423
Traffic Signal Poles	21	0
Utility Poles	18,303	1,589
Utility Boxes	378	63
Telecommunication Towers	47	4

Private Residential Property

Table 37 summarizes the number and percent of private residential properties vulnerable to storm surge and Table 38 summarizes the number and percent of private residential buildings vulnerable to storm surge using Scenario 3. While the inundation associated with Scenario 3 is temporary, it can cause significant damage and have longer lasting impacts, especially to buildings. Note that the impacts shown in Table 38 are based on lateral extents of the buildings and storm surge inundation scenarios to show vulnerability. Elevations of the first floor of the buildings are not available and have not been evaluated. Buildings built on piers, or otherwise elevated, may not be impacted by the coastal storm surge scenario. In addition, the impacts shown in Table 37 can range from minor impacts of the property periphery to significant impacts that cut off access to the building.

TABLE 37: PRIVATE RESIDENTIAL PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	5,082	516	10.2
2	4,304	509	11.8
3	5,688	2,654	44.3
4	45,942	2,859	48.1
Countywide	21,316	6,538	30.7

¹ Note that impacts may only represent a portion of the property

TABLE 38: PRIVATE RESIDENTIAL BUILDING IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	5,013	117	2.3
2	4,422	79	1.8
3	5,459	1,448	26.5
4	4,659	1,141	24.5
Countywide	19,553	2,785	14.2

Commercial Development

Table 39 summarizes the number and percent of commercial properties vulnerable to storm surge and Table 40 summarizes the number and percent of commercial buildings vulnerable to storm surge using Scenario 3. The impacts shown in Table 40 are based on lateral extents of the buildings and storm surge inundation scenarios to show vulnerability. Elevations of the first floor of the buildings are not available and have not been evaluated. Buildings built on piers, or otherwise elevated, may not be impacted by the coastal storm surge scenarios.

TABLE 39: COMMERCIAL PROPERTY IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted ¹ by Coastal Vulnerability Scenarios	Percent of Total Impacted ¹ by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	378	22	5.8
2	497	68	13.7
3	790	494	62.5
4	261	90	34.5
Countywide	1,926	674	35.0

¹ Note that impacts may only represent a portion of the property

TABLE 40: COMMERCIAL BUILDING IMPACTS DUE TO STORM SURGE

Study Area	Total Number	Number Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	198	8	4.0
2	474	13	2.7
3	534	138	25.8
4	436	33	7.6
Countywide	1,642	192	11.7

Natural Resources and Land Use

The following tables and discussions presents quantitative and qualitative results of Scenario 3 (impacts due to SLR plus storm surge) for each of the natural resources and land uses discussed in Section 3 of this report.

Wetlands

Storm surge can have temporary and/or long-lasting impacts to wetlands. The effects of saltwater inundation of freshwater wetlands have not been evaluated. Prolonged temporary inundation of freshwater wetlands in Scenario 3 could cause significant alteration of habitat. However, temporary saltwater inundation of saltwater wetlands naturally occurs and can replenish saltwater wetland systems. It should be noted that for the purposes of this study, impacts presented herein solely represent wetland areas inundated by coastal storm surge flooding. Impacts to wetlands due to storm surge generally occur

along the Chesapeake Bay in Study Areas 3 and 4 with over 75 percent of the wetlands in these study areas impacted by acreage during Scenario 3. Table 41 summarizes the acreage and percent of the NWI wetlands and Table 42 summarizes DNR wetlands vulnerable to SLR using Scenario 3.

TABLE 41: NWI WETLAND IMPACTS DUE TO STORM SURGE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	17,766	795	4.5
2	6,383	1,452	22.7
3	2,067	1,570	76.0
4	1,121	963	85.9
Countywide	27,337	4,780	17.5

TABLE 42: DNR WETLAND IMPACTS DUE TO STORM SURGE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	35,496	1,746	4.9
2	13,483	3,491	25.9
3	3,468	2,316	66.8
4	3,000	2,048	68.3
Countywide	55,447	9,601	17.3

Critical Areas

Critical area impacts are highest in Study Area 3, however, there are significant impacts in all four study areas. The impacts are primarily along the Chesapeake Bay shoreline. Table 43 summarizes the acreage and percent of the resource vulnerable to coastal storm surge.

TABLE 43: CRITICAL AREA IMPACTS DUE TO STORM SURGE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	608	116	14.7
2	1,608	348	21.7
3	1,030	461	44.8
4	789	331	42.0
Countywide	4,034	1,56	31.1

Agriculture

Agricultural land can be impacted by SLR and coastal hazards in two ways: inundation and saltwater intrusion. Scenario 3, although temporary flooding, could result in damage to crops through saltwater intrusion. Table 44 summarizes the acreage and percent of agricultural land resource vulnerable to coastal storm surge Scenario 3.

TABLE 44: AGRICULTURAL LAND IMPACTS DUE TO STORM SURGE

Study Area	Total Acres	Acres Impacted by Coastal Vulnerability Scenarios	Percent of Total Impacted by Coastal Vulnerability Scenarios
		Scenario 3	Scenario 3
1	114,795	930	0.8
2	55,053	2,656	4.8
3	5,470	1,661	30.4
4	5,721	2,011	35.1
Countywide	181,040	7,258	4.0

5. TARGETED AREAS OF CONCERN

This section discusses resources impacted by SLR and coastal storm scenarios by study areas. Key issues of concern are summarized and areas for targeted action are identified. Three primary factors were considered in identifying and targeting areas of concern:

1. Public Health and Safety – Greater weight is given to resources that, if impacted, would pose a threat to public health and safety, either in the short- or long-term.
2. Geographic Impact – Impacts that could potentially impact a wide-ranging geographic scope are considered a bigger concern versus smaller, localized impacts
3. Functionality – Greater weight is given to resources that would lose function if impacted. Additionally, if the impact is a temporary impact due to storm surge flooding (Scenario 3) the long-term effects on the resources are evaluated.

While Sections 3 and 4 of this report quantify impacts, providing a qualitative description of the full impact is more difficult and is beyond the scope of this report. For example, if a water treatment plant is affected, the influence of that impact will extend beyond the treatment plant itself, affecting all of its end users. Additionally, other water treatment plants within the County may be relied on more heavily to supply clean water to other portions of the County.

Each resource evaluated as part of this study is ranked as either a high concern, moderate concern, or low concern. It is noted that this assessment is somewhat subjective in nature and the data from Section 3 and the maps in Appendices A, B, and C have been used to make a reasonable assessment of concern for each resource based on the criteria set forth in Table 45. A ranking of moderate or low concern does not mean that a resource is not important or that the impacts from SLR and coastal hazards will not be felt.

TABLE 45: RESOURCE CONCERN CRITERIA AND TARGETED ACTION

Concern	Public Health and Safety		Geographic Impact		Functionality	Targeted Action
High	Threatened	and/or	Large regional area	and/or	Resource no longer functions	Develop adaptation/resiliency strategies
Moderate	Possible	and/or	Small regional area	and/or	Some resource failure of intended use or temporary loss of function	Evaluate further and develop adaptation strategies if necessary
Low	Unlikely	and/or	Localized or isolated	and/or	Resource functions with modifications or minor impact	Monitor and/or re-assess in future years

High Concern Resources

A high concern resource is generally a resource when public health and safety is threatened by temporary or long-term inundation, where geographic impacts extend to a large regional area, and/or when inundation would cause the resource to no longer function. Based on the results of the vulnerability assessment, the following resources are of the highest concern.

Emergency Service Facilities: Of the 52 emergency service facilities assessed, five (5) facility properties lie within an area that could be partially inundated by SLR by 2050, nine (9) facility properties could be partially inundated by 2100, and 18 facility properties could be at least partially inundated during a storm surge and SLR by 2050. None of the buildings would be inundated by SLR by 2050, one (1) building could be partially inundated by SLR by 2100, and five (5) buildings could be partially inundated by storm surge and SLR by 2050. Two (2) of the properties impacted by Scenarios 1 and 2 and six (6) of the properties impacted by Scenario 3 occur in Study Area 2. All other impacts to property and buildings occur in Study Areas 3 and 4. While it is understood that some or all of these facilities may have a mutual aid backup plan in place, with the ability to move equipment to higher ground or secondary stations, because of public safety concerns and the possibility of increased response times, emergency services are a high concern and resiliency/adaptation implementation should be a high priority.

Evacuation Routes: Between 0.5% and 1.6% (approximately 1.4 to 4.2 miles) of the County's evacuation routes lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and 3.1% (8.1 miles) could be inundated during a storm surge and SLR by 2050. Typically, the emergency routes are state highways. Substantial reliance on this single mode of transportation for evacuations may endanger citizens if the highway infrastructure is made inaccessible because of SLR. The majority of these impacts occur in Study Areas 3 and 4. Because of high public safety concerns and the likelihood that inundated evacuation routes will further congest the alternate evacuation routes over a large geographic area, inundated evacuation routes are a high concern and coordination with SHA for resiliency/adaptation implementation should be a high priority.

Wastewater Facilities: Of the six wastewater treatment plants identified in this study, three of the properties are partially inundated by the anticipated 2050 SLR and four properties are inundated by 2100 SLR. Four properties are also inundated during a storm surge and 2050 SLR. Additionally, a total of 30 wastewater vacuum stations, pumping stations, and lift stations were identified in the County with two (2) and 12 of those facilities being impacted by 2050 and 2100 SLR, respectively, and 17 impacted by storm surge and SLR by 2050. True impacts to the treatment plants and other wastewater facilities are difficult to quantify as outfall elevations and elevations of other potentially critical mechanical equipment were not evaluated in this study. Although the facility locations may be inundated, the equipment may still function to a certain inundation level. Alternatively, infiltration of sea water into wastewater lines may overload the system and cause failure. Due to the potential of failure of this resource and the public health concerns due to failure, inundation of wastewater facilities is a high concern and resiliency/adaptation implementation should be a high priority.

Other Utilities: Table 17 and Table 36 summarize impacts by type of utility based on QACO's utility dataset for SLR and storm surge scenarios respectively. These utilities can be ranked as high, moderate, or low concern depending on the utility. Utilities of moderate and low concern are discussed later in this section. The following summarizes other utilities of high concern:

- Telecommunication towers – Of the 47 telecommunication towers included in the County’s dataset, two properties are inundated by SLR by 2050, three are inundated by SLR by 2100, and four are inundated by storm surge and SLR by 2050. While the tower structures themselves may not be impacted by inundation, critical electrical equipment components may be impacted causing failure of the resource. Due to the potential for public safety impacts, inundation of telecommunication towers is a high concern and resiliency/adaptation implementation should be a high priority.
- Storm drain systems – Storm drain systems in QACO is comprised of multiple components including catch basins, drop inlets, manholes, and storm drain pipes. For the purposes of this assessment culverts and concrete drains (driveway culverts) are also included as a storm drain feature. The County storm drain system contains more than 21,000 components. Approximately 3% of the total components are inundated by SLR by 2050, 8% are inundated by SLR by 2100, and 17% are inundated by storm surge and SLR by 2050. It is important to note that in this assessment these storm drain features are shown as inundated based on existing ground elevation. Many of these storm drain features are located underground and impacts are expected to be greater. Storm drain systems are noted as a high concern as the affected systems will no longer function through many of the coastal areas of the County and resiliency/adaptation implementation should be a high priority.

Private Residential Property: Approximately 0.3% and 5.1% of the County’s residential buildings lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 14.2% of residential buildings could be inundated during a storm surge and SLR by 2050. At least a portion of 16% and 22% of the County’s residential properties lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 31% could be inundated during a storm surge and SLR by 2050. These percentages increase significantly in Study Areas 3 and 4, specifically in the Bay City, Kent Island Estates, Cloverfield, and Harbor View areas. Many of these homes are already in flood-prone areas and may have elevated first floor elevations to protect against flooding. However, road access to many of these homes and residential areas may be limiting whether the structures are flood-proofed or not. Because this resource poses a threat to public safety and the impacts in many cases expand over a large geographic region it is noted as a high concern and resiliency/adaptation implementation should be a high priority.

Commercial Development: Approximately 29% and 35% of the County’s commercial properties lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 44% could be inundated during a storm surge and SLR by 2050. Approximately 2% and 6% of the County’s commercial buildings lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 12% could be inundated during a storm surge and SLR by 2050. These percentages increase dramatically in Study Area 3, primarily in the Kent Narrows area. Because these impacts expand over a relatively large geographic region and permanent loss of function will occur to many of the businesses, commercial development is considered a high concern and resiliency/adaptation implementation should be a high priority.

Agriculture: Between 1.7% and 2.6% of the County’s agricultural properties lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 4.0% could be inundated during a storm surge and SLR by 2050. Temporary inundation of agricultural areas could result in decreased crop

yields as a result of salt contamination following a coastal storm surge. Additionally, SLR can impact agriculture prior to permanent inundation as a result of soils that are too wet to till. Due to the complete loss of function, inundation of agricultural properties is of high concern and resiliency/adaptation implementation should be a high priority.

Wetlands: Between 13% and 15% of the County's NWI Wetlands lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and 12% and 15% of the County's DNR Wetlands lie within an area that could be inundated by SLR by 2050 and 2100 respectively. SLR plus storm surge inundation is a temporary impact that affects 18% of NWI wetlands and 17% of DNR wetlands. NWI impacts range from 62% to 78% for SLR by 2050 and 2100 in Study Areas 3 and 4 which are a better indication of the impact to this resource. Due to the high percentage of coastal wetlands affected and the loss of unique and protected habitats, this resource is of high concern and resiliency/adaptation implementation should be a high priority.

Critical Area: Over 4,000 acres of Critical Area existing in QACO, of which approximately 500 and 820 acres could be inundated by SLR by 2050 and 2100 respectively. SLR plus storm surge inundation is a temporary impact that affects approximately 1200 acres. The Critical Area provides a protection to the Chesapeake Bay ecosystem by minimizing the adverse effects of human activities on water quality and natural habitats. Loss of function of this resource is of high concern and resiliency/adaptation implementation should be a high priority.

Moderate Concern Resources

A moderate concern resource is generally a resource when public health and safety is potentially threatened by temporary or long-term inundation, where geographic impacts extend to a small regional area, and/or when inundation would cause some resource failure of intended use or temporary loss of function. Based on the results of the vulnerability assessment, the following resources are of moderate concern.

Roads and Bridges: Between 0.3% and 2.1% (approximately 3.6 to 22.7 miles) of the County's roads lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and 5.8% (62 miles) could be inundated during a storm surge and SLR by 2050. Many of these roadway impacts also include bridges. For the purposes of this study bridge impacts were not quantified as elevation data was not available for bridge decks. Inundation of roadway segments would only cause smaller regional transportation disruptions if emergency routes were available. Not including the evacuation routes, inundation of roadways is a moderate concern due to potential local and smaller regional impacts and partial resource failure of intended use and/or temporary loss of function.

Water Supply: Of the eleven water treatment plants identified in this study, one of the properties is partially inundated by the anticipated 2050 SLR and three properties are inundated by 2100 SLR. These three properties are also inundated during a storm surge and 2050 SLR. Like the wastewater facilities, true impacts to the water treatment plants are difficult to quantify as outfall elevations and elevations of other potentially critical mechanical equipment were not evaluated in this study. Although the facility properties may be inundated, the equipment may still function to a certain inundation level, especially at the water tower locations. Alternatively, infiltration of salt water into in-ground drinking water storage tanks will have a long-term impact to fresh water supply. This resource is considered a moderate concern due to the unknown potential failure of this resource and smaller regional area affected.

Other Utilities: The following summarizes other utilities of moderate concern:

- Lamp posts, light poles, utility poles, and utility boxes – These other utilities are combined as similar utilities that have the potential to cause power or other utility outages if inundated. It is difficult to determine what utilities are located on the utility poles or within utility boxes. Typically these resources could include a combination of any or all of electric, cable television, telephone, and/or fiber optic lines. The County’s dataset consists of more than 22,000 lamp posts, light poles, utility poles, and utility boxes, of which approximately 2% and 5% lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 11% could be inundated during a storm surge and SLR by 2050. Since it is not clear what consequences inundation of these resources would pose, and at a minimum, inundation of these resources could cause some resource failure of intended use or temporary loss of function, these resources are considered a moderate concern.
- Stormwater ponds – Of the 415 stormwater ponds identified in the County’s Other Utility dataset, 27 and 60 lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and 90 could be inundated during a storm surge and SLR by 2050. Inundation of stormwater ponds could cause some resource failure of intended use and contribute to nuisance flooding of adjacent areas and are considered a moderate concern. Stormwater ponds can be intimately linked to the storm drain system function. Stormwater ponds located in areas of high priority for storm drain systems could be elevated to the same priority in these locations.

Low Concern Resources

A Low concern resource is generally a resource when public health and safety concerns are unlikely by temporary or long-term inundation, where geographic impacts extend only to a local or isolated area, and/or when inundation would cause a minor impact to the resource or if the resource functions with modifications. Based on the results of the vulnerability assessment, the following resources are categorized as of low concern.

Schools: No school building structures are impacted in any of the modeled SLR or storm surge scenarios. However, of the 38 schools identified Countywide, between one and four of the County’s school properties lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and 9 school properties could be inundated during a storm surge and SLR by 2050. These property impacts are generally at lower elevations on the properties and may include impacts to forested areas, ball fields, and/or other common areas. Typically sufficient warning is anticipated prior to a coastal storm event and public safety is not a concern. Planning will be required to relocate schools’ amenities as needed to avoid SLR impacts to school property. Due to the isolated nature of the impacts to property, and little or no anticipated loss of function, there is low concern for this resource. Schools that are designated as emergency shelters in vulnerable areas in which access is also vulnerable could be elevated to high concern.

Other Utilities: The following summarizes other utilities of low concern:

- Fire hydrants - Approximately 2% and 8% of the County’s fire hydrants lie within an area that could be inundated by SLR by 2050 and 2100 respectively, and approximately 17% could be inundated during a storm surge and SLR by 2050. Since fire hydrant supply is watertight it is anticipated that access to fire hydrants due to inundated roadways will be a bigger concern than the systems

themselves. Due to the fact that a failure of functionality is unlikely, this resources is noted as a low concern.

- Dams – None of the dams from the County’s utility dataset are inundated by SLR in Scenarios 1 or 2. Two of the nineteen dams identified in the dataset are inundated by SLR plus storm surge. These two dams are stormwater pond embankments and do not pose a threat to public safety. No large-scale flood control dams or levees are identified in the County’s utility dataset. Dams, as presented in the County’s dataset, are considered a resource of low concern.
- Substations – No impacts have been determined for any of the SLR and storm surge scenarios based on the County dataset. There is low concern for this resource.
- Transformers – No impacts have been determined for any of the SLR and storm surge scenarios based on the County dataset. There is low concern for this resource.
- Traffic signal poles – No impacts have been determined for any of the SLR and storm surge scenarios based on the County dataset. There is low concern for this resource.

6. ADAPTATION STRATEGIES

Generally, adaptation means adjusting to new conditions and taking steps to mitigate, manage, and avoid the worst possible consequences of the effects of SLR and coastal hazards. Adaptation strategies can be actions to prepare for SLR and coastal hazards in a specific location, such as raising structures out of flood-prone areas or building dikes to keep water out of low-lying areas. Adaptation strategies can also include planning efforts to avoid placement of new infrastructure in vulnerable areas. Additionally, building the capacity to adapt can also serve as a strategy. This can include increasing the availability of data, technical expertise, funding, regulations, coordination, public support, etc. that will allow for selection and implementation of adaptation strategies.

Proactive SLR/coastal hazard planning and incorporation of SLR scenarios into plans for new development, redevelopment, and capital projects not only allows the County to build resiliency in the short-term, but also minimizes the need for more costly upgrades in the future. It can also increase the expected lifespan of infrastructure and support sustainability of natural resources and agriculture.

Strategies presented herein are intended to provide guidance and recommendations to QACO staff for implementation at the County level. Some strategies are more prescriptive than others with the intention that any recommendations will ultimately be developed by the County for implementation. Adaptation planning and implementation plans should be adjusted and improved as more information becomes available.

Adaptation strategies are often grouped into the following categories:

1. **Avoid** – Avoidance strategies seek to limit new development or infrastructure in vulnerable areas.
2. **Accommodate** – Accommodate strategies acknowledge the long-term effects of SLR and coastal hazards, while implementing short-term measures to maintain the existing use of a resource. These strategies decrease the risks of SLR without using potentially more costly protection strategies.
3. **Protect** – Protection adaptation strategies focus on protecting land from inundation or storm-induced flooding through construction of larger, longer-lasting projects such as building levees or raising elevations of roadways and other utilities.
4. **Retreat** – Retreat adaptation strategies allow for natural shore migration through land conservation and planned relocation of structures and other infrastructure.
5. **Build Adaptive Capacity** – The strategy of building adaptive capacity is not a solution in itself but is critically important to provide the data and knowledge to inform the aforementioned adaptation strategies. Communities with more capacity to adapt to SLR and coastal flooding are able to react quickly and make informed decisions.
6. **No Action** – The no-action strategy is the default strategy for communities that do not proactively plan for SLR and coastal flooding. This un-planned retreat results in loss of habitat and infrastructure that are imminent or have already occurred, leaving few viable options for adaptation. This adaptation strategy is not discussed further in this document and is not recommended herein for any identified vulnerable resources.

The following are adaptation strategies that can be used Countywide:

Avoid

- Create elevated County review procedures for future projects in vulnerable areas, limiting or prohibiting new development or infrastructure in areas that are particularly vulnerable.
- Allow coastal wetlands to migrate landward to provide habitat and natural buffer to coastal storms.
- Set up processes for transfer of development rights, conservation easements, and/or setback requirements.

Accommodate

- Provide regulatory incentives that encourage SLR and coastal flooding adaptation and allow for innovative projects.
- Encourage elevation of habitable structures above the base flood elevation plus SLR and/or encourage flood-proofing of vulnerable structures.
- Incorporate development standards and regulations that are more stringent than current regulations and that allow for SLR, such as additional freeboard requirements for new construction and/or redevelopment.
- Foster pilot projects that demonstrate the effectiveness of adaptation actions of agricultural lands affected by SLR and coastal flooding through conversion to tidal marsh systems.
- Create redundancy for at risk infrastructure and emergency services

Protect

- Designate critical shoreline zones for adaptation action and evaluate projects such as living shorelines, thin layer dredge disposal on tidal marshes, and beach nourishment that help to preserve a static shoreline in critical areas.
- Require all infrastructure project planning to incorporate SLR.
- Consider the use of levees, dikes, floodwalls, flood gates, tide gates, and other structural means to protect vulnerable areas.
- Identify and preserve areas for potential wetland migration.
- Flood-proof infrastructure

Retreat

- Allow for natural shoreline migration through land conservation and removal of structures that prevent shoreline movement.
- Evaluate the relocation or buy out potential of structures and infrastructure in vulnerable areas.
- Evaluate the feasibility of land acquisition by government, communities, businesses, or non-profit organizations of vulnerable parcels for permanent protection and management.

Build Adaptive Capacity

- Engage broad public participation in adaptation decisions.
- Improve coordination of permit decisions for adaptation projects among federal, state and local officials.

- Create new partnerships to increase resources for research and development of adaptation options, such as with adjacent Counties, non-government organizations (NGOs), local universities, and state/federal agencies.
- Conduct a comprehensive inventory of funding mechanisms, regulations and policies to remove barriers that prohibit opportunities for SLR and coastal hazard adaptation.
- Consider cost-sharing projects with state and federal agencies, such as SHA, that are mutually beneficial in increasing resiliency for resources with common interests.
- Develop a framework for decision making regarding land protection and restoration strategies based on wetland and habitat vulnerability that would include restoration, protection, and retreat strategies.
- Evaluate the benefits and risks of permitting privately-owned coastal impoundments and evaluate procedures for inspection and maintenance of such impoundments.
- Develop a comprehensive outreach strategy to educate stakeholders about SLR and coastal vulnerability and provide continuing education to affected communities and citizens.
- Install tide gauges and salinity observation stations to monitor changes over time.
- Encourage FEMA to incorporate SLR into their flood models and mapping.
- Develop additional datasets to assess vulnerability of SLR and coastal flooding.
- Identify data gaps and collect necessary data to plan for infrastructure investments that are part of implementation plan for adaptation.
- Improve understanding of impacts to adjacent properties from adaptation actions.
- Provide technical assistance to NGOs, local governments, business owners, and residents.
- Perform an assessment and analysis of funding options for adaptation measures.
- Develop a plan for prioritization of adaptation actions.
- Plan early for SLR and increased coastal flooding.
- Develop a training budget for County employees to receive continued training and understand the best available science and technology for decision making.
- Employ FEMA Community Rating System (CRS) activities

7. RECOMMENDED ADAPTATION STRATEGIES

The impacts discussed in the Vulnerability Assessment from SLR and coastal hazards will not be experienced all at once in the years 2050 or 2100. Adaptation and increasing resiliency needs to be an ongoing effort to combat impacts that are being seen and felt incrementally. Many of the data gaps identified and recommended additional evaluation highlight the need for planning, building adaptive capacity, and incorporating adaptation strategies. This Vulnerability Assessment has compiled a large amount of data but additional site-specific or resource-specific data may be needed before adaptation measures can be implemented in a particular location or for a particular resource.

Avoid, accommodate, retreat, protect, and build adaptive capacity strategies can be undertaken simultaneously to meet the goals of reducing vulnerability to SLR and coastal flooding and increasing resiliency of County resources. It is important to assess and monitor adaptation strategies over time and update longer-term plans to incorporate lessons learned, new data, changing public perceptions, and reflect changing conditions.

Short-term action strategies address the immediate needs of the County to build resiliency and protect against SLR and coastal flooding. These are typically strategies to either provide temporary protection of resources or planning activities for more permanent protection. Short-term action strategies should include evaluation of regulatory changes for development, flood proofing of existing resources, incorporation of SLR in planning for future capital projects, and continued efforts to build adaptive capacity.

Medium-term action strategies begin to implement short-term planning studies and increase the level of protection in the County. Long-term strategies aim to create more permanent solutions and resiliency to achieve lasting protection throughout the County. Monitoring and assessment of previously implemented strategies should be continued for medium- and long-term strategies and adjustments made as new data becomes available. Lessons learned should continually be evaluated and incorporated into planning and implementation of revised strategies. Building adaptive capacity should continue long-term.

Table 46, Table 47, and Table 48 provide recommended short-term, medium-term, and long-term adaptation strategies for public safety and infrastructure resources respectively and Table 49, Table 50, and Table 51 provide recommended short-term, medium-term, and long-term adaptation strategies for natural resources and land use respectively.

TABLE 46: PUBLIC SAFETY AND INFRASTRUCTURE SHORT -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Increase building set-back distances • Identify opportunities for voluntary conservation easements • Create elevated County review procedures for projects in vulnerable areas • Evaluate process for transfer of development rights • Coordinate with private utility companies to incorporate SLR • Encourage FEMA to update Flood Insurance Rate Maps (FIRMs) to include SLR and re-map riverine flooding with SLR effects • Encourage FEMA to update FIRMs to include impacts to storm surge modeling based on SLR 	<ul style="list-style-type: none"> • Improve emergency evacuation plans based on SLR projections • Evaluate boat transportation emergency routes to areas isolated by inundation • Flood-proof at-risk structures • Evaluate regulatory incentives that encourage SLR and coastal flooding adaptation • Evaluate mobile capabilities and mutual aid backup of emergency services 	<ul style="list-style-type: none"> • Evaluate feasibility of levees and other structural measures to protect vulnerable areas • Identify targeted areas to be protected • Evaluate and determine regulatory elevations for vulnerable areas • Coordinate SLR adaptation with SHA • Evaluate elevation of critical component elevations of wastewater and water treatment/ transmission facilities • Coordinate development and Capital Improvement plans to address as many affected resources as possible 	<ul style="list-style-type: none"> • Identify areas of high vulnerability • Evaluate relocation potential of structures and infrastructure in vulnerable areas • Evaluate feasibility of land acquisition of vulnerable parcels • Purchase frequently flooded areas and remove structures 	<ul style="list-style-type: none"> • Improve coordination with Federal, State, and Local officials • Create new partnerships to increase resources for research and development of adaptation options • Conduct comprehensive inventory of funding mechanisms, regulations, and policies to remove barriers to SLR adaptation • Provide technical assistance to local governments, business owners, and residents • Develop a prioritization plan of adaptation actions • Evaluate socio-economic impact of SLR • Participate in FEMA’s Community Rating System and employ CRS activities

TABLE 47: PUBLIC SAFETY AND INFRASTRUCTURE MEDIUM -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Implement conservation easements • Monitor set-back requirements • Limit or prohibit new infrastructure in vulnerable areas • Implement transfer of development rights • Require private utilities to build new infrastructure outside of vulnerable areas • Incorporate new studies from FEMA and updated FIRMs 	<ul style="list-style-type: none"> • Develop plans for mobilization of emergency management services • Require additional freeboard of new homes above the base flood elevation • Incorporate regulatory incentives for innovative projects that adapt to SLR and coastal flooding • Improve boat access for emergency evacuation services 	<ul style="list-style-type: none"> • Require roads to be elevated to provide access to new development and targeted protection areas • Require new development to protect against regulatory elevations in vulnerable areas • Evaluate impacts to adjacent properties from adaptation actions • Coordinate elevation of evacuation routes/ bridges with SHA • Retrofit wastewater and water treatment/ transmission facilities as needed • Elevate wastewater manholes above anticipated SLR and flood elevations to prevent inundation 	<ul style="list-style-type: none"> • Create a special funding mechanism for purchase of frequently flooded structures • Purchase frequently flooded areas and remove structures • Implement rolling easements 	<ul style="list-style-type: none"> • Engage public participation in adaptation decisions • Implement cost-sharing projects with State and Federal agencies • Update Multi-Jurisdictional Hazard Mitigation Plan, Floodplain Management Plan, Zoning Ordinance, Comprehensive Plan, and Capital Improvement Plan to address SLR • Continue FEMA’s CRS program and employ CRS activities • Identify grant opportunities to incorporate SLR adaptation projects

TABLE 48: PUBLIC SAFETY AND INFRASTRUCTURE LONG -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Continue monitoring set-back compliance • Monitor conservation easements • Continue limiting or prohibiting new resources in vulnerable areas • Monitor transfer of development rights procedures and adjust as needed 	<ul style="list-style-type: none"> • Construct new infrastructure projects above the vulnerable elevation • Monitor SLR and coastal flooding effects on infrastructure and adjust regulatory requirements • Continue monitoring regulatory incentives for projects incorporating SLR 	<ul style="list-style-type: none"> • Elevate roadways in targeted protection areas • Retrofit wastewater and water treatment facilities as needed for protection against inundation • Adjust adaptation actions to protect adjacent properties • Coordinate elevation of evacuation routes/ bridges with SHA 	<ul style="list-style-type: none"> • Purchase frequently flooded areas and remove structures • Monitor rolling easement compliance • Remove structures that prevent shoreline movement 	<ul style="list-style-type: none"> • Evaluate adaptive capacity and adapt as necessary • Employ FEMA CRS activities

TABLE 49: NATURAL RESOURCES AND LAND USE SHORT -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Identify opportunities for voluntary conservation easements • Evaluate changes to zoning 	<ul style="list-style-type: none"> • Install salinity observation stations to monitor changes to freshwater resources over time • Evaluate potential crop changes for agricultural areas such as aquaculture 	<ul style="list-style-type: none"> • Identify beaches with high erosion rates • Evaluate living shoreline protection • Identify potential wetland migration areas 	<ul style="list-style-type: none"> • Identify areas of high vulnerability • Identify land conservation areas and protect with easements 	<ul style="list-style-type: none"> • Improve coordination with Federal, State, and Local officials and identify conflicting regulatory requirements • Create new partnerships to increase resources for research and development of adaptation options • Develop framework for decision making regarding land protection and restoration strategies • Evaluate socio-economic impact of SLR

TABLE 50: NATURAL RESOURCES AND LAND USE MEDIUM -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Implement conservation easements • Allow coastal wetlands to migrate landward 	<ul style="list-style-type: none"> • Monitor conversion of freshwater wetlands and agricultural land to salt water wetland 	<ul style="list-style-type: none"> • Replenish beaches • Preserve wetland migration areas • Coordinate sand supply from State or Federal dredging projects for reuse 	<ul style="list-style-type: none"> • Create new land conservation areas 	<ul style="list-style-type: none"> • Implement cost-sharing projects with State and Federal agencies • Encourage DNR to continually evaluate and update Critical Area • Identify grant opportunities to incorporate SLR adaptation projects

TABLE 51: NATURAL RESOURCES AND LAND USE LONG -TERM ADAPTATION STRATEGIES

AVOID	ACCOMODATE	PROTECT	RETREAT	BUILD ADAPTIVE CAPACITY
<ul style="list-style-type: none"> • Monitor coastal wetlands and enhance as needed • Monitor conservation easements 	<ul style="list-style-type: none"> • Enhance conversion of freshwater wetlands and agricultural lands to saltwater wetlands 	<ul style="list-style-type: none"> • Monitor wetland migration and identify/ preserve additional wetland migration areas 	<ul style="list-style-type: none"> • Monitor land conservation areas and reassess as needed 	<ul style="list-style-type: none"> • Reassess County’s adaptive capacity and adjust as needed

8. IMPLEMENTATION PLAN

Implementation of the recommended adaptation strategies can best be achieved at the County level through more stringent regulatory requirements and revision of planning documents to incorporate the impacts of SLR and coastal flooding scenarios. The recommended adaptation strategies in Section 6 are intended to be somewhat broad in nature so that they were not unnecessarily prescriptive. However, since specific actions are not proposed herein the County will need to decide which strategies may work best in the County based on funding, political support, socio-economics, regulatory environment, and County agency organization and objectives. For example, the recommendation to “identify targeted protection areas” is an important recommendation since protection of all County resources is not economically feasible, but will require the County to determine how to best allocate funding to protect those areas most critical to the livelihood of the County residents.

The following identifies implementation opportunities through incorporation of SLR and coastal flooding scenarios into county planning and regulatory documents.

Data Collection to Fill Data Gaps

This report has identified the following data gaps that will help the County plan and update strategies and implementation of projects to build resiliency and protection against SLR and coastal storms:

- First floor building elevations
- Bridge locations and deck elevations
- Road centerline elevations
- Storm drain invert elevations (including outfalls)
- Critical component elevations of wastewater and water treatment facilities
- Locations of private wells
- Locations of septic fields and systems
- Upland forests
- Beaches and dunes
- Saltwater vs. freshwater wetlands
- Piers and boat ramps

These data will be important when prioritizing adaptation strategies, assessing potential projects, allocating funds, and designing and implementing future projects.

Multi-Jurisdictional Hazard Mitigation Plan

The QACO Multi-Jurisdictional Hazard Mitigation Plan (2012-2017) currently does not address the effects of SLR. Understanding the effects of SLR on hazard mitigation will be important in order for the County to coordinate hazard response; update mitigation goals, objectives, and related actions; and implement hazard mitigation policies, programs, and projects. Incorporating SLR scenarios into mitigation planning will help to protect public safety and property, incorporate cost-savings activities and projects, permit access to federal funding for SLR related projects, and promote effective recovery post-disaster.

SLR should be incorporated into the next revision to properly define the Hazard Identification and Risk Assessment (HIRA), identify mitigation goals, and update execution and maintenance plans for flooding

and hurricanes as well as address the effects of SLR on emergency services and emergency evacuation routes. Adaptive management implementation projects to reduce vulnerability to SPR that are included in the report should be listed in the plan to project the potential for FEMA support/funding for these projects.

Floodplain Management Ordinance

The QACO floodplain management ordinance incorporates regulations to protect the public health, safety, and general welfare of the community. The statement of purpose includes “meeting” the community participation requirements of the National Flood Insurance Program (NFIP) as set forth in the Code of Federal Regulations (CFR). The floodplain regulations apply to all special flood hazard areas (SFHA) within the jurisdiction of QACO. While the SFHA as shown on the FEMA maps generally encompass the SLR scenarios presented herein, the SFHAs themselves do not incorporate SLR. As sea levels continue to rise, the SFHAs will become incrementally outdated.

The floodplain management ordinance can be modified to incorporate SLR specifically, or through requirements that exceed FEMA’s minimum standards that will ultimately protect against SLR. For example, QACO has identified the flood protection elevation as the base flood elevation plus two (2) feet of freeboard, which is more stringent than FEMA’s minimum requirement of one (1) foot of freeboard. With SLR projections of two (2) to four (4) feet between 2050 and 2100, the flood protection elevation may need to be reevaluated from time to time as actual SLR is monitored.

Additional requirements and/or more-stringent standards should be evaluated with regards to floodplain setbacks, substantial improvements of structures in SFHAs (including repair of substantial damage), and/or building location requirements as it relates to tidal elevations and/or anticipated SLR elevations. These and other more-stringent regulations will help the County accumulate points towards the Community Rating System (CRS) with FEMA. Protecting against future SLR will also build resiliency in today’s storm events.

Zoning and Subdivision Regulations

QACO Zoning and Subdivision Regulations should be evaluated for comprehensive changes to zoning districts to account for SLR and coastal hazards. Long-range land use plans are the logical place to start adaptation planning and zoning codes can be the strongest potential SLR adaptation regulatory tools. In areas vulnerable to SLR the creation of special districts with restrictive zoning may be needed to begin the orderly disinvestment of those zones over time.

Evaluation of permitted uses by district is recommended, particularly the Countryside District that generally lies within the Critical Area. This may result in permitted uses being revised to conditional uses, or conditional uses being revised to non-permitted uses, to allow the County authority to make informed decisions whether or not to permit uses that will add infrastructure to vulnerable areas.

Increasing setback distances from tidal wetlands will also be an effective tool to build resiliency in mixed-use, commercial, light industrial, and residential uses. Setback distances should be assessed for all districts to evaluate SLR and vulnerable coastal buffers.

Zoning within the areas vulnerable to SLR and coastal flooding, including within FEMA’s effective floodplain could have a requirement for minimum lot sizes or land use to reduce the number of vulnerable structures. This will also contribute to scoring criteria under the CRS.

Comprehensive Plan

A Comprehensive Plan is an advisory document and should be reviewed and revised as change occurs to cover new challenges. The Queen Anne's County Comprehensive Plan (2010) contains the blueprint for the future development and preservation of the County and the plan is the policy foundation upon which the County is built. Comprehensive plans are not law, however the statutes that require their preparation mandate that all zoning or land use laws must be updated in accordance with the plan to prevent the enactment of arbitrary regulation and ensure the public welfare is being served through legislation implementing the goals of the community.

The Comprehensive Plan expresses long-range goals and objectives of the County and can recommend land uses. This is typically a precursor to changes in Zoning. Without accommodations for SLR and related coastal hazards, many of the coastal areas will not be able to sustain build-out scenarios without putting people and property at risk.

Changes to the Comprehensive Plan may include revisions to ultimate land uses to account for areas vulnerable to SLR and coastal hazards. SLR and coastal hazards have the potential to affect many of the elements of the plan including, but not limited to; land use, sensitive areas, water resources, priority preservation areas, historic and cultural preservation, County/Town planning framework, economic development and tourism, and community facilities and transportation.

Capital Improvement Plan

County departments typically recommend an annual capital budget while the County Commissioners approve the budget while considering the priorities established by a long-term plan, typically 5, 10, or 20 years. Planning for SLR should be incorporated into all applicable capital improvement design projects leading to design, as well as long-term plans and budgets. Many of these projects are large-scale projects with long design life expectancies. Incorporating SLR will not only build resiliency into future projects, but will provide a cost savings compared to retrofitting a project prior to the end of its useful life expectancy.

This assessment report identifies roads, bridges, wastewater facilities, water facilities, and other potential capital projects that could be affected by SLR and changing coastal hazards. As these impacted resources are scheduled for upgrades, retrofits, and/or replacement, consideration of SLR should be evaluated.

Capital improvement plans also typically identify options for financing the plan. QACO should continue to assess means to finance projects through grants, cost-sharing, and other alternative funding options. Climate change and disaster-related resiliency grants are becoming more available as climate change and SLR are more understood. The U.S. Department of Urban Development (HUD), FEMA, NOAA, NRCS, and other agencies are providing funding for resilient housing, infrastructure, agricultural, and natural resource projects, especially to communities impacted by major disasters.

Cost-sharing can provide mutual benefits from a wide array of partners. Coordination and agreements with SHA may allow roadway projects to incorporate SLR that otherwise may not have addressed vulnerable areas. Sediments dredged from navigation channels in the Chesapeake Bay are many times deposited in upland confined disposal sites. Partnerships can be developed to use dredged spoils to replenish beaches to protect against erosion and/or to elevate tidal marshes to accommodate SLR without inundation of the resource. This can also save money by reducing transportation costs of dredged material. The County may want to evaluate the benefits of a Regional Sediment Management Plan and

Beneficial Use of Dredged Materials in cooperation with the USACE and State of Maryland to plan for, identify, and coordinate potential opportunities.

Prioritization of Adaptive Management Strategies

Due to the magnitude of the recommendations, the diversity in vulnerabilities, the diversity of resources that are vulnerable, and the realization of funding limitations and capacity – a prioritization strategy should be developed for implementation opportunities. There are a number of means to prioritize adaptive management strategies. Strategies can vary by resource, threat, level of risk, cost of implementation, community, funding, multi-purpose/functions, number of benefactors, or other approaches. The process of setting priorities should be part of the evaluation of how recommendations are incorporated into the various county regulations and plans. Initial prioritized strategies should include staff resources to update plans with recommendations and complete the non-capital opportunities first such as updated mapping, outreach, communication, and avoidance strategies to reduce new vulnerabilities.

Funding

As noted in the Capital Plan Section, there are traditional funding mechanisms available for implementation projects. These funds are limited and there is extensive competition for the funds. Strategies to pursue these funds and position for high potential for reward should be part of an implementation plan. The need to generate additional funding resources is evident and a strategy to develop those alternative programs is vital to an implementation plan. Many communities are looking into creative fee structures, taxes, public/private partnerships, incentive programs, and the like for needed funding.

Public Engagement

Many of the recommended adaptation strategies and implementation plan recommendations include actions pertaining to private land and/or use of public funds through private citizen taxes, each with their own opinions of SLR and each with their own interests in mind. Additionally, much of the County's population resides in upland areas that are relatively unimpeded by SLR and coastal hazards. It is important that adaptation strategies are as equitable as possible across the County. It is also important to gain public buy-in to adaptation strategies. This can be accomplished through dissemination of information, hearing and addressing concerns, and implementing unbiased solutions. Town meetings, charrettes, questionnaires, surveys, flyers, and/or other methods of communication can be used to solicit feedback, identify concerns, and implement solutions. Any engagement efforts need to consider use of language and images that the lay public can understand and relate to personally to be effective. Engaging resources to assist in this communication may be beneficial as part of an implementation plan.

Timeline

The timeline to implement adaptation strategies to build resiliency is largely dependent on available funding and capacity of QACO staff. Short-term recommendations identified herein should be implemented to the extent practicable now and as planning, permitting, design, and construction progresses within the County. As County planning documents are updated, SLR and coastal hazard adaptation strategies should be incorporated. Medium-term and long-term recommendations should be incorporated as feasible and identified in the prioritization of adaptive management strategies plan.

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APPENDIX A

COASTAL VULNERABILITY AREA MAPS

Map A1	Coastal Vulnerability Area Map – Study Area 1
Map A2	Coastal Vulnerability Area Map – Study Area 2
Map A3	Coastal Vulnerability Area Map – Study Area 3
Map A4	Coastal Vulnerability Area Map – Study Area 4
Map A5	Coastal Vulnerability Area Map – Southern Kent Island - North
Map A6	Coastal Vulnerability Area Map – Southern Kent Island - South

APPENDIX B

INFRASTRUCTURE IMPACT MAPS

Map B1	Infrastructure Impacts – Study Area 1
Map B2	Infrastructure Impacts – Study Area 2
Map B3	Infrastructure Impacts – Study Area 3
Map B4	Infrastructure Impacts – Study Area 4
Map B5	Infrastructure Impacts – Southern Kent Island - North
Map B6	Infrastructure Impacts – Southern Kent Island - South

APPENDIX C

NATURAL RESOURCE IMPACT MAPS

Map C1	Natural Resource Impacts – Study Area 1
Map C2	Natural Resource Impacts – Study Area 2
Map C3	Natural Resource Impacts – Study Area 3
Map C4	Natural Resource Impacts – Study Area 4
Map C5	Natural Resource Impacts – Southern Kent Island - North
Map C6	Natural Resource Impacts – Southern Kent Island - South

APPENDIX D

ASSESSMENT DATASET INVENTORY

Assessment Dataset Inventory

Dataset	Source
Adjacent Counties	ESRI
Critical Areas	Maryland Department of Natural Resources
DNR Wetlands	Maryland Department of Natural Resources
NWI Wetlands	National Wetlands Inventory website
1-ft. Contour Interval LiDAR data	QACO GIS
Address Points	QACO GIS
Buildings (addressable)	QACO GIS
Commissioner Districts (used as Study Areas)	QACO GIS
Incorporated Towns	QACO GIS
Parcels	QACO GIS
Road Centerlines	QACO GIS
Shoreline	QACO GIS
Utilities (lines)	QACO GIS
Utilities (points)	QACO GIS
Agriculture Land Use	QACO GIS (from QACO Parcel dataset)
Commercial Structures	RKK (from QACO Address Point and Building dataset)
Emergency Services	RKK (from QACO Address Point and Building dataset)
Municipal Structures	RKK (from QACO Address Point and Building dataset)
Residential Structures	RKK (from QACO Address Point and Building dataset)
Schools	RKK (from QACO Address Point and Building dataset)
Wastewater Treatment Plants	RKK (from QACO Address Point dataset)
Water Towers	RKK (from QACO provided addresses and Utility Lines dataset)
Ground Storage Tanks	RKK (from QACO provided addresses)
Lift Stations	RKK (from QACO provided addresses)

Dataset	Source
Piers	RKK (from QACO provided addresses)
Pumping stations	RKK (from QACO provided addresses)
Vacuum Stations	RKK (from QACO provided addresses)
Water Booster Pump Stations	RKK (from QACO provided addresses)
Water Treatment Plants	RKK (from QACO provided addresses)
Well House	RKK (from QACO provided addresses)
SLR Scenario 1	RKK (from QACO provided LIDAR)
SLR Scenario 2	RKK (from QACO provided LIDAR)
SLR Scenario 3	RKK (from QACO provided LIDAR)
Emergency Evacuation Routes	SHA (from DelMarVa Emergency Task Force)