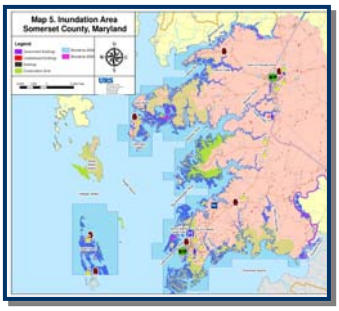
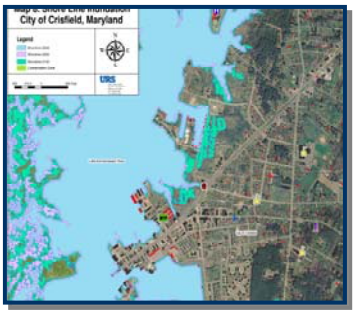
Somerset County, Maryland

Rising Sea Level Guidance

September 24, 2008

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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Somerset County
Sea Level Guidance

September 2008

Prepared By:

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RCQUINN CONSULTING, INC.

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Section 1. Project Objective

Somerset County obtained a grant from the Maryland Department of Natural Resources to assess the County's vulnerability to sea level rise and to review and develop workable revisions to the County's plans, development codes, and regulations to mitigate the identified impacts.

Over the last 50 years, the County has experienced conditions that are now associated with the dynamic nature of coastal regions. Low-lying areas can change in response to dramatic influence of storms. These changes may be subtle in the short-term, but more obvious when a long-term view is taken. These changes may be caused by erosion and, increasingly, small, but significant, increases in the water level in the Chesapeake Bay. Historical maps of Somerset County reveal these trends. Several Bay-front communities once thriving in the early 1900s were abandoned and several of those areas are now under water.

Aerial photographs indicate loss of marsh lands and visual observations from the ground suggest that woodland areas are showing the signs of stress from rising water levels, more frequent storm events, and intolerance to saline conditions. County farmers, with land near shorelines, report loss of farmland from erosion and loss of productivity as salinity increases due to higher water tables and more frequent coastal flood events. The County's Roads Department reports that more frequent road flooding is experienced not only during coastal storms, but during above average high tides. All of these local observations contribute to the growing body of evidence that supports the trend of rising sea levels. This trend is expected to continue in the near future.

The effects anticipated under various sea level rise scenarios include those associated with coastal storm flooding, both intensity and frequency, and those associated with more gradual changes in groundwater levels and drainage. The vulnerability assessment describes some of the associated problems that may occur, with particular emphasis on the effects related to coastal flooding.

The recommendations address suggested modifications to the County's planning and regulatory mechanism, including the Floodplain Management Ordinance/Building Code, Zoning Ordinance, Subdivision Regulations, Comprehensive Plan, and Hazard Mitigation Plan.

1-1. The Maryland Climate Action Plan (2008)

Issuance of the Governor's Executive Order Establishing the Maryland Commission on Climate Change (E.O. 01.01.2007.07) and the recent publication of the *Maryland Climate Action Plan* [1] signal the State's position that there is sufficient evidence of sea level rise with anticipated effects that may result, therefore, feasible adaptive actions should be identified and undertaken. As part of the effort, the Adaptation and Response Work Group looked at options to address impacts to (a) existing built environment

infrastructure, (b) future built environment infrastructure, (c) human health, safety and welfare, (d) public awareness, and (e) resources and resources-based industries.

The *Maryland Climate Action Plan*, released in August 2008 by the Maryland Commission on Climate Change, provides a comprehensive assessment of anticipated effects of climate change. The report also offers numerous options for mitigating the effects and for adapting to the anticipated changes. It is expected that state agencies and others will refine those recommendations in the coming years, perhaps by legislative initiatives, changes in existing programs and regulations, or by development of new programs.

Although the State is taking significant and concrete steps towards recognizing the effects of sea level rise, some may still consider that sea level rise is either too uncertain or will occur so slowly that local governments need not take action now. However, just as local governments manage land use and development to provide for the public's long-term benefit, safety and welfare, so too should local governments consider the possible long-term impacts associated with sea level rise.

Section 2. Recommendations

In the sections below, the following measures are explained in more detail and the documents where changes to incorporate these measures could be made are identified:

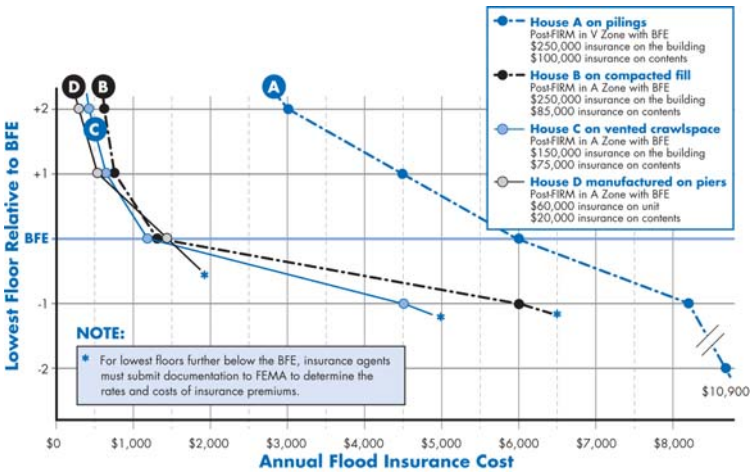
- Require buildings in floodplains to be on higher foundations (freeboard).
- Recognize increased flooding through 2050 by adopting a 'floodplain planning zone'.
- Adopt Coastal A Zone requirements in areas where waves may be 1.5 feet or higher.
- Redelineate the landward boundary of Conservation Zone to coincide with the 2050 inundation area and reduce the allowed density (retain current zoning for existing villages).
- Recognize that wetlands will migrate inland, groundwater levels will rise, and saltwater intrusion will increase.
- Modify on-site septic requirements to anticipate impaired performance as water table levels rise.
- Require stream/tributary buffers or conservation easements.
- Require planning for certain roads to anticipate more frequent flooding.
- Anticipate that some buildings will be relocated, elevated on higher foundations, or abandoned.

2-1. Floodplain Map

- Work with FEMA, MEMA and MDE to develop digital Flood Insurance Rate Maps (Hazard Mitigation Plan, high rated action).
- Adopt an 'adjacent flood zone' (term used in the *Climate Action Plan*) or a 'floodplain planning zone' that adds to the FEMA-delineated Special Flood Hazard Area for those areas anticipated to be inundated based on the 2050 scenario (Maryland *Climate Action Plan*, EBEI-8).
- Based on the current Flood Insurance Rate Map, there are no V Zones (coastal flood hazard areas where waves higher than 3-feet are anticipated). Request that as part of the upcoming map revision, FEMA/MDE determine if there are areas where waves between 3 feet and 1.5 feet are expected and delineate the Limit of Moderate Wave Action as a planning layer (i.e., the inland extent of the 1.5-foot wave, also called the Coastal A Zone).

2-2. Building Code/Floodplain Ordinance

- Coordinate the floodplain management ordinance with the flood requirements of the building code.
- Regulate the 'adjacent flood zone' as SFHA (Maryland *Climate Action Plan*, EBEI-8).
- Require use of perimeter wall foundations and piling/column foundations (avoids drainage problems, facilitates potential future relocation of buildings).
- Require the lowest floor of all new buildings and substantially-improved buildings to be at least 2 feet higher than the currently required Base Flood Elevation (Hazard Mitigation Plan, medium rated actions; Maryland *Climate Action Plan*, EBEI-8). NFIP flood insurance savings will accrue (see figure).



- If areas with waves 1.5 feet and higher (Coastal A Zone) are delineated, apply V Zone requirements (Maryland *Climate Action Plan*, EBEI-8).
- Require new and replacement manufactured homes to be installed on foundations in accordance with the Residential Code; specifically according to the requirements in Sec. 324 of the Residential Code for flood hazard areas (Hazard Mitigation Plan, medium rated action).

- Develop procedures and forms to facilitate making substantial damage determinations (of the 2,647 buildings flooded in Hurricane Isabel, approximately 300 buildings sustained "major damage").

2-3. Water & Sewer

- For undeveloped lots within the predicted 2050 inundation area (even those in *Management Area A* north and east of Princess Anne), that meet current 'adequate treatment zone' (2 to 4 feet depth to aquifer) and normal septic field testing, require site plans to designate future location for retrofit system (mound or holding tank). See Comprehensive Plan, Sec. 5.4.
- Require holding tanks to be designed for buoyancy conditions based on 2050 inundation depths.
- Require, on lots where existing septic systems are failing, installation of mound systems or tanks (Comprehensive Plan identifies eight locations with failure rates between 7% and 50%).
- Within the predicted 2050 inundation area, require proposed central package treatment systems to be designed and installed to recognize anticipated flooding and groundwater conditions.

2-4. Comprehensive Plan (2002)

- Incorporate recognition of existing flood hazard areas and anticipated 2050 inundation areas ('floodplain planning zone') throughout the Comprehensive Plan.
- Recognize that existing development will be at-risk of more severe and frequent flood damage than anticipated based on the FEMA flood maps.
- Recognize that existing septic systems will fail as groundwater levels rise.
- Recognize that private water wells will increasingly be impacted by saltwater intrusion.
- Recognize that limits should be placed on extending County sewer service to highly vulnerable areas (e.g., to structures in the erosion setback zone).
- Recognize that some existing roads will flood more frequently.
- Develop policy to encourage physical relocation of sound buildings and for handling abandoned private buildings and lands (Maryland *Climate Action Plan*, EBEI-8).
- Request State participation in evaluating long-term options for Smith Island, given its current vulnerability to flooding, high groundwater levels, saltwater intrusion, and the anticipated loss of land due to erosion and sea level rise that will exacerbate these limiting conditions.

2-5. Zoning Ordinance (1999, with amendments)

- Redelineate the Conservation Zone to capture those parts of the 2050 inundation area that are not currently within the Conservation Zone (Maryland *Climate Action Plan*, FBEI-1).
- Change the allowable density in the Conservation Zone to fewer units (currently 1 dwelling unit per 5 acres).
- Delineate a new 'floodplain planning zone' based on anticipated inundation through 2050.
- Create a stream buffer/conservation easement.

2-6. Subdivision Ordinance (2005)

- Modify Sec. III.B.2(c) to suggest that preapplication sketch plans include the 'floodplain planning zone', (if adopted).
- Modify Sec. III.C.2(c)(11) to require that preliminary plats delineate the 'floodplain planning zone' (if adopted).
- Modify Sec. III.B.2(c) to suggest that preapplication sketch plans show – if the subdivision is in the SFHA or 'floodplain planning zone' and if onsite septic is proposed – the location of the septic field on each lot and the additional area reserved for mound system/tank.
- Modify Sec. III.C.2(c) to require that preliminary plats show – if the subdivision is in the SFHA or 'floodplain planning zone' and if onsite septic is proposed – the location of the septic field on each lot and the additional area reserved for mound system/tank.
- Consider modifying Sec. III.D to require that final plats show the SFHA and, if adopted, the 'floodplain planning zone', to provide notice to future owners.

2-7. Construction Standards Manual for Roads, Streets and Incidental Structures (2005)

- Based on the typical problems experienced by roads in low-lying areas that are frequently inundated, identify requirements for elevated roads or for low-water crossings (i.e., design them to be low to avoid blocking drainage, but require owners to acknowledge access limitations).
- For elevated roads:
    - If the intent is to improve bedding as groundwater levels rise, removal of more unsuitable material to bear the placement of thicker fill materials may be required. "Subgrade Preparation" already indicates the County's determination will be based on results of test borings and a minimum of 12" is expected. Flexibility already exists, thus no

change is required. If the desire is to be more explicit, then there is a need to determine either where this requirement would apply (e.g., all roads that are below a certain elevation) or develop site characteristics that will be used by the County to determine where elevated road beds will be required.

- Require more underdrains/crossdrains to allow for drainage.

2-8. Comprehensive Water and Sewerage Plan

- Examine the Plan for revisions to address anticipated impacts (Maryland *Climate Action Plan*, EBEI-8).
- High water table is recognized as a 'severe restraint on development' (Comprehensive Plan, Chapter 11).
- Work with property owners to determine the feasibility of replacing traditional septic systems with mound systems or holding tanks.

2-9. Capital Plan (not provided for review)

- Identify roads that flood frequently (three most likely to be affected are Rt. 362 to Mount Vernon, Rt. 363 to Chance and Deal Island, and Rt. 361 to Frenchtown-Rumbly). Depending on travel demand, consider raising surfaces or acknowledge that frequent overtopping will occur and replace with low-water crossings.
- Undertake structural evaluation of existing County-owned buildings and facilities (including central water supply facilities and central sewerage facilities and plants operated by the Board of Education) in the SFHA to determine vulnerability to flooding, including the elevation of the lowest floor relative to the current and predicted flood elevation and whether inundation would likely cause structural damage (engineered buildings may get wet, but that does not necessarily render them inoperable) and whether low-cost measures can be implemented to reduce damage (e.g., relocate emergency generators, protect emergency fuel supplies, move highly vulnerable uses/contents, etc.). Certain cost-effective measures may be eligible for federal grant funding. [Mitigation Plan, Goal 5, Objective 5.5 and high rated action]
- Identify areas where tidal flooding surcharges storm drainage and install backflow/flex valves.

2-10. Public Communication and Outreach

- Develop handout to inform citizens about flood insurance and permit requirements for existing buildings (Hazard Mitigation Plan, medium/high rated action; see example from Kent County, DE).

- As part of pursuing changes in ordinances, schedule workshops to explain the short-term and long-term benefits of the changes. Use these workshops to provide information about current flood hazards and ways property owners can reduce vulnerability [the *Climate Action Plan* recommends notifying all affected property owners directly (but does not recognize costs associated with implementation).]
- Evaluate recommendations to determine eligibility for credits under the NFIP's Community Rating System, a program that provides discounts on federal flood insurance premiums as a function of how a community exceeds the minimum requirements. The Hazard Mitigation Plan identifies working with MDE to become eligible for the CRS as a medium rated action. Many of the recommendations would qualify for CRS credits (an estimate of credits and likely discount amount has not been made).

2-11. Hazard Mitigation Plan (June 2005)

The plan characterizes coastal flooding and riverine flooding, but does not clearly address potential losses due to erosion. Relocating buildings subject to imminent collapse due to erosion is an eligible activity under some of FEMA's mitigation grant programs. The plan should be revised to include erosion hazard and identification of risk if the County may decide to pursue funding for relocation.

The plan identifies only one "repetitive loss" property in Somerset County (and two in Crisfield). After flooding events, the County should request a list from FEMA of NFIP-insured buildings that have received multiple claim payments. FEMA administers several programs to fund mitigation grants for projects that reduce future flood damage (although the benefit-cost analyses are based on existing floodplain mapping). The most likely programs are those that focus on what are called "repetitive loss" properties (after declared disasters, other funds become available). See Hazard Mitigation Plan, Goal 5, Objective 5.4. For those properties, the County could investigate working with owners to obtain funding for (Hazard Mitigation Plan, medium rated action):

- Elevation-in-place (owners provide non-federal cost-share).
- Relocating buildings to sites outside of the SFHA and/or away from areas subject to imminent collapse due to erosion (owners provide non-federal cost-share).
- Dry floodproofing (nonresidential only (including public buildings), and only in FEMA-designated A/AE Zones).
- Acquisition (e.g., if adjacent to County-owned facilities where the addition of land is desirable; County provides non-federal cost share).

2-12. Emergency Operations Plan

- Verify that manufactured home parks and subdivisions have evacuation plans filed with Emergency Management (see Floodplain Management Ordinance, Sect. 5.4(c)).

Section 3 Somerset County's Existing Flood Hazards

In 2005, the Maryland Department of the Environment and the Eastern Shore Regional GIS Cooperative issued *An Assessment of Maryland's Vulnerability to Flooding* [2]. Using the current effective Flood Insurance Rate Maps prepared by FEMA, the report notes that approximately 58% of Somerset County's total land area of 329 square miles falls within a FEMA-designated flood zone. FEMA uses 1-percent-annual chance flood (also called the "100-year flood") to delineate Special Flood Hazard Areas (also called "100-year floodplains"). Figure 1 shows the extent of the FEMA floodplain, shaded to indicate flood depths which are deepest near the shoreline.

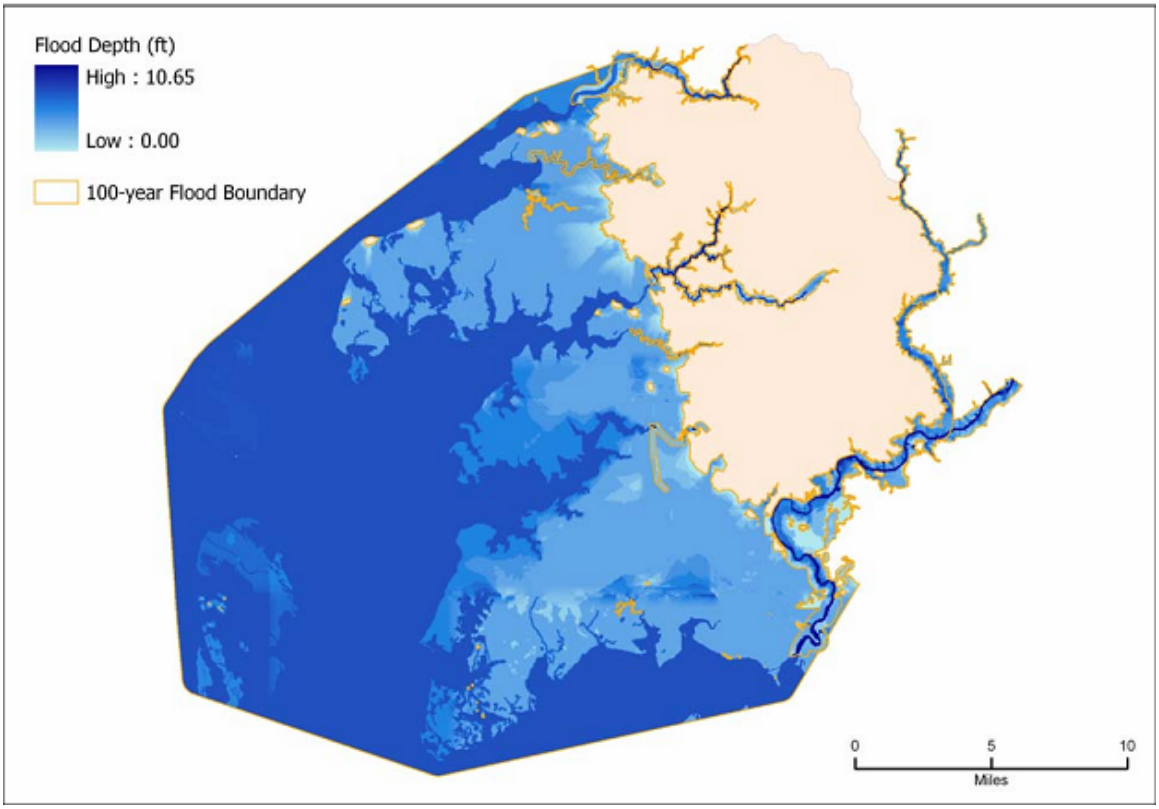


Figure 1. Special flood hazard area (based on FEMA maps) [2]

The MDE report includes data estimating the number of structures at risk of flooding for every Maryland County. In Somerset County:

- 4,440 structures are located in the floodplain (44% of all structures in the County)
- An estimated 10,523 people live in the 4,440 structures (2.37 people/household)
- Total value of those structures is $243 million (for average of $54,700 per structure)
- Only 1,488 flood insurance policies were in force (only 33.5% of the structures).

As of June 30, 2008, 1,367 NFIP flood insurance policies were in effect in Somerset County.

Table 1 lists the current FIRM panels and their respective effective dates. FEMA and the Maryland Department of the Environment are converting these maps to digital format and updating the delineations along nontidal waterways. These new maps are expected to be released in 2009. Revised FIRMs, based on a new analysis of Chesapeake Bay flooding and delineated on new topography, are anticipated within the next few years. The County will be required to adopt the new maps in order to continue to participate in the National Flood Insurance Program (NFIP).

Table 1. Current Effective FIRMs

FIRM PANEL #	Effective Date
2400610025A	06/15/1981
2400610050A	06/15/1981
2400610100A	06/15/1981
2400610125D	06/16/1995
2400610150B	06/16/1992
2400610175A	06/15/1981
2400610200A	06/15/1981
2400610225B	06/16/1992
2400610250B	06/16/1992
2400610275B	06/16/1992
2400610300A	06/15/1981
2400610325A	06/15/1981
2400610350B	06/16/1992
2400610375B	06/16/1992
2400610400B	06/16/1992
2400610425C	07/20/1998
2400610450A	06/15/1981

3-1. Managing Floodplain Development

Somerset County manages development in the FEMA-mapped Special Flood Hazard Areas by administration of the Somerset County Floodplain Management Ordinance of 1993 (Ordinance No. 556). The County was initially identified by FEMA has having special flood hazard areas in 1975 and the first FIRM was published in 1981. The County has recognized flood hazards in its development decisions for more than 30 years.

The County also issues building permits pursuant to the Maryland Building Performance Standards, which includes provisions that FEMA has determined are consistent with the NFIP's flood-damage resistant requirements. The Maryland Department of the Environment has determined that the ordinance conforms to the requirements of the National Flood Insurance Program.

Of particular interest for this report is the current requirement that new buildings and substantially improved buildings[1] have their lowest floors (as defined in the ordinance and the building code) elevated to or above the Base Flood Elevation. This satisfies the minimum requirement in floodplains subject to tidal flooding[2]. However, this minimum requirement does not take into account anticipated increases in the expected flood levels. If expected those increases are used to delineate the area that will be subject to flooding, the total land area known as the "floodplain" will increase.

The Maryland Department of the Environment regulates activities proposed to take place in the nontidal Waters of the State, including the 100-year floodplain of those waters. The State's requirements are in addition to those administered by the County. The State requires that new buildings and substantially improved buildings have their lowest floors elevated to one-foot above the water surface elevation of the 100-year flood, where that elevation is to be determined based on hydrology that assumes contributing watersheds are built-out according to existing zoning. The State uses the FEMA maps as a minimum.

3-2. Existing Flood Hazards (Hurricane Evacuation Maps)

The flood maps used to administer the local floodplain management ordinance and the building codes are based on the 1-percent-annual chance flood (SFHA). SFHAs are not depictions of flooding that may result from a specific category of hurricane. There is no direct relationship between hurricane category and the frequency of resultant flooding. It is only after a storm has occurred that its effects can be compared to the statistically defined flood that is called the "100-year" flood.

[1] Substantially improved buildings are existing buildings that are proposed to be improved (or repaired) for which the cost of the improvement (or cost to repair the building to its pre-damage condition) equals or exceeds 50% of the market value of the building before the work is undertaken.

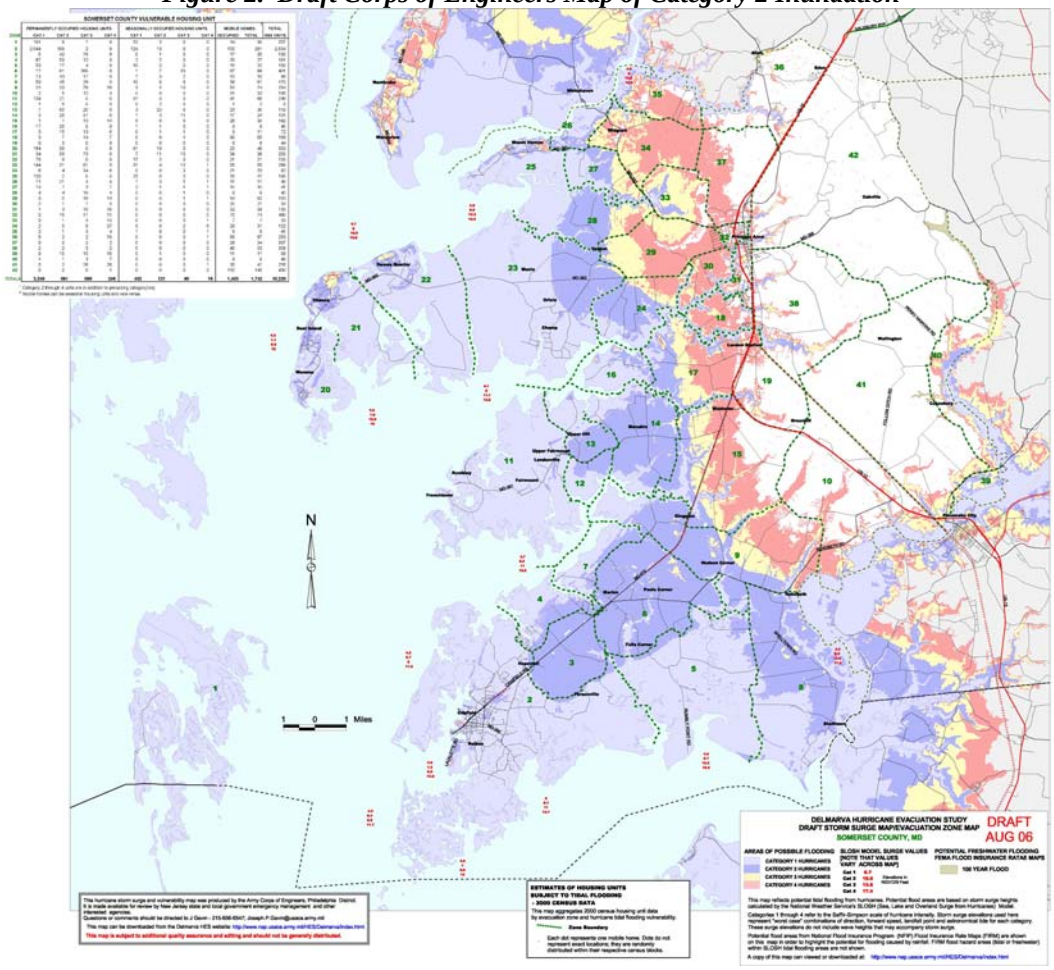
[2] Nontidal waterways are subject to both County and State requirements; the State requires that lowest floors be at least one-foot above the 100-year flood elevation.

The Philadelphia District of the U.S. Army Corps of Engineers is preparing a revised hurricane evacuation study for the Chesapeake Bay (mid-2008). It will illustrate areas of possible inundation for suites of Category 1, 2, 3 and 4 hurricanes. Figure 2 illustrates the area that is expected to be inundated by Category 2 hurricanes (for any given storm, the actual area inundated will vary based on the specific point of land fall, forward speed, and several other variables).

The storm surge analyses indicate that surge elevations for a Category 2 storm surge will range up to 10 feet above the NGVD29 datum. These elevations do not include wave heights (which are approximately 50% of the water depth, see Study Methodology). With wave heights added, the effects of storm surge could rise to 14-15 feet.

The simply addition of one-foot of sea level rise indicates that Category 2 storm surge elevations will rise to at least 11 feet. Thus, with added wave heights, the effects of storm surge can reasonably be anticipated to rise to 1-1.5 feet. Note that the Corps' analysis does not include anticipated sea level rise.

Figure 2. Draft Corps of Engineers Map of Category 2 Inundation



3-3. Other Existing Conditions

The Somerset County Health Department estimates that there are 5,072 homes with individual septic systems (approximately 47% of all homes). Nearly 1.5 percent of these property owners apply for replacement systems annually. This number has increased in recent years. As shoreline erosion increases, and as the Bay's water level rises causing above average high tides, it is reasonable to consider that these conditions contribute to the increasing number of septic system failures.

Groundwater is the sole source for drinking water. The County utilizes two principal aquifers for most of its water needs. The Manokin Aquifer is the primary source, especially for private wells. The Patapsco Aquifer is a deeper and older source which is known to meet all primary drinking water standards. The Patapsco is used by most public water systems in the County, with the exception of Princess Anne's system. Currently, the Manokin is beginning to show signs of stress as some wells have been experiencing withdrawal limitations or failure. To date, these deep confined aquifers have not exhibited signs of salt water intrusion, however, as sea levels rise, advancing salt water intrusion may affect shallower wells. [8]

Section 4. Vulnerability Study

The purpose of a vulnerability study is to estimate the people and property that are at risk of impacts from a hazard. The reasonableness of the results depends on:

- How well the hazards can be defined or delineated,
- How much detail is available to describe the types and numbers of existing development (residences, commercial properties, and transportation and other public infrastructure) that is exposed to the hazards,
- How much detail is available to project the anticipated types and numbers of new buildings and other development that are likely to be constructed over the period of interest.

The reasonably anticipated effects attributed to rising sea level are of two types: those related coastal storm flooding and those that will alter aspects of the environment and normal hydrology:

- Flood depths will increase and affect a larger area (and flooding may occur more frequently)
- Effects of waves on top of storm surge inundation will extend farther inland
- Shoreline erosion will accelerate
- Groundwater levels will increase
- Wetlands will migrate inland

- Saltwater intrusion will extend farther inland

Ideally, in order to estimate the impact of those future conditions on existing development (and anticipated development), those conditions would be delineated or described with sufficient detail and justification. Some of the sea level rise effects can be estimated and shown on a map (notably flooding and erosion), while there are limitations that do not allow that level of detail to be developed for other effects:

- Flood depths and areas effected. Using several assumptions, new flood elevations can be estimated and projected inland boundaries of the "future" condition floodplain can be delineated on topographic mapping.
- Effects of waves. In theory, because wave heights are largely a function of stillwater depth and exposure to winds, the areas where waves may increase flooding could be approximated. This could be done by re-running FEMA's computer models or by examining the predicted depth of water compared to ground elevation and delineating those areas where the depth of water is sufficient to support waves of a specific height.
- Shoreline erosion. Based on the State's long-term data, the areas predicted to experience shoreline erosion over a period of time can be delineated.
- Groundwater/water table levels. The actual effects related to sea level rise are functions of soil types and other factors. If seasonal depths to groundwater were known at enough locations, and if an assumption is made that a 1-foot sea level rise will cause a commensurate rise in groundwater, then a rough estimation of where groundwater will be close enough to the surface to be a limiting factor could be made.
- Wetlands migration. The actual effects of sea level rise on the type and location of wetlands are functions of soil types, past land usage, and daily hydrology (drainage). A reasonable assumption might be that for every foot of sea level rise, the wetlands will migrate inland to encompass adjacent lands that are within one-foot elevation of the current wetland boundaries.
- Saltwater intrusion. The actual effects of sea level rise on saltwater intrusion are functions of soil types and other factors, including water extraction. Even with several assumptions, it would be very difficult to estimate the likely effects.

The next question is whether there is sufficient data to identify the people and property that fall within the areas identified to experience the effects attributed to sea level rise. Ideally, data would be available for all buildings (type, size, date, elevation of lowest floor, etc.), as well as zoning designations for all vacant parcels in order to estimate future development. This level of detail is not available for Somerset County.

To the extent feasible given the limitations of the available data, this study examines Somerset County's vulnerability to the impacts of rising sea level reflected by commensurate increases in the mean water level in the Chesapeake Bay. Because of the

limitations outlined above, the only hazard area that can be reasonably delineated is the anticipated storm inundation area. While the scenarios considered potential sea level rises for the years 2025, 2050, and 2100, for consideration of recommended actions, the County has selected to focus on the sea level rise scenario anticipated by the year 2050.

4-1. Study Methodology

The historical rate of sea level rise is predicted to be approximately 3.1 mm/year or approximately 1/8 in/year. [3] Table 2 indicates the cumulative erosion and sea level rise anticipated by the years 2025, 2050, and 2100.

In addition to higher floodwater levels, the impacts of sea level rise will be exacerbated by shoreline erosion. The annual rate of erosion along the Maryland shoreline is approximately 1 foot per year. [4] This rate of erosion is considered 'slight' and 59% of the County's 1,106 miles of shoreline is eroding at this rate. The remainder of the shoreline is eroding at rates greater than 1 foot/year; a small segment of the shore is eroding as rapidly as 8 feet/year, particularly in the Chance and St. Stephen's area of the County.

Table 2. Sea Level Rise and Erosion: Three Scenario Periods

		Scenario Periods		
	Annual Rate	2025	2050	2100
Sea Level Rise	3.1 mm / ~1/8"	53 mm / 2 in	130 mm / 6 in	285 mm / 12 in
Erosion	1 ft	17 ft	42 ft	92 ft

Maps that show the predicted shoreline changes for the three scenario periods were developed using digital elevation models and comparing the predicted water surface elevations with ground elevations to illustrate likely anticipated expansion of the floodplain.

Coastal storms generally have high winds that generate waves on top of storm surge flooding. The height of waves depends on several variables, such as wind direction, storm duration, and depth of water. As flood depths increase as a result of sea level rise, waves will also increase in height (the rule of thumb is that wave heights are 40-50% of the stillwater depth). Thus, while predicted inundation areas can be estimated by assuming certain rises in sea level, the areas where waves of 18" or more will occur can be identified only with more specific analyses than used for this report.

Sea level rise and the resulting increases in storm surge flooding can reasonably be assumed to impact housing, infrastructure, and critical facilities:

- Housing damaged by more severe flooding means citizens repair or rebuild; if this rebuilding occurs outside the County, there is a loss of tax revenue and income for the County.

- Rising water causes a loss of wetlands and fishing habitats in addition to affecting the location of marinas and shipping channels; this affects the County's economy.
- Rising water overflows roads, increases the moisture in the ground making it more difficult to install septic systems, reduces the natural ability for the land to drain with drainage channels filling with water, buried utilities become more difficult to install or keep in the ground because of buoyancy on tanks and maintenance problems with utilities laying in water or in very high water tables.
- Rising water across roads and bridges cuts off access to parts of the County making living, working or servicing some areas of the County more difficult.
- Critical facilities such as hospitals, police or fire stations, and schools and shelters may be inundated with rising water or may have services affected by water overflowing access roads and bridges. This reduces overall services to County citizens which in turn could affect the County's economy.

4-2. Study Results

The results consider how sea level rise might affect the County's population and housing, infrastructure, and critical facilities. A complete evaluation of how all of these potential impacts might affect the economy is not included.

Figure 3 illustrates the anticipated additional six square miles of land area that is projected to be subject to flooding by 2050. For simplicity, area is delineated assuming a 1-foot increase in the Base Flood Elevation to account for the compounding effects of shoreline erosion and increased wave heights, both of which will influence the actual water surface elevation in the year 2050. Figures 4 and 5 illustrate the current shoreline and the projected shoreline in 2050, respectively. Note that at the scale shown, the shoreline (delineated in darker blue) appears as solid areas because of the crenulated nature of the shoreline.

Figure 3. Projected inundation area and shoreline for 2050.

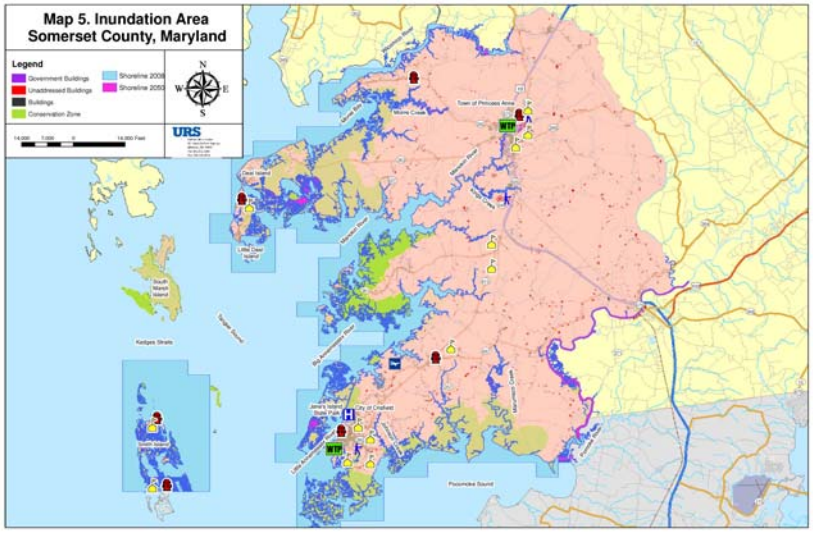


Figure 4. Current Shoreline 2008.

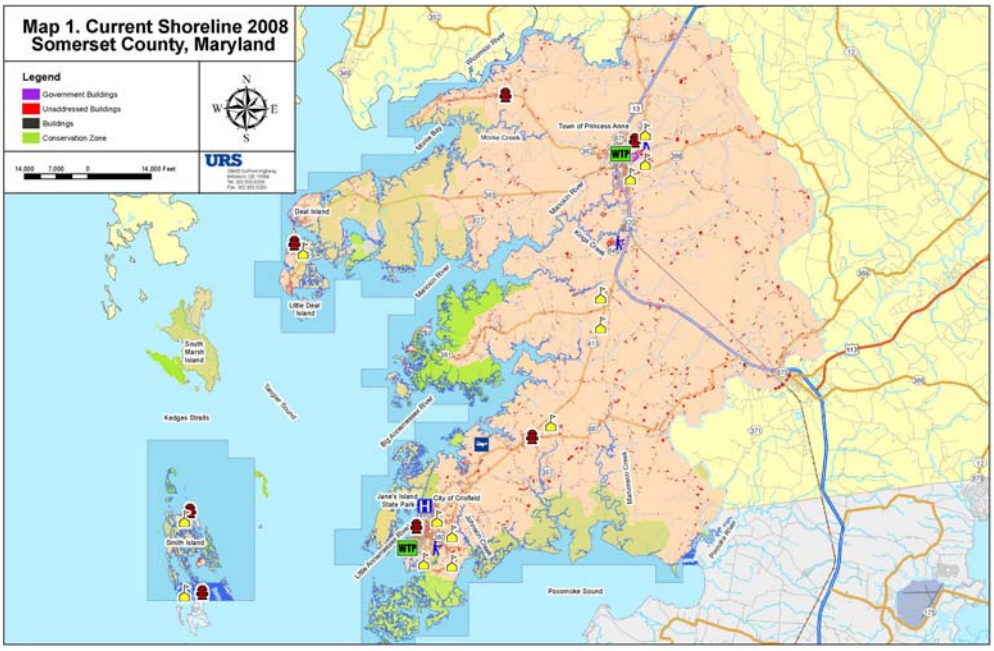
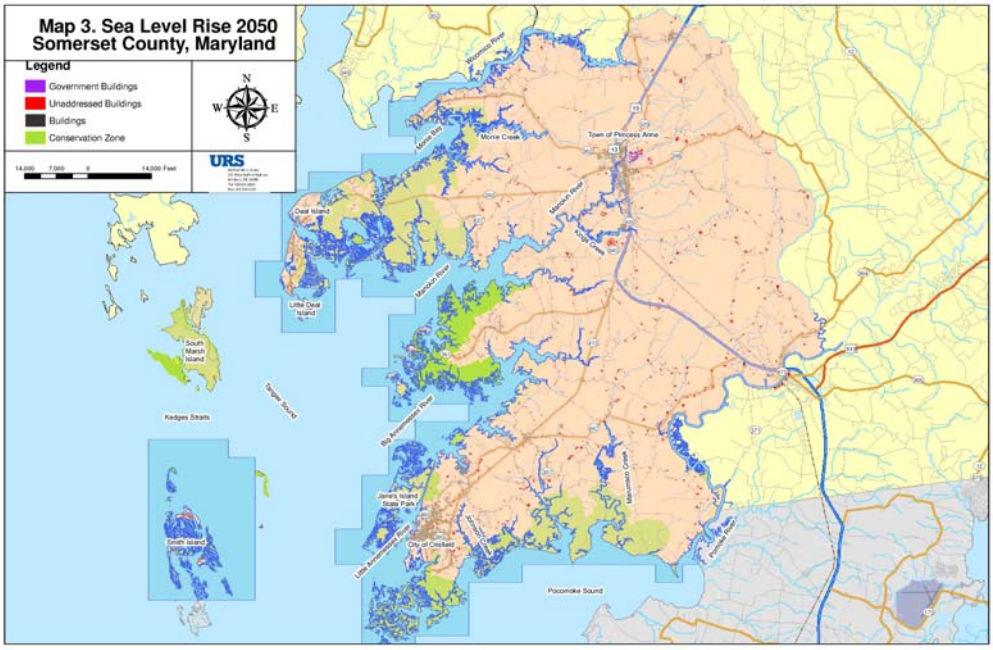


Figure 5. Map of 2050 shoreline.



Sometime during the 92 years between the present and 2100, Dames Quarters, Janes Island State Park, and Smith Island are predicted to be almost completely under water as the Bay's average level goes up nearly one-foot. The Frenchtown-Rumbly and Crisfield areas will see a significant amount of land covered by a one-foot rise, but most of those areas will be remain above sea level. Figure 6 illustrates how low the land on Deal Island is in 2008. The approximate height of flooding 2100 (water depth plus waves) is shown for reference.

Figure 6. Deal Island (red line illustrates approximate height of predicted top of wave from Category 2 hurricane in 2100)

4-3. Housing and Population

In 2000, Somerset County's population was 24,747 and, according to the Maryland Department of Business and Economic Development, it is expected to grow to 28,100 in 2015. Because most jobs are being created in the northern part of the County, the expectation is that most of that population increase will occur in that area, rather than near the shoreline. Approximately 1/3 of the County's population lives in the Crisfield area which is almost entirely in the flood plain. [5]

The estimated number of housing units in 2000 was 10,092, for an average of 2.45 people/housing unit. Approximately 67% of the housing was built prior to 1979, which is

considered, for this study, the approximate date when the County adopted floodplain maps and began administering the floodplain ordinance.

The MDE report noted 4,440 buildings in the SFHA, of which it is reasonable to assume that at least 67% (2,974) were built prior to 1979. The percentage is likely higher because so much early development occurred near the water.

In order to develop an estimate of economic vulnerability to the housing stock in the year 2050, with no increases in building inventory or property values being considered, the following methodology was used:

1. Assume all buildings in the plain are in FEMA-designated A zones, which means the effects of damaging waves are not considered (an assumption that underestimates the likely damage).
2. The Base Flood Elevations throughout the floodplain are 6-feet NGVD (water this deep can support waves that approach 3-feet in height, thus the assumption of no waves will considerably underestimate potential damage). Taking waves into consideration, flood depths in Somerset will range from about nearly 9-feet deep to less than a foot at the inland boundary of the floodplain. Assume that the average depth of water plus waves above grade will be 4-feet.
3. The NFIP's flood insurance claim history provides depth/damage curves to estimate losses based on water depths and whether homes are one- or two-story (see Table 3). For one-story homes, the percent damage estimate for 4-feet of water is 29% for structural damage and 44% for contents damage. The percent damage estimate for 1-foot of water is 14% for structural damage and 21% for contents damage. [6]
4. Based on the MDE evaluation, in 2005 there were 4,440 structures in the floodplain with an aggregate value of $243 million (average value of $54,700). Approximately XX new homes have been built in the floodplain between 2005 and mid-2008. Considering the potential impact of a single flood of a magnitude that inundates the projected floodplain, and using the assumptions that all 4,400 structures are one-story homes, that 67% (2,974) were built prior to 1979, and the remainder (1,426) were built elevated to comply with floodplain requirements and would be exposed to 1-foot of flooding caused by projected increase in BFE, then:
    a. If 2,974 homes with an aggregate value of $163 million are flooded by an average depth of 4-feet, the projected cost of structural damage is $47 million ($163 million x 29%). The estimated contents damage for these homes is $72 million ($163 million x 44%).
    b. If 1,426 homes with an aggregate value of $80 million are flooded by an average depth of 1-foot (associated with sea level rise), the projected costs of structural damage is $11 million ($80 million x 14%). The estimated contents damage for these homes is $17 million ($163 million x 21%).

5. The total estimated economic impact of only physical damage (structure and contents) associated with a single event is $147 million. Between 2005 and 2050, it is probable that multiple flood events of varying magnitudes will occur.
6. Potential economic losses developed by the Maryland Emergency Management Agency using FEMA's loss estimation model HAZUS, were determined to be $132 million for buildings and contents (good agreement with the above estimate). [2]

Table 3. The NFIP's A Zone Depth-Damage Functions [6]

TABLE 22: A Zone Depth-Damage Functions Used in this Study

Flood Depth (ft)*	One-Story, No Basement		Two-Story, No Basement	
	Building Damage (%)	Contents Damage (%)	Building Damage (%)	Contents Damage (%)
< -2	0	0	0	0
-2	0	0	0	0
-1	0	0	0	0
0	9	14	5	8
1	14	21	9	14
2	22	33	13	20
3	27	41	18	27
4	29	44	20	30
5	30	45	22	33
6	40	60	24	36
7	43	65	26	39
8	44	66	29	44
> 8	45	68	33	50

* Depth is measured from the top (walking surface) of the lowest floor.

4-4. Infrastructure

In low-lying areas, flooding can damage roads, bridges, railroad beds, septic systems, water distribution systems, and electric, telephone and cable distribution systems. The most likely flood scenario in Somerset County is a hurricane that combines storm surge and high winds. High velocity waters, repetitive impacts by waves, and high winds contribute to erosion and scour.

Water velocity, erosion, and saturation can weaken road beds and paved surfaces. There are many roads in low-lying areas, most with assumed low traffic counts. The most significant roads that already experience some problems with flooding and that are most likely to be severely affected by the year 2100 are:

- Rt. 362 leading to Mount Vernon

- Rt. 363 leading to Chance and Deal's Island, and
- Rt. 361 leading to Frenchtown-Rumbly

This study did not examine the vulnerability of bridges to exposure of more frequent flooding and higher waves, since vulnerability of such structures is dependent on the nature of substrate, scour at piers, the elevation of the bridge surface, and the type of bridge construction. Bridge structures themselves might not be vulnerable, but the approaches could be inundated more frequently or experience more damage.

The scenarios of sea level rise indicate that inundation will adversely impact private septic fields as groundwater levels rise. Areas that already have limitations due to poor drainage will be further constrained, and it is anticipated that use of on-site septic will be constrained in larger areas. Flooding of septic fields may contribute to water contamination. Septic fields may be damaged by flooding, although typically are able to perform after groundwater levels recede. If repairs are required after flooding, the time required to re-occupy may be lengthened.

The area around Crisfield is serviced by either a County sewage system or the City of Crisfield public system. Sea level rise may affect public sewage systems in several ways. Saltwater intrusion may extend farther inland, which could affect the durability of underground components. Higher groundwater levels may make it more difficult to maintain stable underground components. If flooding shifts buildings to the point that sewer pipes are dislodged, contamination may result. Perhaps the most significant impact will be if existing treatment facilities are impacted by more severe flooding, as well as more frequent flooding. However, in general, the anticipated increase in flood levels associated with sea level rise is less concerning than the effects on normal groundwater levels and saltwater intrusion.

The water distribution system may not be seriously affected by sea level rise unless there is saltwater intrusion into the distribution network or if saltwater intrusion affects the durability of underground components. Water leads into buildings could break if flooding shifts buildings off of foundations. As with septic and sewage systems, in general, the anticipated increase in flood levels associated with sea level rise is less concerning than the effects on normal groundwater levels and saltwater intrusion.

The electric, telephone and cable distribution systems should not be seriously affected by sea level rise alone. Wind speeds as low as 70 to 80 mph can bring down overhead lines and transformers. While this part of the infrastructure is still vulnerable, the most likely damage mode is from wind, not water. Flooding associated with coastal storm systems tends to be of relatively short duration (12-24 hours). Problems associated with saturated soils and loss of support of power and telephone poles or transformer supports are unlikely. The primary sandy soil in the lower end of the County should help reduce losses to the electric distribution system as high groundwater will fall rapidly when flooding recedes.

4-5. Critical Infrastructure/Facilities

The Somerset County *Multi-Hazard Mitigation Plan* [9] includes information about critical facilities and public facilities throughout the County. Using available location data, Table 4 lists those facilities that are within the current floodplain and within the 2050 projected inundation area. It is important to note that the location data does not include information regarding elevations; some of these facilities were constructed after the County began to issue permits in accordance with the Floodplain Management Ordinance. Estimates of damage associated with increased flood depths have not been prepared: FEMA has not developed depth-damage curves for these types of facilities.

Table 4. Critical and Public Facilities Located in 2050 Projected Inundation Area.

Vicinity	Facility Type	Facility Name	Location
Crisfield			
	School	Crisfield Christian Academy	134 Maryland Ave
		Crisfield E.S	1 Asbury Ave
		Crisfield H.S	Somerset Ave
		Woodson M.S.	281 Woodson School Rd
	Hospital/N. Home	McCready Memorial	201 Hall Hwy
	Fire/Rescue	Crisfield CO #2	906 W. Main St
	Transportation	Crisfield Airport	4784 Jacksonville Rd
	Police	DNR Police	Rear of Norris St
		Crisfield Police	West Main Street
	Utility	Crisfield WWTP	West Main St
		Water Tank	
		Sewage Pump Station	
		Coast Guard	Norris Drive
	Marina/Dock	Janes Island Ramp	Alfred Lawson Drive
		Jenkins Creek Ramp	GPS 37.9650 75.8476
	Major Bridge	S-0009 Cash Corner Rd	Johnson Creek
		S-0010 Byrd RD	Near McCready Hospital
		S-0012 Calvary RD	Jenkins Creek
		S-0025 Ape Hole Rd	South East of Crisfield
	College	U of MD Eastern Shore	11868 Academic Oval
	Post Office	Westover Post Office	8930 Crisfield hwy
	Transportation	State Highway Administration	Ocean Hwy
		County Roads Dept	8981 Sign Post Rd
Princess Anne			
	Major Bridge	S-0011 Sign Post RD.	Back Creek
Fairmount Manokin			
	Fire/Rescue	Fairmount Fire Station	27407 Fairmount Rd
	Utility	WWTP	26760 Rumbley RD
		Sewage Pump Station	
	Major Bridge	S-0003 Millard Long RD	Back Creek
		S-0004 River Rd	Big Annemesex River
		S-0013 Rumbley Rd	Teague Creek

Vicinity	Facility Type	Facility Name	Location
		S-0014 Frenchtown Rd	Frenchtown
		S-0015 Frenchtown Rd	Frenchtown
Marion			
	School	Marion E.S	Hudson Corner Rd
		Somerset CO Dev Center	5574 Tulls Corner RD
	Fire/Rescue	Marion CO #3	28390 Crisfield Marion RD
	Utility	Electric Substation	31390 Crisfield Hwy
	Major Bridge	S-0006 LQ Powell RD	East Creek
		S-0008 Marumsco RD	Marumsco Creek
		S-0018 Coventyr Parish RD	Rehobeth Branch
		S-0019 Bryan Hall RD	Marumsco Creek
Mount Vernon			
	Fire/Rescue	Mr. Vernon CO #6	27440 Mt. Vernon RD
	Major Bridge	S-0020 Whitehaven Ferry RD	Near Widgeon
Ewell			
	School	Ewell E.S	Ewell Schoolhouse
	Fire/Rescue	Ewell CO #1	3990 Smith Island Rd.
	Utility	WWTP	
		Pump Station	
	Major Bridge	S-0021 Smith Island RD	Ewell
Tylerton			
	School	Tylerton E.S	3019 Union Church Rd
	Fire/Rescue	Tylerton CO #7	21140 Tuff St.
	Utility	WWTP	
		Pump Station	
Deal Island			
	School	Macedonia School	10901 Riley Roberts Rd
	Fire/Rescue	Deal Island/Chance CO #4	10090 Deal Island RD
	Major Bridge	Rt. 363-- Deal Island Bridge	Deal Island

References

[1] *Maryland Climate Action Plan*, Maryland Commission on Climate Change, August 2008.

[2] *An Assessment of Maryland's Vulnerability to Flooding*, John M. Joyce, Michael S. Scott, August 2005

[3] *Worcester County Sea-Level Rise Inundation Model, Technical Report*, Maryland Department of Natural Resources & Geological Survey, November 2006

[4] Shoreline facts for Somerset County, http://shorelines.dnr.state.md.us/planning.asp (accessed September 2008).

[5] *Anticipated Responses to Sea-Level Rise in Somerset County, MD*, Jim Titus, EPA, February 2001

[6] *Evaluation of the National Flood Insurance Program's Building Standards*, Christopher P. Jones, William L. Coulbourne, Jamie Marshall, Spencer M. Rogers, Jr., October 2006

[7] *State of Maryland Hazard Mitigation Plan*, Maryland Emergency Management agency, 2004.

[8] Comprehensive Water and Sewerage Plan, Somerset County, Maryland, 2008.

[9] *Somerset County Multi-Hazard mitigation Plan*, Somerset County, Maryland, June 2005.

APPENDIX A

Map 1. Current Shoreline 2008
Somerset County, Maryland

Legend

- Government Buildings
- Unaddressed Buildings
- Buildings
- Conservation Zone

N
W E
S

14,000 7,000 0 14,000 Feet

URS
28485 DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0200

Wicomico River
Monie Bay
Monie Creek
Town of Princess Anne
WTP
Manokin River
Kings Creek
Deal Island
Little Deal Island
South Marsh Island
Tangier Sound
Kedges Straits
Big Annemessex River
Jane's Island State Park
City of Crisfield
Little Annemessex River
Johnson Creek
Smith Island
Marumsco Creek
Pocomoke River
Pocomoke Sound
352
349
13
12
675
5
362
388
363
627
920
640
364
413
361
113
675
366
667
371
357
12
679
460
380
175

Map 2. Sea Level Rise 2025
Somerset County, Maryland

Legend

- Government Buildings
- Unaddressed Buildings
- Buildings
- Shoreline 2025
- Conservation Zone

N
W E
S

14,000 7,000 0 14,000 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Wicomico River
Monie Bay
Monie Creek
Town of Princess Anne
Deal Island
Manokin River
Kings Creek
Little Deal Island
South Marsh Island
Tangier Sound
Kedges Straits
Big Annemessex River
Smith Island
Jane's Island State Park
Little Annemessex River
City of Crisfield
Johnson Creek
Marumsco Creek
Pocomoke Sound
Pomoke River

Map 3. Sea Level Rise 2050
Somerset County, Maryland

Legend

- Government Buildings
- Unaddressed Buildings
- Buildings
- Conservation Zone

N
W E
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14,000 7,000 0 14,000 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Wicomico River
Monie Bay
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Town of Princess Anne
Manokin River
Kings Creek
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South Marsh Island
Tangier Sound
Kedges Straits
Smith Island
Big Annemessex River
Jane's Island State Park
Little Annemessex River
City of Crisfield
Johnson Creek
Marumsco Creek
Pocomoke Sound
Pomoke River

352 349 13 529 362 388 363 627 920 640 364 12 413 361 675 113 366 667 371 357 679 460 380 175

Map 4. Sea Level Rise 2100
Somerset County, Maryland

Legend

- Government Buildings
- Unaddressed Buildings
- Buildings
- Conservation Zone

N
W E
S

14,000 7,000 0 14,000 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Wicomico River
Monie Bay
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Kedges Straits
Big Annemessex River
Jane's Island State Park
Smith Island
Little Annemessex River
City of Crisfield
Johnson Creek
Marumsco Creek
Pocomoke River
Pocomoke Sound

352 349 13 529 362 388 363 627 920 640 364 413 361 675 113 366 371 667 357 12 679 460 380 175

Map 5. Inundation Area
Somerset County, Maryland

Legend

- Government Buildings
- Unaddressed Buildings
- Buildings
- Conservation Zone
- Shoreline 2008
- Shoreline 2050

N
W E
S

14,000 7,000 0 14,000 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Wicomico River
Monie Bay
Monie Creek
Town of Princess Anne
WTP
Manokin River
Kings Creek
Deal Island
Little Deal Island
South Marsh Island
Tangier Sound
Kedges Straits
Big Annemessex River
Smith Island
Jane's Island State Park
City of Crisfield
Little Annemessex River
Johnson Creek
Marumsco Creek
Pocomoke River
Pocomoke Sound
352
349
13
675
362
388
363
627
920
640
364
413
361
113
366
667
371
357
12
679
460
380
175

Map 6. Shore Line Inundation
Deal Island, Maryland

Legend

- Shoreline 2008
- Shoreline 2025
- Shoreline 2050
- Shoreline 2100
- Conservation Zone
- Government Buildings
- Unaddressed Buildings
- Buildings

N
W E
S

3,000 1,500 0 3,000 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Monie Bay
363
PR
Messicks Ditch
PR
Tangier Sound
Fishing Creek
Little Deal Island

Map 7. Shore Line Inundation
Smith Island, Maryland

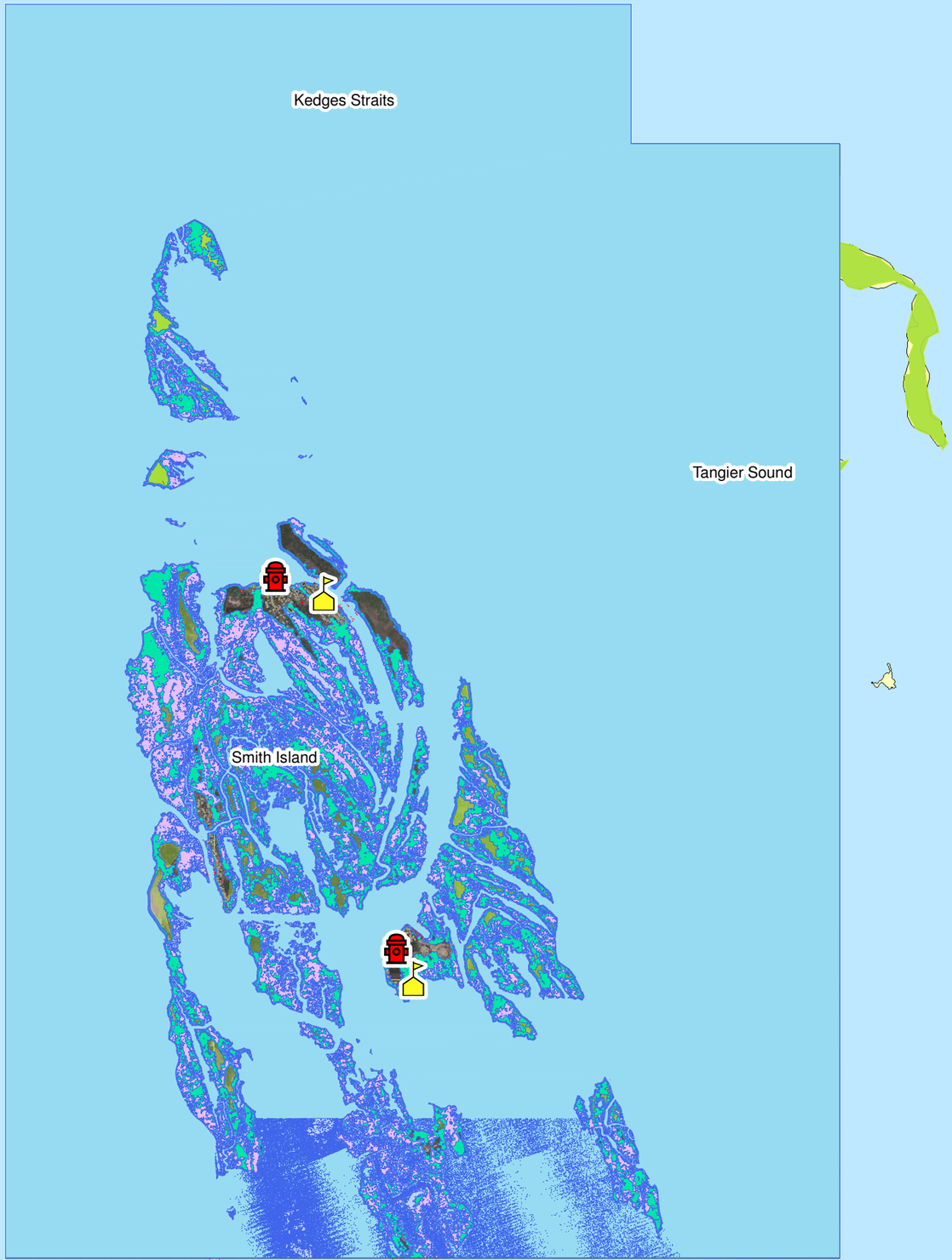
Legend

- Shoreline 2008
- Shoreline 2025
- Shoreline 2050
- Shoreline 2100
- Conservation Zone
- Government Buildings
- Unaddressed Buildings
- Buildings

N
W E
S

3,600 1,800 0 3,600 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320



Map 8. Shore Line Inundation
City of Crisfield, Maryland

Legend

- Shoreline 2008
- Shoreline 2050
- Shoreline 2100
- Conservation Zone

N
W E
S

825 412.5 0 825 Feet

URS
DuPont Office Suites
201 West DuPont Highway
Millsboro, DE 19966
Tel: 302.933.0200
Fax: 302.933.0320

Little Ammemessex River

City of Crisfield

WTP

Somerset County

Critical and State-Owned Facilities Located in Storm Surge Inundation Areas

Legend

Facilities At Risk

- Airport Facility
- Educational Facility
- Emergency Operations Center
- Fire Department Facility
- Fresh Water Pumping Station
- Police Department Facility
- Hospital/Health Related Facility
- State Airport Facility
- State Detention Center
- State Educational Facility
- State Hospital/Health Related Facility
- State Owned and Operated Facility (other)
- State Armory
- State Transportation Facility
- Transportation Facility
- Waste Water Pumping Station
- Above Ground Storage Tank Sites
- Underground Storage Tank Sites
- EPSC Locations
- Gas Chlorine Plants
- Large System Sources
- Hazardous Waste Generators
- DJS Offices and Facilities
- Bridges
- Dams

Storm Surge Inundation Areas

- Category 1 Hurricane
- Category 2 Hurricane
- Category 3 Hurricane
- Category 4 Hurricane

Streams

Major Roads

- Limited Access Highway
- Highway
- Local Roads

Boundaries

- County Boundary
- Municipal Boundary

Miles: 0, 3, 6, 9, 12

Princess Anne

Crisfield

May, 2004


NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE


MARYLAND
DEPARTMENT OF
NATURAL RESOURCES


COUNTY SOMERSET
SEMPER EADEM