Assessing the County's Readiness for a Climate Related Event

Grade Level: 9th-12th

Subject Area: Earth Science, Environmental Science

Virginia Standards of Learning: ES. 1, ES. 8, ES.10, ES. 11,

Objectives:
Students will:

- Interpret local maps to identify key areas of their county
- Compile resources to develop a plan for their county
- Inform others of their research through a final presentation
- Make informed decisions regarding climate change

Summary:
Students will participate in a role playing scenario in which they represent different stakeholder groups, including emergency responders, land planners, and watermen. Using a variety of provided resources, students are given a task to present on, whether it be creating an evacuation route for their county and identifying shelters, establishing new areas for development, or locations for the best catch of crabs in the year 2050.

Vocabulary: emergency responder, land planning, watermen, stakeholder, elevation, development, water quality, storm surge

Materials:
2 printed maps of your county
1 printed map of the Chesapeake Bay
3 labeled folders with printed resources and corresponding worksheets
Markers
Computer

Procedure:

****This lesson was designed for two high schools located in coastal counties bordering the Chesapeake Bay. Should you wish to recreate this lesson, similar resources such as those found in the appendices, can be compiled for your county through local government offices.**

Compiled in 2014 by education staff at the Chesapeake Bay National Estuarine Research Reserve in Virginia for use in the B-WET *Climate Education for a Changing Bay* program

Introduction

1. Explain to your students that they will be acting as a group of stakeholders concerned about how climate change will impact their county; whether through land planning, emergency response time, or as their way of life as watermen. Begin the lesson by having a conversation with your students asking questions about what they already know about each of the three named groups. For example:

    a) What do you know about development in our county?

    b) Where do we have the most development?

    c) Where do we have the most agricultural land in our county?

    d) How can we benefit from some of the rural areas in the county?

    e) What are emergency responders?

    f) How to they provide aid during an extreme weather event?

    g) Do you know of any shelters in our county?

    h) How could watermen be affected by water quality?

    i) How do watermen impact the local economy?

Activity

1. Divide students into three groups, 1) Land Planners, 2) Emergency Responders and 3) Watermen.

2. Give each group a folder with the corresponding questions and resources. (You will need to compile these folders prior to giving the resources to your students.) The resources for the Land Planning group can be found in Appendix 1, the Emergency Responders are in Appendix 2, and the resources for the Watermen are in Appendix 3.

3. Give the Land Planning group a blank county map with markers and a laptop. Give the Emergency Responder group a blank map of your county with markers. Give the Watermen group a blank map of the Chesapeake Bay with markers. (You may wish to print the maps as a poster size and laminate for reuse.)

4. Once all of the materials have been handed out, explain to your students that they are to draw on their maps once they have answered the questions on their worksheet. Students should be prepared to present their findings to the class as a conclusion. The Land Planners are to think about potential areas for future development and areas of current development that will be impacted by climate change. The Emergency Responders will

identify shelters within the community and develop an evacuation plan. The Watermen will decide where they will be most successful in the year 2050 catching blue crabs in the Chesapeake Bay.

5. Check in with each group as they work their way through the questions. Each group has different questions to guide them through their provided resources.

Wrap Up

1. Have each group take a turn presenting their information to the class. Each group should highlight what steps they had to consider prior to drawing on their map. Each group should explain what they did on their map.

2. After the groups present review the positive items they mentioned. And add any additional comments as needed.

3. Conclude the lesson by explaining to your students that there are many people concerned about climate change, not just scientists but also the groups which they represented. As they get older, climate change is a topic that will continue to be discussed and that they may eventually be in the situation to make informed decisions as a land planner, emergency responder, or watermen.

Background Information

The impact of climate change on coastal areas will be seen across a diverse suite of physical and chemical variables including changes in air, water and soil temperatures; water chemistry; the quantity, timing and intensity of precipitation; the intensity of storm events; and changes in sea level. Understanding changes in sea level and inundation, and the associated responses of critical habitats and coastal communities are key to the Chesapeake Bay region. Relative sea level rise rates and associated impacts within the southern Chesapeake Bay region represent some of the highest rates and threats reported along the U.S. Atlantic coast.

There will be many different impacts to the Chesapeake Bay region as a result of climate change. Concern for these impacts is justified given that current and projected rates of sea level

rise reflect a greater increase over what we experienced during the last century. Low lying coastal communities have to act now to plan for these future impacts. Climate change is not something only scientists are concerned about, community members, such as land planners, emergency responders, and watermen, are all involved in the discussion together, planning for their future.

Land planners have to establish ways to maximize the ecological services provided by the natural habitats. They need to consider how the community benefits from the natural environment now, and how climate change will impact these areas. One of the ways land planners can think about their community and future impacts is by considering the land elevation with respect to sea level. Surveying the land or looking at a topographic map can tell a lot about how an area may be impacted by rising sea levels or increased flooding due to storm events. Future developments may need to build be in higher elevations, or current infrastructure may need some modifications in order to prepare for climate related events.

Emergency responders within a community play a vital role when considering how a community can plan for climate change impacts. One of the impacts of climate change will be increased storm events and increased intensity of storm events. In a storm event like a hurricane, emergency responders must be able to safely notify community members of the storm, while also working to establish an evacuation route, should that be necessary, and appropriate shelter areas. In order to prepare the community for such events, emergency responders must be sure that everyone knows of the evacuation plan and shelters far in advance. Safe shelters can be established in buildings that can be accessed during a storm event and are in a centralized location, such as local schools. Emergency responders know that proper communication with the

public is vital in order to prepare and inform the community of climate change and its associated impacts.

Many watermen are concerned with the impacts from climate change as they are already seeing sways in their catch due to water quality issues. Increased temperature, salinity, and runoff are projected with climate change and will affect water quality. Marine organisms rely heavily on specific water conditions for their habitat and for different development stages within their life cycle. The health and distribution of many marine organisms could be affected as the water quality parameters change. As water conditions change, watermen are faced with moving their fishing grounds, switching to a different catch, or finding a new career. This can prove to be very costly for watermen as switching to a different catch would require the purchase of new equipment and licenses, switching to a different fishing ground would use up fuel and work time, and finding a new career can be extremely difficult. Watermen depend on the water as a way of life, and in turn support the local economy through their career.

Community members can all work together to be sure that their county is prepared with the knowledge necessary to understand the impacts of climate change. It is very important to recognize that our everyday actions can have a big impact on the community and the Chesapeake Bay. People can work together to reduce their impact on climate change by making small daily changes in their lives, such as carpooling to school or work together, walking rather than driving, choosing to recycle, being water conscience, and environmentally friendly.

Appendix 1 – Land Planning Questions and Resources

You and your group members are acting as a group of land planners which will be having a discussion about how climate change could impact your future plans for development in your community. You all live near the coast and have some prior knowledge about where development occurs and where there are areas for concern. Discuss with your group members what you already know about land planning. Please write your discussion points in the space below:

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You will be focusing on the long-term ecosystem impacts of climate change. In order to predict the long- term landward movement of marshes, you will need to take into consideration sea level rise, land subsidence, and growth of marshes. Please use the provided materials to help you answer the following questions. Look through all of the materials first; some of the materials are general information about your county and local maps. Your discussion will then be reported to the class as a conclusion of the program in a discussion panel. Please ask the instructors should you have any questions.

Questions:

1. What are some factors that you think land planners need to take into account when thinking about their community and climate change?

2. Where in your county do you find tidal wetlands? What is an example of a tidal wetland?

3. Knowing that the marsh can build up and will move landward as sea level rises; draw on your map where the marsh could potentially reach using the provided materials? Do you have any developments too close to the marsh edge, how could this impact the marsh?

4. As a land planner how could you maximize the natural services provided by these habitats?

5. Visit NOAA Sea Level Rise and Coastal viewer at http://csc.noaa.gov/slr/viewer/. Zoom in on the map to your county. Under Sea level slide the bar up to 2ft. SLR. And read the map overview on the left. What areas in your county are most likely to see impacts due to the sea level rise?

6. Now slide the Sea level bar to 3ft. SLR, was there much change in the land that would be affected? (Remember back to the school visit when we discussed different models for future SLR, some have an accelerated rate.

7. Using the provided materials, and the blank map draw out where you would like to see development in your county in the future. Label where each of the following will be built by the year 2050. (It may be helpful to draw where the water will be by 2050 when planning) Keep in mind that existing infrastructure could still be used!
    a. Neighborhoods
    b. New schools
    c. Fire stations and police stations
    d. Shopping centers
    e. Farm land
    f. Parks
    g. Access to water front

8. How did you choose the areas that you decided to develop?

Wetland Benefits Snapshot

Gloucester County, Virginia

Protecting Wetlands = Coastal Communities That Are Safer, Cleaner, and More Economically Productive

Healthy wetlands provide more than just a pretty view. Wetlands are a pivotal part of the natural system, supplying tremendous benefits for coastal communities. Even small acreages can provide some level of benefit. The location, health, and size of individual wetlands also play a role. This snapshot demonstrates three key benefits of wetlands in Gloucester County.

Based on 2006 NOAA land cover.

29%

41,677 acres
of Gloucester County's land area is wetland.

More Economically Productive: Wetlands Support Fishing Economies

Coastal wetlands provide habitat for many aquatic species that contribute to local food supplies and fishing-related industries.

In addition to providing a base for commercial fishing jobs and revenue, wetlands also support recreational and charter fishing. These economic benefits extend beyond county boundaries.

Based on 2011 ENOW and 2011 ENOW for Self-Employed Workers.

Commercial Fishing	County	State
Jobs	141	3,840
Output from businesses	unavailable*	$645.8 million
Revenue from self-employed	$4.7 million	$76.8 million

*See the frequently asked questions page to learn why this data is not available.

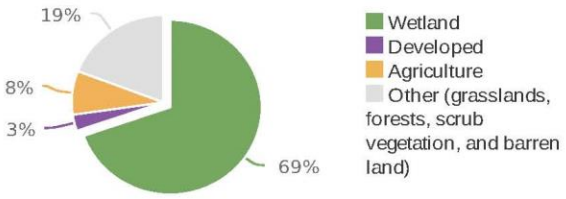
Safer: Wetlands Reduce Flood Impacts

17% (23,660 acres) of Gloucester County's land area is in the floodplain.

Wetlands located in coastal and riverine floodplains can protect people and their property, community infrastructure, and agricultural investments from floods. Wetlands act as natural sponges, holding floodwaters and lowering flood heights.

Based on Best available as of 2010 FEMA Flood Zones (100-year); 2006 NOAA land cover.

Gloucester County's Floodplain



NOAA Coastal Services Center
LINKING PEOPLE, INFORMATION, AND TECHNOLOGY

Source: NOAA Coastal Services Center, http://www.csc.noaa.gov/digitalcoast/tools/snapshots

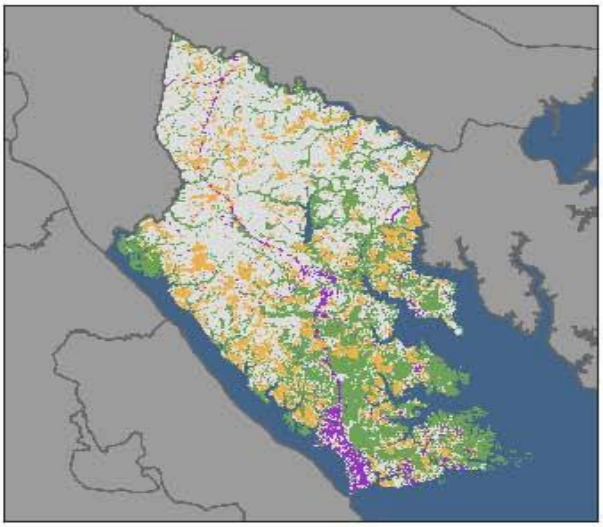
Cleaner: Wetlands Improve Water Quality

Runoff associated with concrete, asphalt, rooftops, and other impervious surfaces is a leading cause of water pollution.

Wetlands near developed and agricultural areas trap pollutants and excess nutrients in surface runoff, keeping water bodies cleaner. This natural filtering helps prevent water use restrictions, such as beach and shellfish closures, and reduces the need for costly treatment systems.

Based on 2006 NOAA land cover.

- Wetland
- Developed
- Agriculture
- Other (grasslands, forests, scrub vegetation, and barren land)



Next Steps

Understanding how wetlands benefit a coastal community can provide strong incentives for wetland protection. The following suggestions and resources provide guidance in moving forward with these efforts.

Integrate wetland protection priorities into community planning Encouraging wetland protection and development in appropriate places makes communities more resilient. Resources are available to help communities incorporate wetland protection considerations into existing planning efforts.

- Introducing Green Infrastructure for Coastal Resilience training(http://www.csc.noaa.gov/digitalcoast/training/green)
- Roadmap for Adapting to Coastal Risk training(http://www.csc.noaa.gov/roadmap/)

Prioritize wetlands for protection Additional factors can influence wetland protection priorities. Consult local experts regarding wetland size, location, and quality; fish and wildlife considerations; regulatory requirements; and tourism, recreation, and other benefits. Resources are available to help communities with the selection and prioritization process, including

- C-CAP land cover data(http://www.csc.noaa.gov/landcover/) and online atlas(http://www.csc.noaa.gov/digitalcoast/tools/lca/)
- National Wetlands Inventory data(http://www.fws.gov/wetlands/Data/index.html)
- Habitat Priority Planner tool(http://www.csc.noaa.gov/hpp/)
- Essential Fish Habitat Mapper(http://www.habitat.noaa.gov/protection/efh/habitatmapper.html)

Discover additional helpful resources More tools, data, and information, including funding sources, are highlighted on the frequently asked questions page(http://www.csc.noaa.gov/snapshots/faq/wetland-benefits.pdf)

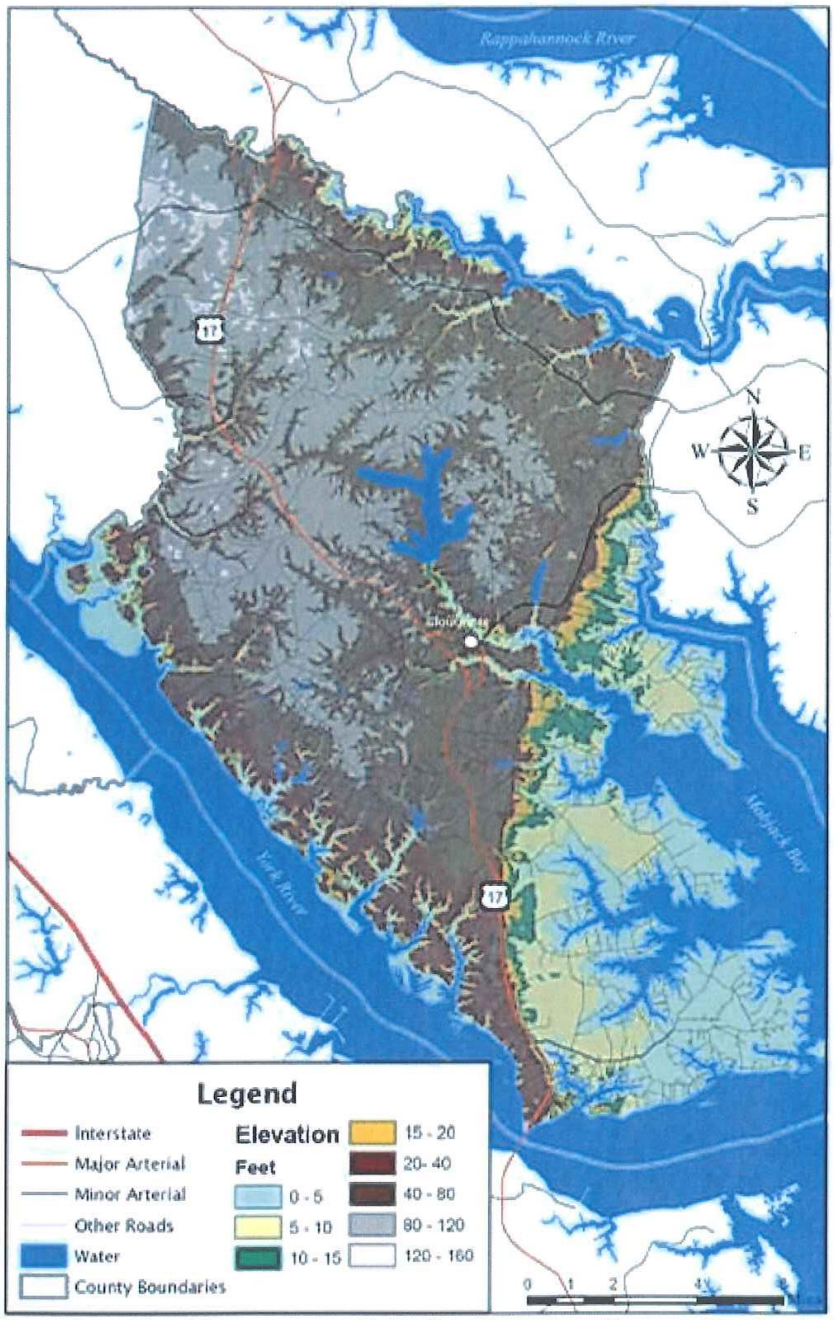
Data Sources for This Snapshot

- **Land Cover Data**(http://www.csc.noaa.gov/digitalcoast/data/ccapregional) NOAA Coastal Change Analysis Program
- **Flood Zones**(http://msc.fema.gov) Federal Emergency Management Agency 1% Annual Chance Flood Zones
- **Economics Data**(http://www.csc.noaa.gov/enow) NOAA Economics: National Ocean Watch
- **Self-Employed Workers**(http://www.csc.noaa.gov/digitalcoast/data/enow-nes) NOAA Economics: National Ocean Watch for Self-Employed Workers

Source: NOAA Coastal Services Center, http://www.csc.noaa.gov/digitalcoast/tools/snapshots

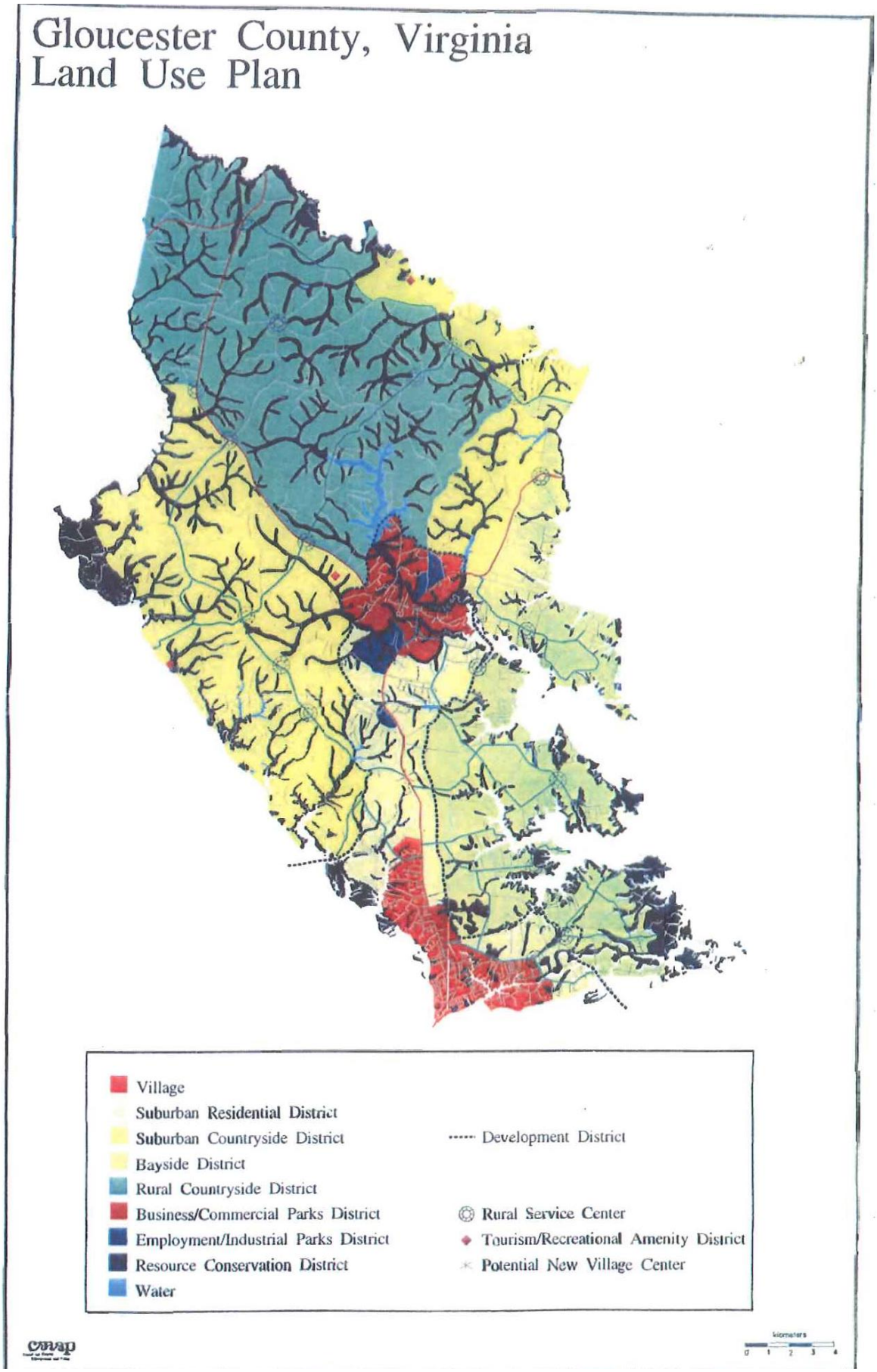
Figure 8

Gloucester County Elevation Profile

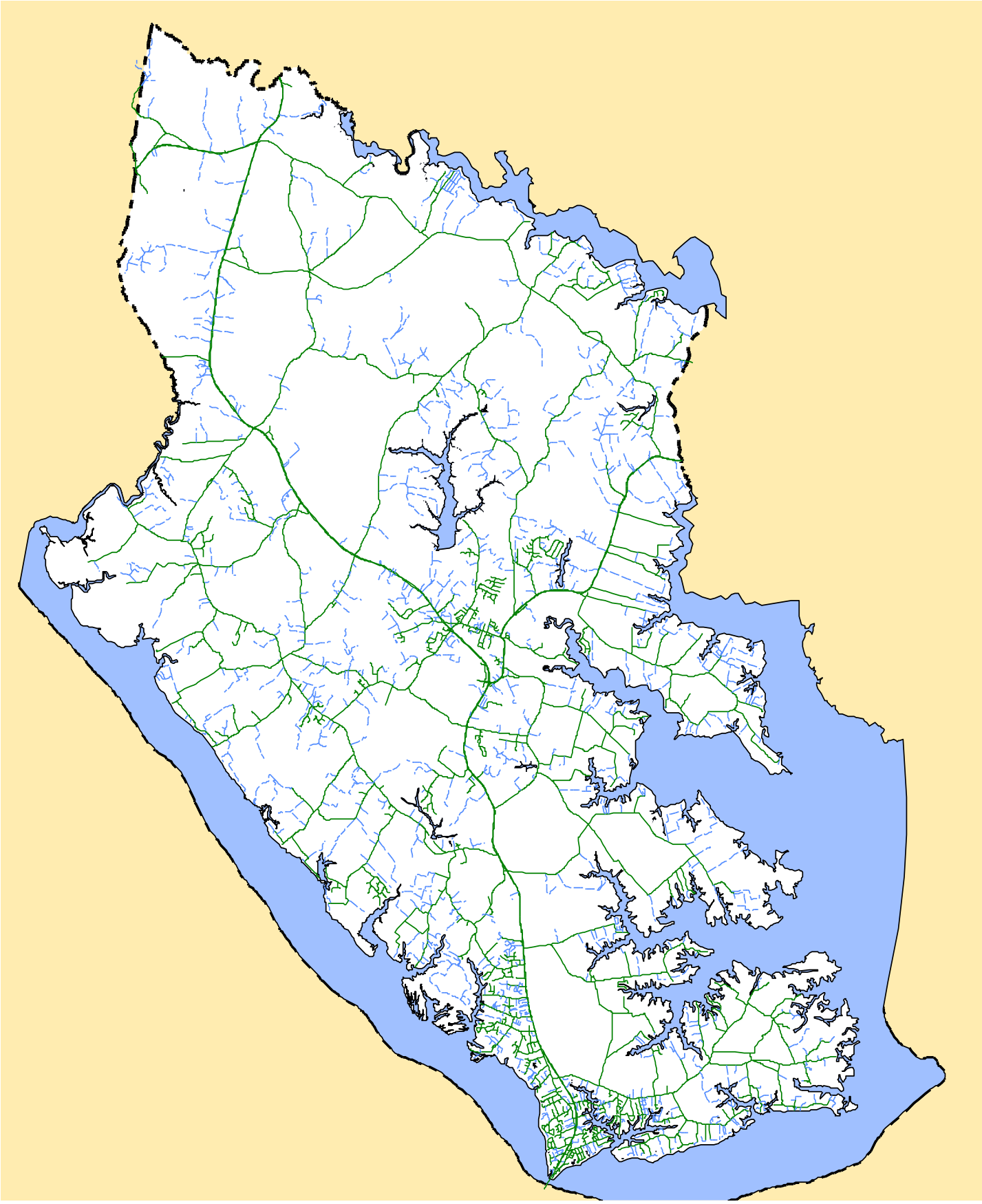


Source: County Base GIS layers were provided by United States Census Bureau and the Elevation GIS layers were provided by USGS.

Source: A Coastal Floodplain Management Plan For Gloucester County, Middle Peninsula Planning District Commission, http://www.mppdc.com/



Source: County of Gloucester Planning and Zoning, http://www.gloucesterva.info/Planning/tabid/571/Default.aspx



Source: County of Gloucester Geographic Information Systems, http://www.gloucesterva.info/gis

Appendix 2 – Emergency Responder Questions and Resources

You and your group members are acting as a group of emergency responders which will be having a discussion about how your local community will be impacted by a storm event. You all live near the coast and have some prior knowledge about storm events in our area. Discuss with your group members what you already know how your coastal community is impacted and responds to storm events, for example road closures due to flooding. Please write your discussion points in the space below:

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One of the impacts of climate change will be increased storm events and increased intensity of storm events. Please use the provided materials to help you answer the following questions. Look through all of the materials first; some of the materials are general information about storm events and local land maps. Your discussion will then be reported to the class as a conclusion of the program in a discussion panel. Please ask the instructors should you have any questions.

Few points to consider:

1. Increased sea level due to storm surge is not only caused by hurricanes, it can occur from winter storms and strong winds!
2. Sometimes ferries, bridges, and roadways can be shut down due to storm events.

Questions:

1. What is a storm surge, and what causes it?

2. Look at the VIMS tidewatch chart and instructions. What was the storm surge from Hurricane Irene?

3. Now look at the storm surge inundation map for your county. Hurricanes need not make landfall or move directly across Virginia to cause great damage. Hurricanes are classified into five categories based on wind speed and potential to cause damage.
    a. Category One- Winds 74-95mph
    b. Category Two – Winds 96 – 110mph
    c. Category Three – Winds 111 – 129mph
    d. Category Five – Winds greater than 157mph

    What areas in your county are likely to have storm surge inundation from a Category 1 hurricane and a category 2 hurricane?

4. What is the elevation in those areas which will be effect from storm surge during a category 1 or 2 hurricane?

5. Projected storm surges are one of the main reasons that evacuations are ordered. Your job is to now use the provided map and draw out an evacuation plan for the residents in your county. You will need to look at the inundation maps and your topographic map to consider elevation when drawing out your route.
    a. Map a route which will get your town residents on a main route out of the county.
    b. Identify roads that will be closed.
    c. Identify community shelter areas.
    d. Identify possible building or infrastructures that could face issues.
    e. Identify and schools or emergency response buildings in these areas.

6. Can you identify any pros or cons for a community issuing an evacuation?

7. Looking forward, how could you as an emergency responder prepare your community for future impacts of climate change? How would you notify your community members of future impacts?

8. Would you suggest having emergency services available in other areas of your community, if so where?

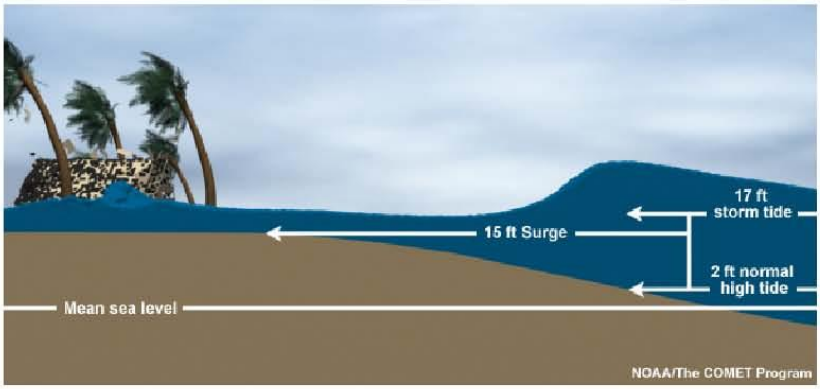
BOLIVAR PENINSULA IN TEXAS AFTER HURRICANE IKE (2008)

Introduction to Storm Surge

National Hurricane Center

Storm Surge Unit

What is Storm Surge?



Storm surge is an abnormal rise of water generated by a storm, over and above the predicted astronomical tide.

- It's the change in the water level that is due to the presence of the storm
- Since storm surge is a difference between water levels, it does not have a reference level

Storm tide is the water level rise during a storm due to the combination of storm surge and the astronomical tide.

- Since storm tide is the combination of surge and tide, it *does* require a reference level
- A 15 ft. storm surge on top of a high tide that is 2 ft. above mean sea level produces a 17 ft. storm tide.

Inland Extent

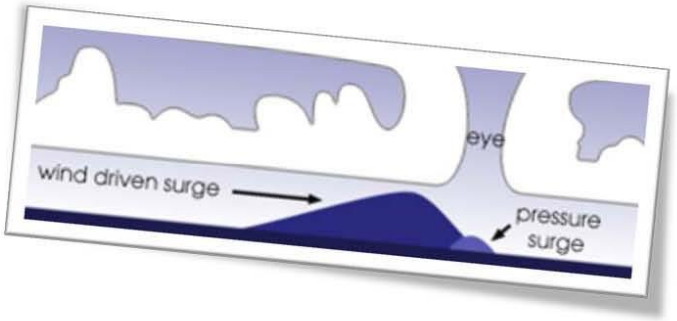
Storm surge can penetrate well inland from the coastline. During Hurricane Ike, the surge moved inland nearly 30 miles in some locations in southeastern Texas and southwestern Louisiana.

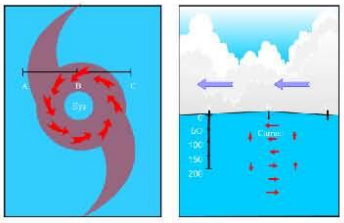
Vulnerability

All locations along the U.S. East and Gulf coasts are vulnerable to storm surge. This figure shows the areas that could be inundated by water in any given category 4 hurricane.

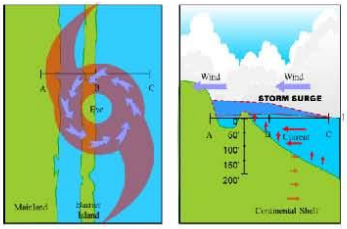
What causes Storm Surge?

Storm surge is caused primarily by the strong winds in a hurricane or tropical storm. The low pressure of the storm has minimal contribution!

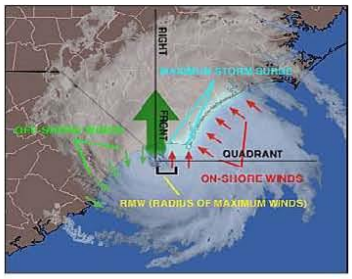




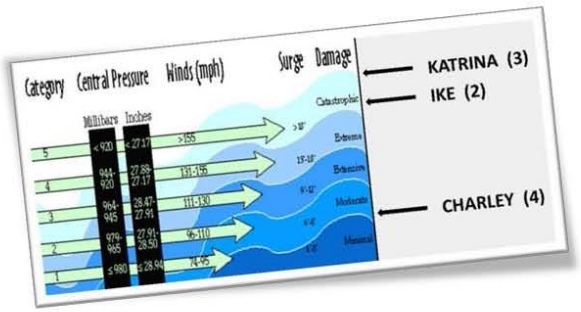
The wind circulation around the eye of a hurricane (left above) blows on the ocean surface and produces a vertical circulation in the ocean (right above). In deep water, there is nothing to disturb this circulation and there is very little indication of storm surge.



Once the hurricane reaches shallower waters near the coast, the vertical circulation in the ocean becomes disrupted by the ocean bottom. The water can no longer go down, so it has nowhere else to go but up and inland.



In general, storm surge occurs where winds are blowing onshore. The highest surge tends to occur near the "radius of maximum winds," or where the strongest winds of the hurricane occur.



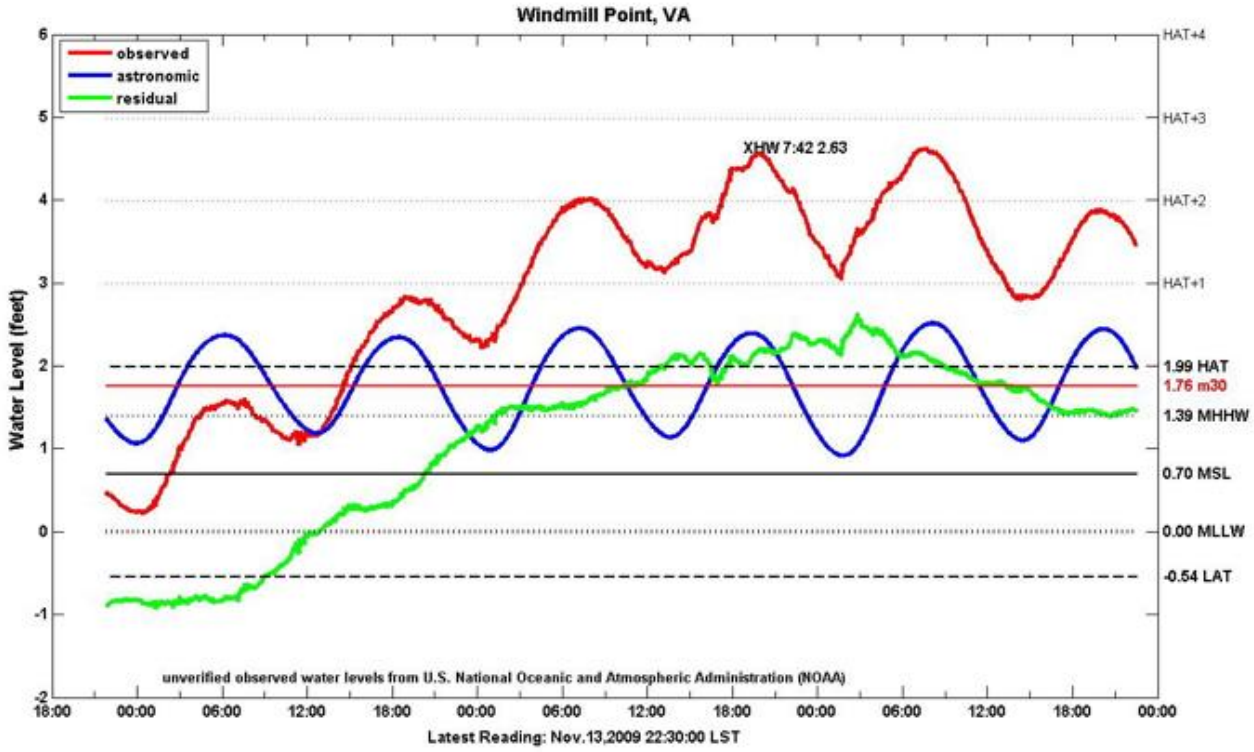
The Saffir-Simpson Hurricane Wind Scale: Surge Not Included

Too many exceptions to fit the scale:

- Hurricane Katrina, a **category 3** at landfall in Louisiana, produced catastrophic damage with a 28-ft. storm surge.
- Hurricane Ike, a **category 2** at landfall in Texas, also produced catastrophic damage with a 20-ft. storm surge.
- Hurricane Charley, a **category 4** hurricane at landfall in Florida, produced a storm surge of 6 to 8 ft.
- Hurricane Irene, a **category 1** hurricane at landfall in North Carolina, produced extensive damage with an 8 to 11 ft. storm surge.

Source: National Hurricane Center, http://www.nhc.noaa.gov/surge/surge_intro.pdf

How to read a Tidewatch Chart



Legend & Definitions

Red line = observed water level (unverified data from the U.S. National Oceanic and Atmospheric Administration)

Blue line = predicted astronomic tide

Green line = Residual difference between predicted and observed water level. Values are positive when observed values exceed predicted values, and negative when observed values fall below predicted values.

m30 is the 30-day mean water level covering the period of observation shown. It represents a time-local departure from MSL that is due to a combination of the seasonal tide, the decadal change in sea level, and the long-term sea-level trend relative to the land. The vertical reference for the astronomic tide is m30. For this chart, the m30 value is 1.76 feet above mean lower low water (MLLW), and 1.06 feet above mean sea level (MSL).

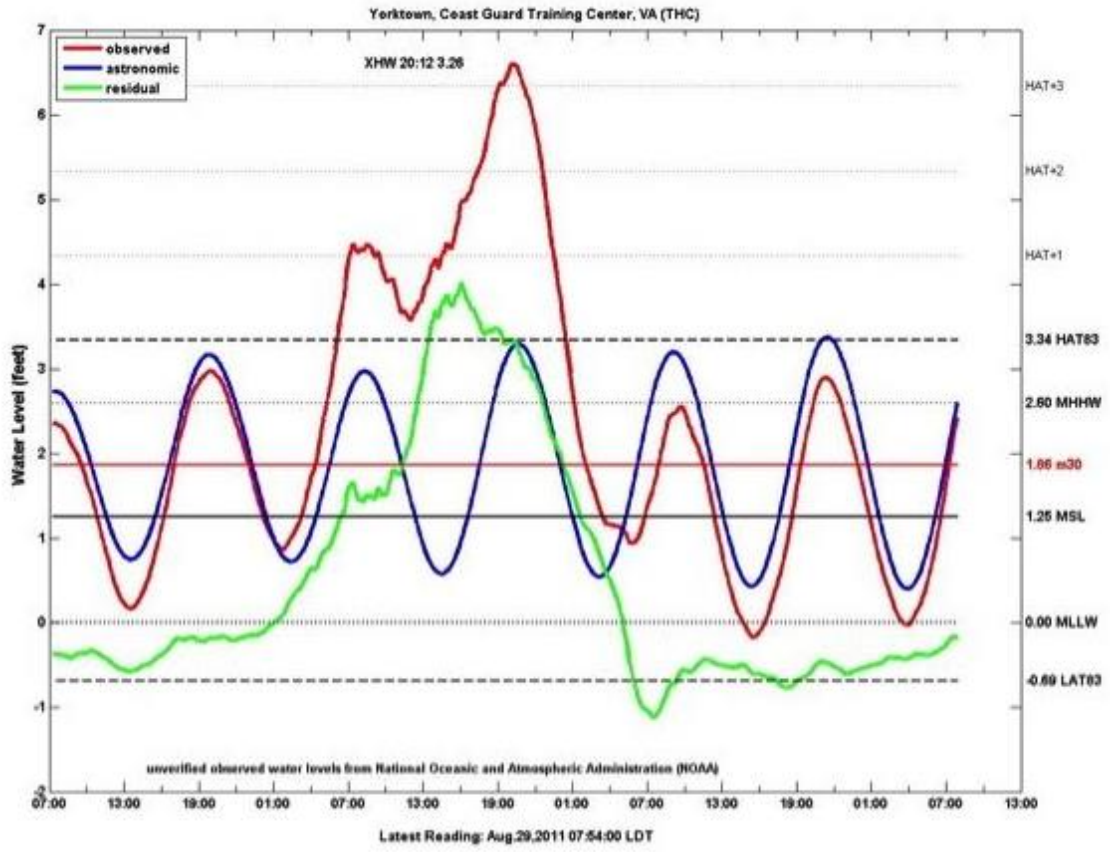
HAT is the elevation of Highest Astronomical Tide for the station shown. No predicted tide referenced to MSL or MLLW should ever be higher than HAT.

LAT is the elevation of Lowest Astronomical Tide for the station shown. No predicted tide referenced to MSL or MLLW should ever be lower than LAT.

MHHW, MSL, MLLW are the tidal datums of Mean Higher High Water, Mean Sea Level, and Mean Lower Low Water as defined by NOAA's National Ocean Service for the 1983-2001 National Tidal Datum Epoch (seehttp://tidesandcurrents.noaa.gov/).

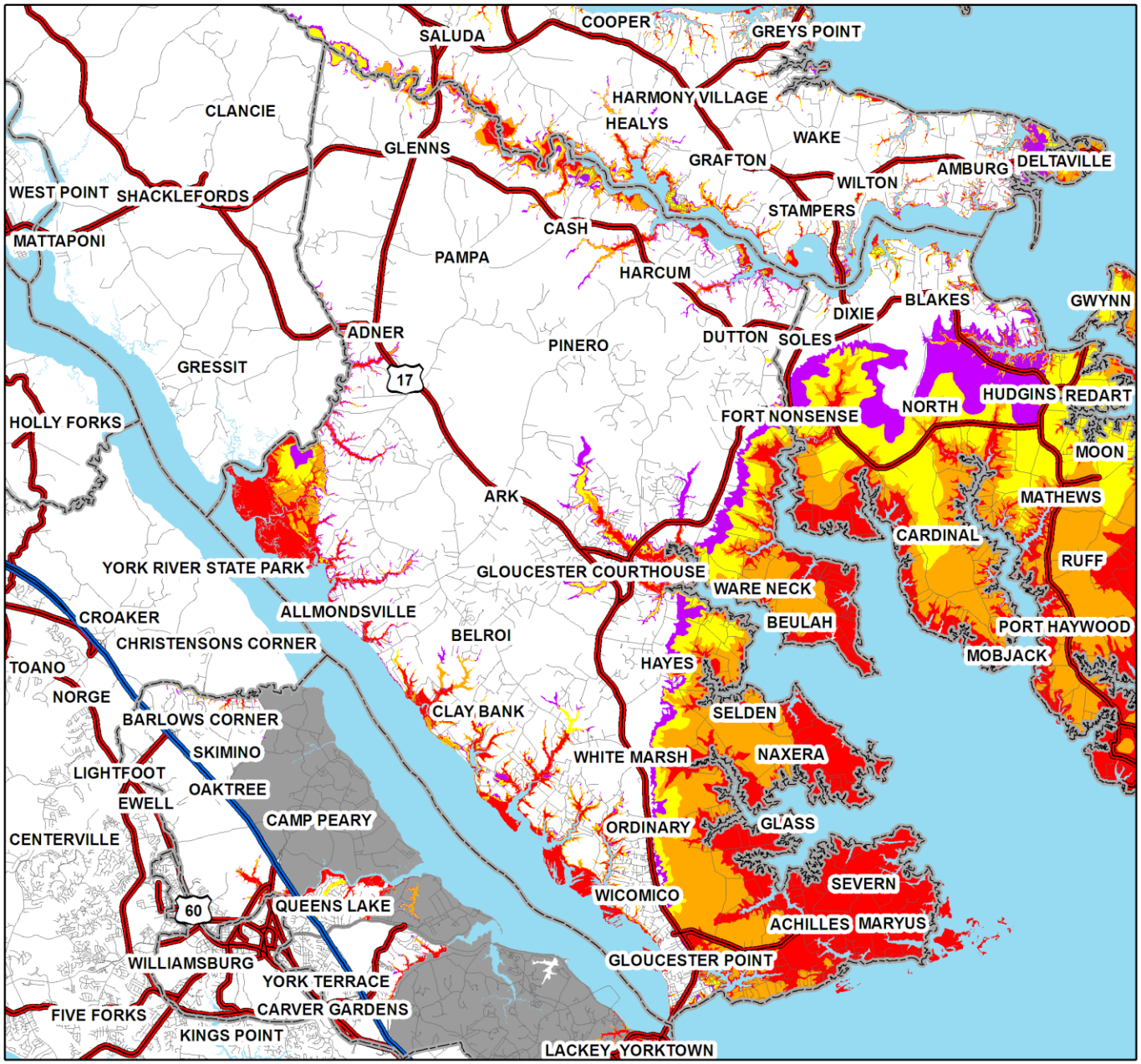
Extratidal High Water (XHW) and **Extratidal Low Water** (XLW) are observed water-level extremes measured above the tidal datum HAT (XHW) or below the tidal datum LAT (XLW). These extremes occur only in the presence of a weather-induced residual water level or 'storm surge' (observed water level minus the astronomic tide), a sea-level anomaly (m30-MSL vertical difference) or, more often, a combination of the two. The astronomic tide—the water level change occurring at tidal frequencies—will not exceed either datum in the absence of a sea-level anomaly.

Hurricane Irene Tidewatch Chart



Source: Virginia Institute of Marine Science, http://www.vims.edu/bayinfo/tidewatch/index.php

Commonwealth of Virginia Storm Surge Inundation Maps



Gloucester

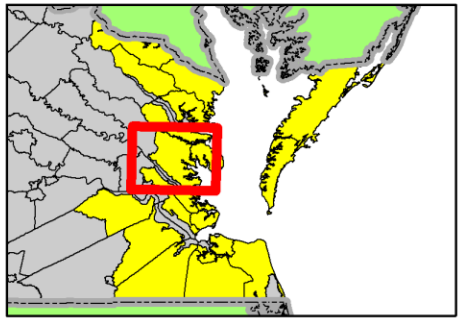
Storm Surge Inundation

- Area Not Included
- Category 1
- Category 2
- Category 3
- Category 4
- Interstates
- Primary Routes
- Addressed Roads
- Jurisdiction Boundaries

N

VIRGINIA DEPARTMENT OF EMERGENCY MANAGEMENT

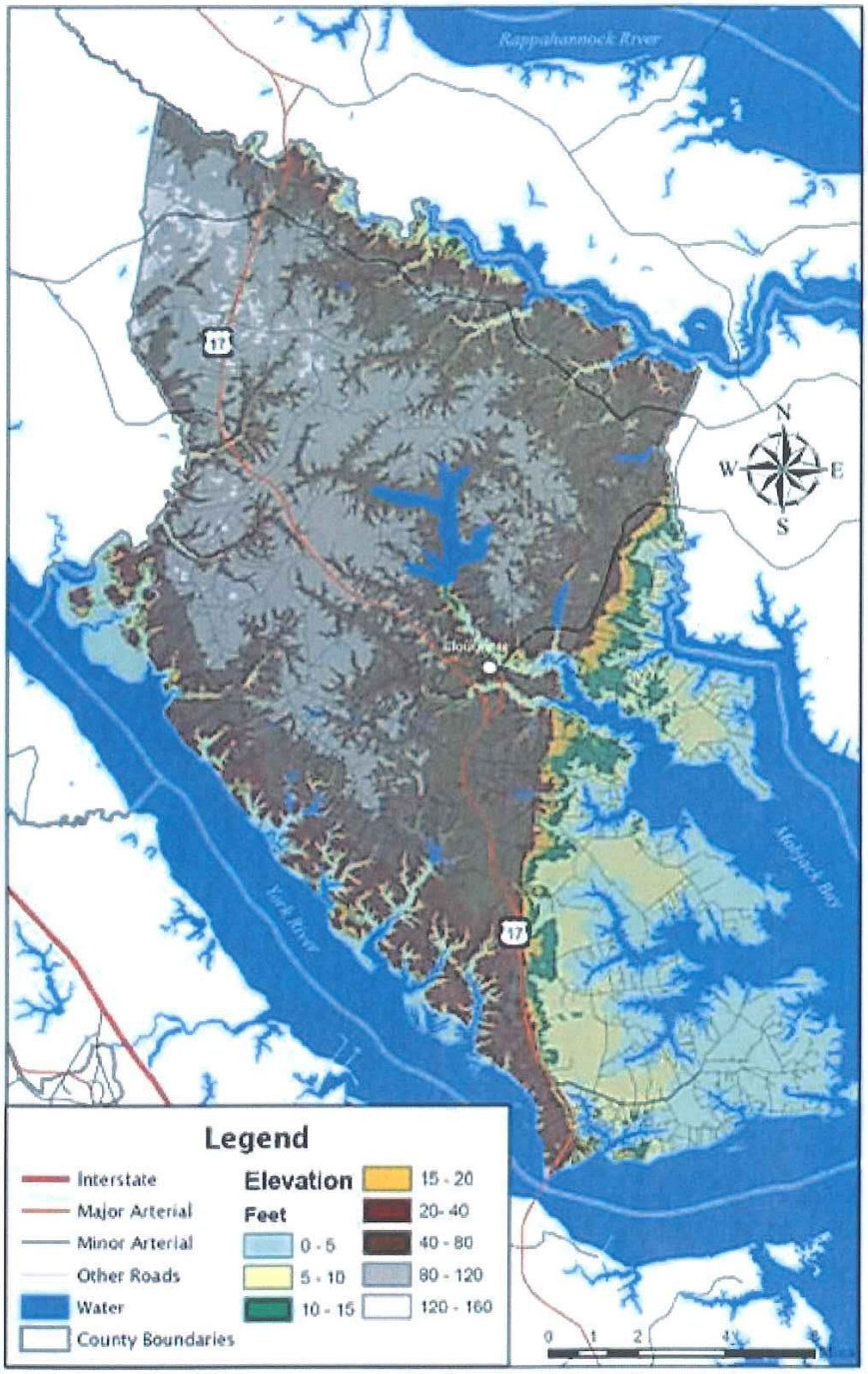
0 1 2 3 4 5 6 7 8
Miles



Source: Virginia Department of Emergency Management, http://www.vaemergency.gov/readyvirginia/stay-informed/hurricane/storm-surge

Figure 8

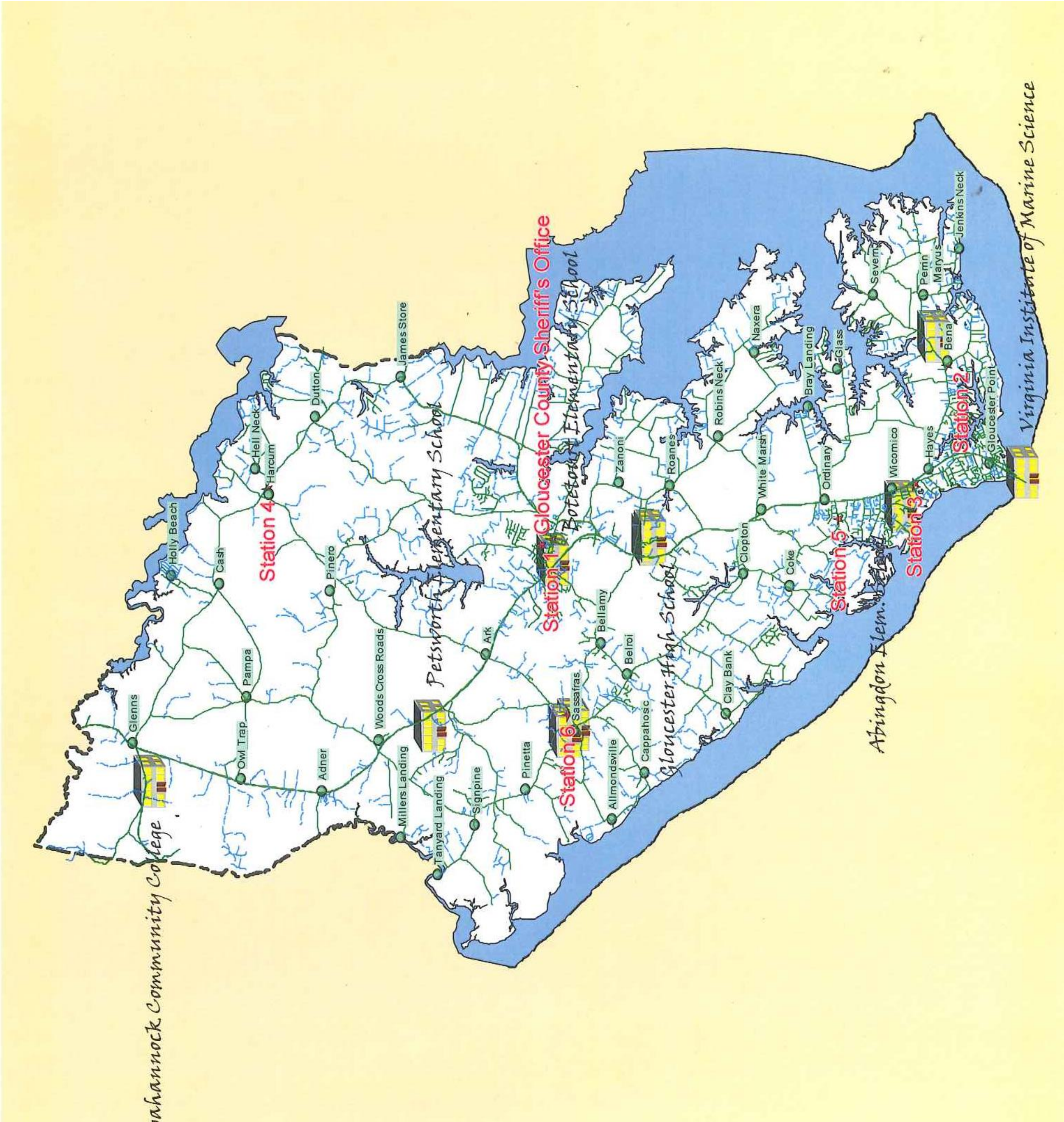
Gloucester County Elevation Profile



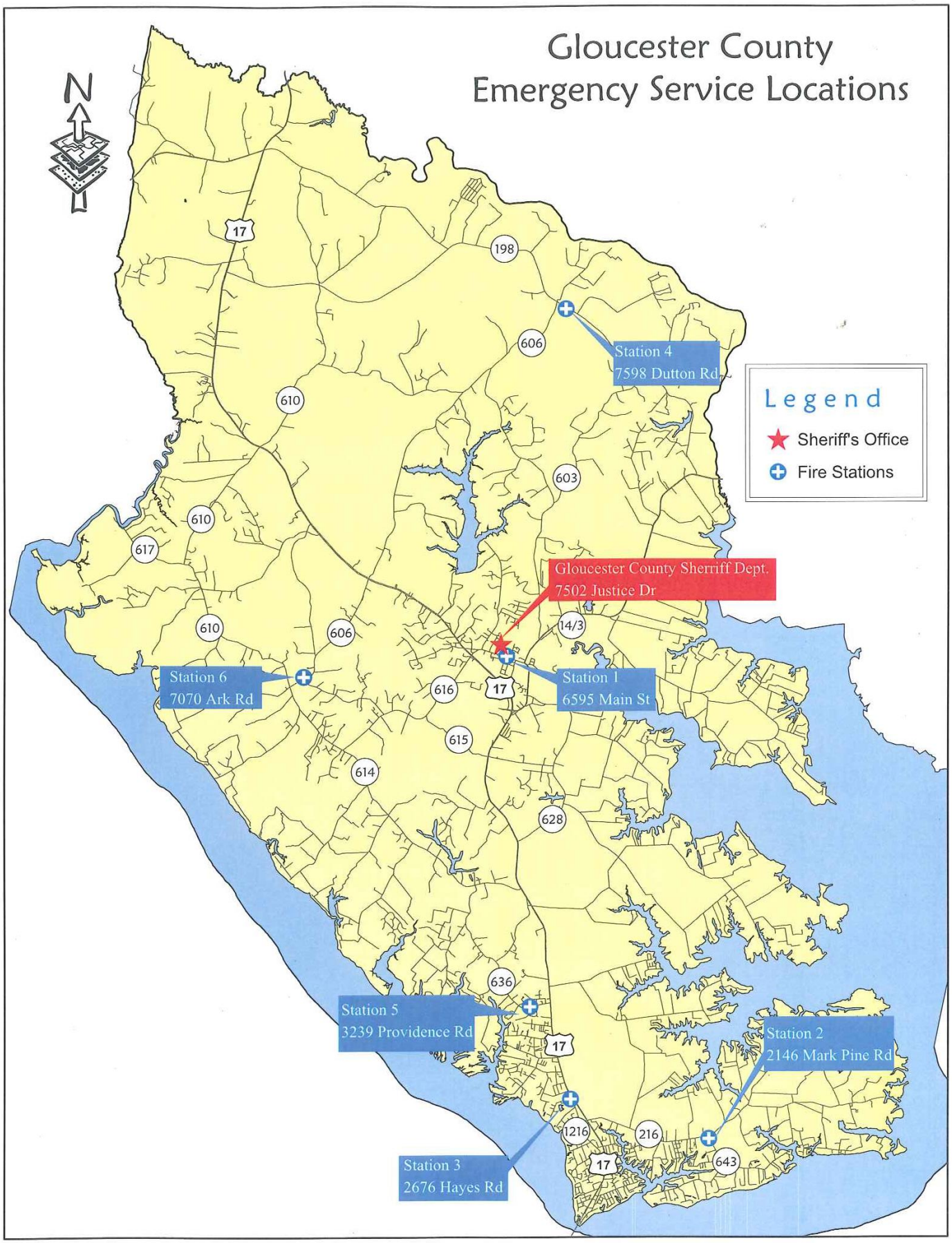
Source: County Base GIS layers were provided by United States Census Bureau and the Elevation GIS layers were provided by USGS.

Source: A Coastal Floodplain Management Plan For Gloucester County, Middle Peninsula Planning District Commission, http://www.mppdc.com/

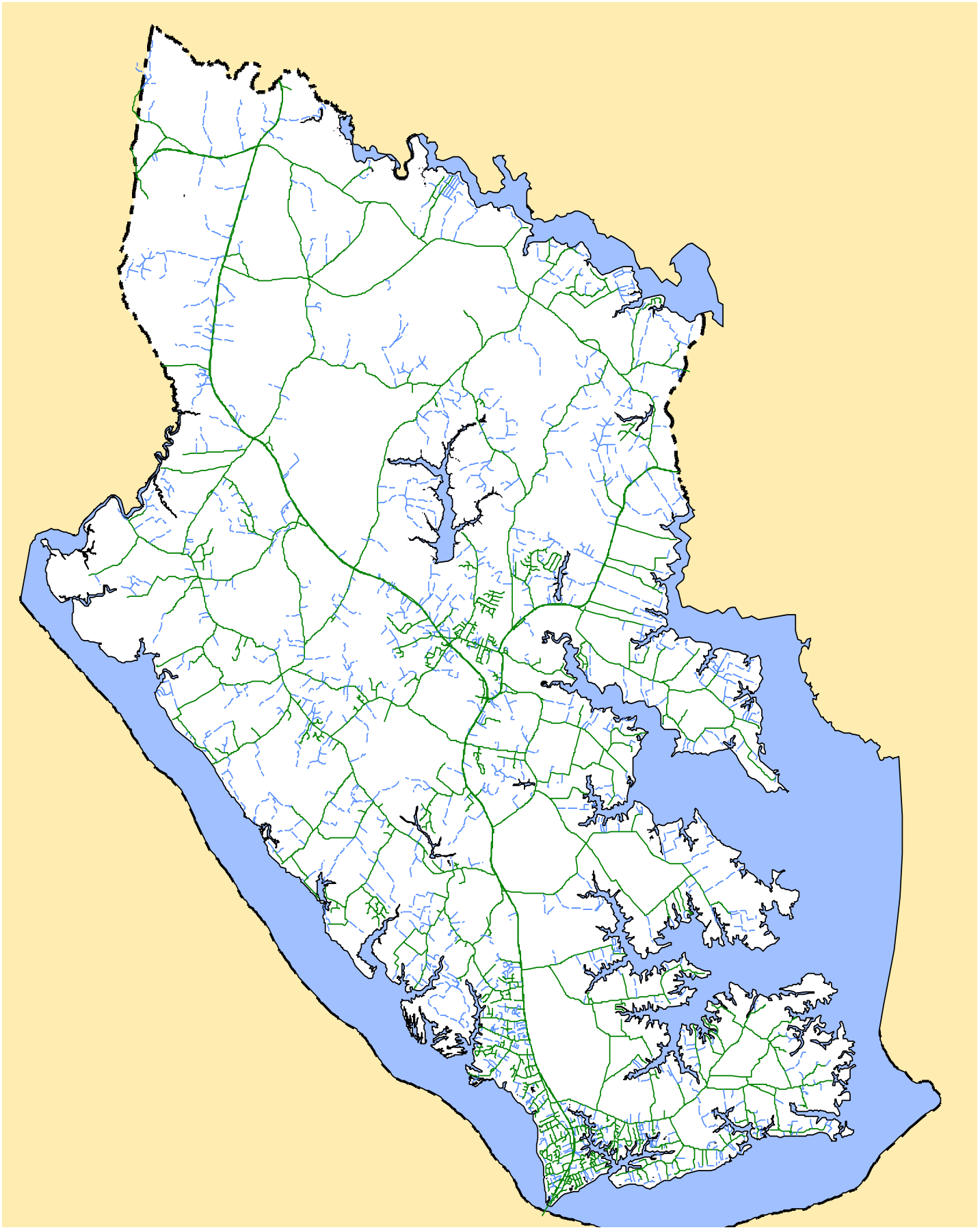
Source: County of Gloucester Geographic Information Systems, http://www.gloucesterva.info/gis



Source: County of Gloucester Geographic Information Systems, http://www.gloucesterva.info/gis



Source: County of Gloucester Geographic Information Systems, http://www.gloucesterva.info/gis



Source: County of Gloucester Geographic Information Systems, http://www.gloucesterva.info/gis

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