Middle Peninsula Climate Change Adaptation

An assessment of potential Anthropogenic and Ecological Impacts of Climate Change on the Middle Peninsula

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant **FY2008 NA08NOS4190466 Task 12.04 of** the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its sub agencies.

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Executive Summary

Although climate change is a global phenomenon, local strategies to adapt and plan for climate changes will be important to protect public safety, health and welfare. With well over 1,000 miles of linear shoreline in the Middle Peninsula, there is a considerable amount of coastline that may be directly impacted by climate change. In October 2008, the Middle Peninsula Planning District Commission (MPPDC), funded through the Virginia Department of Environmental Quality's Virginia Coastal Zone Management (CZM) Program, began a three year endeavor working with member localities and a variety of stakeholder groups to assess and discuss climate change impacts.

A Climate Change Advisory Workgroup, consisting of appointed county representatives and stakeholders, including transportation, sanitation, public health, recreation, scientists, planners, and local businesses, for the Middle Peninsula was established. They were tasked with identifying critical anthropogenic and ecological impacts of climate change and sea level rise to their respective sector as well as to the region. A series of monthly meetings with the Workgroup pinpointed specific impacts of concern which were then mapped and assessed through GIS (Geographic Information System). Using available topographic data, MPPDC staff generated county maps to assess the economic and ecological impacts of 1 ft sea level rise by 2050 for select vulnerable areas within each county. The assessment revealed that approximately $187,005,132.10 - $249,451,074.50 worth of infrastructure (ie. roads, houses, onsite disposal systems, etc) and wetland function may be impacted and/or lost by sea level rise.

Introduction

Climate change is a phenomenon that can be defined as changes in climate (eg. temperature, precipitation and wind) that can be measured over an extended period of time. Although temperature, precipitation and wind changes are the three direct factors that attribute to climate change, they have countless indirect impacts that affect numerous land use sectors (eg. water resources, agriculture biodiversity, forests, recreation, energy, transportation, coastal ecosystems, infrastructure, business, public health and emergency response). Due to the unbiased nature of climate change, these changes will impact both the ecologic and anthropogenic dynamics of the Middle Peninsula.

According to the Intergovernmental Panel on Climate Change (IPCC), Virginia temperatures are estimated to increase by 3°F in the winter, spring, and summer, and increase 4°F in the fall, while precipitation is estimated to increase by 20% in all seasons by 2100. The National Wildlife Federation has estimated that there will be an 11.2 inch sea level rise by 2050 and a 27.2 inch sea level rise by 2100. However it is important to note that due to variations within models, sea level rise estimates are inconsistent amongst publications. Furthermore, with much of the land in the Middle Peninsula currently facing subsidence and erosion issues, the region is ultimately more vulnerable to sea level rise. Consequently, what are the implications of these changes to the Middle Peninsula and how will the region plan to adapt?

Project Overview

The Middle Peninsula Planning District Commission, funded through the Virginia Coastal Zone Management (CZM) Program, has begun a three year endeavor working with member localities and a variety of stakeholder groups to assess and discuss climate change impacts. Year one of this project focused on the collection, assessment and analysis of potential ecologic (ie. wetlands, conserved lands, etc) and anthropogenic (ie. personal property, public property, etc) impacts of climate change, specifically due to sea level rise. In addition to identifying impacts, an economic and ecologic impact of sea level rise in select locations of the Middle Peninsula was conducted. In year 2, MPPDC staff will focus on educating the general public and local elected officials, and staff, about climate change and regional impacts, including the

findings during year 1 of this project. And finally year 3 will initiate public policy discussion and development to respond, or adapt, to climate change impacts.

Summary of Stakeholder Findings and Workgroup Meetings

To begin to understand concerns of climate change (eg. sea level rise) impacts to the Middle Peninsula, a Climate Change Advisory Committee (CCAW) was created. Consisting of appointed county representatives and stakeholders, including transportation, sanitation, public health, recreation, scientists, planners, and local businesses, the committee collaborated through a series of meetings to identify critical anthropogenic and ecological impacts of climate change. At the first meeting on February 12, 2009 the workgroup was given an opportunity to share their initial reactions and concerns of climate change, or sea level rise (Table 1) and whether or not their affiliate was currently discussing or taking actions to adapt to climate change.

Table 1: Initial thoughts and responses to climate change from the CCAW.

Affiliation	Responses
Agriculture	- The county needs to have more oversight of retention ponds - Due to lack of ditch maintenance in Gloucester water inundation is a problem. - Agriculture technology is adapting to changes in climate and droughts. -Hurricane Isabel caused loss of farm land (eg. Gloucester County); since water was unable to drain off the fields it caused eventual subsidence.
Tidewater RC&D	-Affiliate has not talked about climate change to date.
Gloucester County Planner	- During comprehensive plan steering committee meetings there were some people who expressed disbelief in climate change, but the consensus was to include climate change in the plan. - Gloucester County's hazard mitigation plan suggests using funds to raise houses, but currently there is no money to raise roads or houses so the burden falls into the hands of the private land owner. - As far as storm water, Gloucester County just follows state regulations.
Hampton Roads Sanitation District (HRSD)	- All plants are in low areas of the region and therefore are vulnerable to sea level rise. -Private homes at risk are a risk to HRSD's revenue stream. - As sea level rises, there will be groundwater backup which will impact inland systems. This problem will go beyond the water's edge.
Middlesex County Planner	-The County has not discussed climate change. -Middlesex is not encouraging development in floodplain areas. -There's no money for road elevation or maintenance within the county.

	-The County will consider adding climate change to the next comprehensive plan.
Mathews County Planner	- The County has not discussed climate change. - Mathew's is currently updating their comprehensive plan and zoning, and will include climate change in the plan.
Tappahannock assistant town manger	- The county has not yet discussed climate change.
Fisheries	-Witnessed a 2-3 inch subsidence from Isabel and about 8 inches of silt in other areas. -As a shellfish farmer he ran fecal coliform tests in drainage ditches and found counts to be very high. Water is being polluted from leaking septic tanks that flow into drainage ditches and into adjacent bodies of water. -Would not consider living breakwaters to mitigate tides but is considering using aquaculture floats and racks. - There are potential economic losses.
Virginia Department of Health (VDH)	-The topic of climate change has not yet been raised or discussed. -Air quality from wildfires, vector water borne diseases are a few of the potential risks that are of concern
Resident	-Concerned because no one is doing anything and that we are operating at status quo -Concerned about wetlands bank
Essex County Administer	-Currently updating the county comprehensive plan and is hoping to address climate change. -Looking at rezoning to address septic regulation changes,

One can see that throughout the Middle Peninsula, there has been little thought about climate change, especially as impacts may impose on industry and everyday life within the region.

Therefore to initiate thoughts and gather specific concerns about anthropogenic and ecologic impacts of climate change, MPPDC staff supplied workgroup participates with a worksheet to complete for the next meeting. The worksheet asked participants to contribute thoughts, ideas and comments about a variety of ecologic and anthropogenic impacts. On the worksheet, MPPDC staff provided sample climate change impacts to respective categories aimed to assist participants in appropriately framing their answers. Workgroup responses are summarized in table 2.

Table 2: A culmination of CCAW responses to identify critical anthropogenic and ecologic impacts of climate change.

	Response - Comments
ANTHROPOGENIC (human) IMPACTS	

Recreation	• Public access points
	  ○ Access points, but are working on this with Town Project "Riverwalk"
	  ○ Many public access boating points have little to no land associated with them so that rising sea level or erosion may continue to decrease the area available to patrons for parking, boat launch, etc.
	• Though [recreation] may be affected this should not be a primary focus
	• Decreases the opportunities for warm season activities such as boating, sailing, kayaking, fishing, etc. Could impact a major sector of the county's employment base.
	• Impacts on recreational fishing
	• Potential positive impact of opportunities for outdoor exercise over an extended period of the year, combating the negative effects of sedentary lifestyles.
	• Negative impact of curtailing outdoor exercise opportunities during heat waves. Danger of heat stress or heat stroke for those who do continue to exercise in extreme conditions.
	• These shifts in activities should be gradual enough for localities to handle however the increased growth in warmer coastal climates and tourism related population shifts have already impacted the region. Most localities play catch up and don't adequately plan for these shifts in demands due to increased permanent and temporary populations. Many localities see increased recreation as a positive thing, but the potential impacts of "loving a place to death" need to be evaluated and managed in order to protect the qualities of a community that attracted people to it initially.
	• Public Access is already a problem and with SLR will likely continue unless local governments take advantage of acquisition programs to acquire vulnerable properties along the coastal areas and use them for public access and other recreational opportunities.

Transportation	• More travel disruptions associated with road washouts and flooding • Would not spend time working through these issues, but changes will be costly • Access to businesses and residences due to road washouts and flooding could diminish the value of a number of properties in the county. • Reduction in opportunities for water-based navigation impacts commercial and recreational boating in the county. This in turn decreases potential tourism dollars for the county. • Road damage from heat and increased risk of flooding are the two biggest concerns • Some areas may be cut off from evacuation or assistance due to flooding, washouts, or damage to bridges • Snow and Ice is not a significant issue in this region other than the random unpredictable storms. The larger issue of impact to existing roads from SLR and compaction (sinking) is a real problem for both access and the increased risk during emergencies (fire, rescue, health issues) from lack of safe access to areas flooded or damaged by flood events. There is limited funding for repair and

	Response - Comments
ANTHROPOGENIC (human) IMPACTS	
Transportation cont.	maintenance of existing facilities and additional burden will be placed on governments to address these issues. Increased conflicts over a person's rights to live where they want and the cost to the overall community will have to be addressed and policies made. The tax rates may be affected on some of the previously premier waterfront homes when the access to these homes are impacted (like choosing to live on an island with only ferry service).
Infrastructure	• Property loss • Increased demands on storm water management systems • Over time, we need to remove things out of harm's way rather than taking the approach of adding armor; we should force at risk buildings and faculties to move outside of the affected area rather than continue to develop and then retrofit • Storm water management • Potential property loss and increased need for shoreline protection are two biggest concerns • Frequent flooding: Certain areas can be isolated by washed-out roadways and cut off from evacuation or from relief services in an emergency. • Storm water management: increased risk of surface water reservoir contamination, shellfish waters and recreational waters contamination, increased risk of harmful algal blooms. • Property Loss: Displaced and ill-housed people; people attempting to live in unfit housing following storms due to lack of options leading to health problems related to injury, infections, respiratory issues, etc. • The impacts to coastal properties will have to be addressed relative to the overall cost to the community to provide services to these higher risk areas. Localities will need to decide how they handle the need to provide services to tax payers in high risk areas without unduly burdening other taxpayers whose properties do not pose such a significant financial and public safety risk. • The private sector, through the inability to obtain insurance for some of these properties as risk, may have an influence on the location of these homes before the locality comes to a point of having to make these decisions.
Business	• Impacts on infrastructure • Lowest area of interest • Higher insurance (or even availability) and shift in business opportunities are two biggest concerns. Many local public water supplies use groundwater sources, where flooding of the wellheads and follow-up sampling and contamination may temporarily disrupt business. • These issues do not seem to be a major concern in Gloucester since most businesses are located outside the typical flood prone areas, however the regional impact of increased and more extreme weather events along with the existing lack of convenient access to major transportation systems could further impact Gloucester and the region from competing for viable and sustainable businesses within the community. The vulnerability of the existing infrastructure of bridge and tunnels to major employment centers is also a factor that impacts quality of life and the ability to do business in this region.

	Responses- Comments
ANTHROPOGENIC (human) IMPACTS	
Health	• More heat related strokes • Reduced summer air quality • High priority, but we really don't know how health is affected • Air quality and increased risk of disease are two biggest concerns • "Heat waves are already the most deadly weather-related exposure in the U.S., and account for more deaths annually than hurricanes, tornadoes, floods, and earthquakes combined" (CDC). Aging population is expected to lead to higher numbers of heat-related deaths; other risks include living alone, lack of air conditioning, and use of certain medications. • Affects from heat rashes to heat stroke. Aggravate chronic cardiovascular and respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD). Vulnerable groups may be able to afford air conditioning and may not be able to seek temporary respite from the heat elsewhere due to lack of mobility or transportation. • Heat waves during which temperatures remain above normal during the night as well as daytime hours can disrupt sleep and lead to overall fatigue and mental stress. • Climate change may cause changing distribution of vector-borne and zoonotic diseases already prevalent in the U.S. and may also cause re-emergence of diseases such as malaria and dengue fever which were prevalent, or may result in new introductions and spread of disease agents (e.g. West Nile Virus). This is a complex issue because the ecology and life cycles of both the vector or animal host and the germs may be affected by climate change. For example, the malaria parasite reproduces at a higher rate as temperature increases and mosquitoes take more frequent blood meals as well. Diseases that show seasonality may change in their range or become prevalent through a longer period of the year. • Heat causes increase in ground-level ozone concentrations. Ozone causes lung injury and increases severity of respiratory diseases. (Current projections suggest this will be more critical in other regions of the country. • Use of air conditioning increases electricity demand resulting in burning of fossil fuels which produces airborne particulates which add to respiratory disease problems as well as contributing further to climate change • Reduced summer air quality: Increased temperatures and carbon dioxide concentrations at ground-level may result in increased plant metabolism and pollen production and increased fungal growth and spore release causing aggravated allergic reactions and respiratory diseases. • Mental disease: Worry about the future, traumatic experiences, loss of relationship with place, separation from or loss of family and friends, disruption of mental health care, displacement, socioeconomic disruptions • Water-borne and Food-borne diseases: Pathogens include bacteria, viruses and parasites. Pathogen replication, survival, and persistence rates; transmission rates; and disease ranges are all affected by environmental conditions. Some water-borne and food-borne illnesses show seasonal patterns are probably under the greatest environmental influence. Higher temperatures are believed to produce a higher number of parasitic infections and higher bacterial replication, persistence, survival and transmission. Viral

	Response - Comments
ANTHROPOGENIC (human) IMPACTS	
Health cont.	• pathogens have mixed response to higher temperatures but may have decreased transmission rates. • On-site Wastewater Disposal: Rising groundwater levels will inundate drainfields impairing function for both disposal and soil treatment. Possible change of development patterns. Flushing of contaminants and nutrients into surface waters and groundwater. • Solid waste sanitation While this is an impact of concern from a public health issue, it is difficult to deal with on a local level. It does impact emergency services and the ability to provide for people with some of these issues.
Emergency response	• Increased demands on emergency response – more cost • Not significantly different if we were able to move folks out of harm's way; we have had just as many emergency response issues related to snow and ice as we have to other types of storms • Increased demands on emergency response becomes more problematic for the county since it is already experiencing a reduction in the number of fire and rescue volunteers. • Increased demand, as well as ability to respond to those demands (if road is under water!) are both major considerations • This is potentially a significant impact to the localities on the MP with volunteer fire and rescue squads. As the risks increase, it may be more difficult to recruit volunteers to meet the challenges particularly as they also need to protect their families. • The fiscal liability for localities to provide for emergencies through an EOP and provide for facilities to meet the demand for shelters during flooding, fires and storm events is increasingly complicated – providing a place for people with respiratory problems, pets, etc. that meets all the requirements mandated by increasingly strict legislation is a big burden on small localities with limited staff and funding. When a small locality also has to accept and provide for refugees from adjoining coastal communities, this burden increases exponentially.
Energy	• Increased demands overall • Need to consider these impacts, although they may be difficult to measure/estimate • Increased load on the energy grid during peak summer months is a great concern. Costs and potential for power outages will have greatest impact • Other sources of energy will be needed to meet the increased demands as well as to reduce the impact of the current energy systems. In many cases localities will need to consider code amendments that will address alternative energy sources to provide for increased demands.

	Response - Comments
ECOLOGICAL IMPACTS	
Hydrology and water resources	• Changes in water quality • Increased risk of flooding • Town flooding (ie. Kirby St between 1st and 2nd streets) • The increased risk of flooding in terms of short and long-range land use planning. Drafting policies and procedures and securing funding to address elevation of structures, elevation/relocation of roads and utilities, acquisition of properties, and demolition of structures is critically important to the County for the present and for the future. In addition, amendments to the zoning and subdivision ordinances as how to address future plans of development for those areas of the county potentially affected by flooding are equally important. • increased risk of flooding is probably most important. The warmer water temperatures will affect aquatic vegetation & thus, water quality. Drought and competition for water will likely have some impacts, but not to the same extent as in other localities that are experiencing higher rates of growth or that have more "farm" land. • Shallow wells may fail to continue to provide a dependable water source requiring replacement with deeper wells. Dependability of deeper wells may also be affected. • Flooding of wellheads and shallow wells can lead to contamination. Owners may need to do water sampling and/or well chlorination requiring education/assistance for the task and is a cost. • Drowning and injuries increase • Algal blooms including Harmful Algal Blooms are related to elevated temperatures and nitrification of surface waters as may happen during intense rain events with increased surface runoff. Virginia Department of Health has developed a "Harmful Algal Bloom Response Plan". Harmful Algal Bloom affect fish and other estuarine life and people can be affected as well. • From a Land Use Planning perspective, I am concerned with the increased competition for water especially since we do not have a good handle on how much groundwater is available for development. The state requirement for a Water Supply plan should provide us with more data on what resources are available, however I do not know if it will take into account increased risk of drought. The droughts of recent years is one of the primary reasons for the mandated study. • I am also concerned with increase flooding and the inability of our current privatized storm water management system to handle increased flooding from both tidal events and more intense storm events. Older developments and existing dam structures are not designed to handle the storm water from increased development and more intense storm events. The county requires that HOA's maintain storm water BMP's and if these fail, the homeowners may not have the mechanism or the means to repair them. • Flooding also impacts infra structure and homes. The location of homes in flood prone areas also puts the sheriffs and volunteer fire and rescue squads at risk • Changes to the hydrology also impacts the county's natural resources and therefore is a potential risk to the county's economy from tourism, recreation and the working watermen.

	Response - Comments
ECOLOGICAL IMPACTS	
Agriculture	• Increased demand for irrigation • Changes in crop yields • Agriculture practices will adapt to changes, though subject to increased cosmoses, less flavor, fewer choices • Increases in mosquitoes and knats with warmer temperatures • The increased demand for irrigation water is important if the water used is potable. Increased use of potable water for irrigation could potentially reduce the amount of water in the aquifer available for human consumption and use. • Rising air temps will be of some concern, and farms will likely be most affected by the increased demand for water to mitigate heat stress and maintain crop yields. • Shortages and increased food prices have the potential to negatively affect nutrition of consumers. • Increased competition for source water. • While this is not my area of expertise, the county has, through its comprehensive plan, indicated the desire to protect its rural character and agricultural and forestal operations. If these industries are impacted, there will be more pressure to change the use of these lands to another use that would be more profitable. Therefore impacts to agriculture will result in increased development pressure. • Impacts to agriculture also impact the economy and sustainability of our area. Rather than reduce the agricultural products produced here, it should be diversified in order to have the area be more self-sufficient and use locally grown products which support or economy and reduce the need for shipping to and from other areas. • decrease in availability of irrigation water from ponds and fresh water sources • increase in salinity of water in tidal rivers which will restrict the use of river water for irrigation purpose (these is already being evidenced in years of drought where the salinity creeps further up the river)
Biodiversity	• Loss of habitat • Loss of species • Biodiversity is a great concern; we do not even begin to understand how species inter-relate and yet we are seeing conditions change very rapidly to eradicate, displace or hybridized species. • Climate change will certainly shift the distribution of species. • This in an impact to our ecology and while humans can adapt, these changes could have results that are less pronounced but impact the quality of life for everyone – from the backyard bird watcher, hunters, fisherman, watermen, etc. Much of the Bay's economy and economic viability is based on its bounty and beauty. Changes to the ecology will ultimately impact everyone to some degree.

	Response - Comments
ECOLOGICAL IMPACTS	
Forests (including parks)	• Increased risk of forest fires • Mon culture system in forestry that will be hard to sustain; potential benefits to seeing a more natural forest type return that mitigate several of the impacts that you suggest • An increased risk of forest fire impacts a traditional economic base for Mathews County. Although the number of people employed in forestry jobs has remained flat over the past decade, this employment sector is still important to the county. • Risk of forest fires and shift in distribution of species are probably the two biggest concerns. • Forest and brush fires have negative effects on air quality releasing particulates that aggravate respiratory disease symptoms. Recent local droughts have led to fires in southern Gloucester County with air impacts noticeable for miles. Fires in the Great Dismal Swamp in Virginia and North Carolina, where the forests and the peat soils burn and smolder for extended periods were evident here in the Middle Peninsula. • Similar response to agriculture above. Although increases in growth and productivity in the short term may result in increased harvesting of forests and open land to development as does the potential for the negative impacts from other risks to healthy forests. • Increased risk of forest fires from climate change is unclear, but potentially is a safety issue in areas where human habitation or construction interfaces with forest lands. • Planning for fire protection and for reduced risk of structures need vulnerable habitats is currently needed and may become a greater local government priority as the risks increase • loss of productively in species that demand a colder climate • economic value of hardwood grown in colder climates is generally higher than those grown in warmer climate (lumber production versus pulp production)
Coastal Resources and ecosystems	• Loss of coastal wetlands and other coastal habitats due to sea level rise, erosion • Coastal erosion • See level rise will be devastating to impacts upon natural processes and these we cannot mitigate by simply applying erosion control methods • The impact of increased shoreline erosion could mean additional requests for revetments and bulkheads to harden the shoreline of waterfront properties. The attendant loss of wetlands and sub-aquatic vegetation could negatively affect species such as crabs, oysters and fish. • Sea level rise could mean the loss of the historic New Point Comfort Lighthouse. • The increased risk of pollution could impact the County's attempts to promote aquaculture for shellfish and/or finfish species. • The rise in sea level will have the most pronounced impacts on our coastal wetlands. If they are not able to migrate upland at a pace equal to sea level rise, we will lose this important area's functionality as both a buffer and a habitat.

	Response - Comments
ECOLOGICAL IMPACTS	
Coastal Resources and ecosystems cont.	• Sewage disposal systems have frequently been located near shorelines, a 50' setback under the 1971 Regulations, a 70' setback under the 1982 Regulations and at 100' setback when Chesapeake Bay Preservation Ordinances affect their placement. These setbacks are a function of drawdown of the seasonal water table due to better natural drainage patterns proximate to shorelines. The trend of increasing erosion can lead to increased non-point source pollution from septic systems position closer to erosion front and damage and loss of parts of drain fields. • Erosion has also led to the isolation of wells in open water. • Because coastal wetlands reduce the affects of storm surge, their loss will result in more dangerous and damaging storms and loss of housing, etc. • Nearly all water for domestic and business use is groundwater sourced in the MP. Wells are currently affected by saltwater intrusion to the point of being unusable or requiring expensive reverse osmosis treatment in discrete locations, which would be expected to expand. • May contribute to mental distress (risk of pollution from coastal hazardous waste sites due to sea level rise). The risks to coastal environments affect all the items listed to the left and impact the costs involved both on an individual level and on a local government level. The costs of protecting resources threatened by these changes are usually beyond the capacity of individuals and even more so local governments. Without regional solutions to some of these impacts, they are destined to continue with only minor incremental solutions.
Aquatic ecosystems	• Loss of near shore habitat and coastal wetlands • High importance: may be the crux of the issue • Shift in species and loss of habitat/wetlands. • This impacts the ecology and all that is involved in that plus the economy that is based on the health of the aquatic ecosystems (tourism, recreation and watermen)
Additional Comments	• All of the potential impacts associated with climate change could have negative consequences for Mathews County in terms of losses to property, population and its traditional economic base. Since the county's tax base relies heavily upon the value of residential waterfront property and water-dependent uses, potential sea level rise and flooding could mean losses that have no currently identifiable replacements. • While the categories are listed separately, it is clear that they are all related and each impacts one another. Although some people, agencies, etc. may care or be responsible for one or a few of the potential impacts, each impact has a ripple effect on the community in some way or another. All require coordination, planning and resources to manage the impacts as well as clear policy decisions as to which impact a locality (or higher level of government) is willing to put resources into. A cost benefit analysis and or risk analysis of each of the impacts is needed to determine where a locality is willing to focus its limited resources for the good of the overall community.

Other meetings of the CCAW consisted of MPPDC staff educating the participants and gaining feedback from the workgroup. For instance MPPDC staff provided the workgroup with information regarding how other communities, domestically and internationally, are dealing with climate change and/or sea level rise. Also the workgroup gave feedback to initial assessment attempts by MPPDC staff. For further details of the Climate Change Advisory Workgroup meetings, please refer to the minutes in Appendix 1.

Spatial Assessment of Potential Climate Change Impacts within the Middle Peninsula

Although there were a variety of specific anthropogenic and ecologic impact concerns the MPPDC staff were most interested in those with public policy implications. Table 3 shows the public policy and mapping matrix developed by MPPDC which guided staff through a spatial assessment of climate change impacts (Table 3).

Since LIDAR data for the Middle Peninsula is not currently available, GIS provided a format for assessing sea level rise impacts using elevation/topographic data. MPPDC staff assessed the economic and ecological impacts of a 1 ft sea level rise by 2050. *Please note that these estimates may be considered conservative, especially as recent reports highlight accelerated rates of climate change.*

To access the impacts, MPPDC staff gathered all available data to reflect the concerns of the workgroup. Once this data was mapped, the number of structures (eg. homes, business, onsite disposal systems, roads and shoreline hardening) and the amount of wetland acres inundated by sea level rise were quantified for select areas of the Middle Peninsula. Cost estimates were then collected to calculate the total short term and long term impact costs of sea level rise. A report titled, *Assessing the economic an ecological impact of sea level rise for select vulnerable locations in the Middle Peninsula*, was produced (See Appendix 2 for the full report). The report is organized by county and takes the reader through a variety of locations where sea level rise will cause significant ecologic and/or economic losses.

Table 3: Public policy and mapping matrix of identified anthropogenic and ecological impacts of climate change			
Public Policy Issues	**Policy Strategy**	Can it be mapped?	**Mapping Strategy**
Flooding	Land use planning tools	Yes	Denote flood prone areas
-Roads		Yes	Map evacuation routes, bridges
-Residential and Industrial		Yes	Map residential and industrial infrastructure
-Wellheads		Yes	Denote the location of the wellheads
Land Use	Land use planning tools	Yes	Denote land uses
Well depth	Virginia Department of Health (VDH)	Yes	Denote the location of the well
Water supply	-Land use planning tools -State water supply plan (eg. Conservation measures, Water Rationing, Rainwater harvesting, Water reuse)	Yes	Denote current sources of water
-Irrigation	Consideration of water reuse	Yes/No	Storm water management and Permitted activity
Storm water Management	Land use planning tools - Storm water management, Pollution Prevention programs, Low-Impact development	Yes	Topography of area and current infrastructure denoting potential flow of storm water (If permitted)
Agricultural and forestal operations	Land use planning tools	Yes	Inventory vulnerable agriculture and forestry areas (below certain elevations) Blue/Green infrastructure
Forest Fires	Land use planning tools Virginia Department of Fire	Yes/No	Anticipated and repetitive fires
Coastal Erosion	Land use planning tools Virginia Marine Resource Commission (VMRC) - Shoreline protection measures - Wetland grass planting	Yes	Inventory hard shorelines to date VIMS data
Water Pollution	Land use planning tools	Yes	VDH/DEQ
Sewage Disposal Systems/ Onsite systems	Land use planning tools - point sources/ non point sources	Yes	Inventory OSDS and public sewage systems
Cultural and historical sites	Land use planning tools	Yes	Virginia Historical Society (VHS) Local information
Coastal Access points	Land use planning tools	Yes	Map coastal access points (state/local/quasi)
Insurance availability		Yes	Areas where insurance is available
Property Loss	Land use planning tools (upland/ lowland)	Yes	Repetitive loss insurance claims
-Private/public Investment		Yes	Public projects (local and state)
-Tax Base		Yes	Revenue Reduction
Emergency Response		Yes	Map major highways

Conclusions:

The economic and ecological impact assessment of sea level rise in vulnerable areas within the Middle Peninsula revealed that approximately $187,005,132.10 - $249,451,074.50 of infrastructure and wetland functions would be impacted and/or lost due to 1 ft sea level rise by 2050. And as a reminder this assessment did not account for **all** locations within the Middle Peninsula and therefore, the actual economic and ecological loss would be more devastating than those presented here.

Through year one of this project, an understanding of anthropogenic and ecological impacts of climate change to the Middle Peninsula was developed, which laid a foundation for year 2 of this project. With generated maps as well as an economic and ecological assessment of sea level rise, MPPDC staff will set out to educate both the general public and local elected officials about climate change in year 2. Also MPPDC staff will continue to work with local elected officials as they begin to address public policy questions that pertain to the health, safety and welfare of their constituents.

Project Outcomes:

- Introduced and discussed the issue of climate change and sea level rise to the Middle Peninsula Planning District Commission.
- Created a Climate Change Advisory Workgroup to identify anthropogenic and ecological impacts of climate change and sea level rise within the Middle Peninsula.
- Educated the Climate Change Advisory Workgroup as to what climate change is, how it is currently impacting the region and how other communities, domestically and internationally, are adapting to climate change and sea level rise.
- Developed regional and county maps that depicted predictions of sea level rise and impacted structures and wetlands.
- Conducted an Economic and Ecological assessment of sea level rise to select vulnerable areas within the Middle Peninsula.

APPENDIX 1

Climate Change Advisory Workgroup Meeting Minutes

Climate Change Advisory Workgroup

Meeting 1

February 12, 2009

The first meeting of the Climate Change Advisory Workgroup was held in Regional Board Room at the MPPDC offices in Saluda, VA on Thursday, February 12, 2009. Mr. Lewie Lawrence, Director of Planning at the MPPDC, welcomed those in attendance. Workgroup members in attendance: Jim Pyne (HRSD), Keith Horsley (Gloucester County farmer), Pat Tyrell (RC&D), Anne Ducey- Ortiz (Gloucester County), John Shaw (Mathews County), David Whitlow (Essex County), Pat Duttry (VDH, Jeff McDermott (Gloucester resident), Jack White (Mathews resident), Trip Little (Middlesex County), Todd Janeski (Chesapeake NEMO) and Skip Stiles (Wetland Watch). MPPDC staff in attendance included Jackie Rickards, Sara Stamp, and Clara Ciera.

Once introductions were made by all workgroup members, a brief overview of the project was provided. Mr. Lewie Lawrence shared a recent example from Gloucester County that gave some insight into affects of climate change at the local level. In December 2008, a constituent called his local representative in Gloucester County to discuss an issue with his road flooding during not only storm events but lunar tidal cycles and winds from the south. There was an initial thought of raising a ½ mile of the road 10", but after quick calculations from VDOT the estimated cost for just material and labor was $320,000; which was 18% of Gloucester Area VDOT's Road Budget. This example provides great insight into future impacts and concerns that localities will face in regards to infrastructure loss, property loss and the cost involved in these projects. Figure 1 provides a great visual of these potential issues. Not only does it provide a depiction of the flood zones (A, AE, and VE) and the residential homes (red dots) and roads that may be impacted, but it displays the ½ mile of road that Mr. McDermott was asking to be raised. Now when you consider all the infrastructure, both residential and roads, in Guinea that will be impacted by sea level rise, how will local government deal with this?

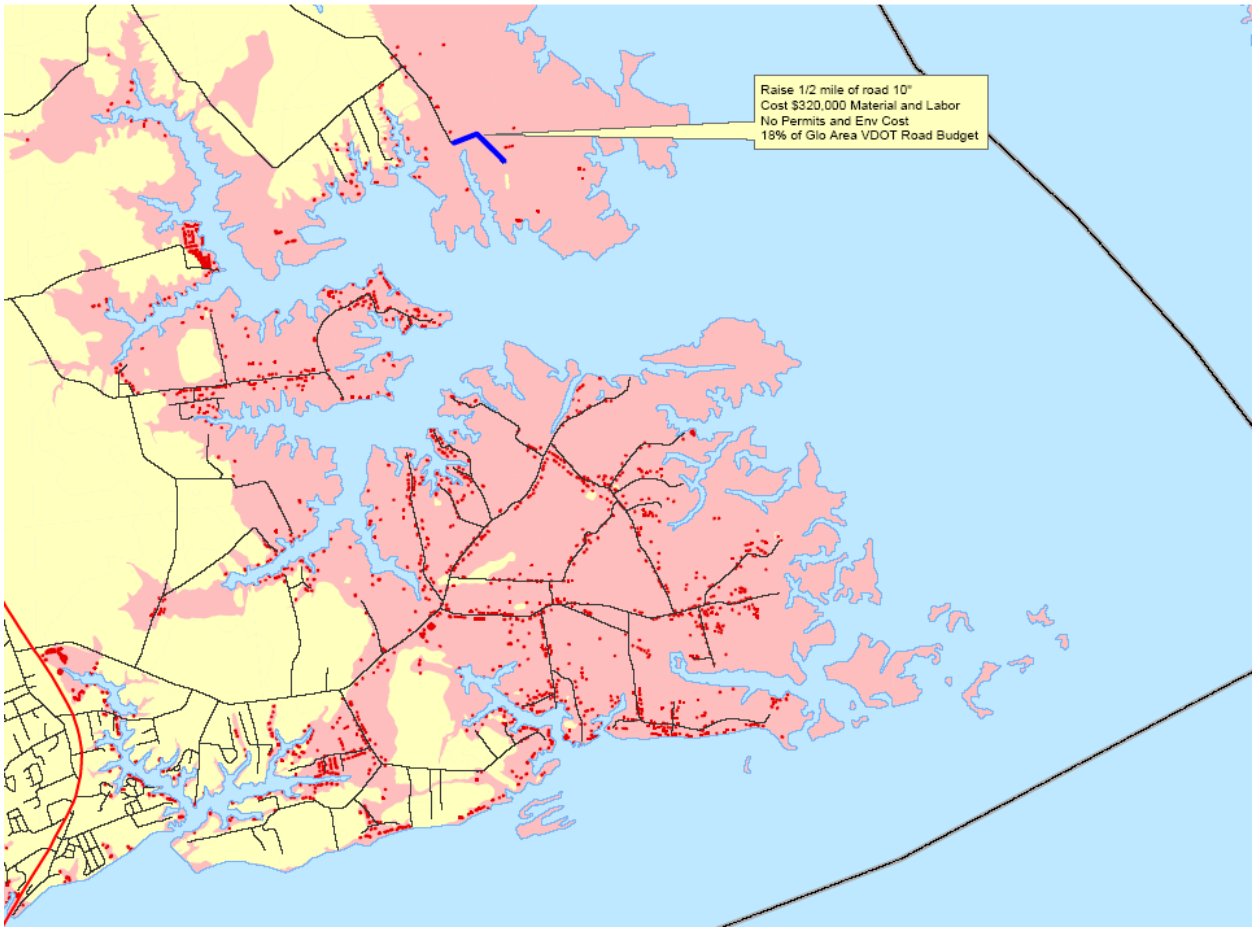


Figure1: Map of residential homes in flood zones (A, AE, VE) in Gloucester County.

Following this introductory example to put some local context to the issue of climate change a presentation introduced the project to the workgroup (See Appendix 1). The purpose of the presentation was to explain to the workgroup why they were invited and what we would like to achieve as a result of these meetings.

Skip Stiles, our guest speaker, who is executive director Wetlands Watch, gave a presentation about climate change. This provided more insight into local issues, including personal property tax, land use and septic drainfields.

Lewie then provided a summary of the All Hazards Assessment of the Middle Peninsula which was completed in 2005. The assessment not only prioritizes the hazards on the Middle Peninsula but it also shares the economic vulnerability of these hazards to each county. From the report hurricanes were identified as the natural disaster the poses the most risk, followed by winter storms, tornados, and then coastal flooding. For more information please refer to the following link: http://www.mppdc.com/ahmp/FInal_compressedfilesize.pdf

Once staff provided the workgroup with some general information in regards to climate change, we asked workgroup members to share what their affiliation as been talking about in regards to climate

change, or provide the group with examples they have encountered within their localities due to climate change or sea level rise. Below is the table of workgroup member's affiliations and their responses:

Affiliation	Responses
Agriculture	- thinks that the county needs to have more oversight of retention ponds - water inundation due to lack of ditch maintenance - Agriculture technology is adapting to changes in climate and droughts -hurricane Isabel caused loss of some farming land. The water was unable to drain off the field causing eventual subsidence
Tidewater RC&D	-Affiliation has not talked about climate change
Gloucester County Planner	- in initial discussions with the comp plan steering committee there were some that didn't think climate change was real, but the consensus was to include it in the plan - Within the hazard mitigation plan suggests using money to raise houses, but there is no money to raise roads to houses and usually falls into their hands of the private land owner. - as far as storm water, Gloucester County just follows state regulations
HRSD	- All plans are in low areas and therefore are vulnerable. -houses at risk are a risk to HRSD's revenue. - Groundwater backup-goes beyond the water edge and will see more problems with inland systems.
Middlesex County Planner	-The county has not spoken about climate change -not encouraging development in floodplain areas -There's no money for roads -County is considering putting climate change in next comp plan
Mathews County Planner	- The county has not discussed climate change. - They are in the process of updating their comp plan and zoning and they are may include it
Tappahannock assistant town manger	- The county has not discussed this
Fisheries	-saw 2-3 inch subsidence from Isabel and about 8 inches of silt in other areas. -drainage ditches let septic systems; as a shellfish farmer he ran fecal coliform tests in ditches and found counts to be very high since it is polluting water from drainage fields -would not consider living breakwaters but is considering using aquaculture floats and racks to mitigate tides - there are potential economic loses -he has a mile of shoreline with 18 acres, however it was turned down for easement
VDH	-the topic has not yet been raised -air quality from wildfires, vector water borne disease are a few of the potential risks that are of concern
Resident	-is concerned because no one is doing anything and that we are

	operating at status quo -concerned about wetlands bank
Essex County Administer	-currently updating the county comp plan and hoping to address climate change -looking at rezoning to address septic regulation changes: R2-A2 density change 1 acres – 5 acres land in sandy soil along water

In response to the Resident's comments the Agriculturists questioned why large businesses, like Walmart and Lowe's have exceptions to fill wetlands, while farmers don't have this opportunity. Moreover there was some dialogue about the changes in septic tank regulations and how it needs to change. However the Gloucester County Planner stated that the homebuilder is lobby strong which makes things hard to change. According to HSDS the VDH former director of the Division of Onsite Sewage and Water services voices that "he wanted out of the planning business".

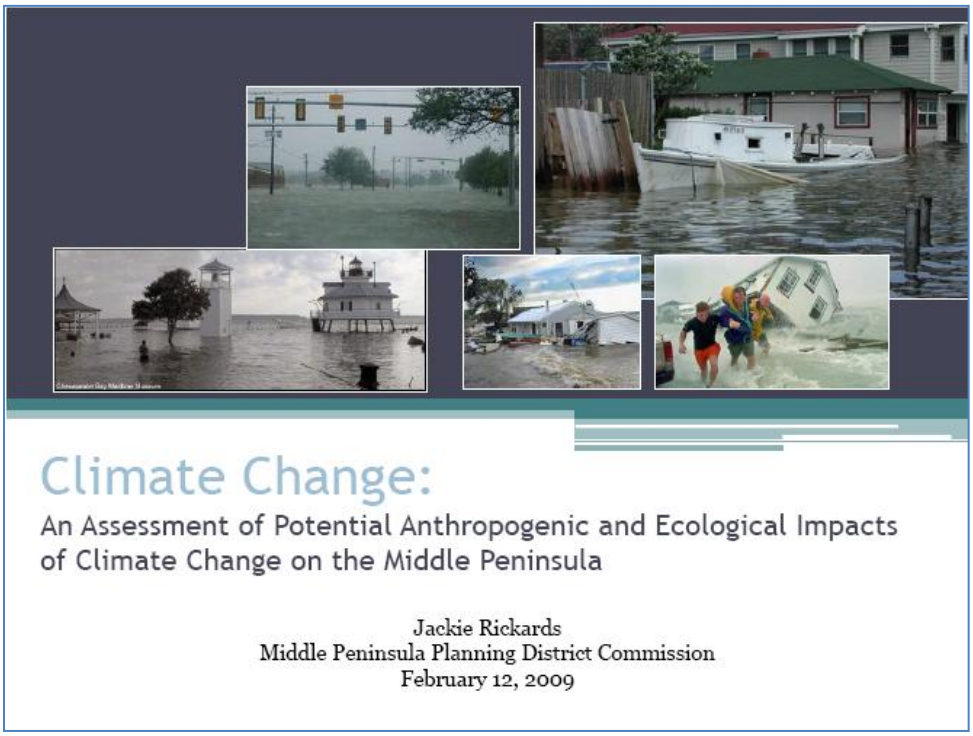
The agriculturists questioned why there are not county steering committees to deal with climate change. Mr. Lawrence explained that hopefully from this workgroup information will be passed to the County Administrators and Town Managers. From there the county boards can discuss whether or not to initial their own county committee, however this workgroup is merely a starting point.

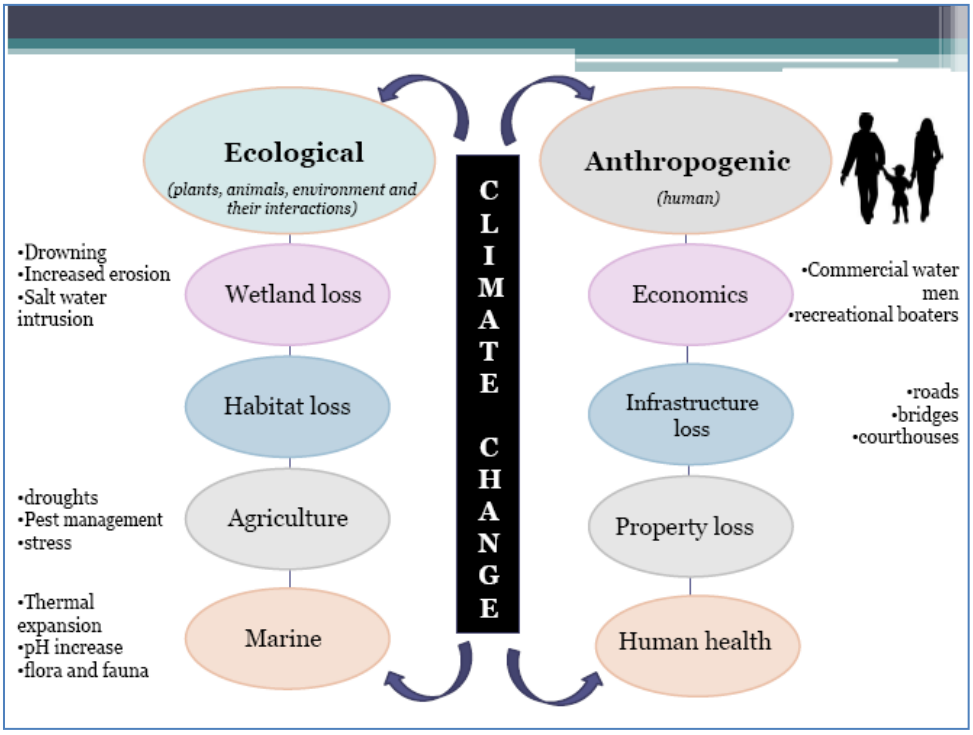
Once the discussion was complete MPPDC staff handed out a worksheet (See Appendix 2) for the workgroup members to complete by February 27, 2009. The worksheet asked workgroup member to identify critical human and ecological impacts. These identified impacts will then be assessed and mapped.

The workgroup was asked if there was any other information that about climate change that they would like to be supplied with and the only suggestion was in regards to how other communities, internationally or domestically, were dealing with climate change issues and/or sea level rise.

It was decided that only three back to back meetings will be needed to gather the desired information for this project. The next meeting was scheduled for March 12, 2009.

Appendix 1: Introduction to climate change project





Purpose

- Assess the potential anthropogenic and ecological impacts of climate change within the Middle Peninsula
  - **Human Communities and Institutional Impacts**
  - **Estuarine Environment and Coastal Wetlands**
  - **Marine Fisheries**
- **Year 1 – collection, assessment and analysis of potential impacts of climate change on the Middle Peninsula**
  - Year 2- facilitation of presentations and discussions
  - Year 3- initial stages of policy development

Your role.....

- Discuss and identify **critical** anthropogenic and ecological impacts needed to be assessed and mapped within the Middle Peninsula

What **we** will be doing?

- Facilitate workgroup
  - Creating maps and assessments
  - Creating a matrix of impacts
- Year 2 of project:
  - Facilitation of presentations and discussions of climate change issues at a policy level

Questions

Jackie Rickards
email: jrickards@mppdc.com
phone: 804-758-2311

Appendix 2: Climate Change Advisory Worksheet

Climate Change Advisory Worksheet:

What risks of climate change are most important to you?

The objective during year 1 of this project is to collect, assess, and analyze available information on climate change and identify critical human and ecological impacts needed to be assessed and mapped within the Middle Peninsula. From your perspective please identify what issues and impacts of climate change are most important to you (and/or your affiliation).

Use the tables provided on the following pages to collect your thoughts, ideas, and comments. For each division, there are a *sample* climate change impacts to assist you when thinking about these divisions. However, please note that you are not limited to comment on just the *sample* of impacts, but we recommend that you add your individual ideas to the worksheet. Also there is a section at the end of the document to share any additional comments you may have about climate change impacts.

Please return this worksheet to me by **February 27, 2009**, either by snail mail or through email.

If you have any questions please feel free to contact me by phone at 804-758-2311 or by email at jrickards@mppdc.com.

Thanks for your time!!

Middle Peninsula Planning District Commission
P.O. Box 286
Saluda Professional Center
125 Bowden Street
Saluda, Va 23149
Phone: 804-758-2311 Fax: 804-758-3221

Within each section identify impacts of climate change most important to you?

	Sample Impacts	Response - Comments
ECOLOGICAL IMPACTS		
Hydrology and water resources	- Increased risk of drought - Increased risk of flooding - Increased competition for water - Warmer water temperatures - Changes in water quality of water - Other	
Agriculture	- Changes in crop yields (varies by crops) - Potential ability to "double crop" - Increased risk of heat stress - Increased risk of pest outbreaks and weeds - Increased demand for irrigation water due to longer and warmer growing seasons - Shift in the distribution and range of species - Other	
Biodiversity	- Shift in the distribution and range of species - Loss of species not able to adapt to changes - Increased competition for invasive species - Loss of habitat - Other	
Forests (including parks)	- Increase in growth and productivity in the near term where soil moisture is adequate and fire risk is low - Shift in the distribution and range of species - Increased risk of insect outbreaks - Increased risk of the forest fire - Increased competition from invasive species - Other	
Coastal Resources and ecosystems	- Increased erosion or damage due to coastal infrastructure, dune, beaches another natural features due to sea level rise and storm surge - Loss of coastal wetlands and other coastal habitats due to sea level rise, erosion - Increased coast for maintenance and expansion of coastal erosion control (natural or man-made) - Saltwater intrusion into coastal aquifers due to sea level rise - Increased risk of pollution from coastal hazardous waste sites due to sea level rise - Loss of cultural and historical sites on coastline due to sea level rise and related impacts - Other	
Aquatic ecosystems	- Shifts in species range and distribution - Increased competition for invasive species	

	- Loss of near shore habitat and coastal wetland to sea level rise, where sufficient space for habitat migration is not available - Increased stress on cold water species - Other	
	Sample Impacts	**Response - Comments**
ANTHROPOGENIC (human) IMPACTS		
Recreation	- Increased opportunities for warm season activities in milder regions of the US - Decreased opportunities for warm season activities during the hottest part of the year, particularly in the southern US - Reduced opportunities for cold season recreation - Shifts in tourism dollars within a community from one recreation sector to another, or from communities losing recreational opportunities to communities gaining opportunities - Public access points - Other	
Transportation	- Fewer travel disruption and lower maintenance and infrastructure costs associated with snow and ice - More travel disruptions associated with road washouts, and flooding - Increased road surface dames from higher temperatures - Potential reductions in water-based navigation due to lower summer stream flows - Increased maintenance requirement of roadside an median strip vegetation - Increased brush fires in roadsides and median strip vegetation - Other	
Infrastructure	- Need for new or upgraded flood control and erosion control structures - More frequent road washouts and flooding - Increased demands on storm water management systems with the potential for more combined storm water and sewer overflows - Reduced effectiveness of seawall with sea level rise - Property loss - Other	
Business	- Price volatility in energy and raw product markets due to more extreme weather events - Increased insurance premiums due to more extreme weather events	

	- Fewer shipping disruptions associated with snow and ice - Impacts on business infrastructure located n floodplains or coastal areas - Shift in business opportunities - Other	
Health	- More heat related stress, particularly among the elderly, the poor and other vulnerable populations - Fewer extreme cold-related health risks - Increase in vector-borne illnesses (ie. West Nile) - Reduced summer air quality (ie. causing respiratory issues) - Other	
Emergency response	- increased demands on emergency response serviced related to extreme weather events (heat, flooding, storms) - Other	
Energy	- Reduced heating demand during winter months - Increased cooling demand during summer months - Other	

Additional Comments:

Climate Change Advisory Workgroup
Meeting 2
March 12, 2009

The second meeting of the Climate Change Advisory Workgroup was held in the Regional Board Room at the MPPDC offices in Saluda, VA on Thursday, March 12, 2009. Miss Jackie Rickards, MPPDC staff, welcomed those in attendance. Workgroup members in attendance: Jim Pyne (HRSD), Marcie Parker (VDOT), Pat Tyrell (RC&D), Anne Ducey- Ortiz (Gloucester County), John Shaw (Mathews County), David Whitlow (Essex County), Pat Duttry (VDH), Jeff McDermott (Gloucester resident), Jack White (Mathews resident) and Trip Little (Middlesex County). MPPDC staff attending the meeting included Lewie Lawrence, Sara Stamp, and Clara Ciera.

At the first meeting of the Climate Change Advisory Workgroup there was a suggestion to share how other communities, domestically and internationally are currently dealing with climate change. Consequently, Mrs. Sara Stamp opened the meeting with a presentation titled *Responses to Climate Change Impacts* (see Appendix 1).

Next, Miss. Jackie Rickards introduced the committee to a climate change mapping and policy matrix (Appendix 2) that was developed by MPPDC staff. Anthropogenic and ecological issues that had public policy implication were placed in a table. Next to each issue a policy and mapping strategy was addressed. This table was explained to the group and they were asked to provide feedback to the staff. The group suggested that the maps be as accurate as possible and that the PDC should map a few scenarios to provide some insight to the future as well as the present.

Due to the amount of data that is needed to be collected than mapped, the next meeting will be planned for the end of June or the beginning of July. The group was informed that a letter will be sent at the beginning of June that will provide a specific time and place for the meeting.

Appendix 1: Presentation

Responses to Climate Change Impacts

Sara Stamp

Middle Peninsula Planning District Commission
March 12, 2009

Responses to Sea Level Rise Impacts

How to mitigate the impacts of sea level rise on coastal property...

- Soft
- Hard
- Super Engineering
- Planning Responses

Soft

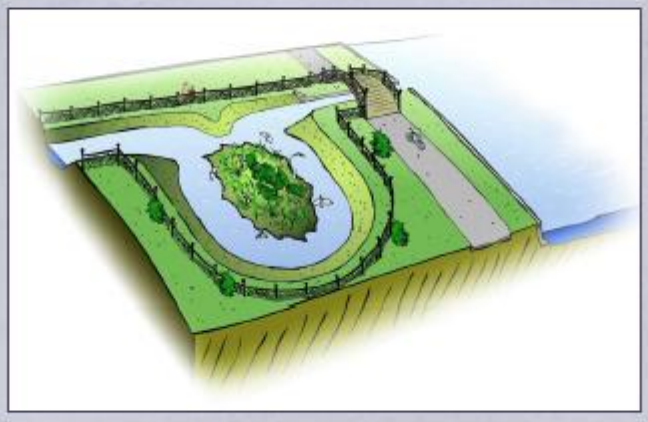
- Beach nourishment
- Living Shorelines
- Wetland Artificial Sedimentation

Beach nourishment – large scale

Beach nourishment – small scale

Living Shorelines

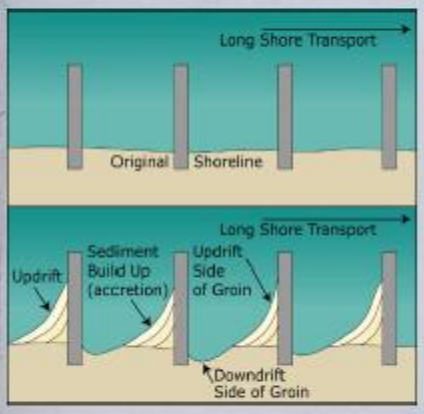
Wetland Artificial Sedimentation



Hard

- Groins/groin fields
- Seawalls/bulkheads/revetments
- Breakwaters/rip rap/sills

Groins/groin fields



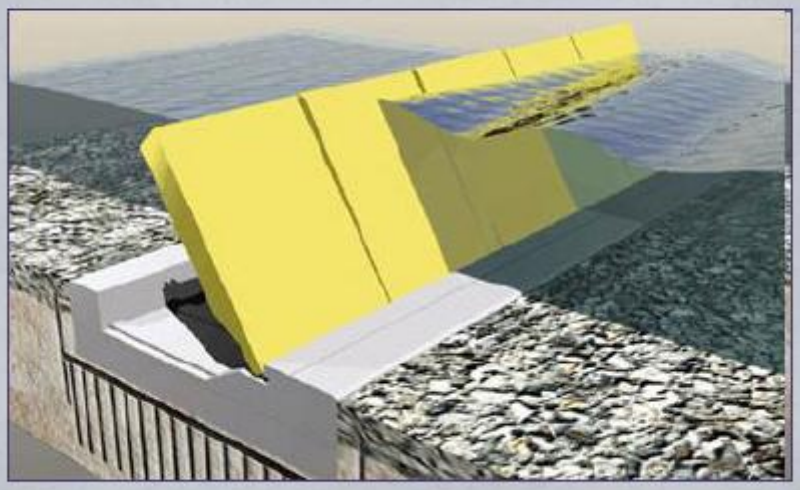
Seawalls/Bulkheads/Revetments

Super Engineering

Here's how the British hold back the waters from flooding London

And the Dutch solution to protecting an entire nation that mostly rests below sea level...

The Italians are defending their city on the sea, Venice:



And...

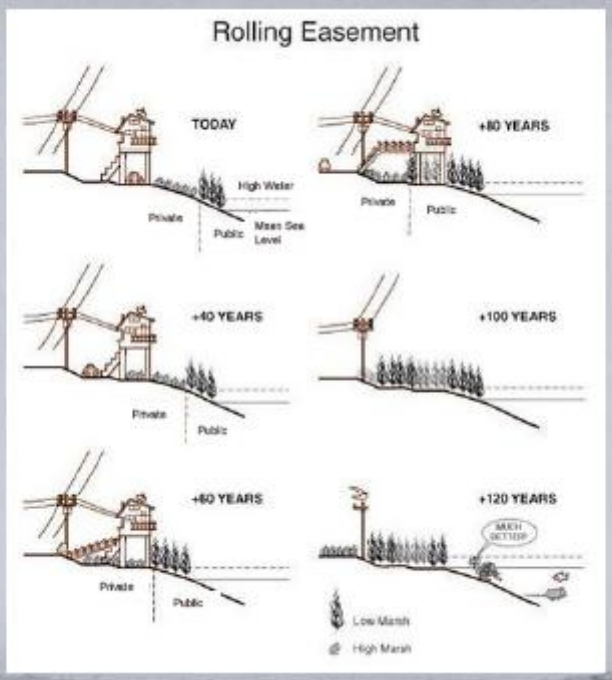
Here's how the richest, most powerful and technologically advanced nation on earth protected against the long-forecasted flooding of New Orleans:

Planning Responses

- Elevating Structures
- Set-backs
- Rolling Easements
- Abandonment

Require Elevated Structures

Set-backs



Abandonment

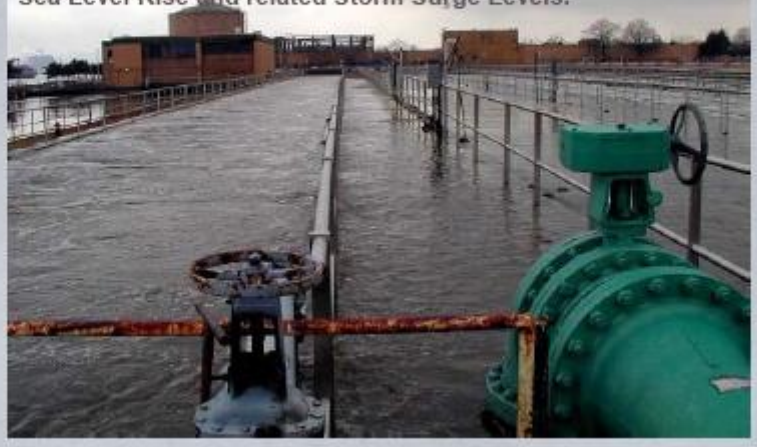
Maryland

Pacific Islands

How to mitigate the impacts of sea level rise on coastal infrastructure (water, sewer and roads)…

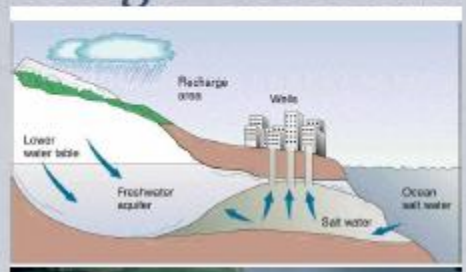
- Protect
- Redesign
- Elevate
- Relocate

Overflowing Overflowing Treatment TanksTanks, NYC DEP Bronx WPCP, March 2001-Storm. High surge tides blocked discharge of treated sewage into East River and caused Back-up. *Considered DEP Action*: Construct Flood Walls against Sea Level Rise and related Storm Surge Levels.



Redesign - OSDS

Redesign - Reservoirs



Elevating Infrastructure - $$

Relocating Infrastructure - $$$$$

Land Use Responses to Other Climate Change Impacts

- Temperature
- Water

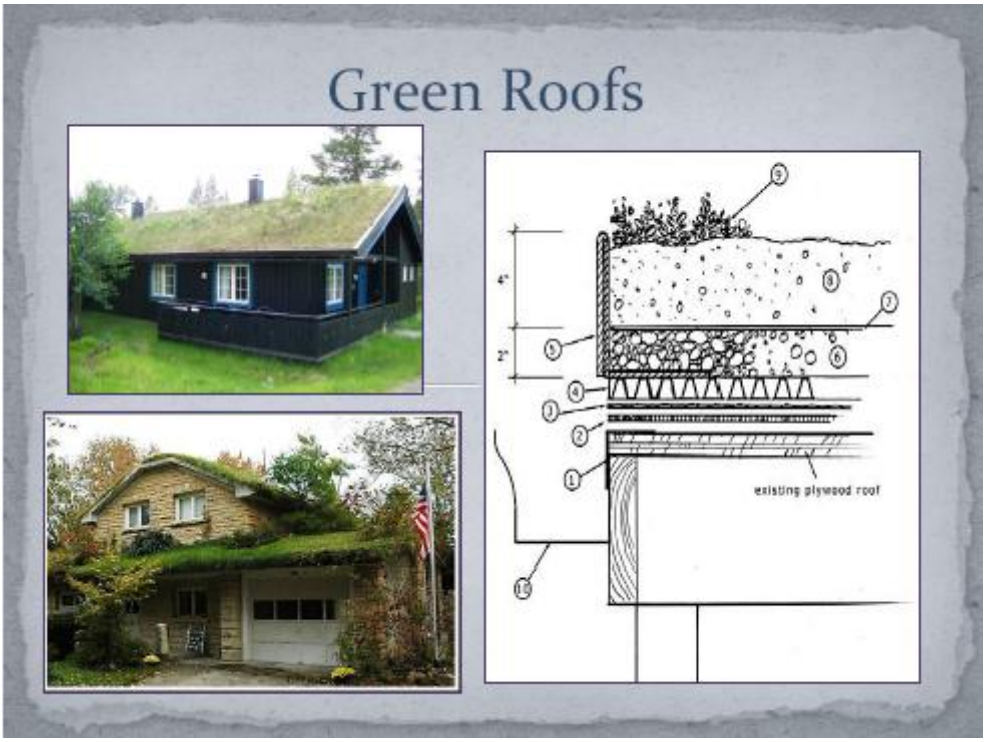
Agriculture/Forestry

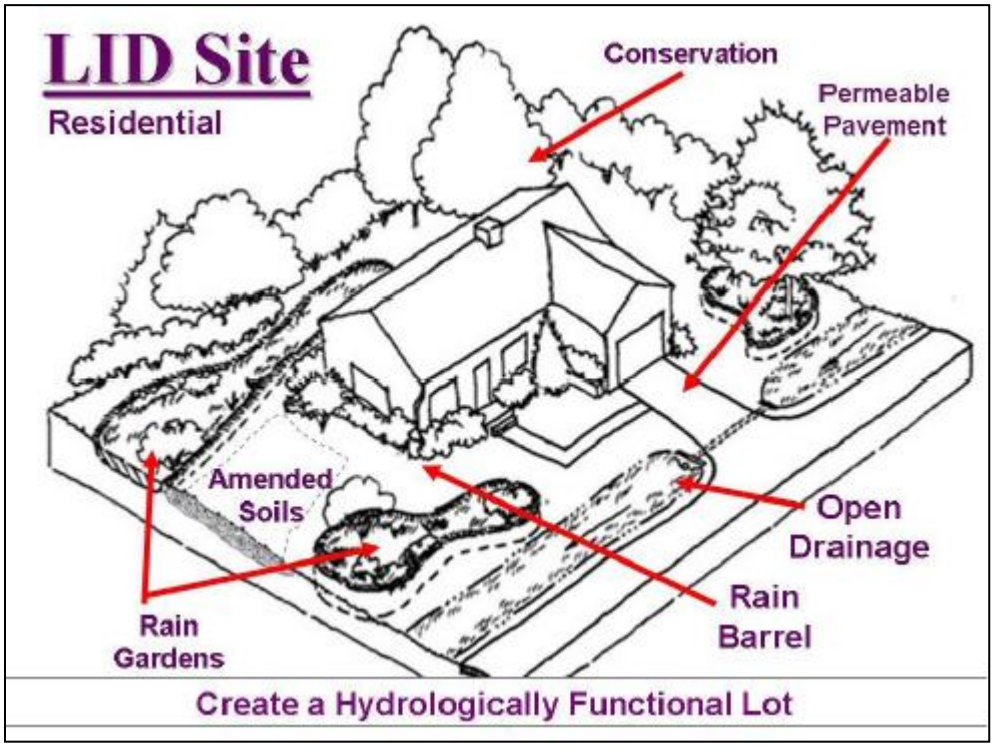
- Adjusting production to reflect changes
- Educational programs
- Improve water efficiency



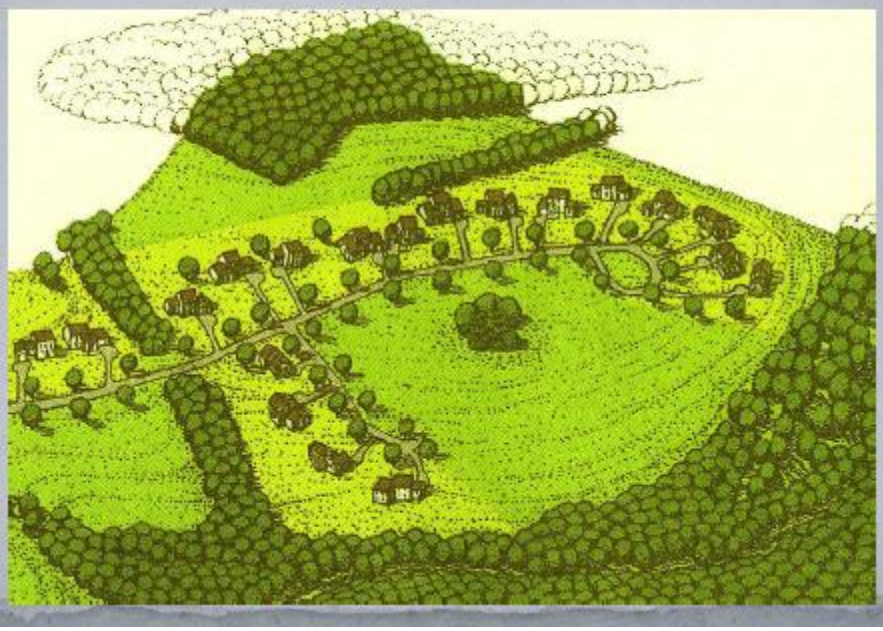
Stormwater Management

- Green Roofs
- Low – Impact Development (LID)
- Conservation Subdivisions


Green Roofs
existing plywood roof


LID Site
Residential
Conservation
Permeable Pavement
Amended Soils
Open Drainage
Rain Barrel
Rain Gardens
Create a Hydrologically Functional Lot

Conservation Subdivions



Questions?

Sara Stamp
(804) 758-2311
sstamp@mppdc.com

Appendix 2: Public Policy and Mapping Matrix

Pblic Policy Issues	Policy Level		Policy Strategy	Can it be mapped?	Mapping Strategy	Priority (H/M/L)
	State	Local				
Flooding	√	√	Land use planning tools	Yes	· Denote flood prone areas	
-Roads	√			Yes	· Map evacuation routes, bridges	
-Residential and Industrial	√	√		Yes	· Map residential and industrial infrastructure	
-Wellheads	√	√		Yes	· Denote the location of the wellheads	
Land Use		√	Land use planning tools	Yes	· Denote land uses	
Well depth	√	√	Virginia Department of Health (VDH)	Yes	· Denote the location of the well	
Water supply	√	√	Land use planning tools State water supply plan (eg. Conservation measures, Water Rationing, Rainwater harvesting, Water reuse	Yes	· Denote current sources of water	
-Irrigation	√	√	Consideration of water reuse	Yes/No	· Storm water management · Permitted activity	
Storm water Management	√	√	Land use planning tools - Storm water management - Pollution Prevention programs - Low-Impact development concepts	Yes	· Topography of area and current infrastructure denoting potential flow of storm water · If permitted	
Insect control	√	√	Land use planning tools - Insect pest control management	Yes	· Spray districts	
Agricultural and forestal operations		√	Land use planning tools	Yes	· Inventory vulnerable agriculture and forestry areas (below certain elevations) · Blue/Green infrastructure	
Forest Fires	√	√	Land use planning tools Virginia Department of Fire	Yes/No	· Anticipated and repetitive fires	
Coastal Erosion		√	Land use planning tools Virginia Marine Resource Commission (VMRC) - Shoreline protection measures - Wetland grass planting	Yes	· Inventory hard shorelines to date · VIMS data	
Water Pollution	√	√	Land use planning tools	Yes	· VDH/DEQ	
Sewage Disposal Systems/ Onsite systems	√	√	Land use planning tools - point sources/ non point sources	Yes	· Inventory OSDS and public sewage systems	
Cultural and historical sites	√	√	Land use planning tools	Yes	· Map cultural and historical sites · Virginia Historical Society (VHS) · Local information	
Coastal Access points	√	√	Land use planning tools	Yes	· Map coastal access points (state/local/quasi)	
Insurance availability	√	√		Yes	· Areas where insurance is available	
Property Loss	√	√	Land use planning tools - upland/ lowland	Yes	· Repetitive loss insurance claims	
-Private/public Investment	√	√		Yes	· Public projects (local and state)	
-Tax Base	√	√		Yes	· Revenue Reduction	
Emergency Response	√	√		Yes	· Map major highways	

Climate Change Advisory Workgroup
Meeting 3
July 1, 2009

The third meeting of the Climate Change Advisory Workgroup was held in the Regional Board Room at the Middle Peninsula Planning District Commission (MPPDC) offices in Saluda, VA on Wednesday, July 1, 2009. Miss Jackie Rickards, MPPDC Regional Projects Planner I, welcomed those in attendance. Workgroup members in attendance were: Jim Pyne (HRSD), Marcie Parker (VDOT), Pat Tyrell (Tidewater RC&D), Chris Perez (Gloucester County), Matthew Rowe (Mathews County), Pat Duttry (VDH), Pam Mason (VIMS), and Jack White (Mathews resident). Also in attendance were Lewie Lawrence, MPPDC Director of Regional Planning, and Sara Stamp, MPPDC Regional Projects Planner II.

Miss. Rickards began the meeting with an update on the progress that has been made since the March 12, 2009 meeting. Over the last three months MPPDC staff have gathered the best available GIS (Geographic Information Systems) data to map the anthropogenic and ecological impacts of sea level rise. Data sets were gathered from a variety sources including state agencies, VIMS, consultants and county data. Each county map consisted (1) a county wide map depicting the projected rise in sea level, (2)several pullout boxes that showcased localized 'hot spots' within the county where there could be significant ecological and anthropogenic impacts, and (3) general observations relating to the anticipated impacts of sea level rise. [To see county maps please refer to Appendix 1]. In conjunction with the maps, MPPDC staff have started to assess the amount of anticipated economic impact due to sea level rise. At the meeting two examples from Mathews County were reviewed in detail. The first example highlighted Point Road and the possible effects on the New Point Comfort area if Point Road was flooded. The second example focused on the anticipated impacts of sea level rise on Bohannon. To see calculations please refer to Appendix 2.

Once updates of the projects were explained Mr. Lawrence began to ask the workgroup for feedback in regards to the maps and calculations that were presented thus far. Matthew Rowe commented that representing the anticipated economic impact-losses in dollars and figures was an efficient way to get through to local government. Jack White shared that local governments have some hard decisions to make, but it's a public responsibility to take action. One workgroup member asked Marcie Parker if VDOT has begun to think about the impacts of sea level rise on roadways. Ms. Parker explained that if road concerns do not appear in the county's comprehensive plan, than VDOT does not consider the topic high priority.

In response to the examples from Mathews County, Pat Tyrell, suggested that MPPDC present this information to Ron Hatchey, the Emergency Management Planner. She questioned how service areas would be redefined and would this would change their service definition. Ms. Pam Mason also commented on the Mathew example, with focus on tax implication example. She mentioned that though there may tax losses in current coastal areas, valuation could shift inland to properties that become the new waterfront properties, which could offset some tax losses. Finally Ms. Mason suggested the same economic valuation that was calculated for the anthropogenic impacts should be calculated for the ecological losses.

Mr. Lawrence shared with the committee that the maps were presented at the Commission meeting on June 24, 2009. Due to modest reactions and discussion of the maps amongst Commissioners, Mr.

Lawrence questioned how the MPPDC staff can communicate more effectively about climate change/sea level rise to local governments? Workgroup members suggested showing the historical changes in sea level rise and/or show photographs of how the ecology is changing (ie. *Spartina* growing under sea bush on coastal properties).

Through the discussion and comments that were shared at the meeting, MPPDC will continue to work on the maps and the valuation of economic and ecologic losses due to sea level rise.

Mr. Lawrence adjourned the meeting.

APPENDIX 2

Assessing the economic and ecological impacts of sea level rise for select vulnerable locations within the Middle Peninsula

Assessing the economic and ecological impacts of sea level rise for select vulnerable locations within the Middle Peninsula

2009

With well over 1,000 miles of linear shoreline, the Middle Peninsula is under direct threat from accelerated climate change. Specifically, sea level rise will impact coastal communities and infrastructure, as well as the region's natural resources.

Total Long term Costs of Selected Areas in the Middle Peninsula
$187,005,132.10 – $249,451,074.50

This project was funded by the Virginia Coastal Zone Management Program at the Department of Environmental Quality through Grant **FY2008 NA08NOS4190466 Task 12.04 of** the U.S. Department of Commerce, National Oceanic and Atmospheric Administration, under the Coastal Zone Management Act of 1972, as amended. The views expressed herein are those of the authors and do not necessarily reflect the views of the U.S. Department of Commerce, NOAA, or any of its sub agencies.

Table of Contents

Executive Summary

Climate change is a phenomenon that can be defined as changes in climate (eg. temperature, precipitation and wind) that can be measured over an extended period of time. Although temperature, precipitation and wind are considered the three direct factors attributing to climate change, as they change they have countless anthropogenic and ecological indirect impacts:

Water Resources may become stressed as the frequency of droughts increase; also the frequency and intensity of flooding events may increase.

Agriculture may be at increased risk of heat stress as well as pest outbreaks and weeds; also changes in crop yield may prevail.

Biodiversity may be impacted by shifts in specie distribution and/or loss of species and habitats.

Forests are at increased risk of insect outbreaks, forest fires, and intrusion of invasive species.

Coastal Ecosystems may experience increased coastal erosion and risk of pollution due to inundated infrastructure [as a result of sea level rise as well as storm events]; increased rates of saltwater intrusion into freshwater resources may also occur.

Aquatic Systems may lose near shore habitats and coastal wetlands as sea level rises; shifts in specie ranges and distributions may occur.

Public Health may be exposed to more heat related stress, an increase in vector borne illnesses (ie. West Nile); and reduced summer air quality due to increased production of ground level ozone may impact public health.

Transportation and road access may become limited as the frequency of flooded roads may occur due to sea level rise and intense storms; also this will increase the maintenance costs of impacted/damaged roads.

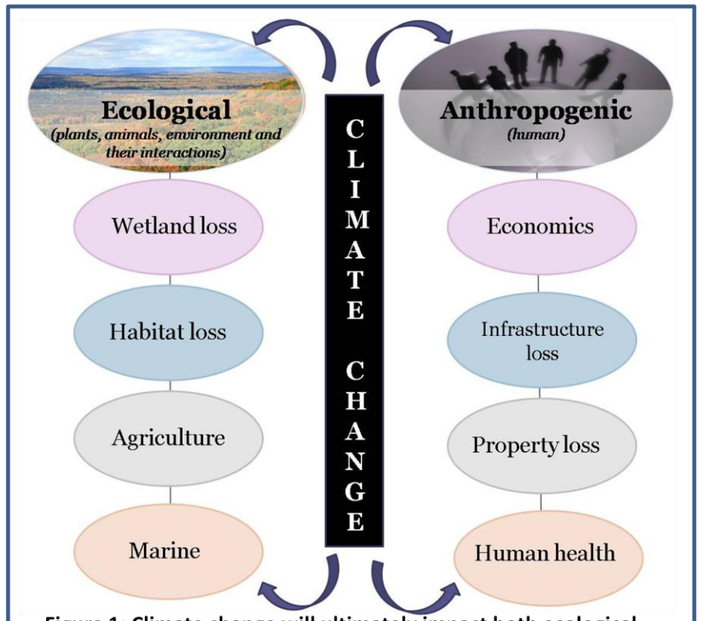


Figure 1: Climate change will ultimately impact both ecological and anthropogenic dynamics.

Infrastructure (public and private) may be impacted if located within floodplains or low lying coastal areas, causing insurance premiums to increase; loss of private and public infrastructure due to sea level rise (loss of private and public investments) may also occur.

Emergency Response may have to redefine service areas and services as roads become flooded due to sea level rise and/or storm events; also there may be increased demands for services related to extreme weather events**.**

According to the Intergovernmental Panel on Climate Change (IPCC), Virginia temperatures are estimated to increase by 3°F in the winter, spring and summer, and increase 4°F in the fall, while precipitation is estimated to increase by 20% in all seasons by 2100. The National Wildlife Federation predicts that within the Upper Tidewater Region (where the Middle Peninsula is located), sea level will rise 11.2 inches by 2050 and 27.2 inches by 2100. However, other reports document variations in quantitative estimates of sea level rise, due to variable discrepancies amongst the scientific models being utilized.

Consequently, due to the unbiased geographic nature of climate change, the Middle Peninsula will experience both ecologic and anthropogenic impacts (Figure 1). Therefore to understand these implications the Middle Peninsula Planning District Commission (MPPDC), funded through the Virginia Coastal Zone Management (CZM) Program, has began a three year endeavor to specifically assess and discuss the economic and ecologic impacts of climate change. Working closely with member localities and a variety of stakeholder groups, year one of this project has focused on the collection, assessment and analysis of potential ecologic (ie. wetlands, conserved lands, etc) and anthropogenic (ie. personal property, public property, etc) impacts of climate change, particularly due to sea level rise. Additionally an economic and ecological impact assessment of sea level rise in select locations within the Middle Peninsula was conducted.

In February 2009, a Climate Change Advisory Workgroup, consisting of appointed county representatives and stakeholders groups, including transportation, sanitation, public health, recreation, science research, planners, and local businesses, was established. The Workgroup was tasked with identifying critical anthropogenic and ecological impacts of climate change and sea level rise to their respective sector as well as to the region. A series of monthly meetings with the Workgroup pin pointed specific impacts of concern which were then able to be mapped and assessed using GIS (Geographic Information System).

Since LIDAR data for the Middle Peninsula is not currently available, GIS provided a format for assessing sea level rise impacts using elevation/topographic data. MPPDC assessed economic and ecological impacts of a 1ft sea level rise by 2050. *Please note that these estimates may be considered conservative, especially as recent reports highlight accelerated rates of climate change.*

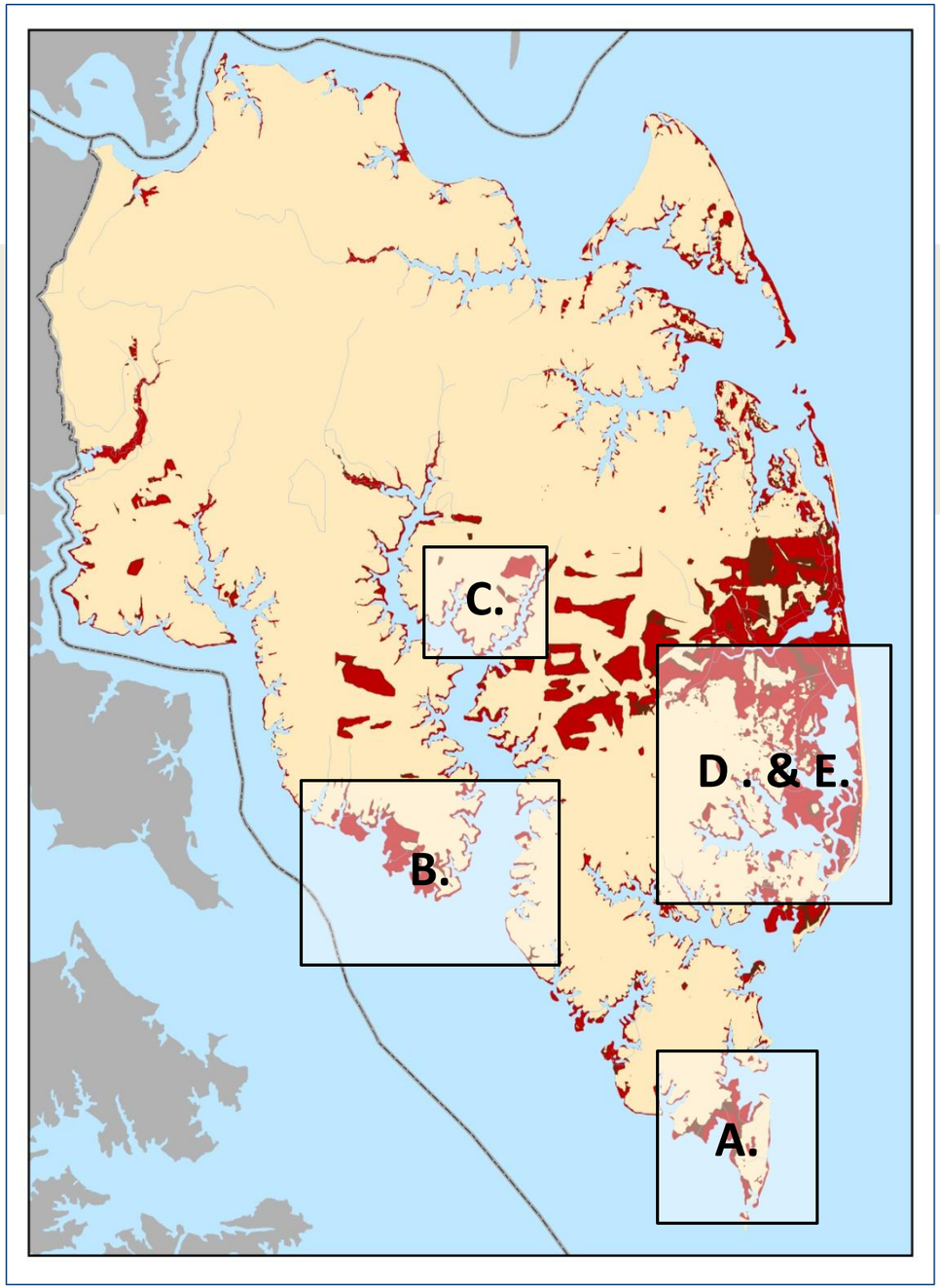
To access the impacts, the number of structures (eg. homes, business, onsite disposal systems, roads and shoreline hardening) and the amount of wetland acres inundated by sea level rise were quantified for select areas of the Middle Peninsula. Cost estimates were then collected in order to calculate the total long term impact costs of sea level rise. The table below depicts the total long term impact costs counties may endure as sea level continues to rise.

Table 1: Total (ie. Anthropogenic costs + Ecological costs) long term impact costs of select areas within the Middle Peninsula

County	Total Long Term Impact Costs
Mathews	$87,307,088.81 – $95,310,925.72
King and Queen	$12,241,827.90 – $28,769,415.95
Middlesex	$44,735,683.61 – $45,604,189.41
King William	$4,184,119.88 – $22,808,296.26
Gloucester	$26,453,620.67 – $38,895,790.63
Essex	$12,082,791.25 – $18,062,456.50
TOTAL COSTS:	**$187,005,132.10 – $249,451,074.50**

This document is a consortium of selected areas within the Middle Peninsula that highlight the economic and ecological impacts of sea level rise. This document also begins to pose pertinent questions that local governments will need to consider concerning public health, safety and welfare.

Mathews County

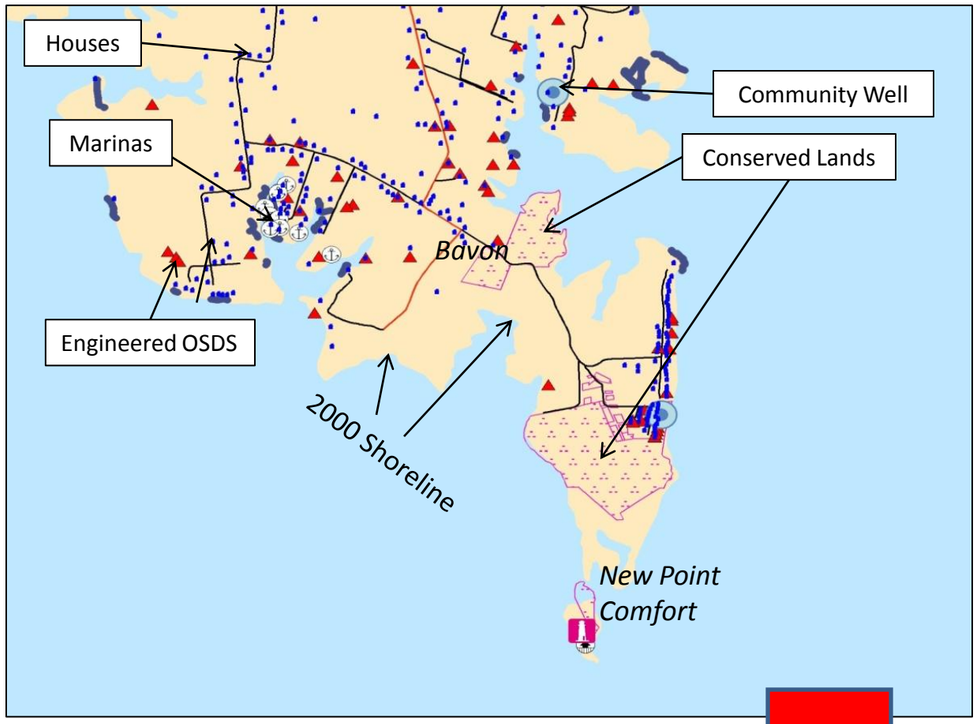


A. New Point Comfort
B. Bohannon
C. Retz
D. Onemo and Diggs
E. Onemo and Diggs – Ecological impacts

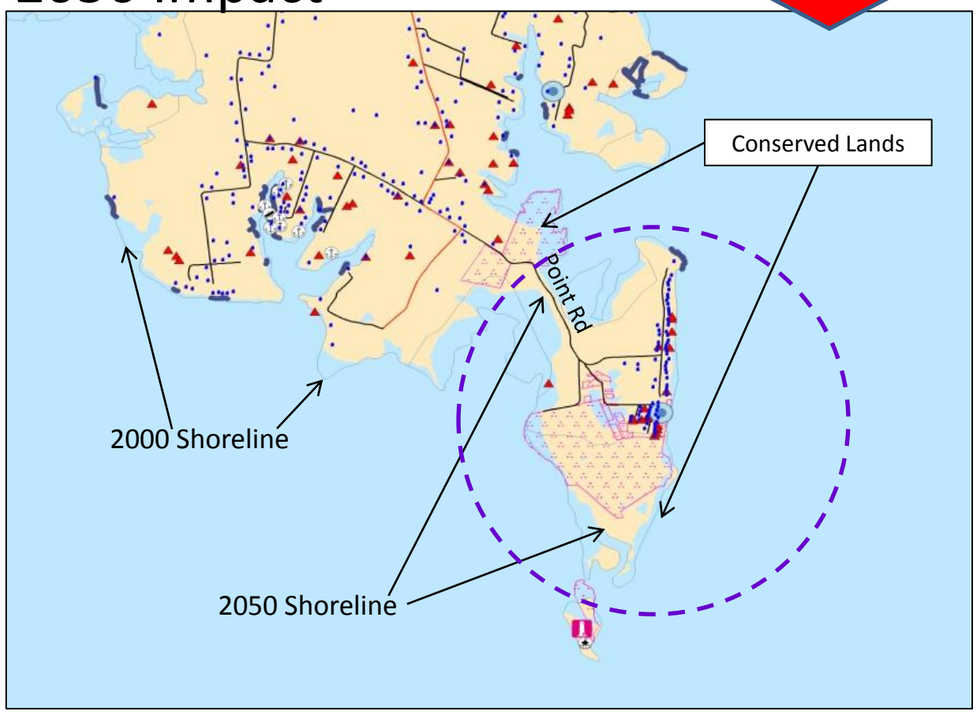
A

New Point Comfort: If Point Road floods consider the amount of infrastructure impacted

2000 Current



2050 Impact

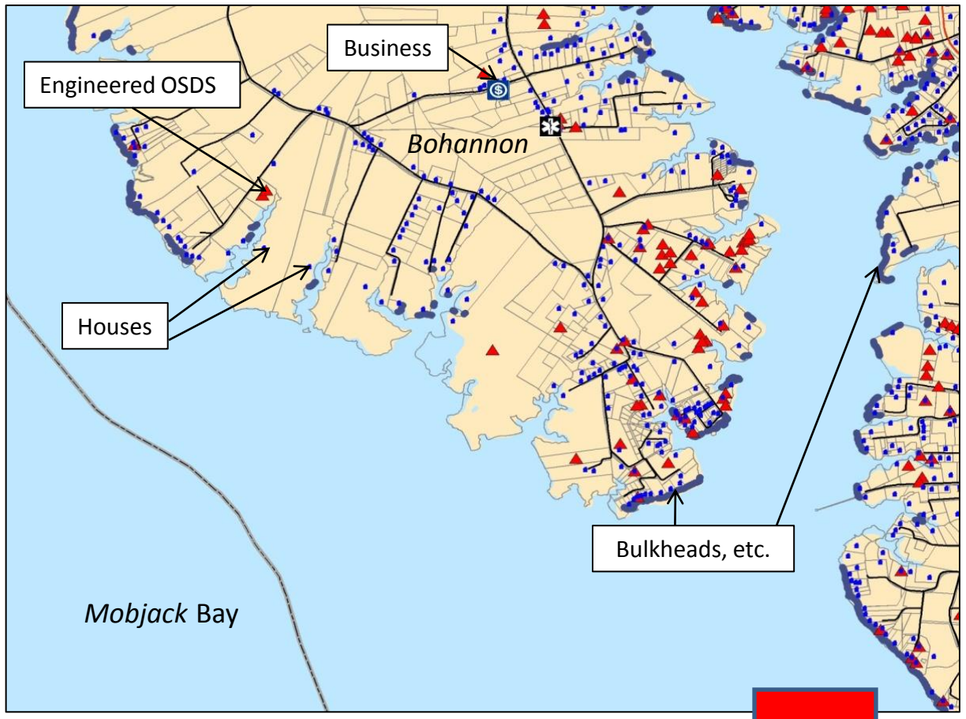


Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	72	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$16,464,168
Engineered OSDS	20	$18,000 (MPPDC Regional Estimate)	$360,000
Conventional OSDS	52	$4,000 (MPPDC Regional Estimate)	$208,000
Community Well (with 41 connections)	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	31	$3,000 (MPPDC Regional Estimate)	$93,000
Shoreline Harding	658.122 ft of riprap	$60/foot (University of Minnesota)	$39,487.37
VDOT Road Segments	1,250.67 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $186,349.83 Long term: $931,749.15
TOTAL			**Short term:$17,391,005.20 Long term: $18,136,404.52**

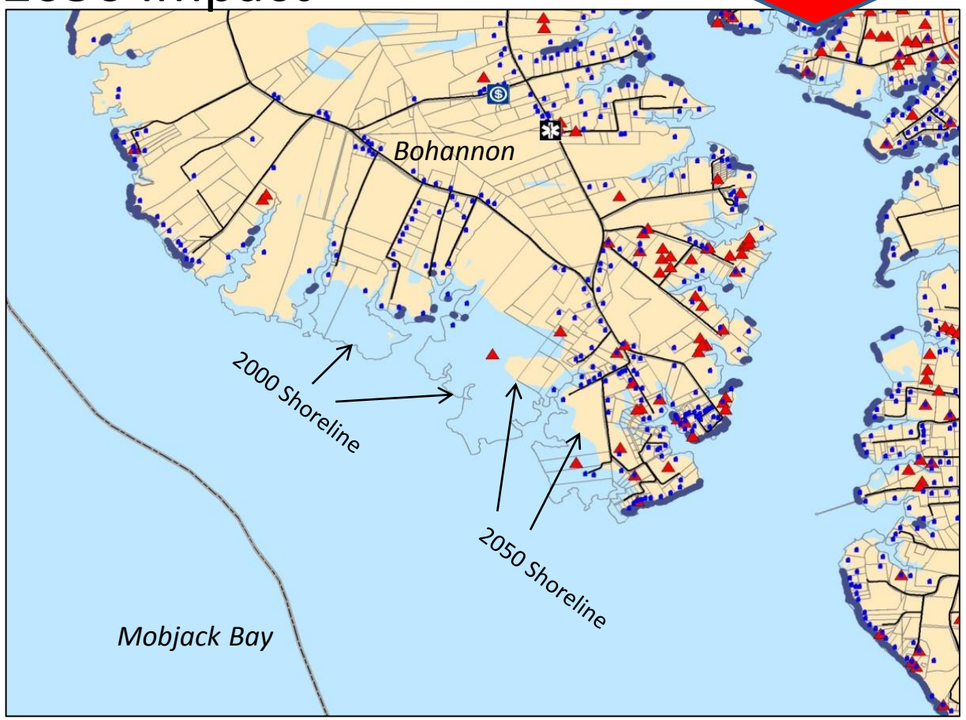
- How will residents get to their house?
- How do residents get access to schools?
- How are OSDS and wells serviced?
- How are the roads serviced?
- How will conserved lands be accessed?
- How will EMS service this area?

B

2000 Current



2050 Impact



Bohannon: Inundation of low lying coastal areas will cause redistribution and/or lose of tax revenues

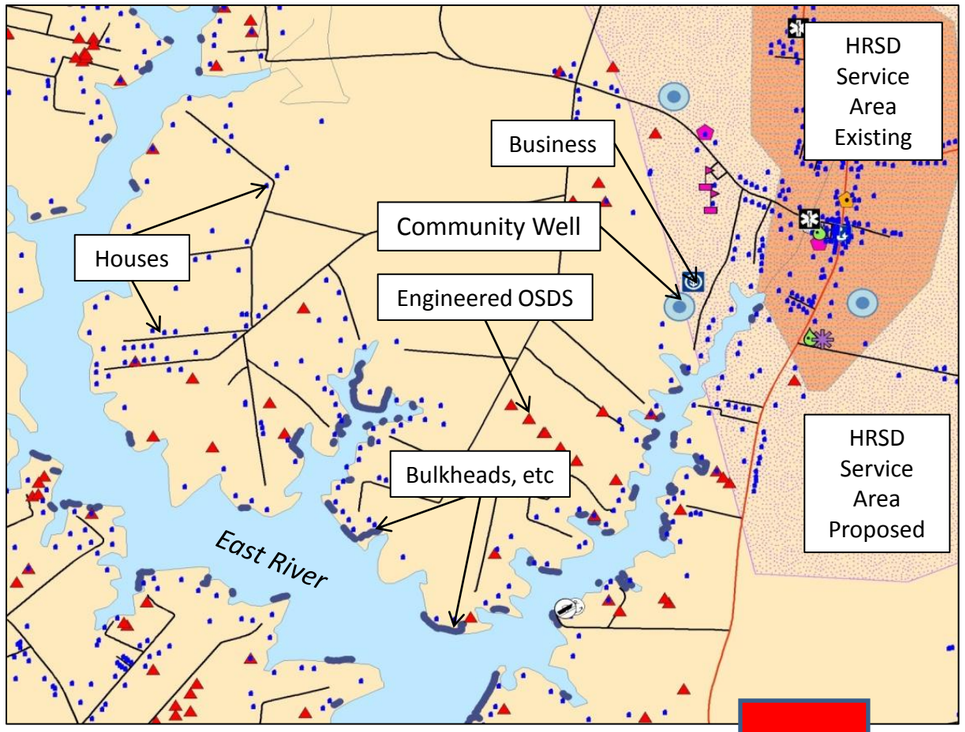
Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	39	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$8,918,091
Engineered OSDS	8	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	31	$4,000 (MPPDC Regional Estimate)	$124,000
Private Wells	39	$3,000 (MPPDC Regional Estimate)	$117,000
Shoreline Hardening	13,928.04 ft	$450/foot (MPPDC Regional Estimate)	$6,267,618
VDOT Road Segments	391.35 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $58,311.15 Long term: $291,555.75
TOTAL			**Short term: $15,629,020.15** **Long term: $15,862,264.75**

*****30% of all the parcels depicted in this snapshot are directly impacted by sea level rise. How are tax revenue losses compensated for?***

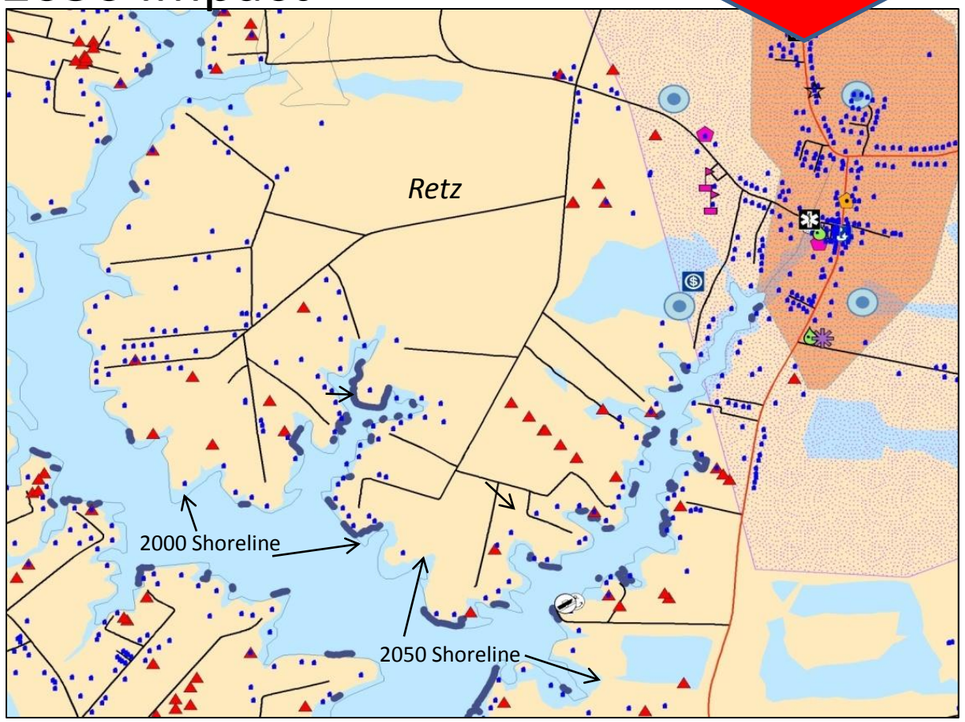
Total Parcels in Mathews County	11,107
Total Parcels in Snapshot	778
Impacted Parcels	217
Percentage of Impacted Parcels in Snapshot	30%

C

2000 Current



2050 Impact



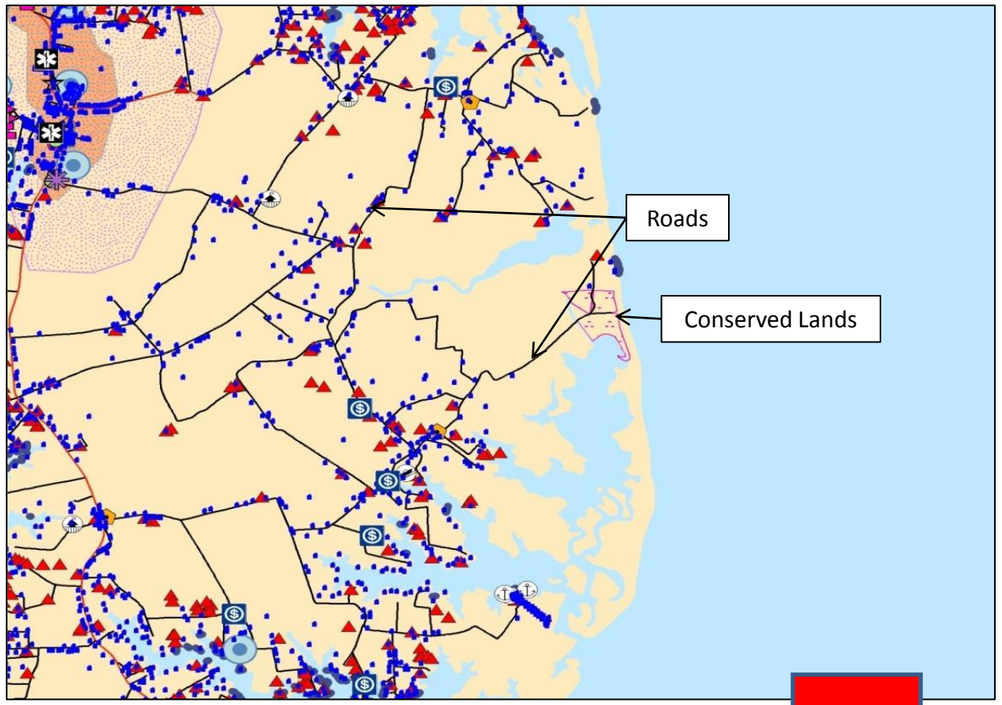
Retz: How will constituents handle private infrastructure maintenance, enhancement and/or losses?

Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	17	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$3,887,373
Engineered OSDS	5	$18,000 (MPPDC Regional Estimate)	$90,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	17	$3,000 (MPPDC Regional Estimate)	$51,000
Conventional OSDS	15	$4,000 (MPPDC Regional Estimate)	$60,000
Shoreline Harding	6,658.95 ft	$450/foot (MPPDC Regional Estimate)	$2,996,527.50
VDOT Road Segments	854.77 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $127,360.73 Long term: $636,803.65
TOTAL			**Short term:$7,252,261.23 Long term: $7,761,704.15**

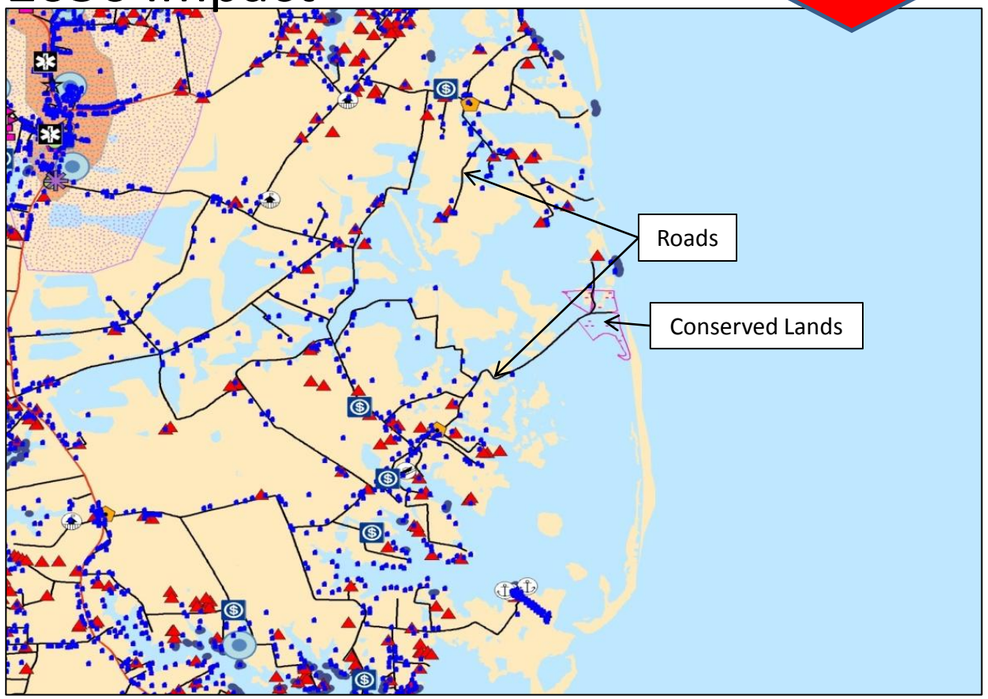
Proposed Hampton Road Sanitation Districts (HRSD) Service Areas will be inundated. Consequently proposed areas may need to be reevaluated and altered.

D

2000 Current



2050 Impact



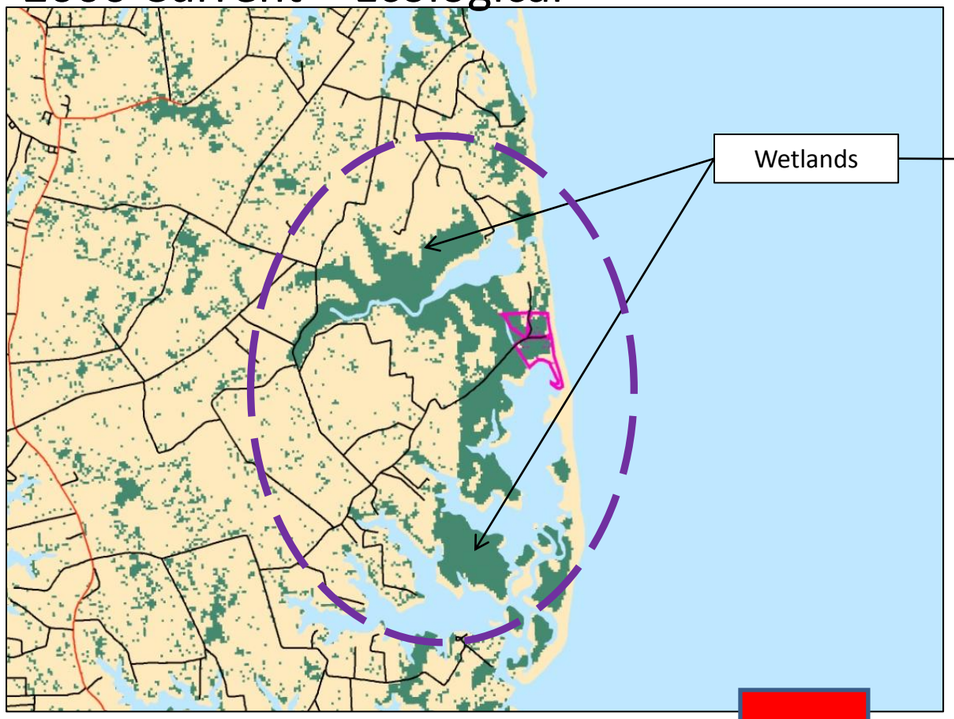
Onemo and Diggs: With the most costly impact due to infrastructure inundation, how will constituents and local government respond and adapt to sea level rise?

Infrastructure	Amount of Structures Impacted	Average Cost	Total Cost
Houses	59	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$13,491,471
Engineered OSDS	17	$18,000 (MPPDC Regional Estimate)	$306,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	59	$3,000 (MPPDC Regional Estimate)	$177,000
Conventional OSDS	42	$4,000 (MPPDC Regional Estimate)	$168,000
Shoreline Harding	9,374.4 ft	$450/foot (MPPDC Regional Estimate)	$4,218,480
VDOT Road Segments	35,645.68 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $5,311,105 Long term: $26,556,031.60
TOTAL			**Short term:$23,712,056** **Long term: $44,956,982.60**

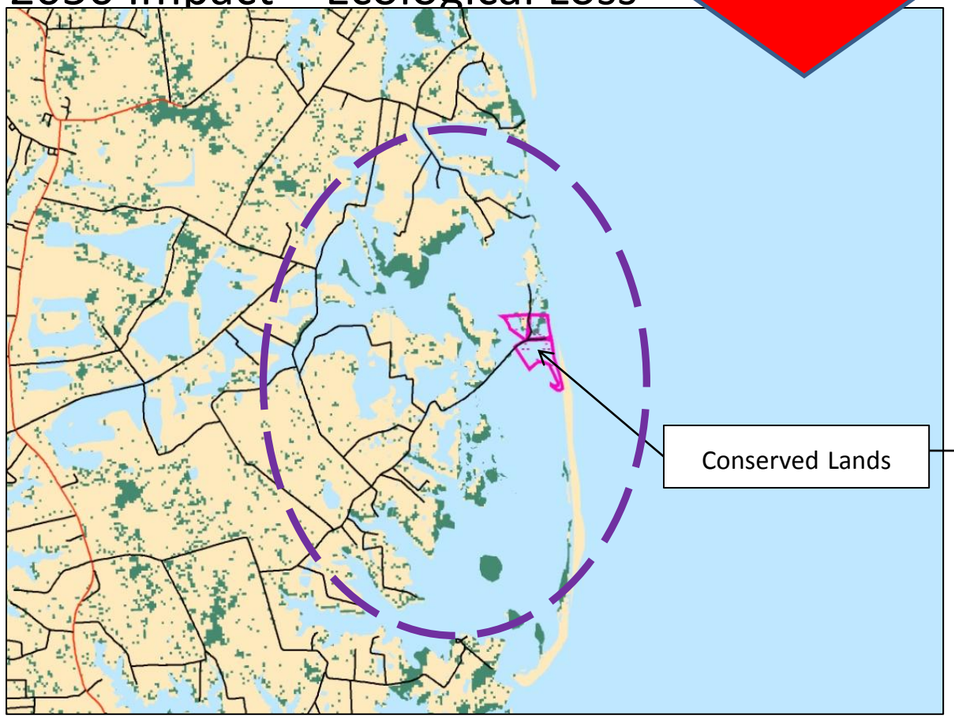
E

Onemo and Diggs: Inundated wetlands will result in fish, reptile, bird, and wildlife habitat impact and loss

2000 Current – Ecological



2050 Impact – Ecological Loss



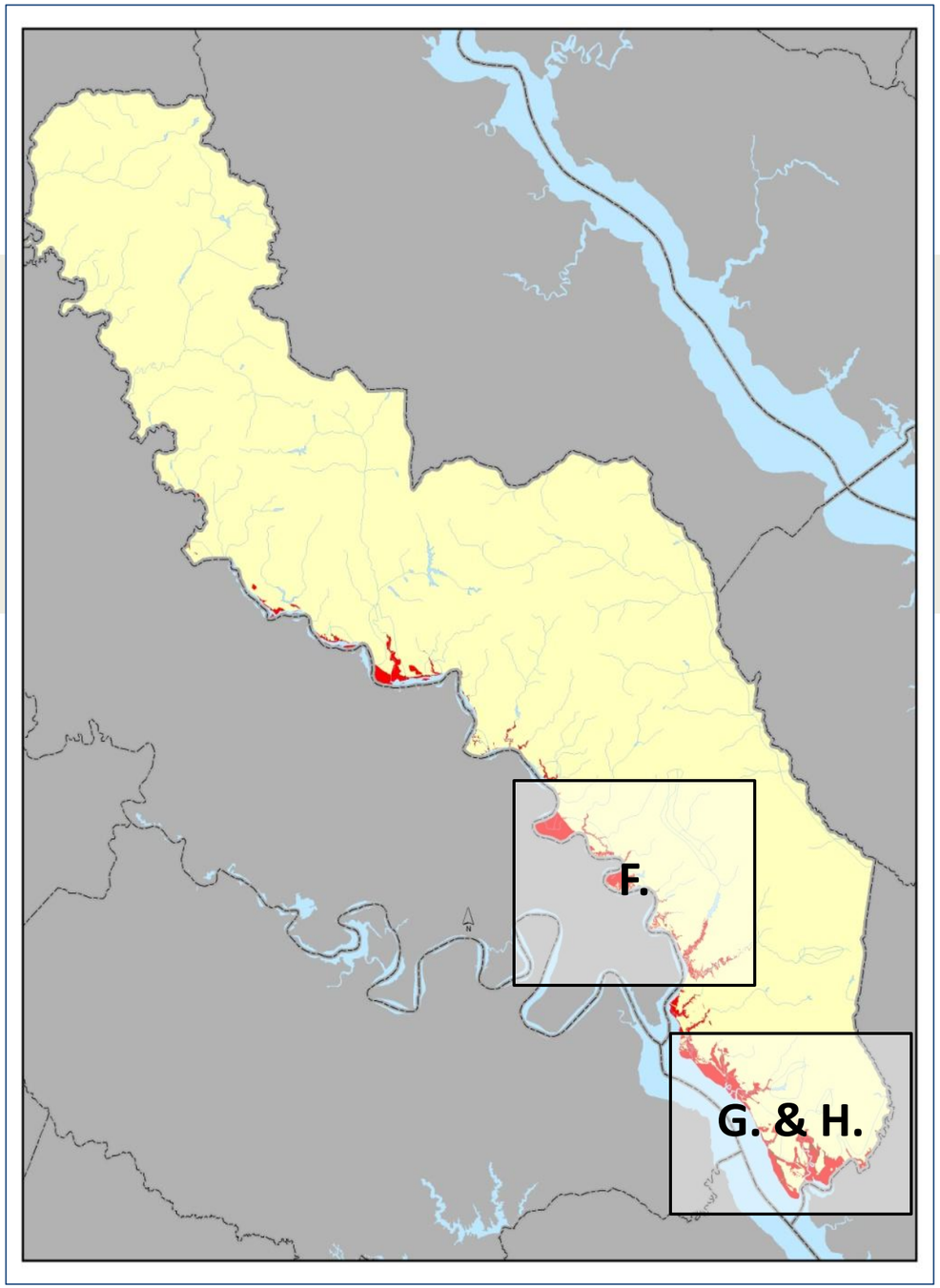
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 954.77 954.77 954.77	 $45,828.96 $241,556.81 $17,185.86
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	954.77	$276,568.23 - $8,179,199.52
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	954.77	$8,592.93 - $109,798.55
Total value lost or redistributed: $589,732.79 - $8,593,569.70			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and wildlife habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -altering aesthetics of River and Bay vista -waterfowl habitat loss may impact bird watching

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

Conserved Lands Impacted	
Bethel Beach Natural Area Preserve	Quantitative: 63.31 acres of terrestrial land converts to subaqueous land due to inundation Qualitative: -Public access and enjoyment of to terrestrial conserved land will be limited - Habitat loss will impact the globally rare northeastern beach tiger beetle and beach plant as well as colonial nesting birds

King and Queen County



F. Roane

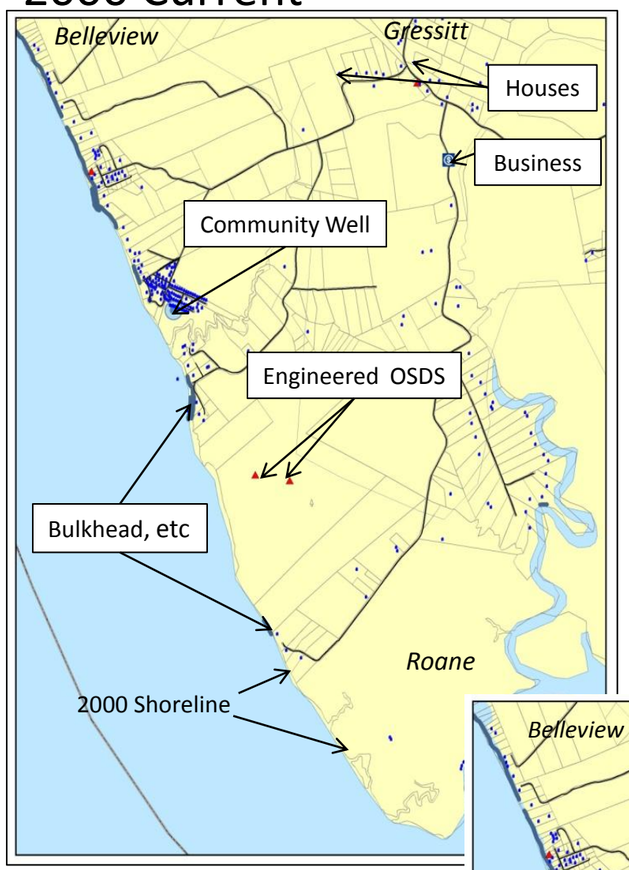
G. Roane –
Ecological Impacts

H. Heart Quake Trail Area –
Ecological Impacts

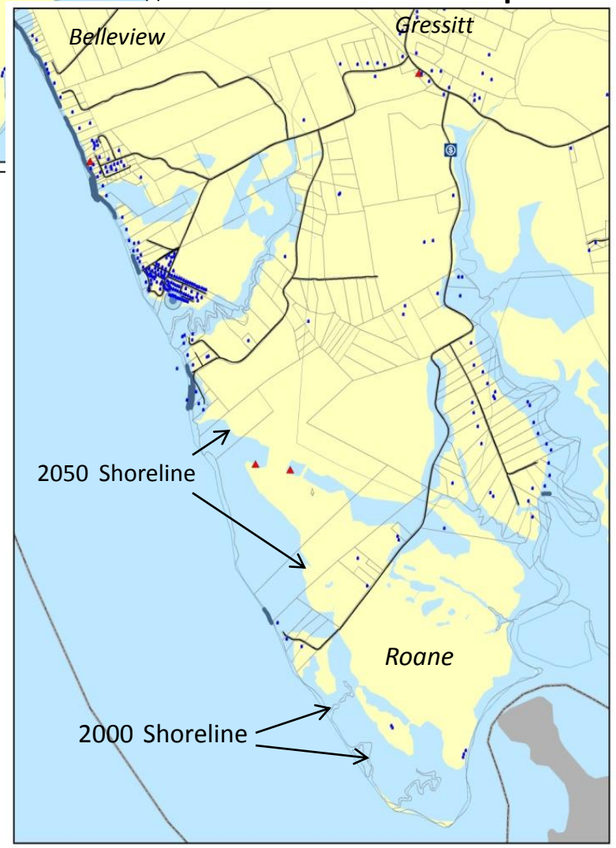
F

Roane: Significant inundation of private infrastructure may be costly to the constituent but may have public implications especially as onsite septic disposal systems are impacted.

2000 Current



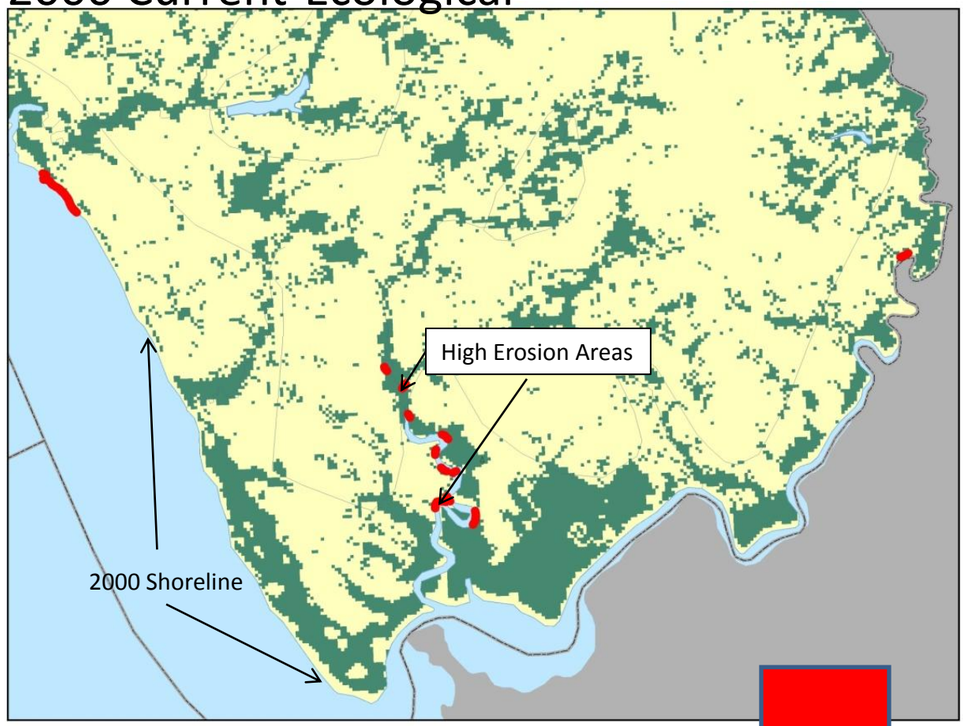
2050 Impact



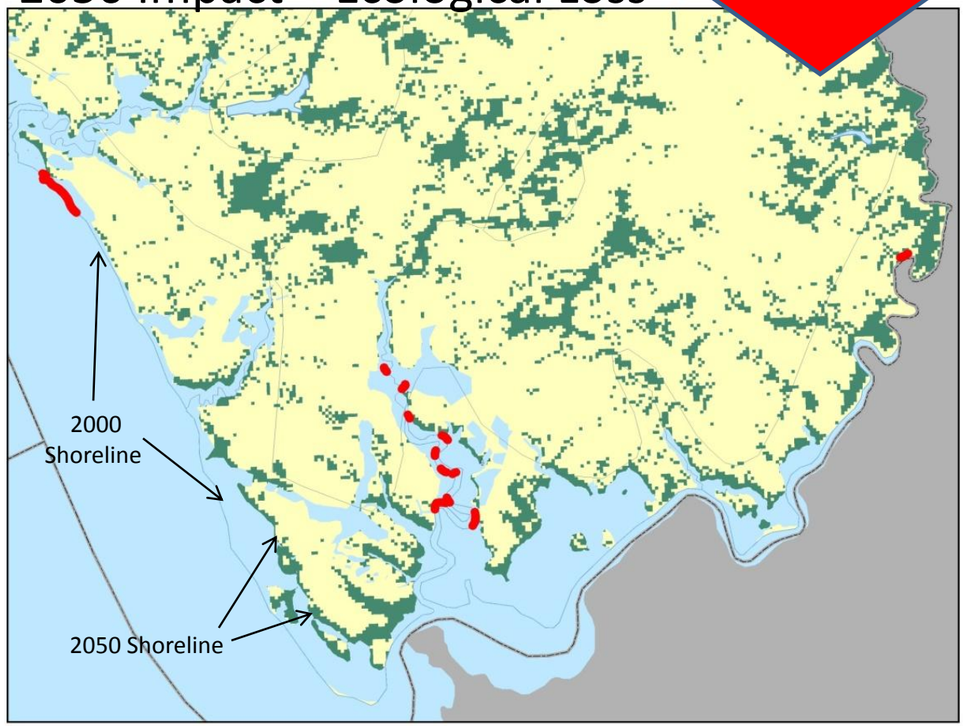
Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	37	$228,669 Estimated median house or condo value in 2007 (City-Data.com)	$8,918,091
Engineered OSDS	1	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	36	$4,000 (MPPDC Regional Estimate)	$124,000
Community Well (65 connections)	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	37	$3,000 (MPPDC Regional Estimate)	$111,000
Shoreline Hardening	6,977.04 ft	$200/foot (MPPDC Regional Estimate)	$1,395,408.26
VDOT Road Segments	7,934.30 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $58,311.15 Long term: $291,555.75
TOTAL			**Short term: $10,790,810.41** **Long term: $11,024,055.01**

**NOTE: There are 37 private wells that are directly impacted by inundation, however 232 private wells may be indirectly impacted in this snapshot by salt water intrusion as sea level rises.

2000 Current-Ecological



2050 Impact – Ecological Loss



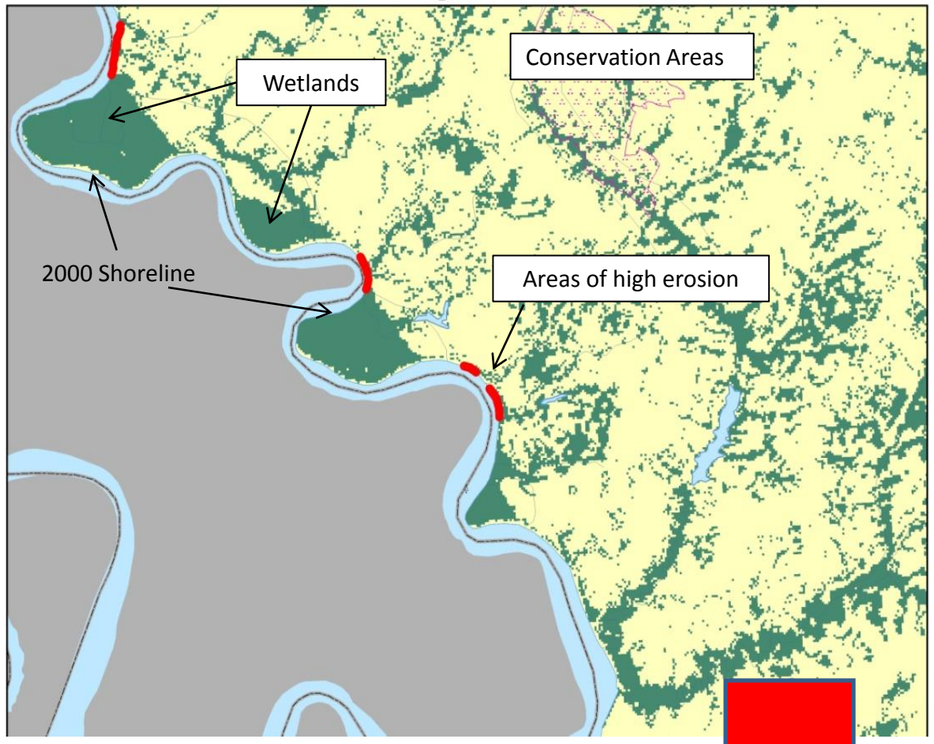
Roane: Inundation of wetlands will expose inlands to more frequent and intense storm surges due to climate change

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	1,247.57	$59,883.36
Waterfowl Habitat	$253[b]	1,247.57	$315,635.21
Mammal and Reptile	$18[c]	1,247.57	$22,456.26
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	1,247.57	$361,383 - $10,687,520.49
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	1,247.57	$11,228.13 - $143,470.55
Total value lost or redistributed: $770,585.96 - $11,228,965.87			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -biodiversity	

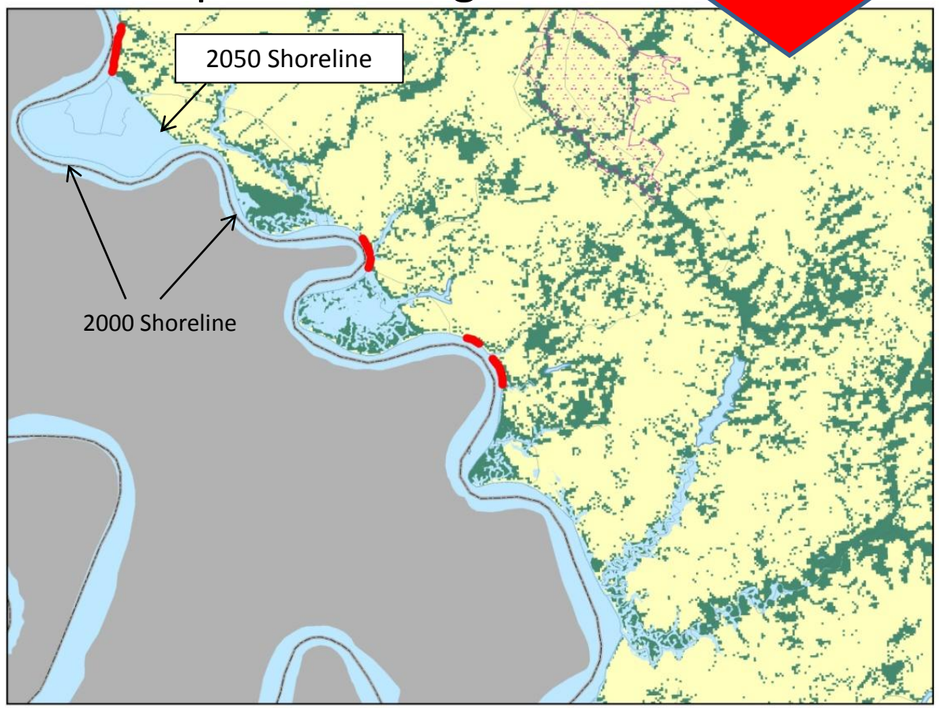
[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

4,014.60 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current-Ecological



2050 Impact – Ecological Loss



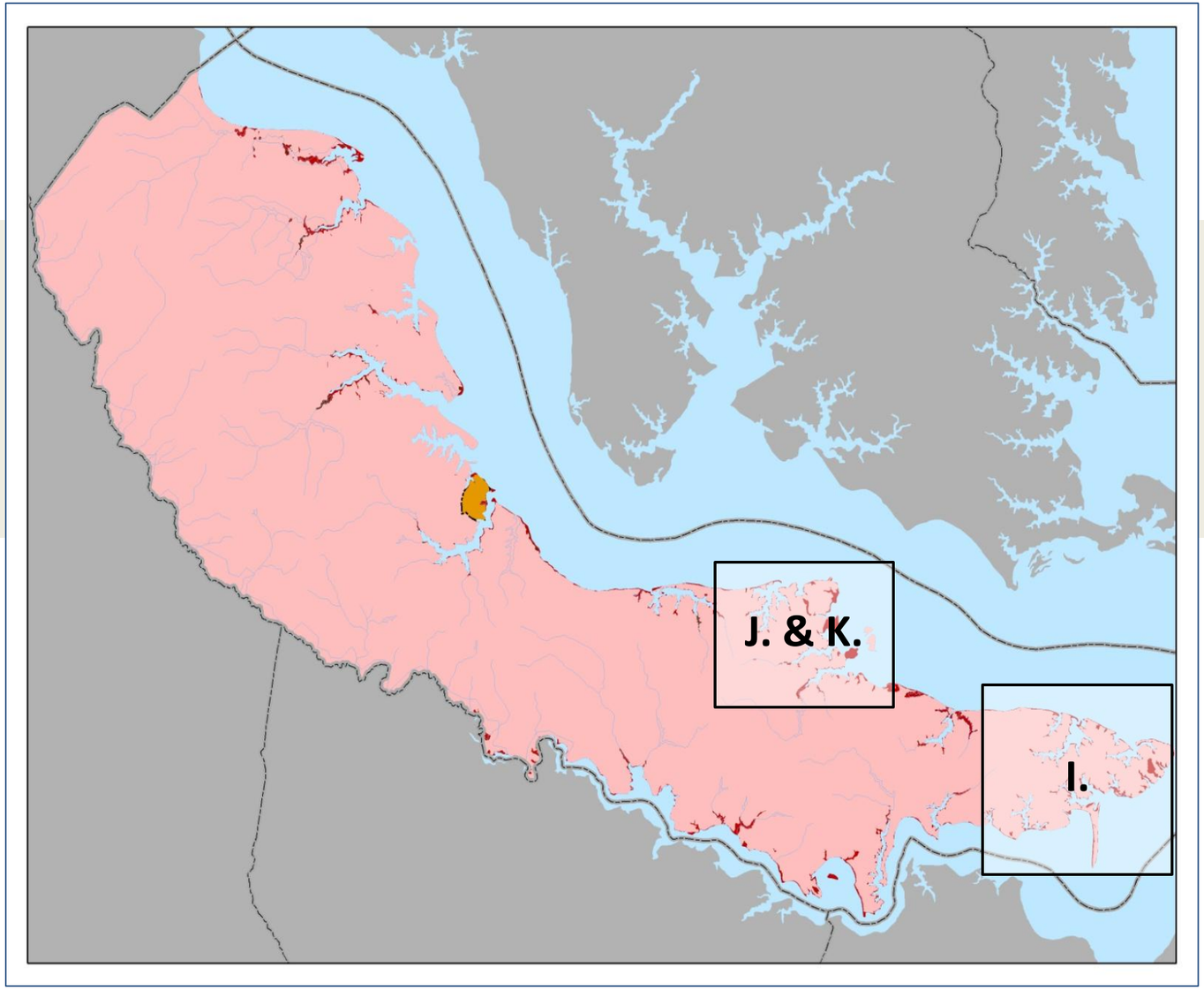
Heart Quake Trail Area: Inundation of tidal wetlands lining the Mattaponi River will reduce habitat and spawning grounds for anadromous migratory fish (ie. Shad, herring and stripped bass) and the associated angling industry

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	723.99	$34,751.52
Waterfowl Habitat	$253[b]	723.99	$183,169.47
Mammal and Reptile	$18[c]	723.99	$13,031.82
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	723.99	$209,718.18 - $6,202,183.41
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	723.99	$6,515.91 - $83,258.85
Total value lost or redistributed: $447,186.90 - $6,516,395.07			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -migratory fish and waterfowl habitat	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -biodiversity

[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989

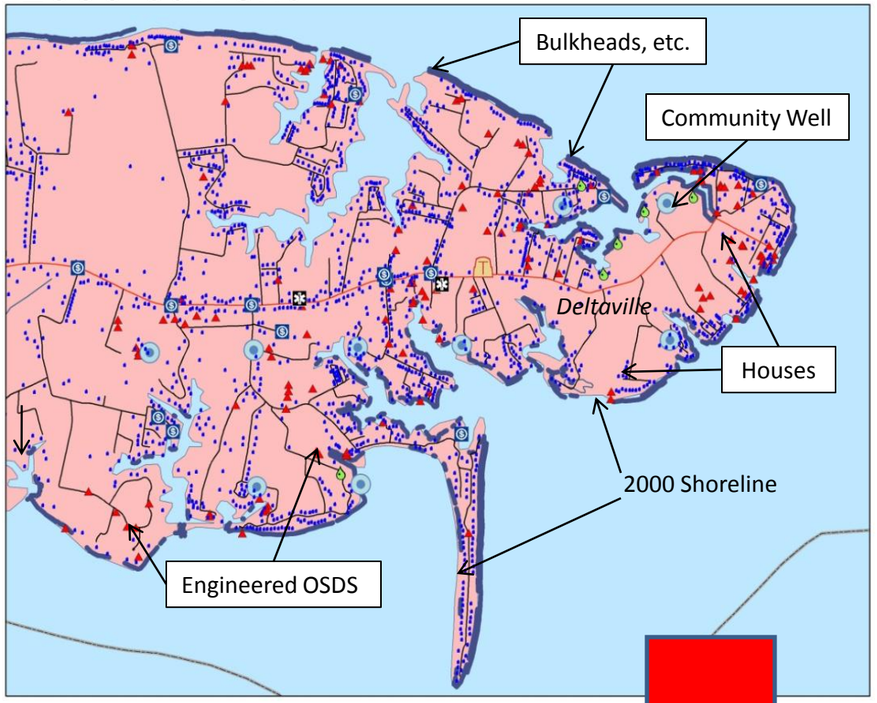
5,375 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area



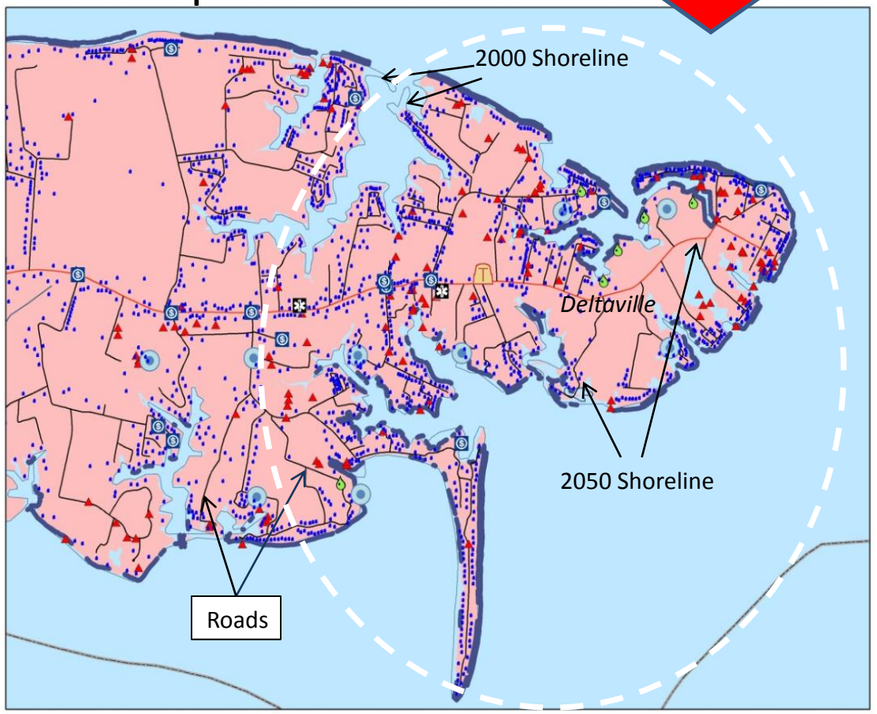
Middlesex County

I. Deltaville
J. Locklies
K. Locklies – Ecological Impacts

2000 Current



2050 Impact

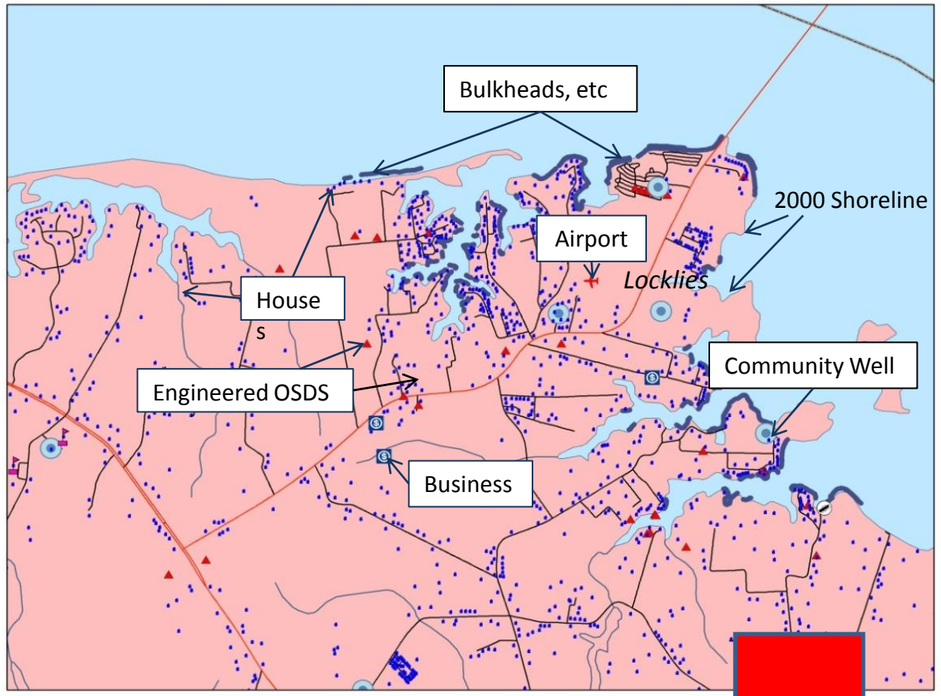


Deltaville: A desired Bay and River vista draw people to the coast, but coastal living may come at higher cost due to inundation of public and private infrastructure

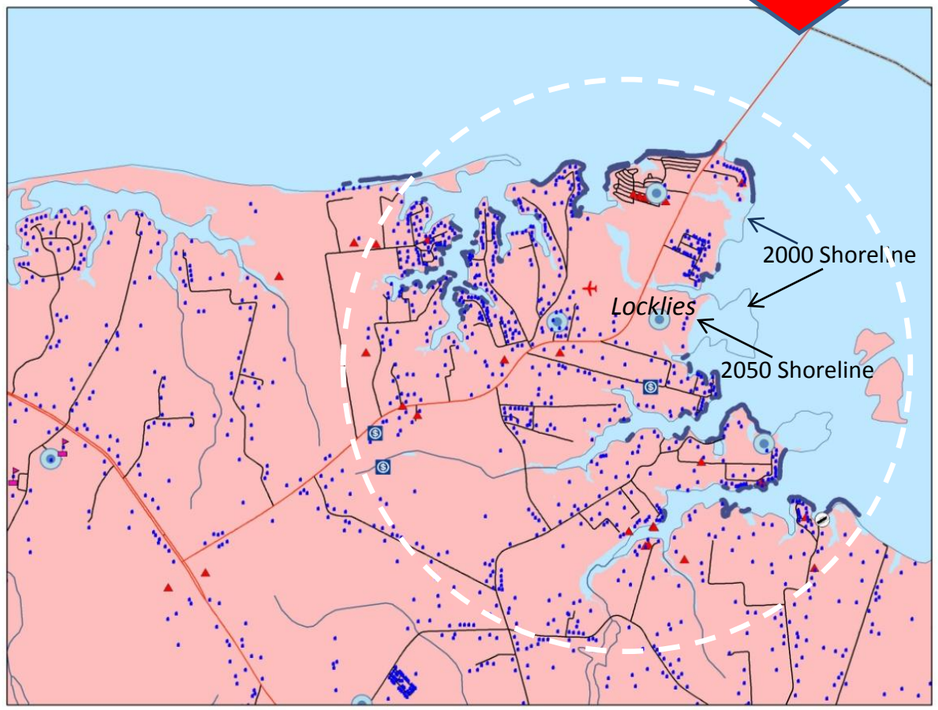
Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	17	$226,617 Estimated median house or condo value in 2007 (City-Data.com)	$3,852,489
Engineered OSDS	20	$18,000 (MPPDC Regional Estimate)	$360,000
Conventional OSDS	14	$4,000 (MPPDC Regional Estimate)	$56,000
Community Well (with 2 connections)	2	$40,000 (MPPDC Regional Estimate)	$80,000
Private Wells	17	$3,000 (MPPDC Regional Estimate)	$51,000
Shoreline Hardening	51,255.16 ft	$450/foot (MPPDC Regional Estimate)	$23,064,822
VDOT Road Segments	3,582.51 ft	Short term: $149/sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $533,793.99 Long term: $2,668,969.95
TOTAL			**Short term: $27,947,104.99** **Long term: $30,082,280.95**

J

2000 Current



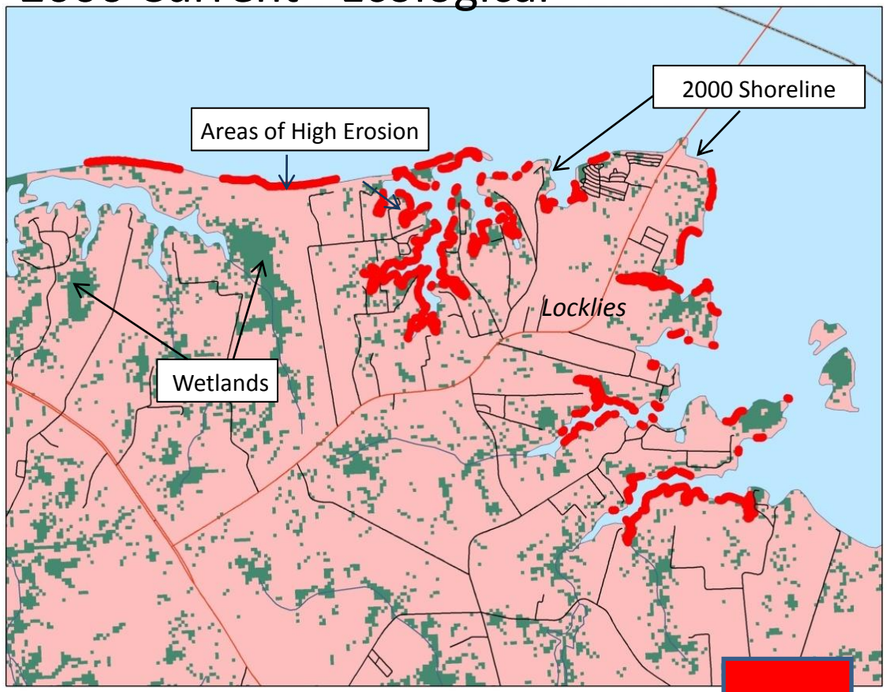
2050 Impact



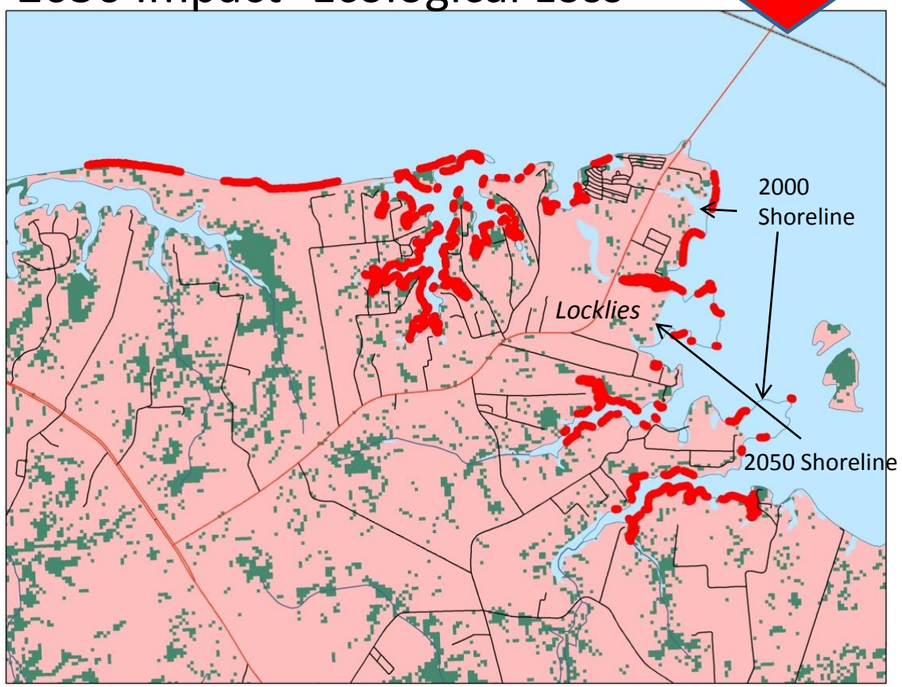
Locklies: Will shoreline hardening be sufficient to protect coastal communities from sea level rise?

Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	4	$226,617 Estimated median house or condo value in 2007 (City-Data.com)	$906,468
Engineered OSDS	3	$18,000 (MPPDC Regional Estimate)	$54,000
Conventional OSDS	4	$4,000 (MPPDC Regional Estimate)	$16,000
Private Wells	4	$3,000 (MPPDC Regional Estimate)	$12,000
Shoreline Hardening	27,461.38 ft	$450/foot (MPPDC Regional Estimate)	$12,357,621
VDOT Road Segments	1,668.89 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $248,664.61 Long term: $1,243,323.05
TOTAL			**Short term: $13,594,753.61** **Long term: $14,589,412.05**

2000 Current - Ecological



2050 Impact- Ecological Loss

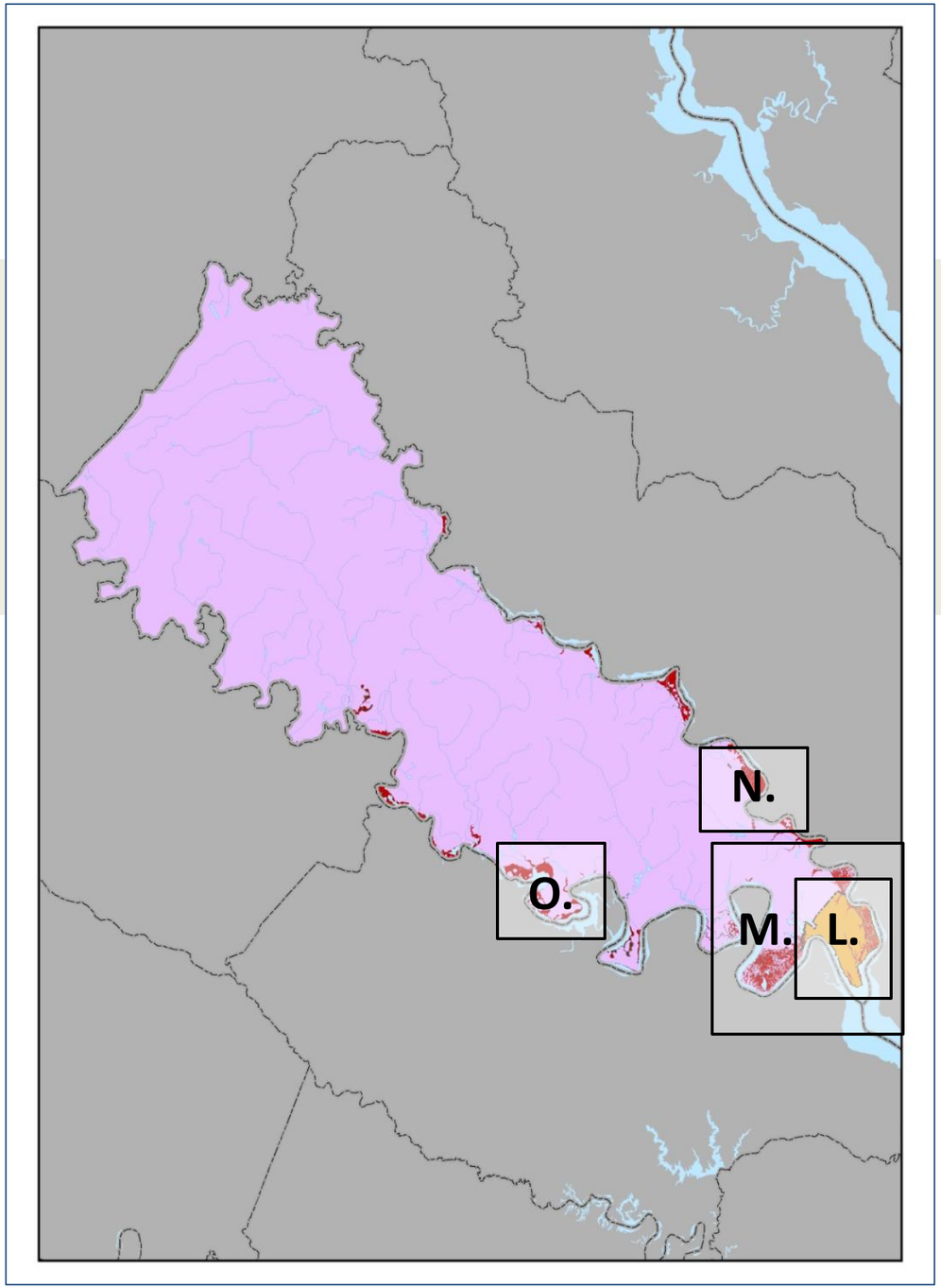


Locklies: With abundant sandy and loamy soils on the coastal, high erosion areas are numerous which will likely be highly vulnerable to sea level rise and storm surges

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	103.6	$4,972.80
Waterfowl Habitat	$253[b]	103.6	$26,210.80
Mammal and Reptile	$18[c]	103.6	$1,864.80
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	103.6	$30,009.81 - $887,507.01
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	103.6	$932.40- $11,914.00
Total value lost or redistributed: $63,990.61 - $932,469.41			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista	

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

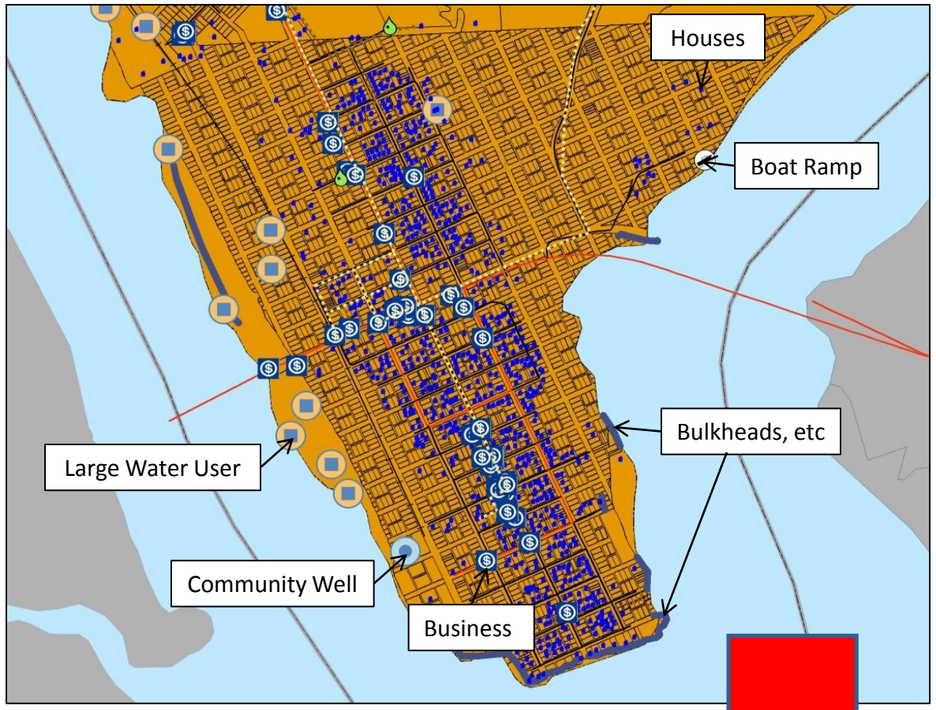
52,655.23 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area



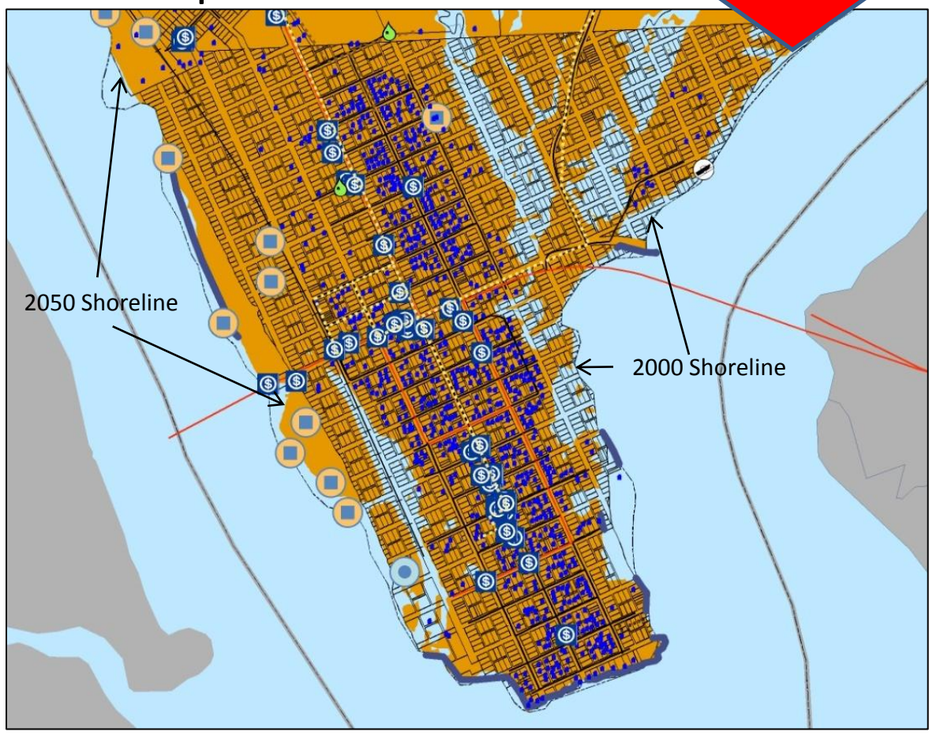
King William County

L. Town of West Point
M. Romancoke to West Point – Ecological Impacts
N. Winona Park Road – Ecological Impacts
O. Pamunkey Tribe Reservation- Ecological Impacts

2000 Current



2050 Impact



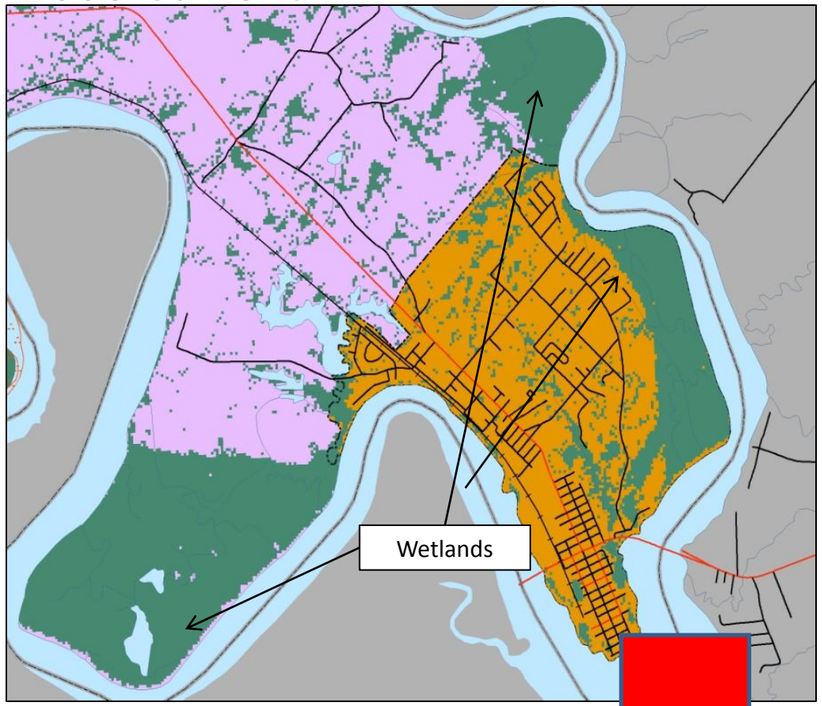
Town of West Point: Private and Public investments are directly impacted by sea level rise

Infrastructure	Amount of flooded structures	Average Cost	Total Cost
Houses	5	$224,339 Estimated median house or condo value in 2007 (City-Data.com)	$1,121,695
Conventional OSDS	5	$4,000 (MPPDC Regional Estimate)	$20,000
Private Wells	5	$3,000 (MPPDC Regional Estimate)	$15,000
Shoreline Hardening	6,052.89 ft	$200/foot (MPPDC Regional Estimate)	$1,210,578
Railroad Tracks	2,200.24 ft	$165.00/foot of track not including the price of the land (Track Guy Consultants)	$363,039.60
VDOT Road Segments	109.47 ft	Short term: $149 /sq ft Long term: $745/sq ft Additional right away acquisition and when raised 10 inches (VDOT Estimate)	Short term: $16,311.03 Long term: $81,555.15
TOTAL			**Short term: $2,746,623.63** **Long term: $2,811,867.75**

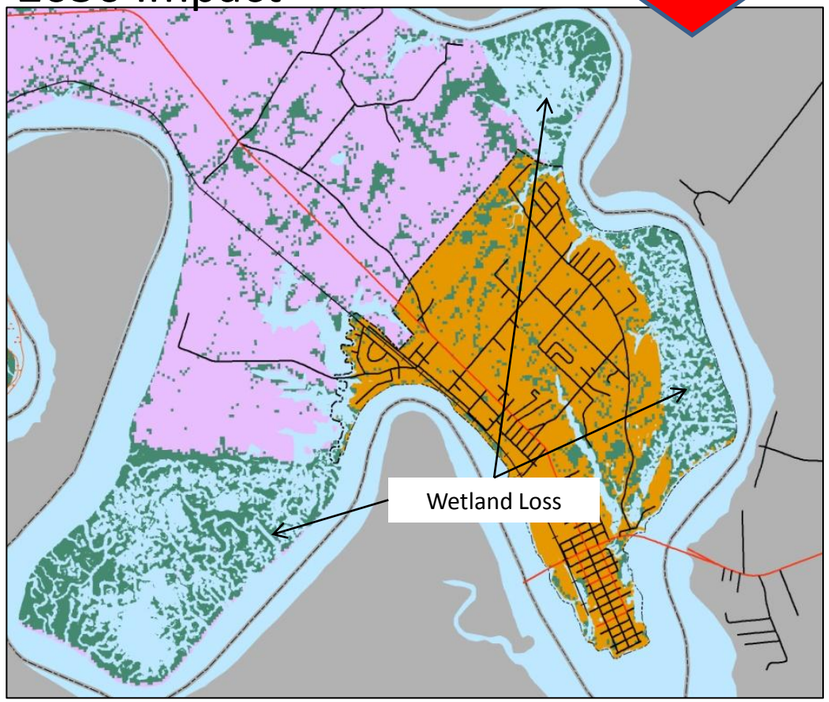
Total Parcels in Mathews County	11,107
Total Parcels in Snapshot	2979
Impacted Parcels	570
Percentage of Impacted Parcels in Snapshot	19.1%

Smurfit Stone may encounter higher operation and maintenance costs due 3 of 7 intake pipes being impacted by sea level rise

2000 Current



2050 Impact



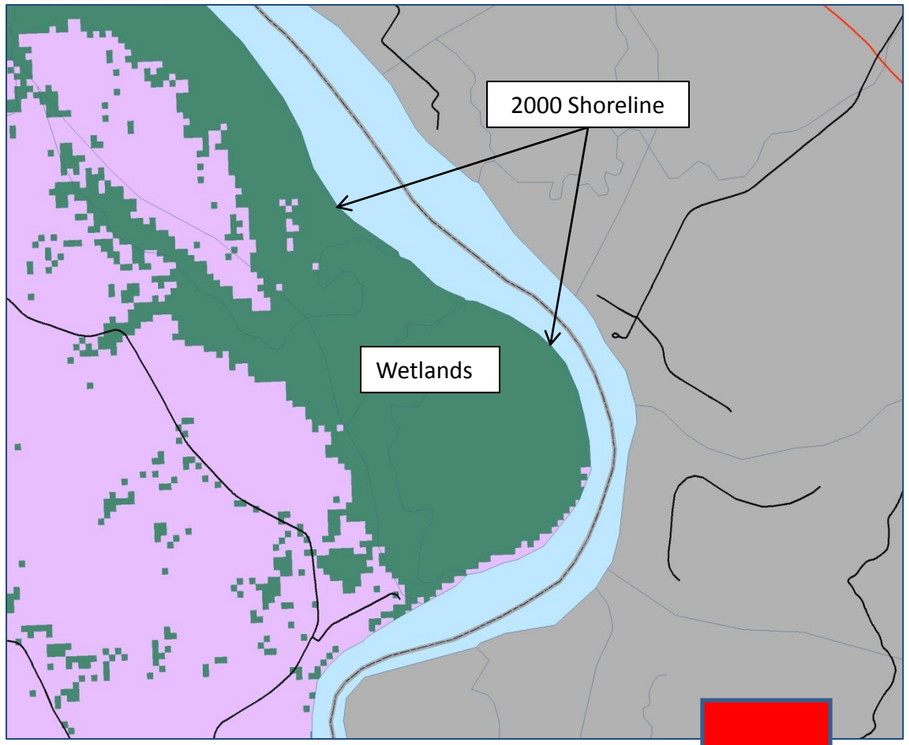
Romancoke to West Point: Significant losses of wetlands surrounding the Town of West Point may increase the towns vulnerability to flooding from climate change, storm surges and tidal changes

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 1,247.57 1,247.57 1,247.57	 $59,883.36 $315,635.21 $22,456.26
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	1,247.57	$361,383 - $10,687,520.49
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	1,247.57	$11,228.13 - $143,470.55
Total value lost or redistributed: $770,585.96 - $11,228,965.87			

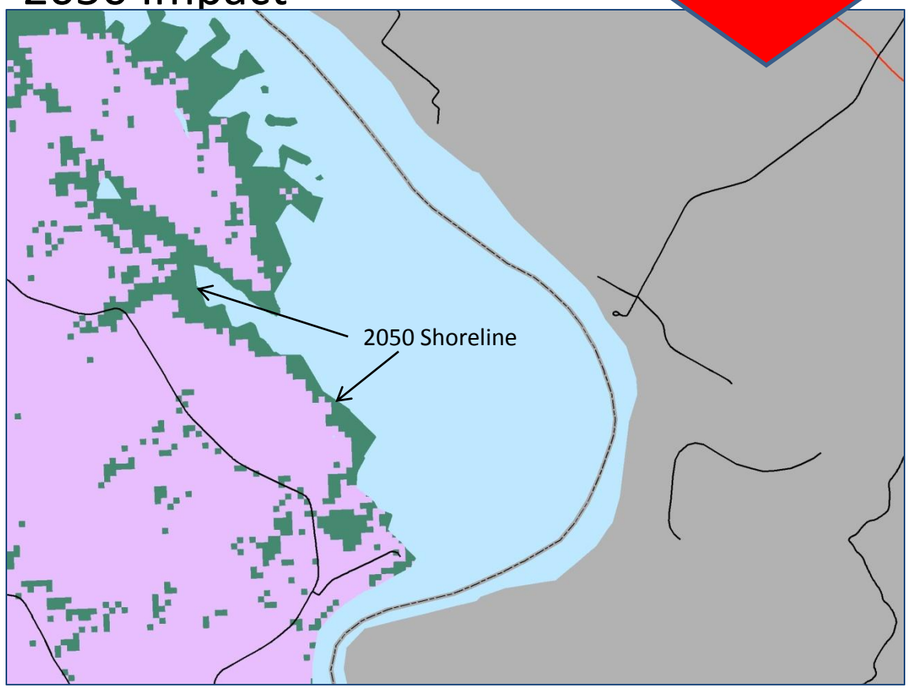
Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

2000 Current



2050 Impact



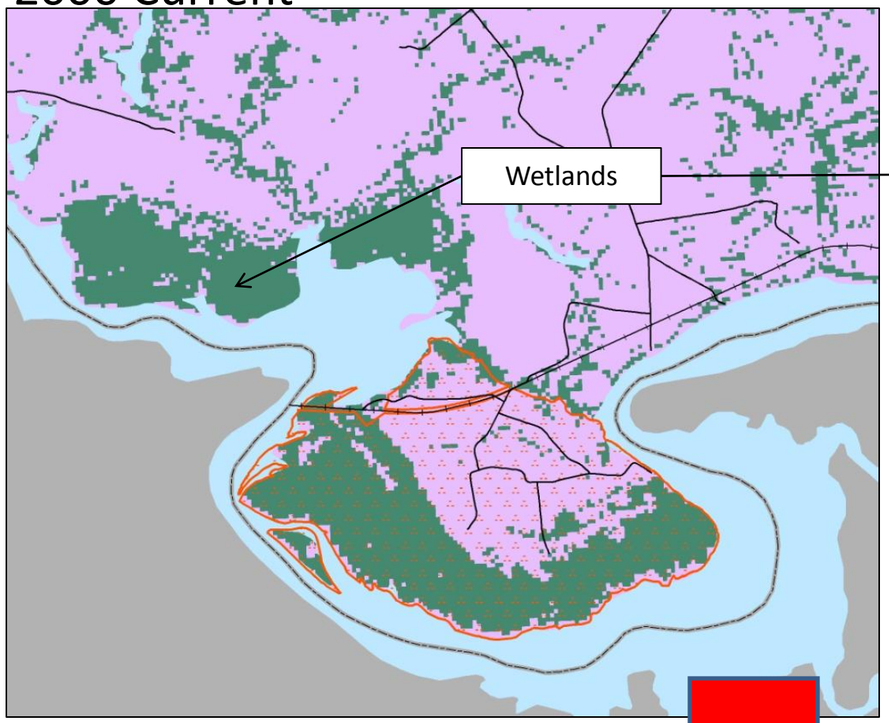
Winona Park Road: 62% of wetlands recorded in 2000 will be inundated due to sea level rise in 2050

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	560.81	$26,918.88
Waterfowl Habitat	$253[b]	560.81	$141,884.93
Mammal and Reptile	$18[c]	560.81	$10,094.58
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	560.81	$162,449.83- $4,804,274.20
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	560.81	$5,047.29- $64,493.15
Total value lost or redistributed: $346,395.51- $5,047,665.74			

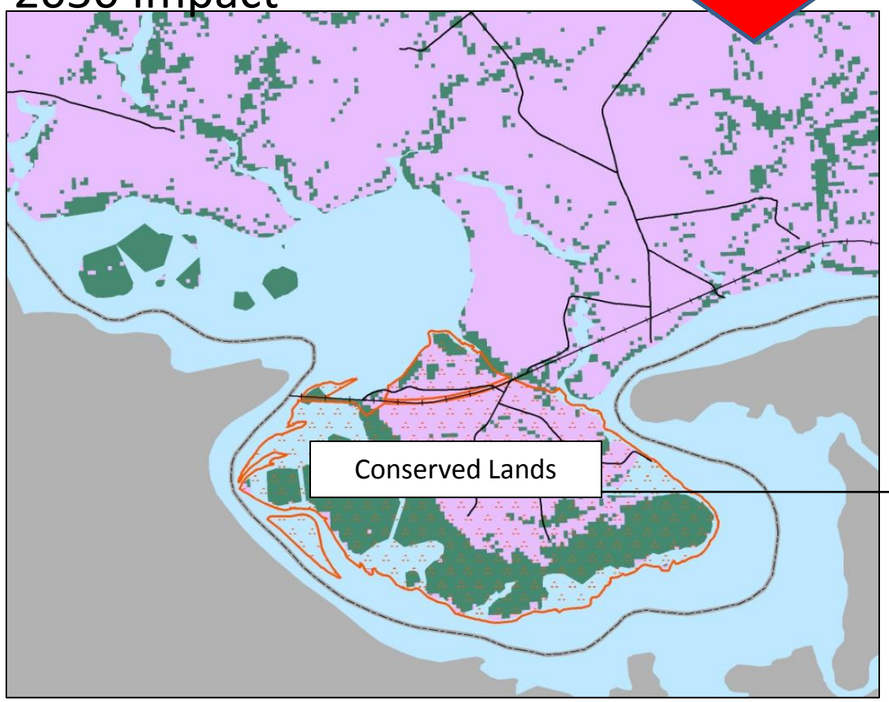
Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

2000 Current



2050 Impact



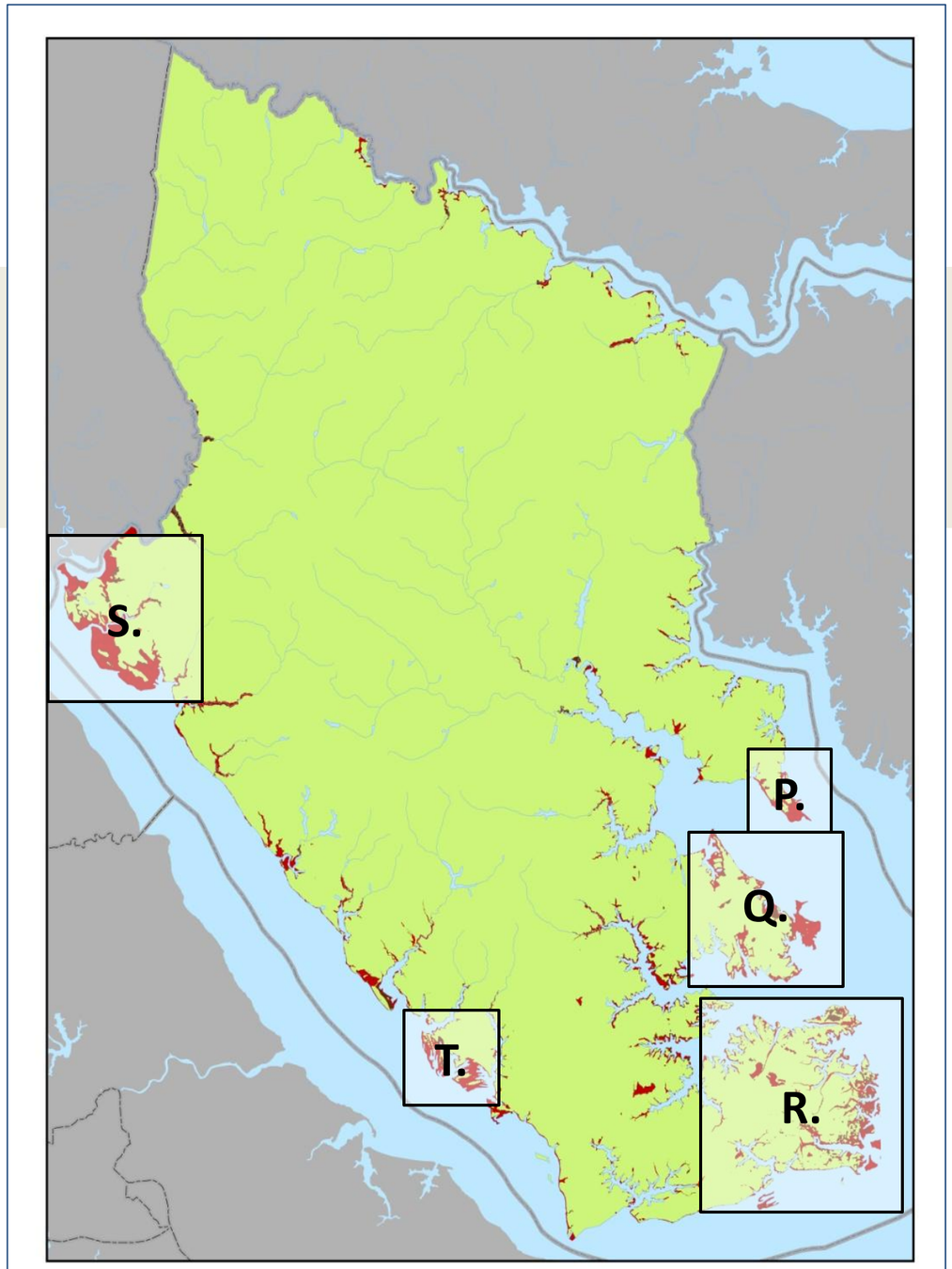
Pamunkey Tribe Reservation: 11% of the tribe's terrestrial land is inundated and converts to subaqueous lands

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	413.28	$19,837.44
Waterfowl Habitat	$253[b]	413.28	$104,559.84
Mammal and Reptile	$18[c]	413.28	$7,439.04
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	413.28	$119,714.82- $3,540,433.38
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	413.28	$3,719.52 - $47,527.20
Total value lost or redistributed: $255,270.66 - $3,719,796.90			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista -saltwater intrusion may impact the tribe's subsistence living on natural resources in the area

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981
[i] Farber and Costanza, 1987 [j] Bell, 1989

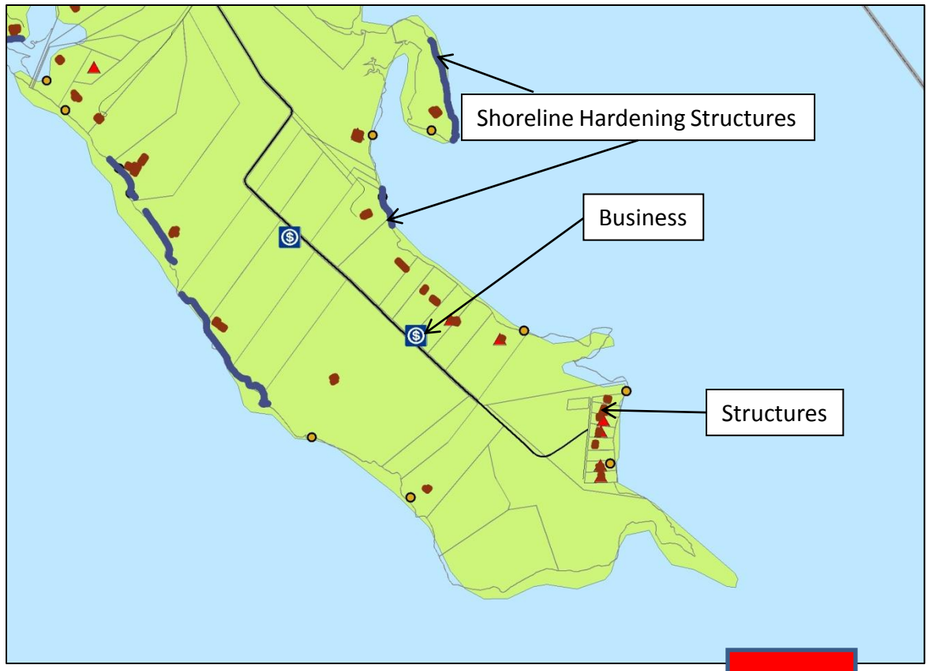
Conserved Lands Impacted	
Pamunkey Tribe Reservation	Quantitative: 127.62 acres of terrestrial land converts to subaqueous land due to inundation Qualitative: saltwater intrusion and loss of wetlands may impact the tribe's subsistence lifestyle centered around pottery making, fishing, hunting and trapping



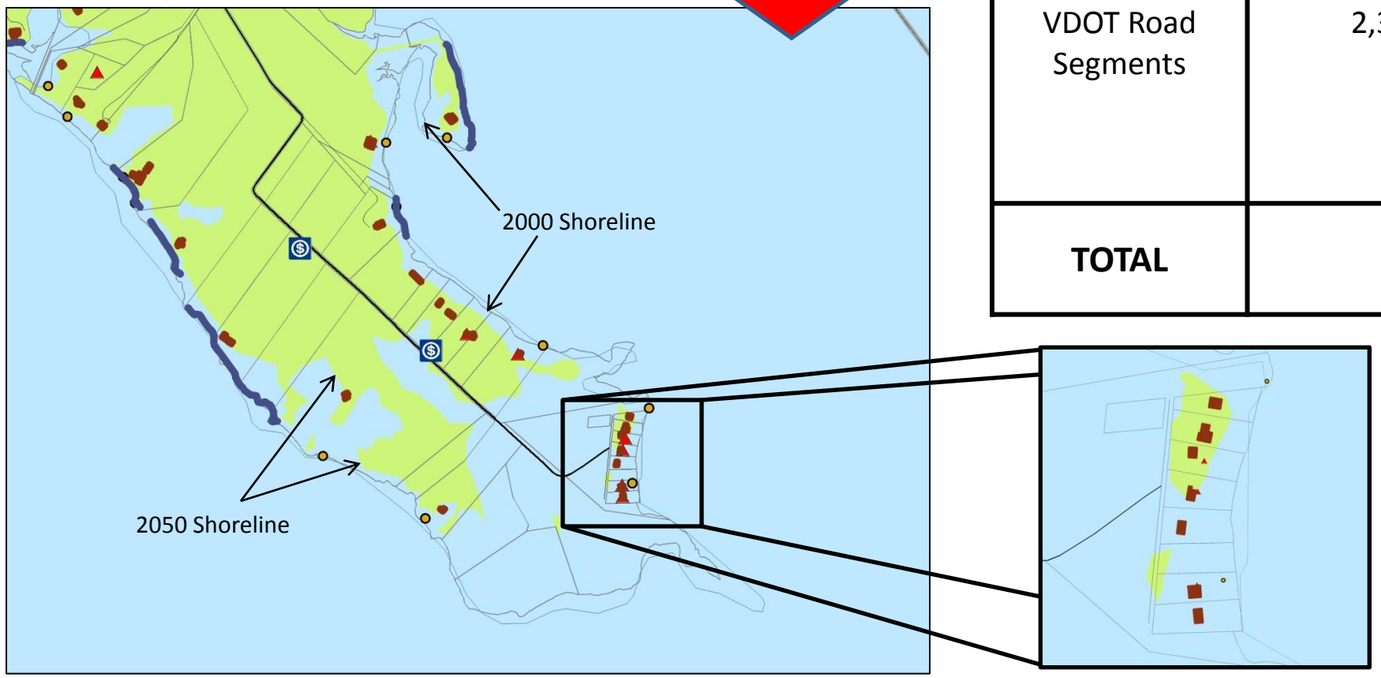
Gloucester County

P. Ware Neck Point
Q. Nexara
R. Guinea
S. Purtan Bay and West End– Ecological Impacts
T. Catlett Islands – Ecological Impacts

2000 Current



2050 Impact



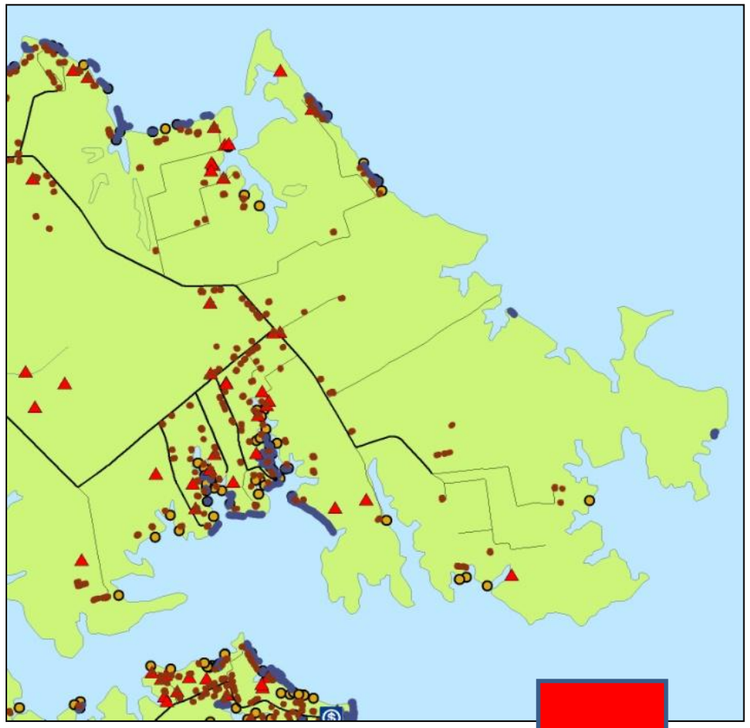
Ware Neck Point: Typical road access to coastal developments become limited as roads are inundated

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	9	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$2,045,637
Engineered OSDS	3	$18,000 (MPPDC Regional Estimate)	$54,000
Conventional OSDS	6	$4,000 (MPPDC Regional Estimate)	$24,000
Private Wells	9	$3,000 (MPPDC Regional Estimate)	$27,000
Shoreline Hardening	8,099 ft	$450/foot (MPPDC Regional Estimate)	$3,644,550
VDOT Road Segments	2,300 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $342,700 Long Term: $1,713,500
TOTAL			**Short term: $ 6,137,887** **Long term: $ 7,508,687**

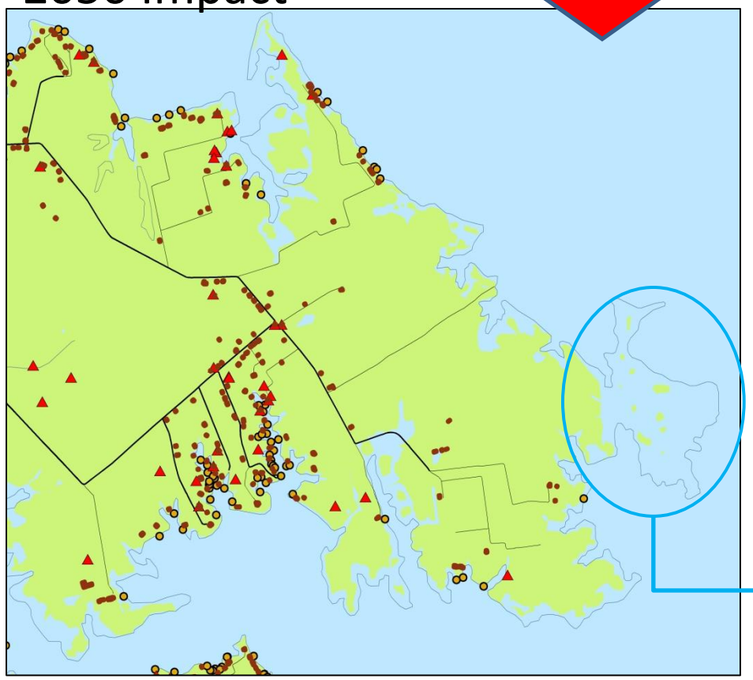
As roads to private property are inundated…..

- How will residents get to their houses?
- How do residents get access to schools?
- How are OSDS and wells serviced?
- How are the roads serviced?
- How will localities recover the lost revenue from property taxes?

2000 Current



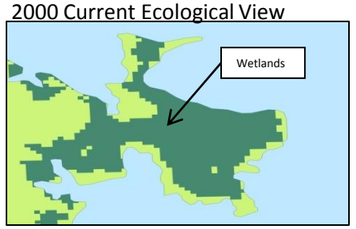
2050 Impact



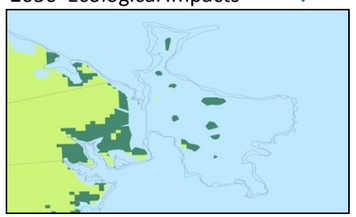
Naxera Area: Costly anthropogenic and ecological impacts due to sea level rise

Infrastructure	Amount of Structures Impacted	Average Cost	Total Costs
Houses	14	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$3,182,102
Engineered OSDS	1	$18,000 (MPPDC Regional Estimate)	$18,000
Conventional OSDS	13	$4,000 (MPPDC Regional Estimate)	$52,000
Private Wells	14	$3,000 (MPPDC Regional Estimate)	$42,000
Shoreline Hardening	5,112.48 ft	$450/ft (MPPDC Regional Estimate)	$2,300,616
VDOT Road Segments	1,500 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $223,500 Long Term: $1,117,500
TOTAL			**Short term: $ 5,818,218** **Long term: $ 6,712,218**

2000 Current Ecological View



2050 Ecological Impacts



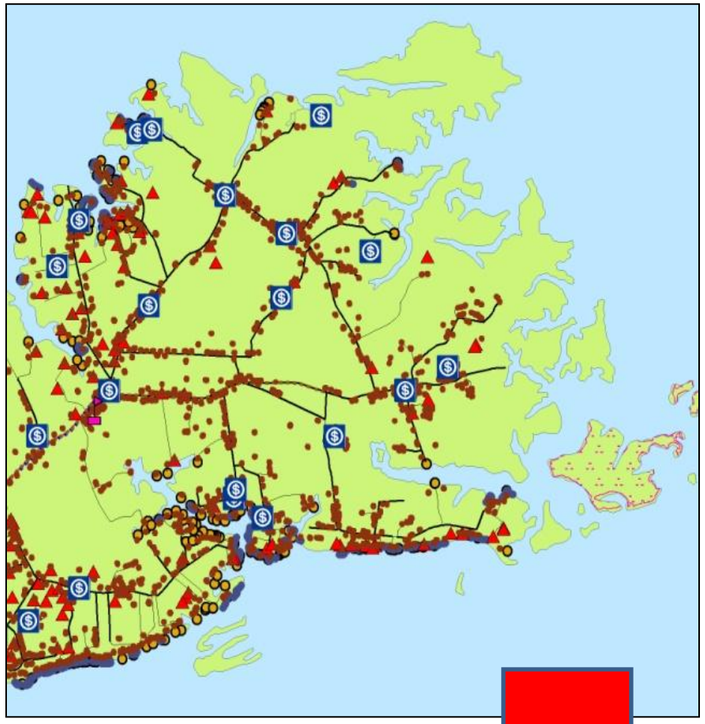
360 Acre Parcel Almost Completely Lost!

-Majority of acreage lost are covered by wetlands (dark green)

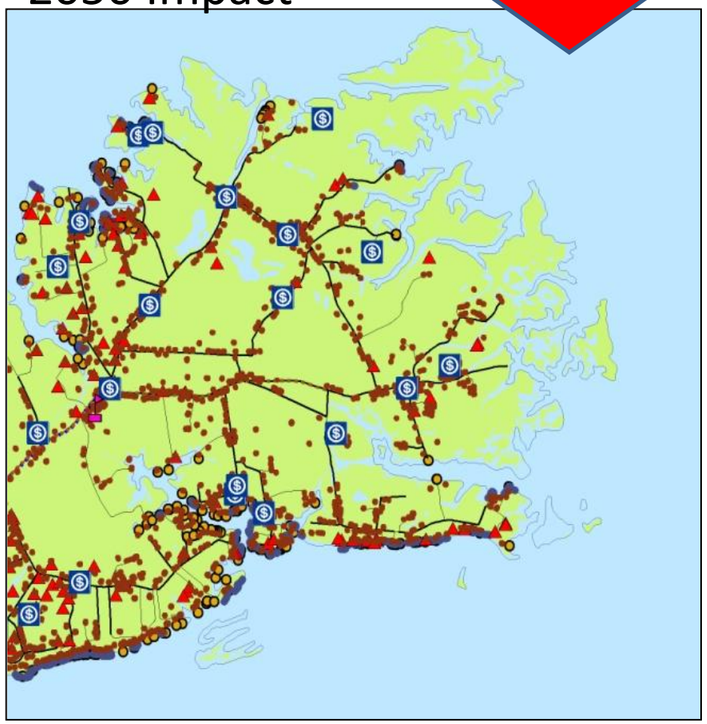
-Estimated Cost of Wetland Loss=

$70,617.35 - $1,032,376.85

2000 Current



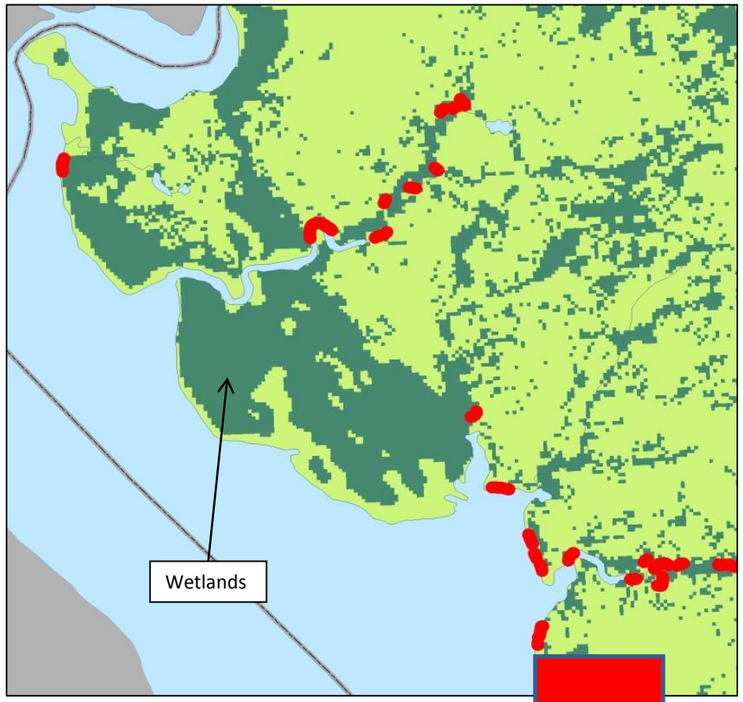
2050 Impact



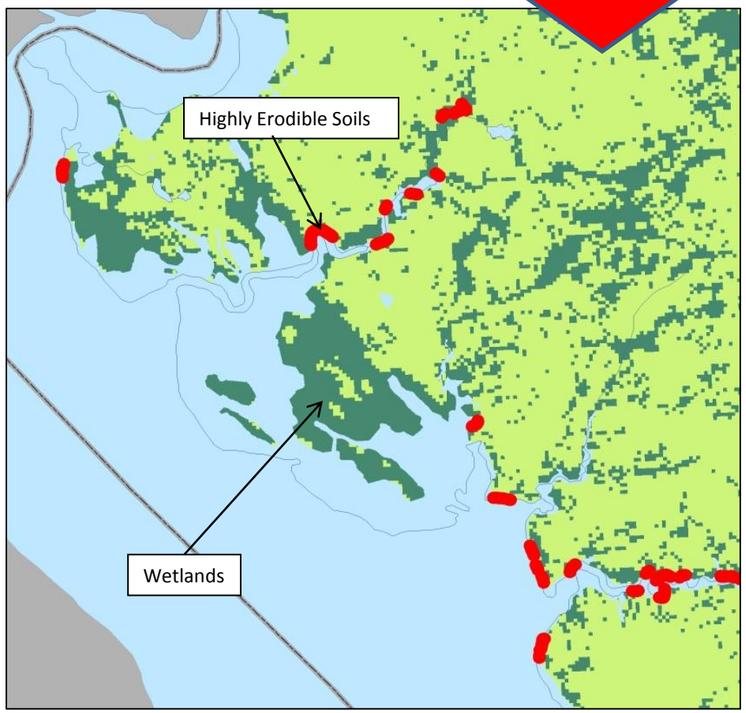
Guinea Area: Inundation of private investments simultaneously have public health implications

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	37	$227,293 Estimated median house or condo value in 2007 (City-Data.com)	$8,409,841
Engineered OSDS	2	$18,000 (MPPDC Regional Estimate.)	$36,000
Conventional OSDS	35	$4,000 (MPPDC Regional Estimate)	$140,000
Private Wells	37	$3,000 (MPPDC Regional Estimate)	$111,000
Shoreline Structures	11,294.9	$450/ft (MPPDC Regional Estimate)	$5,082,705
VDOT Road Segments	1,009 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $150,341 Long Term: $751,705
TOTAL			**Short term: $ 13,929,887** **Long term: $ 14,537,251**

2000 Current



2050 Impact



Purtan Bay and West End Inundated wetlands may increase expose the southern tip of King and Queen County to the open waters of the York River. Ultimately increasing vulnerability to coastal erosion , storm surges and inundation.

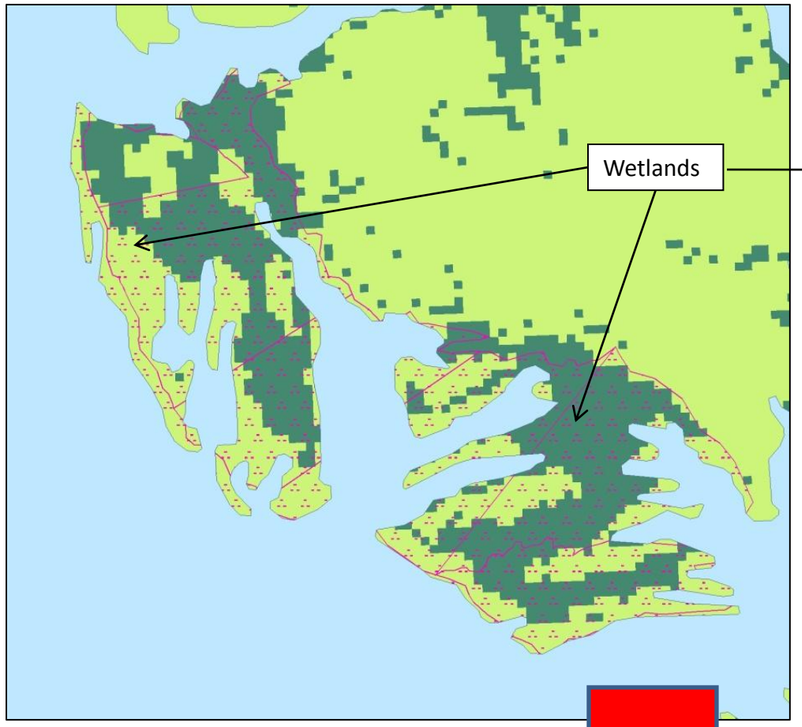
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	879.84	$42,232.32
Waterfowl Habitat	$253[b]	879.84	$222,599.52
Mammal and Reptile	$18[c]	879.84	$15,837.12
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	879.84	$254,863.25 - $7,537,298.93
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	879.84	$7,918.56 - $101,181.60
Total value lost or redistributed: $543,450.77 - $7,919,149.49			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

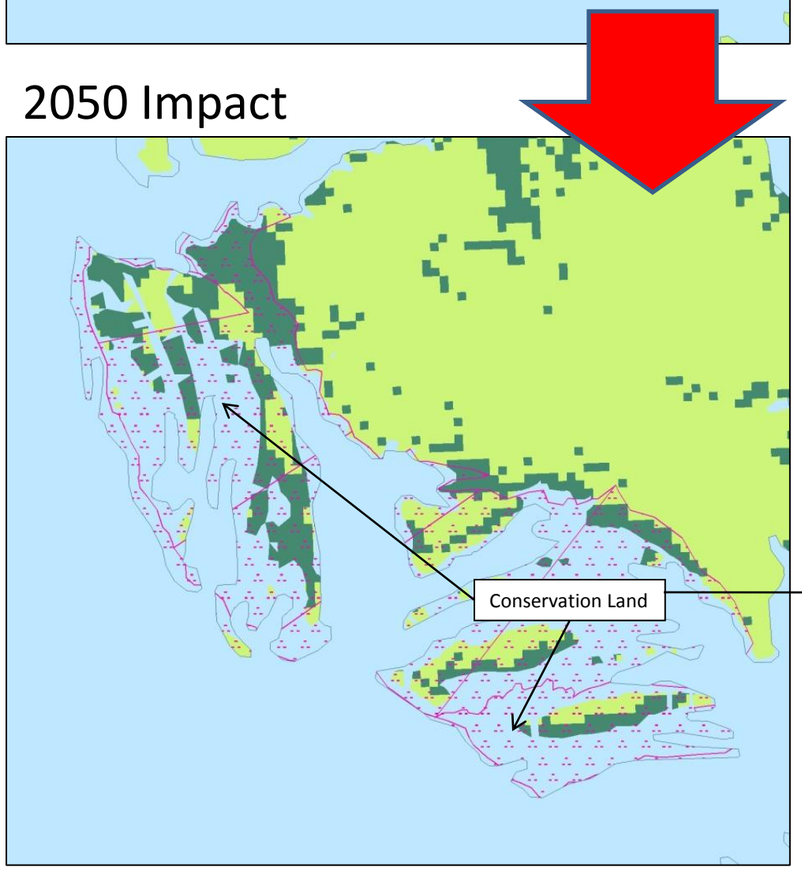
[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

53,495.58 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current



2050 Impact



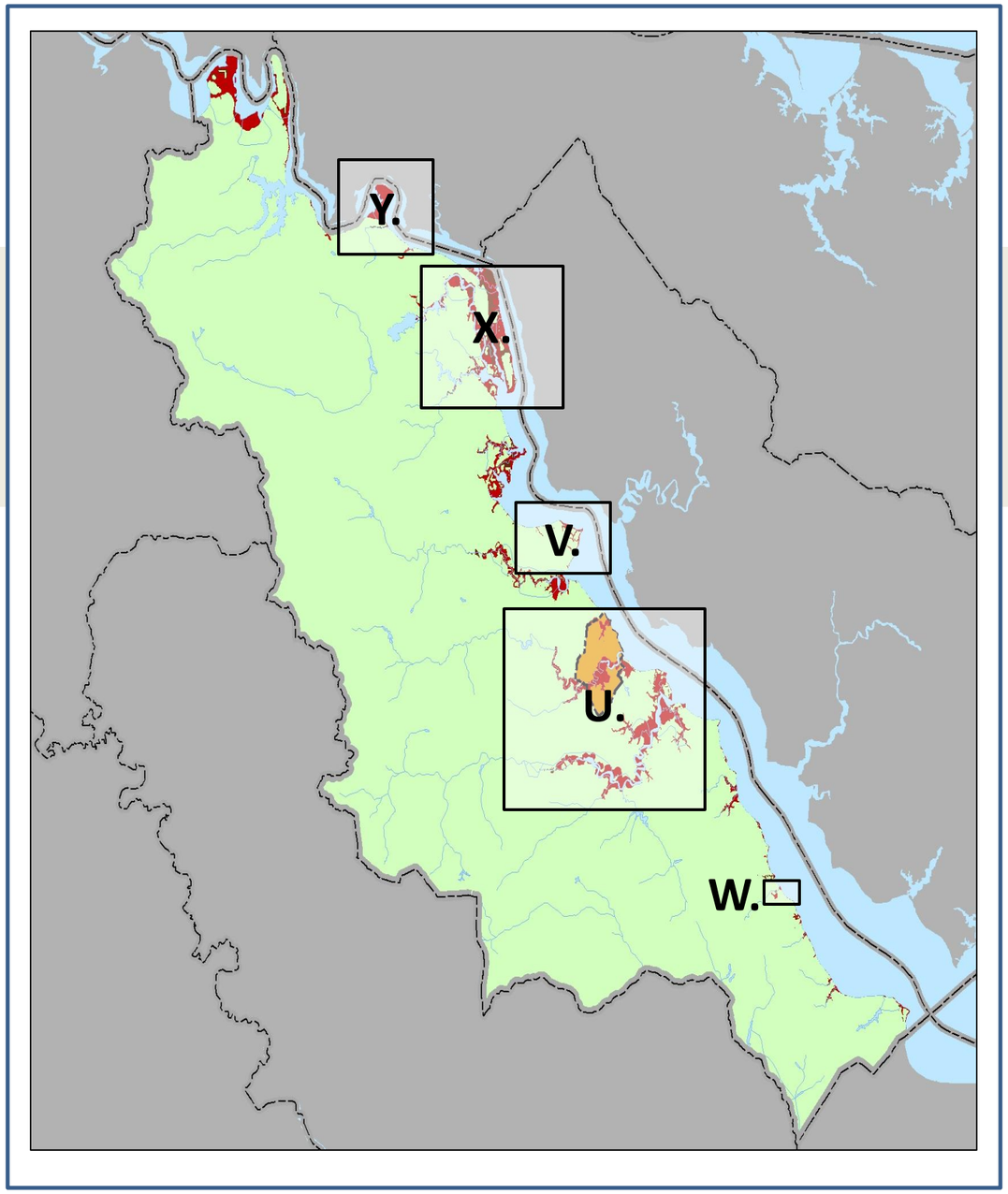
Catlett Islands: Loss of forested wetlands may limit wetland ecology research on these inlands which is currently being conducted by VIMS

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	131.78	$6,325.44
Waterfowl Habitat	$253[b]	131.78	$33,340.34
Mammal and Reptile	$18[c]	131.78	$2,372.04
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	131.78	$38,172.71 -$1,128,915.77
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	131.78	$1,186.02 - $15,154.70
Total value lost or redistributed: $81,396.55 - $1,186,108.29			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

[a] Bell, 1989 [b] Guta and Foster, 1975 [c] Farber and Costanza, 1987 [d] Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j] Bell, 1989

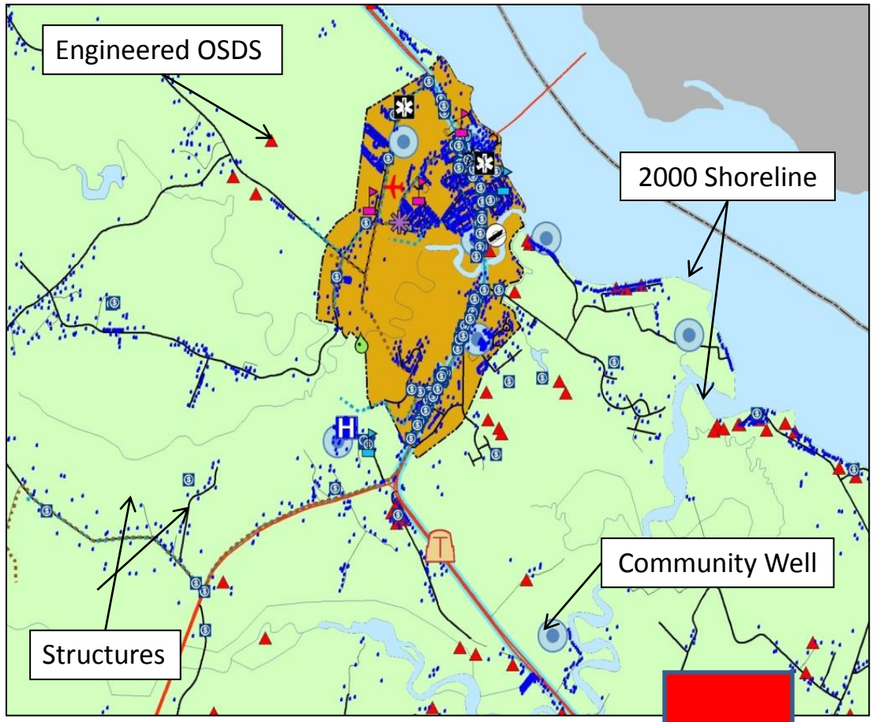
Conserved Lands Impacted	
Catlett Islands - National Estuarine Research Reserve	Quantitative: •Currently there was 536.48 subaqueous acres and 497.39 terrestrial acres of the reserve •In 2050, 375.99 acres of terrestrial land converts to subaqueous land due to inundation



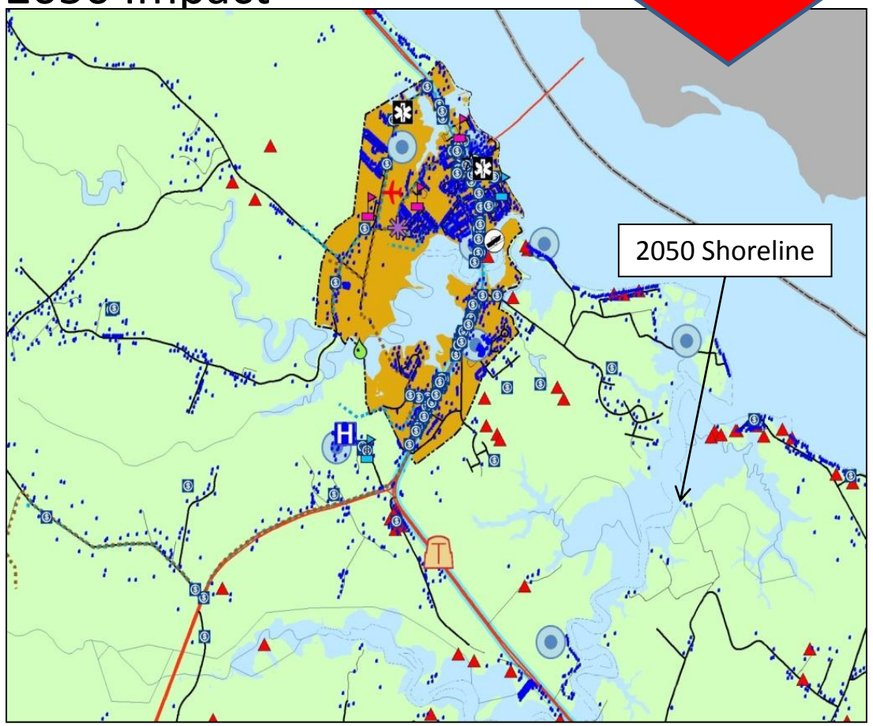
Essex County

U. Town of Tappahannock and Piscataway Creek
V. Gynnfield Subdivision
W. Lower Essex- Cottage Row Road
X. Kendall Road – Ecological Impacts
Y. Layton Peninsula – Ecological Impacts

2000 Current



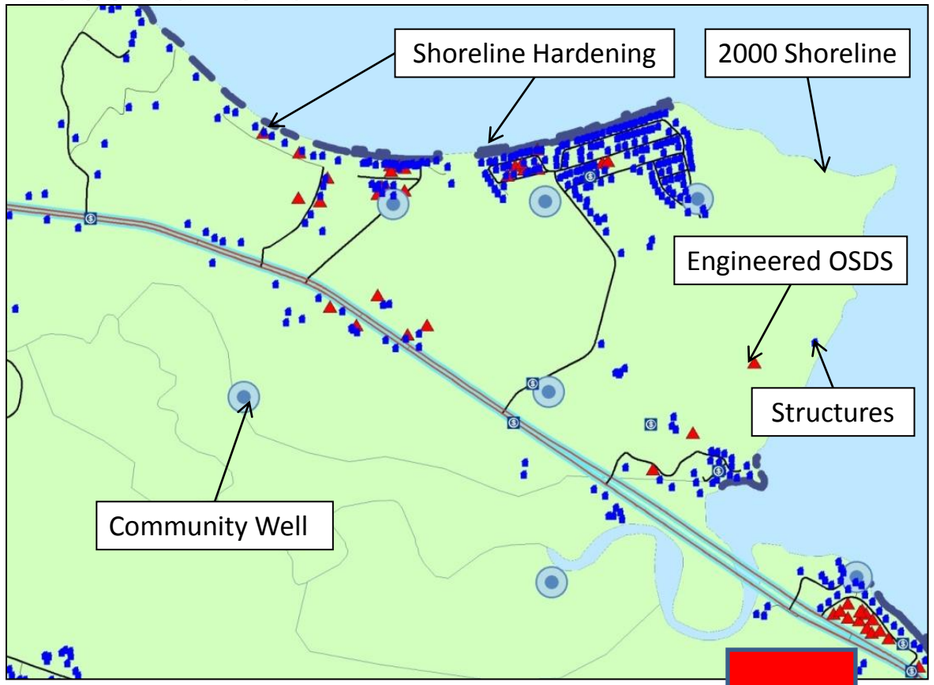
2050 Impact



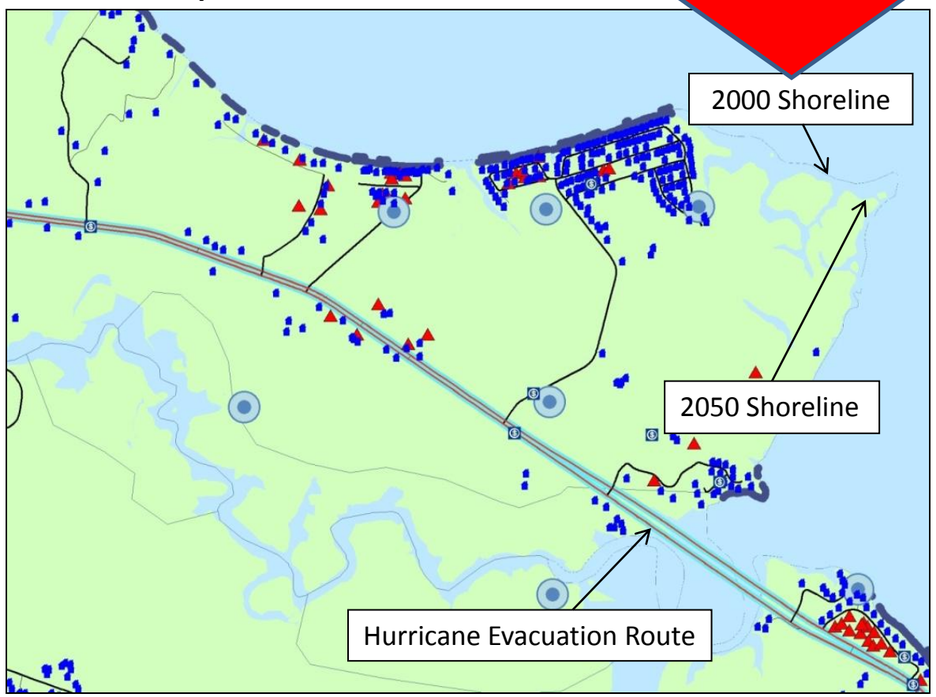
Town of Tappahannock & Piscataway Creek Area

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	7	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$1,381,359
Engineered OSDS	8	$18,000 (MPPDC Regional Estimate)	$144,000
Conventional OSDS	5	$4,000 (MPPDC Regional Estimate)	$20,000
Community Well	1	$40,000 (MPPDC Regional Estimate)	$40,000
Private Wells	2	$3,000 (MPPDC Regional Estimate)	$6,000
Public Water Lines	220 ft	$190/ft (Hampton Roads Sanitation District Estimate)	$41,800
Public Sewer Lines	573.74 ft	$500/ft (Hampton Roads Sanitation District Estimate)	$286,870
Shoreline Hardening	12,341.18 ft	$200/ft (MPPDC Regional Estimate)	$2,468,236
VDOT Road Segments	3,253 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $484,697 Long Term: $2,423,485
TOTAL			**Short term : $4,872,962** **Long term: $6,811,750**

2000 Current



2050 Impact

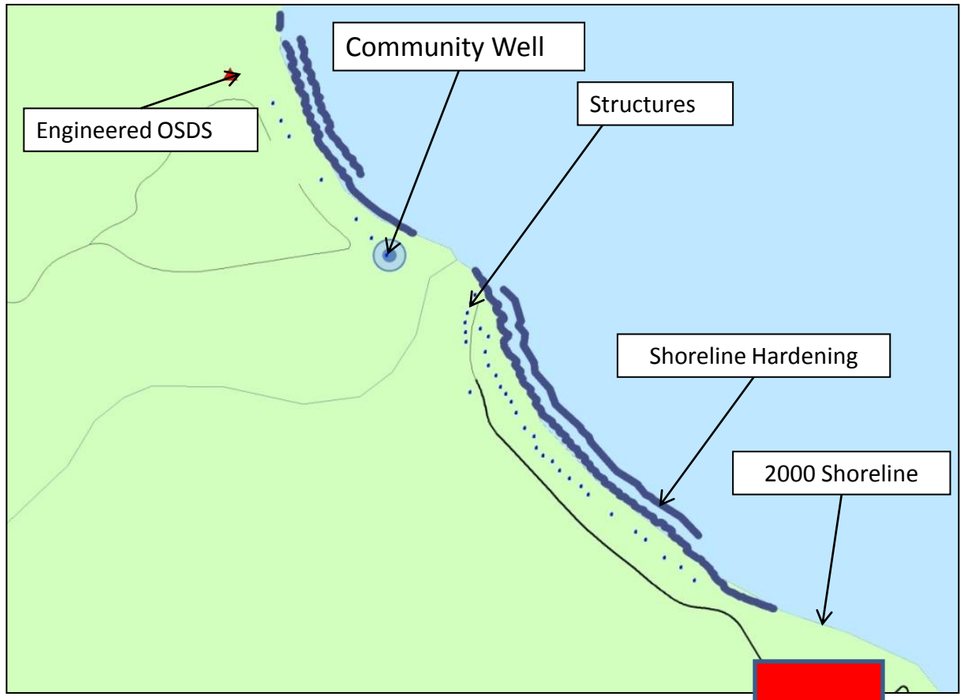


Gwynnfield Subdivision Area: More frequent flooding of Hurricane Evacuation Route 17 will hinder coastal evacuation from Essex, Mathews, and Gloucester Counties

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	1	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$197,337
Conventional OSDS	1	$4,000 (MPPDC Regional Estimate)	$4,000
Shoreline Hardening	3,876.79	$200/foot (MPPDC Regional Estimate)	$775,358
VDOT Road Segments	2,330 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $347,170 Long Term: $1,735,850
TOTAL			**Short term: $1,323,865** **Long term: $2,712,545**

2,160 feet of Route 17 impacted. Route 17 is the designated Hurricane Evacuation Route for parts of the Hampton Road Area.

2000 Current

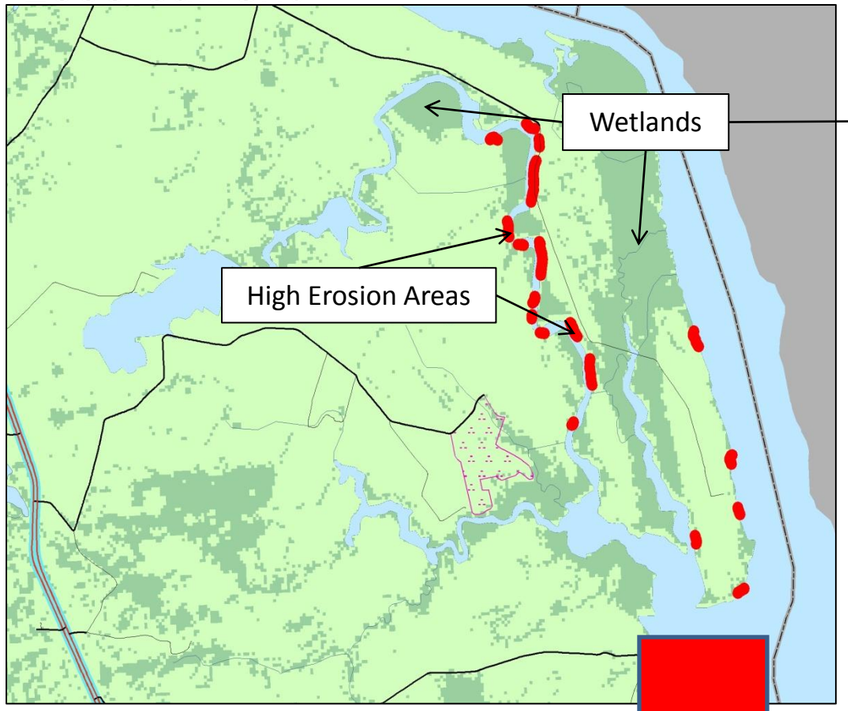


2050 Impact

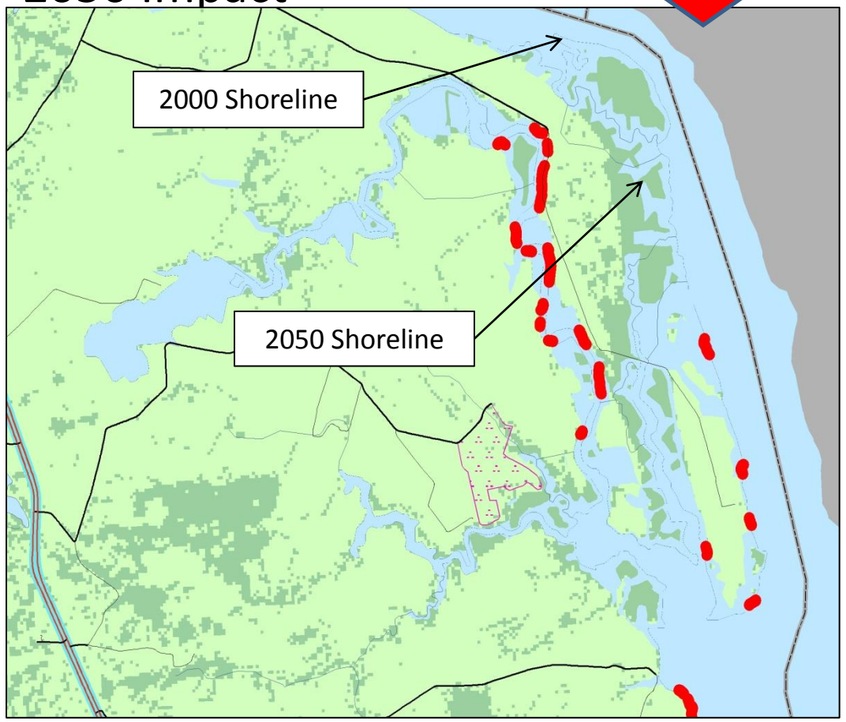
Lower Essex-Cottage Row Road Area: Capital investments to re-locate to the coast may be high but sustaining coastal living may be even higher

Infrastructure	Amount of Flooded Structures	Average Cost	Total Costs
Houses	8	$197,337 Estimated median house or condo value in 2007 (City-Data.com)	$1,578,696
Conventional OSDS	8	$4,000 (MPPDC Regional Estimate)	$32,000
Private Wells	8	$3,000 (MPPDC Regional Estimate)	$24,000
Shoreline Hardening	2,028.54	$200/ft (MPPDC Regional Estimate)	$405,708
VDOT Road Segments	292 ft	Short Term: $149/sq ft Long Term: $745/sq ft Additional right of way acquisition when raised 10 inches (VDOT Estimate)	Short Term: $43,508 Long Term: $217,540
TOTAL			**Short term: $2,083,912** **Long term: $2,257,944**

2000 Current



2050 Impact



Kendall Road Area

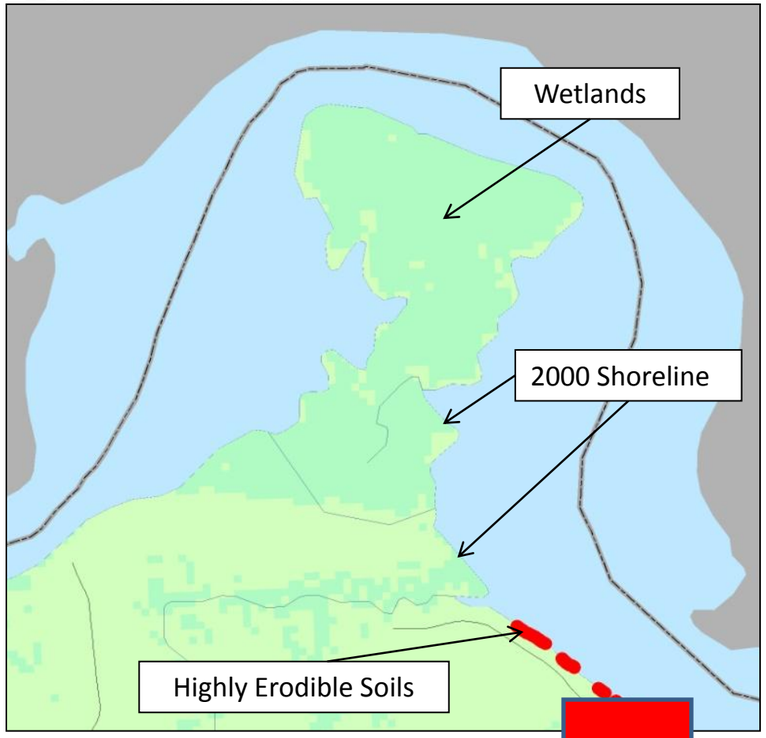
Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors *Fishing and Shellfish Habitat* *Waterfowl Habitat* *Mammal and Reptile*	 $48[a] $253[b] $18[c]	 499.95 499.95 499.95	 $23,997.60 $126,487.35 $8,999.10
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	499.95	$14,420.52 - $4,282,906.67
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	499.95	$4,499.55- $57,494.25
Total value lost or redistributed: $178,404.12– $4,499,884.97			

Qualitative Losses from Wetland Inundation	
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity	-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista

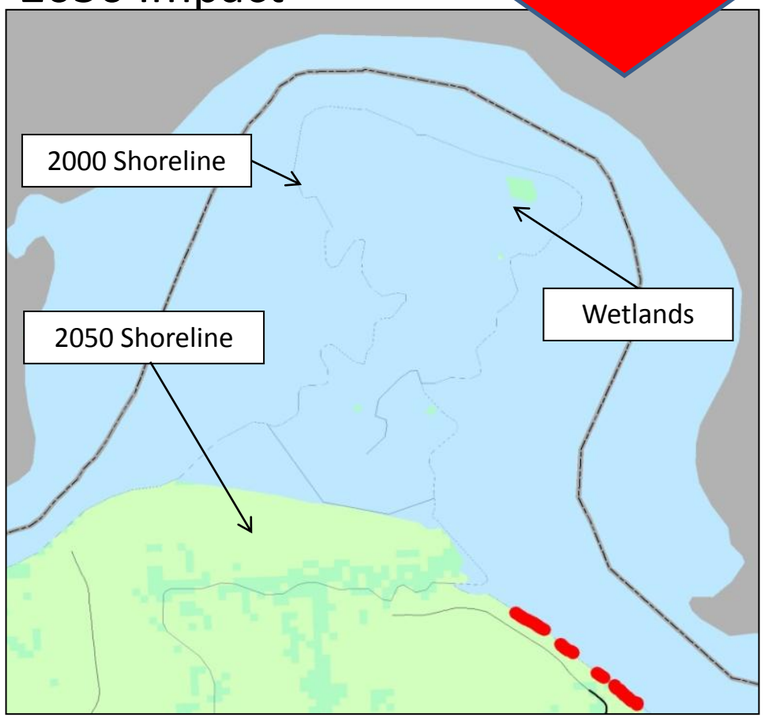
[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989

7,887.73 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

2000 Current



2050 Impact



Layton Peninsula: As an entire ecologic community is altered due to sea level rise, the Rappahannock River may widen and increase coastal erosion to the area

Quantitative Estimates of Lost Wetland Functions			
Wetland Functions	**Value (1996$) ($/acre/year)**	**Estimated loss of wetland acreage**	**Direct/Indirect/Induced Value of wetland Lose ($/year)**
Commercial Factors			
Fishing and Shellfish Habitat	$48[a]	197.80	$9,494.40
Waterfowl Habitat	$253[b]	197.80	$50,043.40
Mammal and Reptile	$18[c]	197.80	$3,560.40
Damage Control Factors *Environmental Projection against erosion, wind, storms and flooding*	$289.67 [d] – $8,566.67[d]	197.80	$57,296.73 - $1,694,487.33
Recreational Opportunities *Consumptive (ie. fishing, timbering, etc) and Non Consumptive (ie. bird watching, sight seeing) uses*	$9[i] - $115[j]	197.80	$1,780.20 - $22,747.00
Total value lost or redistributed: $122,148.13 – $1,780,332.53			
Qualitative Losses from Wetland Inundation			
-flood control and mitigation -fish and waterfowl habitat -nursery area for wildlife -biodiversity		-water quality (ie. assimilation of waste and pollutants) -coastal erosion prevention -aesthetics / River and Bay vista	

[a] Bell, 1989 [b] Guta and Foster, 1975 [c]Farber and Costanza, 1987 [d]Gupta and Foster, 1975 and Thibodeau and Ostro, 1981 [i] Farber and Costanza, 1987 [j]Bell, 1989

866.90 ft of High Erosion Areas will be most vulnerable sea level rise, ultimately altering the geomorphology of the area

Middle Peninsula

Total Economic Impacts of Select Areas:

Summary by County

County	Anthropogenic		Ecological	Total Short term costs	Total Long term costs
	Short term	Long term			
Mathews	$63,984,342.58	$86,717,356.02	$589,732.79 – $8,593,569.70	**$64,574,075.37 – $72,577,912.28**	**$87,307,088.81 – $95,310,925.72**
King and Queen	$10,790,810.41	$11,024,055.01	$1,217,772.89 – $17,745,360.94	**$12,008,583.30 – $28,536,171.35**	**$12,241,827.90 – $28,769,415.95**
Middlesex	$41,541,858.60	$44,671,693.00	$63,990.61 – $932,469.41	**$41,605,849.21 – $42,474,328.01**	**$44,735,683.61 – $45,604,189.41**
King William	$2,746,623.63	$2,811,867.75	$1,372,252.13 – $19,996,428.51	**$4,118,875.76 – $22,743,052.14**	**$4,184,119.88 – $22,808,296.26**
Gloucester	$25,885,992	$28,758,156.00	$695,464.67 – $10,137,634.63	**$26,581,456.67 – $36,023,626.64**	**$26,453,620.67 – $38,895,790.63**
Essex	$8,280,739	$11,782,239.00	$300,552.25 – $6,280,217.50	**$8,581,291.25 – $14,560,956.50**	**$12,082,791.25 – $18,062,456.50**

Total Economic Impact of Select Areas within the Middle Peninsula

Anthropogenic		Ecological
Short term	Long term	
$126,230,366.20	$185,765,366.80	$4,239,764.75 – $63,685,680.69

Total Short term Costs of Selected Areas in the Middle Peninsula	Total Long term Costs of Selected Areas in the Middle Peninsula
$157,470,131.60 – $211,916,046.90	$187,005,132.10 – $249,451,074.50