Marine Emergencies Risk Assessment for the Virginia Beach Fire Department

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Abstract

The problem was the Virginia Beach Fire Department had not conducted a risk assessment specific to marine emergencies. The purpose of this research was to conduct a risk assessment specific to marine emergencies for the Virginia Beach Fire Department. Descriptive research methodology was used to answer the following research questions: (a) What are the physical risk factors associated with the bodies of water in Virginia Beach? (b) What demographics are most at risk for marine emergencies in Virginia Beach? (c) What is the historic service demand for marine emergencies for the Virginia Beach Fire Department? (d) What are the probability and consequences of marine emergencies in Virginia Beach? The physical risk factors researched were number of bodies of water, amount and condition of shoreline, air and water temperature trends, amount of boating activity, and known hazards in each body of water. The demographics were determined by reviewing the demographics reported by the Coast Guard and the Center for Disease Control for boating accidents and drowning incidents respectively. A review of incident data for response of the three Virginia Beach Fire Department fireboats for a four year period was used to determine the service demand history. The incidents were divided into call type, organized by month and time of day. The probability and consequences of marine emergencies were determined using a quadrant analysis matrix. The results demonstrated a significant marine risk for Virginia Beach with over 600 miles of total shore line and nearly 250 square miles of water. The mild weather encourages marine activity with a spike in incidents during the summer months. Incident types ranged from medical calls to commercial vessel fires presenting risk with high probability and high consequence. It was recommended to complete further data collection specific to incident location and time spent managing an incident.

Table of Contents

Tables

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Background and Significance

The City of Virginia Beach is located in southeastern Virginia where the Chesapeake Bay meets the Atlantic Ocean. It has a population of 447,215 permanent residents and is a popular tourist destination hosting 12 million day and night guest annually (Hall, 2016). The City of Virginia Beach has a land mass of 249 square miles and 248 square miles of water. The area of water can be separated into two categories, coastal and inland. Virginia Beach has over 38 miles of beaches and has jurisdictional responsibility for three miles off its coast. This results in 59 square miles of inland waterways and 189 square miles of coastal water. (Virginia Beach, VA, 2016).

The Virginia Beach Fire Department is an all hazard response department with just under 500 employees staffing 19 fire stations, 20 engines, eight ladder trucks, two rescues, a hazmat truck, a technical rescue truck, and three fire boats (About the Virginia Beach Fire Department, 2016). The Virginia Beach Fire Department Marine Team consists of 56 trained members stationed at three different locations around the City. Along the Chesapeake Bay the team utilizes a 35-foot fireboat with 1,500 gallons per minute firefighting capacity. They also respond a 16-foot inflatable rescue boat. On the Atlantic Ocean the team staffs a 41-foot vessel with limited firefighting capacity. The vessel is a repurposed Coast Guard Utility Boat (UTB) with 250 gallons per minute fire pump. In the southern regions of the City, a 24-foot fireboat is trailered covering the areas of Back Bay and the Intercostal Waterway. This vessel has firefighting capacity of 500 gallons per minute.

The Virginia Beach Fire Department was first accredited by the Commission on Fire Accreditation International (CFAI) in 2001 and successfully reaccredited in 2006 and 2011. As part of the 2011 reaccreditation process, the Virginia Beach Fire Department conducted a community risk assessment with the primary focus being structural fire risk. Although a marine emergency risk assessment has not been completed for the Virginia Beach Fire Department, the marine program continues to grow. Over the last ten years, the marine program is the fastest changing program in the Virginia Beach Fire Department. In 2011 the program grew from 24 members and one fireboat to 56 members and three fireboats. The growth continues despite not having a firm understanding on the needs and risk associated with the marine environment in Virginia Beach.

The Virginia Beach Fire Department Marine Team is trained in the disciplines of shipboard firefighting, search and rescue, and damage control. The team works alongside other public safety partners such as the Virginia Beach Police Department Marine Patrol and the Virginia Beach Department of Emergency Medical Services Marine Team. This partnership allows several vessels to respond to an emergency as back up to each other. On a regional scale the team is also a member of the Maritime Incident Response Team (MIRT) which is a task force comprised of nine area fire departments, United States Coast Guard, United States Maritime

Administration, United States Navy, Virginia Pilots Association, and the Virginia Port Authority. The mission of MIRT is to provide immediate on-scene resources and agency liaisons to fires and large scale emergencies in the marine environment (Port of Virginia, 2010).

The Virginia Beach Fire Department must be prepared to respond to emergencies occurring on the nearly 250 square miles of water within its jurisdiction. This preparation has occurred in past by obtaining equipment on grants or equipment readily available at little to no cost. Capabilities of the team have come from an adaptation to the equipment not necessary out of the need the risk creates. By performing a marine emergency risk assessment, the Virginia Beach Fire Department will be better prepared to provide a quick and appropriate level of response to these events. Not only will this risk assessment allow the team to be better prepared, it will allow the fire service leaders of the department to make decisions concerning the future of the team based on actual need.

The Executive Fire Officer Program (EFOP) course Executive Analysis of Community Risk Reduction (EACRR) focuses on developing fire service leaders willing to integrate emergency response with prevention measures (Federal Emergency Management Agency, 2015, pp. SM 1-8). This research focuses on assessment which is the second step in the community risk reduction process. This step of the process involves analyzing the community and identifying risks (Federal Emergency Management Agency, 2015, pp. SM 2-4 - SM 2-7). In order for the Virginia Beach Fire Department to develop a plan for risk reduction and response goals for the marine response program, the department leaders need to have a thorough understanding of the risks involved.

The United States Fire Administration (USFA) has established four goals as part of its strategic plan. This research is linked to three of the four goals. By conducting a marine risk assessment the Virginia Beach Fire Department will be able to work towards the USFA goal of reducing life safety risk through preparedness, prevention, and mitigation. Due to complexity of marine emergencies and the number of agencies involved, planning and preparedness along with a coordinated response becomes critical in the outcome of the incidents. This is directly related to the second goal of the USFA to promote response, local planning and preparedness. By identifying the hazards and risks associated with the marine environment, the Virginia Beach Fire Department will be able to better plan future training and equipment needs for the marine team. This planning with help accomplish the third goal of the USFA of enhancing capabilities and responses to all hazards (United States Fire Administration, 2014, pp. 9-13).

Literature Review

Fire service leaders have an obligation to their community to ensure appropriate resources arrive on emergency scenes in an appropriate amount of time. The all hazard approach adopted by many departments has resulted in a deployment model where along with fire suppression resources, other technical resources must be strategically placed around a community. Although fire stations have been built for hundreds of years without much thought to their placement, a more scientific approach is required today (Center for Public Safety Excellence, 2008, p. 11).

There are several reasons to conduct a risk assessment. The Durham Fire Department had increased or reallocated resources based on instinct or opinion. Despite these changes the fire volume in the community remained constant (Sannipoli, 2014, p. 5). The City of Moorhead had never conducted a risk assessment despite having constant issues with flooding. In addition to the flooding the city also had two major rail lines travel directly through the community. These lines regularly carried crude oil and other potential hazardous material. Without an assessment of risk and vulnerabilities, the Moorhead Fire Department could not optimally plan, prepare, or identify the potential hazards (Strangland, 2013, pp. 7-9). Many departments are accredited though the Commission on Fire Accreditation International (CFAI). Part of this accreditation process is to complete a Standard of Cover (SOC) document. The CFAI states in order to save lives and limit property damage, a department must have sufficient resources on scene before the emergency reaches maximum intensity (Center for Public Safety Excellence, 2008, p. 7). Conducting a risk assessment is part of this process and leads to achieving the goal of a measurable decrease in risk.

When conducting a risk assessment it is important to identify the physical risk factors present. The Central Valley Fire District identified the physical characteristics of railroad traffic through the community of Belgrade, Montana. The physical factors identified were average number of trains, cars per train, and passage time. In addition they identified the number of hazmat rail cars traveling through the community in a single year. Looking beyond the trains themselves the tracks were evaluated for condition, maintenance, and how they are affected by the weather (Culbertson, 2013, pp. 18-19). Geography and placement of critical infrastructure are also physical risk factors to consider. The community of Orange County, Florida used the half mile isolation zone recommended by the Emergency Response Guide to determine the critical structures and population density potentially involved with a railway emergency (Saez, 2012, p. 14).

Forsyth County, GA is located on the southern bank of Lake Lanier. When conducting research on how to prevent drowning incidents within the county, the researchers looked at several physical risk factors. The weather in the region was a risk factor to consider since the lake was a popular location to find relief from the hot temperatures. Although the lake is used year around, the weather as a risk factor was confirmed by showing the majority of incidents occurred from Memorial Day to Labor Day. Another factor considered was location of the incidents in the lake. The majority of the drowning incidents occurred in the public parks and not on the open water or boat related. The park with the most incidents was the closest lake destination to the most at risk population (Wells, 2010, pp. 22-23). Unlike the public parks along Lake Lanier, other types of bodies of water are not designed to be used recreationally. Retention and detention ponds are designed to control storm water. The Town of Grand Chute, WI has 349 retention and detention ponds. The physical risk factor evaluated for the ponds was their location in relationship to other structures and people. A circle with radius of 500 feet was drawn from the center of the ponds to determine how many people were potentially exposed to the dangers of them (Hansen, 2011, p. 28).

Organizations completing a Standard of Cover (SOC) document as part of the accreditation process are directed to look at specific physical risk factors. These include anything increasing demand, hindering response, increasing probability, or increasing the consequences of an emergency. Examples of these physical risk factors include geography, topography, transportation network, climate impact, disaster exposure, development and population growth, and personnel resources (Center for Public Safety Excellence, 2008, pp. 24-26).

In order to reduce a specific risk it is important to determine who is most susceptible to the risk. When conducting a risk assessment, the Durham Fire Department looked at historical data and plotted the incidents on a map. They were able to look at the census track having the most fire incidents and extract the demographic data from the census. Cooking fires occurring in one or two family dwellings were the most common fire incident type. These incidents predominantly affected African American males between the ages of 35 to 44 years old. This data was confirmed by comparing it to the literature and national trends (Sannipoli, 2014, p. 34).

Specific to water related emergencies there is a clear racial disparity for drowning victims under the age of 29 years. Researchers gathered data from 1999 through 2010 comparing the drowning rate of individuals under the age of 29 years. The highest occurrence was American Indian/Alaskan Native (AI/AN) at 2.57 per 100,000 followed by blacks at a rate of 1.90 per 100,000. The data for natural waters showed the same trend with whites at the lowest drowning rate of 0.46 per 100,000 and all others including AI/AN, Asian, black, and Hispanic all between 0.55 and 1.22 per 100,000 (Julie Gilchrist & Erin M. Parker, 2014).

The Executive Analysis of Community Risk Reduction course directs students to create a community demographic profile. This profile should include components such as age, gender, race and ethnicity, social and cultural information, income, education, and housing type. The purpose is because risk is often influenced by economic and social factors (Federal Emergency Management Agency, 2015, pp. SM 2-12). The Virginia Department of Game and Inland Fisheries examined recreational boater accidents from 2012. Specific demographics studied were age of the operator, experience level concerning boat operations, and marine specific education. The majority of incidents occurred with experienced operators having over 500 hours of operating time between the ages of 36 to 55 years but lacking specific marine education (Virginia Department of Game and Inland Fisheries, 2016).

Conducting a historical data driven analysis will give a community an insight on the risks present. The three components typically reviewed in order to establish trends and to predict future incidents include call type, location type, and frequency (Center for Public Safety Excellence, 2008, p. 26). The City of Riverside was hoping to better understand the factors contributing to injuries during a residential fire. The first step in their research was to analyze the historic service demands of the fires within the community. Five years of data was broken down to number of residential fires per district, cause of the fires per district, fire casualty by severity, and demographic factors (Schellhous, 2013, pp. 40-47). There are times in which deriving data from historic records could be difficult or impossible. The Vancouver Fire Department received a demotion in their Insurance Services Office, Inc. (ISO) rating after a review of their capabilities determined they had no fire or rescue response to the river and ports in their community. The decrease in the ISO rating resulted in higher insurance premiums for the citizens and businesses. The Vancouver Fire Department began researching an appropriate fire boat. Since the department relied totally on other agencies to handle emergencies on the water, they had no historic data to determine trends. In order to properly design a boat which would suit their needs, they had to look at similar departments historic service demands (Senchyna, 2009, pp. 25-26).

In order for data to be useful in determining trends, it needs to be accurate and consistent. Researchers assumed gathering drowning incident data for Lake Lanier would be simple, however due to inconsistent reporting they were unable to use the information available from their own department. Realizing many agencies report similar data for different reasons, they were able to obtain the needed information by contacting the Amy Corps of Engineers allowing them to determine the where and when these incidents occur (Wells, 2010, p. 20). In Virginia boaters are responsible for reporting certain incidents to the Virginia Department of Game and Inland Fisheries (DGIF). These incidents include any damage over $2,000 to or by a vessel, injuries requiring medical care, loss of life, and disappearance of any person from a vessel. The historic data has been reported using a ten year boating incident report. In this report they document the number of incidents per year and the number of incidents per 100,000 registered boats. They were able to demonstrate a decrease in these incidents after tougher personal watercraft (PWC) laws were passed in 1998 and after the implementation of a mandatory boater safety course in 2009. In addition to the trends a more detailed report was provided for 2012 which included incidents by month, day of the week, and time of day (Virginia Department of Game and Inland Fisheries, 2016).

During a risk assessment a community will often perform a probability and consequence matrix. When analyzing the potential risk of a railway emergency in Belgrade, Montana the researchers looked at a hazardous material release as being the most probable event. This was based on the amount of toxic and hazardous material transported through or around the community. When looking at the details they analyzed the potential risk to the community such as loss of life and acute injuries, and they looked at the impact to the community such as loss of business (Culbertson, 2013, pp. 23-24). Information from a probability and consequence matrix should be easy to understand and be able to be compared to other hazards. The matrix performed by the City of Casa Grande used a system in which the probability level was assigned a number value. Unlikely to occur was given a value of one and highly likely was given a value of three. In addition they evaluated the potential consequence of an emergency in the facility. A high consequence was given a value of three and low consequence was given the value of one. The probability and consequence values were multiplied together for a numeric value of risk rating (LaFalce, 2013, p. 38). The Charlotte Fire Department looked at historical data to determine probability and the number of people affected as the consequence. Specifically three areas of water rescue were considered. Swift water and flooding had the potential of affecting the entire community of 721,000 and had occurred to a significant level 45 times from 1900 to 2004. In contrast surface water and dive rescue operations are probable to happen but typical involve fewer than ten people per incident (Davis, 2008, p. 41).

The Executive Analysis of Community Risk Reduction course teaches a method of categorizing risk into the categories of extreme, high, moderate, and low. The method includes creating a matrix in which the likelihood is deemed in five areas from almost certain to rare. The consequence is separated into the five categories of insignificant, minor, moderate, major, and catastrophic. The level of risk is assigned based on likelihood and consequence (Federal Emergency Management Agency, 2015, pp. SM 2-36). The Commission on Fire Accreditation International (CFAI) uses a probability and consequence quadrant system. This four risk system categories each risk as low, special, medium, and high. For example a low probability event with a high consequence would be deemed a special risk. This is because the low frequency of the incident would likely mean there are few individuals with real life experience on how to handle the emergency (Center for Public Safety Excellence, 2008, p. 28).

Many fire departments around the country are faced will dealing with water related emergencies. These could be the result of flooding, or from the normal use of natural and manmade waterways. The literature review proved to be helpful but did not address many of the concerns or risk specific to the Virginia Beach Fire Department. Since fire department risk assessment for marine emergencies is not a common topic, it was important to review other types of assessments. Information contained in the railway assessments influenced the assessment of the physical risk factors associated with the marine emergencies. The amount of traffic through the shipping channels is related to the traffic on the railways passing through a community. By reviewing information from non-fire agencies, such as the Coast Guard and the Department of Game and Inland Fisheries, this research was steered towards data sources outside the fire service. The literature review also showed there were several methods in determining the probability and consequence of a risk. The goal is to categorize the risks in a method useful to the department and the community. The foundation for this research has been a thorough literature review.

Procedures

Almost half of the area in which the Virginia Beach Fire Department has jurisdictional responsibility is water. The waterways in Virginia Beach are primarily fed through several river systems with the large bodies being the Chesapeake Bay, Atlantic Ocean, and Back Bay. Maps were created in order to obtain a visual representation of the scope of the potential risk. The first map was obtained through the City of Virginia Beach Communication and Information Technology (ComIT) Geospatial Information Services (GIS). A request was made to produce a map in which all layers were removed with the exception of water. The second map was created using the Center for Coastal Resources Management GIS Data and Maps website. The shoreline inventory report for Virginia Beach was selected in the map viewer, and the jurisdiction boundary layer was turned on. The third map was created using the same shoreline inventory report for Virginia Beach on the Center for Coastal Resource Management GIS Data and Maps website and both the jurisdiction boundary and the shoreline layers were selected. Subsequent maps were created by selecting a single layer at a time. These layers included bank height, bank stability, river systems, and tidal marshes.

The next physical risk factor researched was the climate. Monthly average air temperatures were gathered from the Southeast Regional Climate Center website by selecting the Historic Climate Summaries for Virginia link. Three weather stations were selected in order to provide climate information for different regions in Virginia Beach. Diamond Springs station was selected for its proximity to the Chesapeake Bay, Cape Henry station was selected for its proximity to the Atlantic Ocean, and Back Bay station was selected to provide information on the climate in the southern areas of the city. A limitation in gathering this data occurred. The Cape Henry station had no data after 1970. The two other stations provided data from 1953-2012 for Back Bay and from 1971-2000 for Diamond Springs. Therefore only two of the three stations were used to report climate information. Average monthly water temperatures were gathered from the National Oceanic and Atmospheric Administration (NOAA) website. From the NOAA National Centers for Environmental Information (NCEI) webpage, the link for Coastal Water Temperature Guide was selected. Two regions from this guide were used to determine the water temperature of Virginia Beach. The area of the Chesapeake Bay Bridge Tunnel represented the Chesapeake Bay and the area of Virginia Beach, VA represented the Atlantic Ocean. Another limitation occurred because data for average water temperatures for the inland waterways of Virginia Beach were not readily available.

The Virginia Beach waterways are popular for recreational use as well as commerce and commercial use. The next physical risk factor considered was the amount of boater traffic and overall use of the waterways throughout the year. A request was sent in the form of email to the Virginia Beach Department of Commerce requesting the number of boats assessed for personal property tax in the year 2015. This represents the number of boats registered in Virginia Beach with the Coast Guard or the Virginia Department of Game and Inland Fisheries. Passing through the waters of Virginia Beach are the Atlantic Ocean Channel and the Thimble Shoal Channel. These are the access points for commercial marine traffic to enter and leave the Port of Virginia. From About the Port of Virginia webpage, the number of vessel calls per year was obtained by selecting the link to port statistics.

Through observation and local knowledge specific hazards and uses of the waterways in Virginia Beach will be documented. The majority of these known risks have occurred and prompted a response by the marine team from the Virginia Beach Fire Department. Since an after action report is required on all major incidents and encourage on all marine incidents, unofficial documentation on these hazards are available for review.

The second research question concerned the demographics most at risk for marine emergencies in Virginia Beach. Marine emergencies can be thought of as boat related and non-boat related. For boat related emergencies information was gathered from two sources. The first source was from the United States Coast Guard 2012 National Recreational Boater Survey. This document provided information by region on the demographics of recreational boaters including gender, age, type of boat, and activity of the boaters. The second document, the 2012 Recreational Boater Incident Summary, was provided by the Virginia Department of Game and Inland Fisheries. This document included the demographics of incidents and fatalities related to recreational boating including age, type of boat, and activity of the boaters. Together this information could provide insight on the demographics of the individuals boating and those most susceptible to having an incident. An obvious limitation to this data will be from a lack of depth. The statistics obtained are from a single year and will not be able to demonstrate a trend.

Non-boating marine emergencies include drowning and swimmers in distress. Information was gathered on national trend data from the Center for Disease Control website utilizing the Web-based Injury Statistics Query and Reporting System (WISQARS). Data was retrieved showing demographics of drowning deaths of individuals separated by race and ethnicity, age and gender. The population of Virginia Beach demographics was obtained from USA.com in order to compare with the drowning demographic information.

The Virginia Beach Fire Department uses RedNMX as a records management system (RMS). Information entered in the National Fire Incident Reporting System (NFIRS) is stored in the RMS. From the RMS a report query was selected using a limiter of responding apparatus. The report generated date, time, incident number, address, and call type as entered in the NFIRS report. The first query was completed selecting Fire Boat 1 as a responding apparatus for the year 2012. The report query was repeated for Fire Boat 1 for the years 2013, 2014, and 2015. This entire process was repeated for Fire Boat 6 and Fire Boat 12. The information obtained was used to answer the third research question concerning the historic service demand for marine emergencies for the Virginia Beach Fire Department. The incident types were grouped into seven separate categories. These categories were drowning/swimmer in distress, boat in distress/accident, boat fire, land based fire, medical emergency, good intent, and other. The total number of requests for fireboats was broken down into number per month and number per time of day using a two hour interval. There is a serious limiting factor concerning the data available. In order to truly understand the service demand of an incident, the location of the incident is required. All location points in the data entered into the RMS are land based addresses or intersections. The current RMS does not allow for a coordinate system for true identification of incident location. Therefore a swimmer in distress 50 meters from shore could have the same address location as a boating accident two miles off shore.

Using the information from the historic service demand, the forth research question will be answered. For each of the call types identified in the four year data, a probability and consequences matrix will be completed. The process will follow the guidelines of the Commission on Fire Accreditation International using the system with four risk categories. The risk categories will be low, special, medium, and high. A description of each call type will be given with examples and the probability of occurrence will be based on the historic and national trends. The consequence will be based on human, economic, social, political, and environmental factors. The limitation associated with building this matrix will be subjectivity of the researcher. If there is no historic data showing how an incident could affect the community, the assessment will be subjective.

Results

There were four research questions addressed in this study. The first question addressed the physical risk factors associated with the bodies of water in Virginia Beach. This was accomplished by creating maps in order to have a visual understanding of the potential problem. These maps can be found in Appendix A. Much of the focus of marine emergencies centers on coastal water. Virginia Beach, however has 59 square miles of inland water as well (Virginia Beach, VA, 2016). The concern with inland water tends to be proximity to residential neighborhoods which could make it enticing for children to play around the banks of the water. The total amount of shoreline in Virginia Beach is 632.07 miles. Since Virginia Beach is a residential community, it would make sense neighborhoods would be built close to these shorelines. In fact, 222.29 miles of shoreline are in residentially zoned regions. With this fact comes concern on the bank height and stability. The majority of the banks in Virginia Beach are less than five feet and have been surveyed and deemed stable. Of the 632.07 miles of shoreline, there are 571.23 miles of stable banks under five feet (Center for Coastal Resource Management, 2016).

Weather is always a concern and a potential risk factor when considering marine emergencies. Average maximum and average minimum temperatures were obtained from two separate weather station histories. In the southern portion of the city the Back Bay station reported the average temperatures seen in Table 1 for the period of 1953 to 2012 (Southeast Regional Climate Center, 2016). For the northern area of the city the data was collected from the Diamond Springs station and can be seen on Table 2 (Southeast Regional Climate Center, 2016). Although there are some differences between these weather stations, it is clear Virginia Beach has mild winters and warm summers. This climate does not prevent marine activities from happening year around. January and February are the only two months with average lows below freezing, but since the average highs for those months are above freezing, the water in Virginia Beach does not go through a deep freeze. This means there is no ice related marine activities in Virginia Beach, but also means when ponds and lakes do freeze, they have the potential of being break through hazards resulting in an ice rescue.

Table 1

Monthly Climate Summary for Back Bay Station from 1953-2012

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Ave Max Temp (F)	48.4	50.5	58.0	67.2	74.2	82.1	85.9	85.1	79.9	71.0	62.6	53.3	68.2
Ave Min Temp (F)	31.8	33.3	40.0	48.3	57.4	66.3	70.7	70.2	66.2	56.3	46.1	37.0	52.0

Table 2

Monthly Climate Summary for Diamond Springs Station from 1971-2000

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Ave Max Temp (F)	47.7	49.5	58.9	67.1	74.1	81.1	85.9	85.5	80.3	70.0	59.2	53.5	67.9
Ave Min Temp (F)	30.1	31.2	39.5	47.2	56.3	63.9	68.8	68.5	63.2	51.5	41.1	35.2	49.9

In order to understand the climate risk of marine emergencies it is important to look at the water temperature. The average water temperatures were gathered from a report available from National Center for Environmental Information (NCEI). The information available was from the coastal waters of the Chesapeake Bay and the Atlantic Ocean. These averages can be seen in Table 3. There is always a concern when the air temperatures began rising but the water temperatures are still low. This data shows a potential concern during the months of March through May when a few warm days might encourage marine activity in cold water.

Table 3

Average Costal Water Temperature for the Chesapeake Bay and Atlantic Ocean

	Average Water Temperature (F)	
	Chesapeake Bay	Atlantic Ocean
Jan	46	55
Feb	42	53
March	44	48
April 1-15	56	50
April 16-30	57	53
May 1-15	62	58
May 16-31	66	60
June 1-15	71	70
June 16-30	74	73
July 1-15	77	76
July 16-31	78	78
Aug 1-15	79	80
Aug 16-31	78	81
Sept 1-15	78	75
Sept 16-30	75	72
Oct 1-15	66	70
Oct 16-31	62	67
Nov	56	60
Dec	49	60

In an attempt to understand the amount of boating activity in Virginia Beach, the total number of registered boats was obtained. Deputy Commissioner of Revenue Denise S. Dunthorn reported in the 2015 tax year 13,921 boats were assessed (personal communication, April 1, 2016). In addition to the recreational boats on the water, Virginia Beach serves as a gateway to the Port of Virginia for commercial container ship traffic. From 2012 through 2015 the port has averaged 1,946 ship calls per year. The data suggested a steady flow of ships in and out of the port and does not appear to be seasonal or vary different times of the year. This results in an average of just over five large container ships passing though Virginia Beach waters each day to enter the port (Port of Virginia, 2016). Since a ship call is defined as entering the port, the number of ships passing through the channels is double this number as they are leaving.

The Lynnhaven River empties into the Chesapeake Bay. This waterway in Virginia Beach is very popular among boaters. There are several large marinas along the river with deep water access to the bay. Known hazards in this area include shoals just outside the channels. These shoals could be sand or oyster beds and often cause significant damage if hit. In addition, due to calm waters, this body of water is very popular and the increased boating traffic alone presents a hazard. All recreational activities are popular on the Chesapeake Bay including paddle boarding, swimming, tubing, and fishing.

The Atlantic Ocean is the popular swimming location with the resort beaches. Outside the surf and swim area most boating traffic is large commercial boats. This is a popular location for dolphin watching and tours resulting in large amounts of people per vessel. Also many small boats, personal watercraft, and paddle boarders will use the water just outside the surf and swim area. The Atlantic Ocean is a location in which many marine emergencies can occur due to the number and variety of activity occurring just off the coast.

The southern region consists of Back Bay and the Intercostal Waterway. These areas are very popular with hunters during the fall and winter. Back Bay has many hazards related to duck hunting. Often a hunter will cut their blind after it is no longer useful leaving large amount of debris just under the surface. In addition it is difficult to navigate due to a lack of markers and reference points. The Virginia Beach Fire Department Marine Team has responded to several search and rescue (SAR) incidents in which boaters became disoriented and could not find their way back.

The results gathered from the multiple sources have provided an insight on the first research question. Although the water itself is a risk factor there are many properties unique to the different waterways making them a potential hazard. As recorded by the sheer volume of water present and the amount of shoreline in Virginia Beach it obvious everyone has the potential to be exposed to the hazards. A positive factor noted was the height and quality of the banks. These are primarily inland areas with increased traffic of people who are not intending to get in the water. The stability of the banks increases safety. The weather was a physical risk factor considered and deemed an issue especially when air temperatures increase but the water temperatures remain low. Any incident on the water could have a high consequence if the individuals are not prepared for cold water survival. The number of boats registered in Virginia Beach is not a good indicator of the boat traffic or waterway use. It is likely all boats registered in Virginia Beach are used in Virginia Beach waters, however since the city is a popular tourist attraction it can be assumed there is an increase in boats on the water which are not registered in the city. This number would be difficult to determine and was not estimated as part of this research. Additional risk factors considered were uneven bottom in the inland water, the Chesapeake Bay and along the shore. These shoals could be dangerous. These hazards are typically marked on charts, however debris could cause a hazard and not be reported. Navigating certain areas of Back Bay and other inland water is difficult and considered a physical risk factor to those bodies of water. Virginia Beach waters are suitable for several different water activities. The variety of activities on the water became an additional risk factor considered in this research.

The second research question was to determine the demographics most risk at for a marine emergency in Virginia Beach. Recreational boaters make up a large portion of the risk especially during the summer months in Virginia Beach. Information from a 2012 recreational boater survey conducted by the United States Coast Guard was used to establish a boater demographic profile. Using the information for the southern region of the United States the profile was constructed using gender, age, boat type, and boating activity. The two largest age group of boaters consisted of adults from the ages of 16-24 years at 17.4% and 45-54 years making up 17.1% of the boat users in the southern region. These boaters were primarily male making up 56.7%. Power boats were the predominant boat type at 72.2%, and the top three boating activities were socializing, relaxing alone or with friends, and sightseeing (United States Coast Guard, 2016).

The Virginia Department of Game and Inland Fisheries compiled a report of recreational boater incidents and fatalities. The latest report available is from 2012, and data from this report was used to build a demographic profile of boaters who are most at risk for a boating incident. The largest age group of the operator involved was from 36-55 years making up over half of the incidents. The activity reported during an incident was primarily cruising, although fishing was the number one activity when a fatality was involved. The largest percentage of vessel types involved in an incident was open motorboat (Virginia Department of Game and Inland Fisheries, 2016).

The Center for Disease Control Web-based Injury Statistics Query and Reporting System (WISQARS) was used to obtain the demographics of drowning victims in the southern region of the country. Rates were reported as number of fatalities related to drowning per 100,000 of the population. The primary race affected by drowning was black at a rate of 1.50. Men died in drowning incidents at a rate of 2.18 compared to women at 0.58. Table 4 displays the data when separated by age groups. This information can be compared to similar demographics of the community. Age, race, and gender demographics were obtained from USA.com. Virginia Beach contains 49.12% male and 50.88% female population. The races are white 68.12%, black 19.18%, Hispanic 7.22%, Asian 6.49%, and Native American 0.43%. The breakdown of the population by age can be seen in Table 5 (USA.com, 2016).

Table 4

Rate of Drowning Fatalities for Both Sexes and All Races by Age Group

Age Group	Crude Rate
00-04	3.08
05-09	0.84
10-14	0.61
15-19	1.49
20-24	1.59
25-29	1.39
30-34	1.12
35-39	1.1
40-44	1.13
45-49	1.26
50-54	1.48
55-59	1.41
60-64	1.28
65-69	1.15
70-74	1.42
75-79	1.34
80-84	1.71
85+	1.7
Total	1.37

Table 5

Age Group Population of Virginia Beach

Age Group	Population	Percent of Population
Under 5	29,747	6.68%
5 to 9	28,282	6.35%
10 to 14	28,517	6.40%
15 to 19	28,743	6.45%
20 to 24	35,682	8.01%
25 to 34	72,362	16.24%
35 to 44	58,437	13.11%
45 to 54	63,066	14.15%
55 to 64	49,975	11.21%
65 to 74	29,109	6.53%
75 to 84	15,490	3.48%
85 and over	6,213	1.39%

This information was used to answer the second research question. It is interesting to note for drowning victims age seems to be a factor. The very young and the elderly are most at risk. This data does not separate location of the incident. Although drowning anywhere is a community problem, this research address emergencies in the marine environment. It is clear Virginia Beach contains a similar demographic profile as those at risk for marine emergencies. The highest age concentration in Virginia Beach is the same age most likely to be engaged in boating activities. The data does not show the demographics of the 12-million day and night visitors to Virginia Beach on an annual basis. There is also no data to support if marine emergencies involve local residents or visitors. The data does indicate minorities of any age are at a higher risk of drowning. Adults from 35-45 years are at risk for boating incidents, but it appears to be more related to the activity and skill level of the operator than any other demographic characteristic.

Research question three concerned the historic service demand of the Virginia Beach Fire Department. It was determined the service demand was any call for service of any one of the three fireboats in the Virginia Beach Fire Department. The data was retrieved from the records management system (RMS) using the responding units of Fireboat 1, Fireboat 6, and Fireboat 12 as the search criteria. This information was retrieved for the years 2012-2015 and categorized by call type. The call type was separated into seven areas using the National Fire Incident Report System (NFIRS) incident type as a reference. Swimmer/drowning is used for any incident in which a confirmed drowning was present or a swimmer was in distress and required removal from the water. This call type also included searching for missing swimmers. Boat accident/distress is used for any incident in which a vessel was involved in an accident or become disabled and requested emergency assistance. EMS call on water involves any incident in which the request for emergency service for an injury or illness was not a result of drowning or an accident. Boat fire is used for any incident in which a vessel in the water is on fire. This could be out to sea or secured to a dock. The land fire/marine access is used for any incident in which a fireboat assisted in a land fire. Common examples may include brush fires and house fires along the water. Good intent calls are those in which a call for service has been requested, however, once on scene it has been determined there was no emergency. The other category is used to capture information not typically available as a NFIRS code. Common calls in this call type include assisting the Coast Guard and the Port of Virginia with clearing the shipping channels following a storm. This information is available in Table 6. In addition to call type, the data was also categorized in a chronological manner by dividing the calls for service by month as seen in Table 7 and by time of day in 24-hour format as seen in Table 8.

Table 6

Historic Service Demand of the Fireboats for the Virginia Beach Fire Department by Call Type

Call Type	2012	2013	2014	2015
Swimmer/drowning	39	33	43	28
Boat accident/distress	24	38	45	34
EMS Call on water	61	42	35	33
Boat Fire	8	3	5	5
Land fire/Marine access	2	2	2	4
Good Intent	92	67	76	81
Other	29	28	36	17
Total	255	213	242	202

Table 7

Historic Service Demand of the Fireboats for the Virginia Beach Fire Department by Month

Month	2012	2013	2014	2015
Jan	9	9	12	7
Feb	2	3	12	4
March	10	7	9	9
April	14	9	8	19
May	16	28	31	25
June	51	31	52	29
July	63	38	50	36
Aug	37	37	26	25
Sept	21	21	19	19
Oct	15	15	9	7
Nov	7	5	8	9
Dec	10	10	6	13
Total	255	213	242	202

Table 8

Historic Service Demand of the Fireboats for the Virginia Beach Fire Department by Time

Time of day	2012	2013	2014	2015
0601-0800	4	7	1	11
0801-1000	35	9	15	13
1001-1200	24	24	31	18
1201-1400	33	30	25	28
1401-1600	54	35	38	25
1601-1800	25	29	38	24
1801-2000	35	35	44	43
2001-2200	22	23	22	13
2201-0000	6	12	9	11
0001-0200	5	2	5	4
0201-0400	6	3	10	7
0401-0600	6	4	4	5
Total	255	213	242	202

Information concerning the service demand history not available for evaluation concerned case locations. The address points entered into the RMS were all land based addresses, typically the location a land based fire apparatus would respond to gather further information. There is no data which gives true location of incident types. This means a fireboat could respond 50 meters off shore or two miles off shore and be given the same address.

The information obtained in these results has answered the third research question. The busy months are the warmer ones with increased use of the waters. It was interesting to view the calls separated by time of day indicating most incidents occur in the daylight hours into the evening. As stated earlier, information on exact incident location and a thorough evaluation of the times associated with each incident will provide a better service demand history for the marine environment.

The final research question addressed the issue of probability and consequence for marine emergencies in Virginia Beach. Each of the seven call types were looked at individually, and a probability and consequence matrix was completed. Based on the historic data a probability of high was assigned to the call types swimmer in distress/drowning, boat in distress/accident, good intent, and other. Land fire and boat fire were both assigned a low probability of occurrence. Low consequence was assigned to land fires, swimmer in distress/drowning, boat in distress/accident, and good intent. Both boat fires and other calls were designated as high consequence.

Further separation of call types is needed to better understand the probability and consequence. For example the call in the other call type category include hazmat incidents on the water, search for hazards to navigation, and vehicle accidents involving water. The Virginia Beach Fire Department Marine Team is often called to assist the Coast Guard with clearing the shipping channels. This may occur after a storm or after an incident in which an item large enough to cause an obstruction had not been located. These incidents happen at a regular occurrence due to the amount of marine traffic through the channels. According to Director William Burkett of the Port of Virginia Maritime Incident Response Team (MIRT) if the Captain of the Port is forced to close a shipping channel due to hazard to navigation, the port can lose $1,000,000 every hour a ship is forced to stay in the anchorage (personal communication, February 2, 2016). This has great potential to have a major economic and political impact and is the reason for the high consequence designation. Furthermore, incidents involving a hazardous material become extremely difficult to control in the open water and could have a significant environmental impact.

An explanation is needed to clarify the classification of land based fires. Currently a fireboat is not on the response matrix for building fires near the water. The firefighters assigned to the fireboats are cross-staffed with fire trucks as well. Therefore, unless a fireboat is already on the water, it is not likely they will be called to a structure fire. The consequence is low because those fires are handled by land based fire units. There are times, however when a brush or marsh fire requires the use of a fireboat for access. These fires have a low consequence due to their locations and they are unlikely to spread to structures. The exception to this classification for land based fires deal with marinas. Marina fires are low probability in Virginia Beach as evident by the service demand history. These fires, when they do occur can have serious economic, environment, and human consequences. Therefore marina fires will be looked at separately from other land based fires utilizing a fireboat.

Boat fires are not common in Virginia Beach. Due to this low probability there is also very little data to define this risk. There are also many variables to consider. A fire on an abandoned boat near shore is not a serious incident as compared to the consequence of a fire on a container ship three miles off shore. Even a fire on a recreational boat just off shore poses significant human and environmental consequences thus earning a high consequence label.

A recreational boat carrying less than six passengers has a different consequence in an accident than a sightseeing vessel with 100 passengers. Much like mass transit accidents are categorized differently than passenger vehicle accidents, this distinction should be made for marine accidents as well. Recreational boats in distress or ones involved in an accident carry a low consequence simply due to the number of people affected. These accidents could be upgraded based on fuel spill, location, and current sea state as it could pose an additional risk to the responders. Commercial vessels involved in an accident will be looked at separately and will be labeled with a high consequence designation due to increased people involved and increased danger to the responders.

The Virginia Beach Fire Department Marine Team responds to a large amount of calls on the water deemed to be a good intent. These calls are very common and do not necessary pose a very high consequence. The consequences are limited to the responders and the fact since the fireboats are cross-staffed, while on the water a fire truck is out of service. These types of calls were given a low consequence designation.

Using the quadrant system, call types are categorized in relation to their probability and consequences. Low risk is defined as low probability and low consequence. Special risk is a low probability event with a high consequence. High probability and low consequence events are medium risk. High risk events are those with a high probability and high consequence (Center for Public Safety Excellence, 2008, p. 28). Different call types can be seen in the four risk categories in Table 9.

Table 9

Risk Classification for Marine Emergencies in Virginia Beach

	Low Risk	Special Risk	Medium Risk	High Risk
Incident Type	Structure fires near the water	Boat fires off shore	Swimmer in distress	Hazard to navigation in the shipping channels
	Brush fires near the water	Marina fires	Drowning	Hazardous material release on the water
	Vehicle accidents involving water	Boat accident with more than 6 passengers	Boat accident with less than 6 on board	
		Aircraft accidents on the water	Good Intent	
		Medical call on the water greater than 3 miles off shore	Medical call on the water less than 3 miles off shore	

The fourth and final research question has been answered using the probability and consequence matrix. It should be noted the designations were given based on a comparison of other marine emergencies. Any incident on the water becomes more difficult, complex, and dangerous than a similar incident on land. There are limited resources and based on location the additional resources may not be readily available.

Discussion

The City of Virginia Beach contains a great deal of natural water. In fact nearly half of the area covered by the jurisdiction is water. This includes ocean, bay, lakes, rivers, and ponds. The Virginia Beach Fire Department has a marine team spread through three stations and 56 members. The team has grown rapidly over the past several years with increased training, equipment, and personnel. This growth was not the result of a formal risk assessment of the marine environment. This research focused on identifying components of a risk assessment for the marine environment in the City of Virginia Beach in order to better manage the growth and understand the risk. Using descriptive methodology this research attempted to identify the physical risk factors associated with the bodies of water in Virginia Beach, identify the demographics of those most at risk to marine emergencies, identify the service demand history of the marine team, and identify the probability and consequences of marine emergencies in Virginia Beach.

Several physical risk factors were identified for the bodies of water in Virginia Beach. One factor was the amount of shoreline present throughout the city. With 632.07 total miles of shoreline throughout the community it was obvious all residents were at some level of risk for marine emergencies. The Town of Grand Chute built retention and detention ponds to control storm water run-off. They were successful but in doing so created an additional hazard for the community. These ponds were located throughout the community and presented a significant drowning risk. Through an analysis it was determined any structure within 500 feet of the ponds were at risk. The structures with the most exposure to the ponds were one- or two-family dwellings (Hansen, 2011, p. 41). Virginia Beach has 222.29 miles of shoreline through areas zoned as residential. This results in a similar drowning risk to the citizens in Virginia Beach.

One component of the retention and detention ponds evaluated was the bank. These ponds were built with standards assuring a safer pond and a method to decrease erosion. The bank of the ponds should not exceed a 3:1 vertical slope (Hansen, 2011, p. 39). From a functional and environmental aspect a pond or shoreline with the ability to resist erosion is desirable. Those shorelines are considered stable and could provide a safety measure for citizens walking around the edge of the waterway. The majority of the shoreline in Virginia Beach is considered stable with 571.23 miles being classified as under five feet high and stable (Center for Coastal Resource Management, 2016).

Weather is a risk factor to consider in marine emergencies. Virginia Beach has mild winters with average low temperatures rarely dropping below freezing. The weather makes marine activities possible year around although they are more popular during the summer months. Weather as a risk factor is usually considered when there is a possibility of severe weather. The statistic show the nice weather may actually be a contributing factor to marine incidents. The 2014 statics for the United States showed the majority of the marine incidents occurred in calm waters with waves under six inches, wind was 0-6 miles per hour, visibility was good, and water temperature was between 70 and 79 degrees Fahrenheit (United States Coast Guard, 2015, p. 27). These statistics also indicated the number one incident type was collision with another vessel. The month with the most incidents was July and the time period in which these incidents occurred was from 2:30 pm to 4:30 pm (United States Coast Guard, 2015, p. 28). This information is a validation of the information obtained in this research. For the four year period the historic service demand for the Virginia Beach Fire Department Marine Team was highest in the month of July and busiest from 2:00 pm to 4:00 pm. This would indicate the most likely and predictable risk factor is increase usage of the water in Virginia Beach. The weather can be an asset in predicting the usage by determining when the conditions are ideal for marine activities.

Often when evaluating risk it is easy to focus on the large scale events. The shipping channels along the coast of the Atlantic Ocean and the Chesapeake Bay host traffic from around the world as the container ships enter the Port of Virginia. These ships could contain hazardous material but historically have rarely had an incident. This is similar to researches in Orange County evaluating the risk of railroad traffic. Although the commercial trains carrying hazardous material seem like a greater threat, the more likely incident was found to be the passenger trains (Saez, 2012, p. 18). Marine emergencies along the Virginia Beach waters are primarily recreational boaters and swimmers. With this information it was possible to determine the demographics of people involved in marine incidents. Knowledge of at risk groups will assist the community with targeted preventive measures. Each January members of the Virginia Beach Marine Team set up a booth at the Mid-Atlantic Boat Show and Expo. They have a booth beside the Virginia Beach Marine Patrol from the police department, the Department of Emergency Medical Services Marine Team, and the Coast Guard Auxiliary. The purpose is to discuss safe boat practices and steps to perform in a marine emergency. It is a method to target the demographic most at risk of a boating emergency. This research validates the task. As stated the majority of the incidents will not involve commercial vessels, but will involve the recreational boaters.

When evaluating the fire risk in City of Durham the type of incident, the location, and the time of day was all closely reviewed. Information on location allowed the researcher to isolate the most common building type, zip code, and fire district (Sannipoli, 2014, p. 32). There are several reasons why it is necessary to obtain this information. The first one is by understanding where the events are occurring it is possible to gather demographic information. In addition to demographics, geographic knowledge of incident types could help department leaders re-allocate resources as needed to meet the needs of the community. This information can lead to establishment of goals concerning response times and on-scene times of needed equipment and personnel (Strangland, 2013, p. 32). It was not possible to gather this information during this research. The Virginia Beach Fire Department does not have a system in place to document actual locations of marine incidents. Addresses attached to the reports are land locations usually the spot of the caller or the closest access point for the marine team. There has also not been a method to document benchmark times to determine response goals for the marine emergencies. This information has proved useful for other risks assessments and is needed for further understanding of marine emergencies in Virginia Beach.

There is an inherent risk each time the marine team gets underway for an incident. A cardiac event on a boat has a level of risk higher than a cardiac event in a residential dwelling. Responding crews must take everything into consideration. Prior to responding, the officer will conduct a risk benefit analysis. This is a formal action and will result in a number given before going underway. The process is adopted from the Coast Guard and uses a color system to determine whether a response is possible. Several factors will be weighed and the score will put the responders in green, amber, or red (GAR). The aspects evaluated in obtaining a GAR score include planning, event complexity, asset selection, communications, and environmental conditions (United States Coast Guard, 2009). As emergency responders it is difficult to plan ahead for an event. However by performing a risk assessment the agency is attempting to predict an event prior to it occurring. It is impossible to predict all the conditions associated with an emergency. Part of the GAR worksheet includes steps to take if the score is deemed excessive. Acceptance of the risk is one of the steps if all other things are not possible. The reason to accept the risk would be because the level of the consequence is known. This is another reason it is critical to perform a probability and consequence matrix. There may be situations where the benefit might justify the risk, and knowledge of this prior to an incident will allow the decision makers to make educated choices.

Based on the review of the literature, analysis of the data obtained from this study, and personal observations, an interpretation can be formed. Virginia Beach is at risk for marine emergencies of different types. Over the past several years, based on the risk assessment and the Standard of Cover document produced, specific goals have been set. These goals have focused on the fire risk and the ability to get an effective response force (ERF) on scene in a set amount of time. The Virginia Beach Fire Department is dedicated to ensure a quality response for the community it serves. Contained in the SOC is information related to marine and waterway emergency. There is no real assessment of potential risk, simply a description of the waterways and access points for boaters (Virginia Beach Fire Department, 2011, p. 165). The type of risk mirrors those risks associated with communities on the land. There is a potential for fire, EMS, hazardous material release, accidents, and mass casualty events. The predominant threats by probability include drowning, boating accidents, and medical calls on the water. Until a thorough analysis of location can be completed it is difficult to determine ERF goals. Like most risk in a community it is apparent based on the data the marine risk is seasonal. The consequence of an incident remains the same or even increases with the colder temperatures, but the probability decreases during the winter months. The Virginia Beach Fire Department Marine Team is cross-staffed with fire apparatus. In order for a fireboat to get underway, a fire apparatus is placed out of service. During certain holidays the department increases staffing in order to put the boats on the water during increased boater activity. This model was adopted based on instinct and not with a review of the service demand. The data clearly shows in increase in incidents with an increase in boat activity. There is really no method to track boater activity other than observation.

The Virginia Beach Fire Department is dedicated to limiting risk in the community. The department leaders have produced a risk assessment and SOC document. This study will allow the risk assessment to grow and include the risks associated with the marine environment. The information gathered in this study can assist the department with making sound decisions based on data in order to provide quality service to the community while being a good steward of the taxpayers' money. Further organizational implication include the ability to procure marine equipment based on the risk assessment, focused training at specific risk levels, and a potential re-allocation of resource after more data is collected concerning time and location of incidents.

Recommendations

With a more thorough understanding of risk for the marine environment, the Virginia Beach Fire Department will be better prepared to respond to emergencies. This preparation is due to increased knowledge of the demographics involved, specific physical risk factors of the marine environment, service demand history distribution, and types of calls associated with different risk levels. Not only will this information serve to better prepare the responders, information from this study should be used to help prevent emergencies. For example reducing the false calls and good intent incidents could decrease the risk to the responders. An example of using trends to reduce risk can be found in the actions taken by the Commonwealth of Virginia. After a record year of incidents involving personal watercrafts (PWCs) tougher laws were passed related to who could use them. The next several years saw a steady decline in those emergencies. Also passed in 2009 in Virginia was a phased in mandatory boater education course. The phase in took several years, each year the number of water related incidents decreased (Virginia Department of Game and Inland Fisheries, 2016).

In order to make the most of this research, the Virginia Beach Fire Department will need to create a method to track incident location. This could be accomplished by marking GPS coordinates on scene and adding them to the case address. A look into the records management system's capabilities will be required. In addition to case location, benchmark times will be needed in order to better explain the man hours involved in marine cases. This research did not address time for the incident because the data was unreliable. Defining turnout time, underway time, enroute time, and on-scene time will greatly improve the ability to establish goals for better service delivery.

Future studies should look outside the fire service for data concerning use of the waterways in the community. Fire departments respond to calls for service but do not tend to patrol the waters. Law enforcement agencies patrol, inspect, and document the encounters. These agencies in Virginia include the Coast Guard, Virginia Marine Resources Commission (VMRC), Virginia Department of Game and Inland Fisheries (DGIF), and the local police department marine patrol. Each agency has different interactions with the marine community and patrol with different goals in mind. The information collected could provide a better understanding of peak use, safety violations, size of vessels, and number of people on board. All this information could lead to a more complete risk assessment.

The literature review indicated many departments conduct a risk assessment in order to better allocate resources. This research has provided a stepping stone for the Virginia Beach Fire Department to reevaluate the marine program to ensure resources are adequate for the risk levels. This process needs to be constant. Whether this research is used by other departments or the Virginia Beach Fire Department, there needs to be a constant reevaluation to ensure risk levels have not changed and the department is serving the community as expected.

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Appendix A: Maps

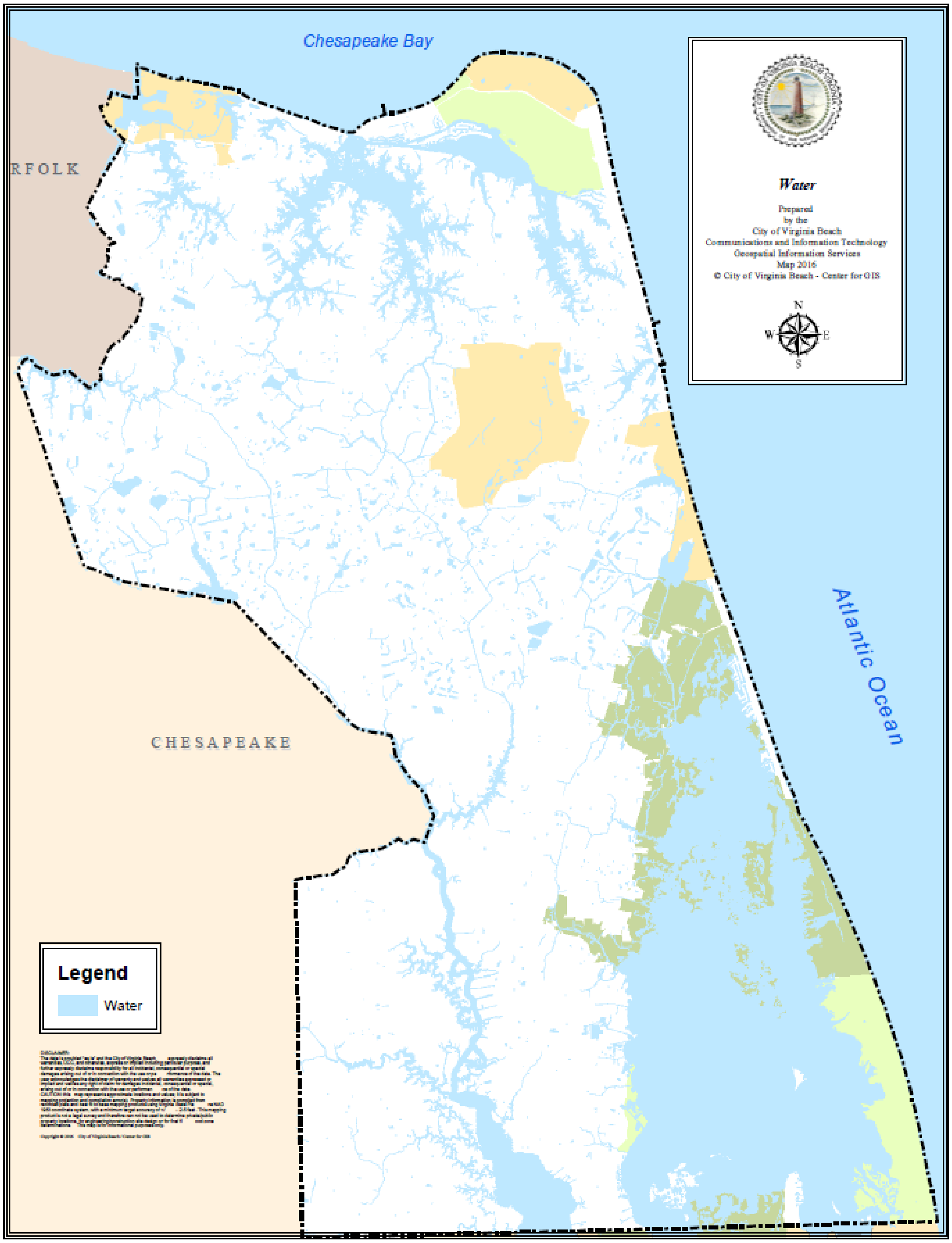

Figure 1. Visual representation of the amount of water located within the boundaries of the City of Virginia Beach.

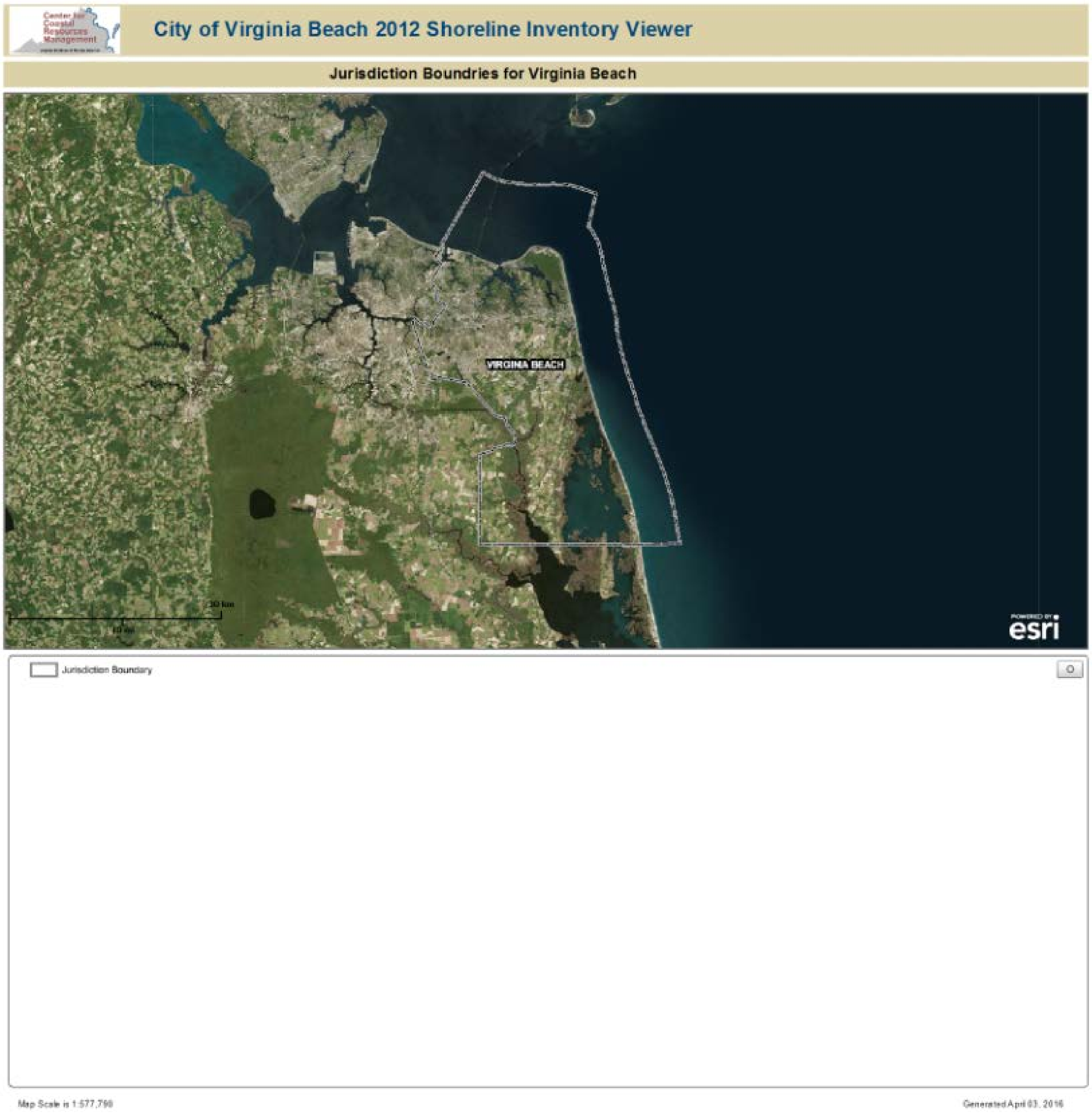

Figure 2. Map of Virginia Beach showing the jurisdiction boundaries off the coast (Center for Coastal Resource Management, 2016).

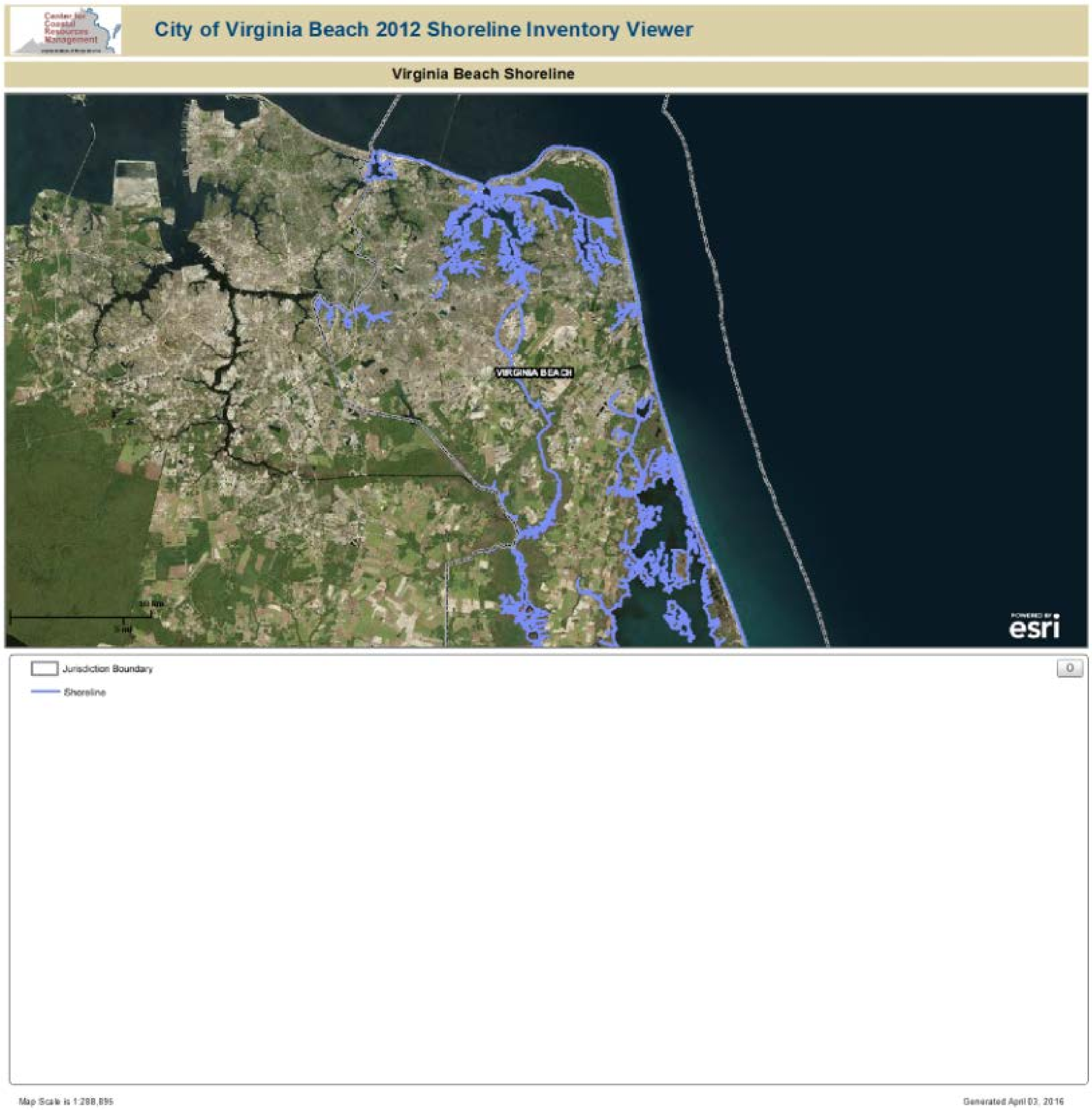

Figure 3. Map showing the shorelines of Virginia Beach (Center for Coastal Resource Management, 2016).

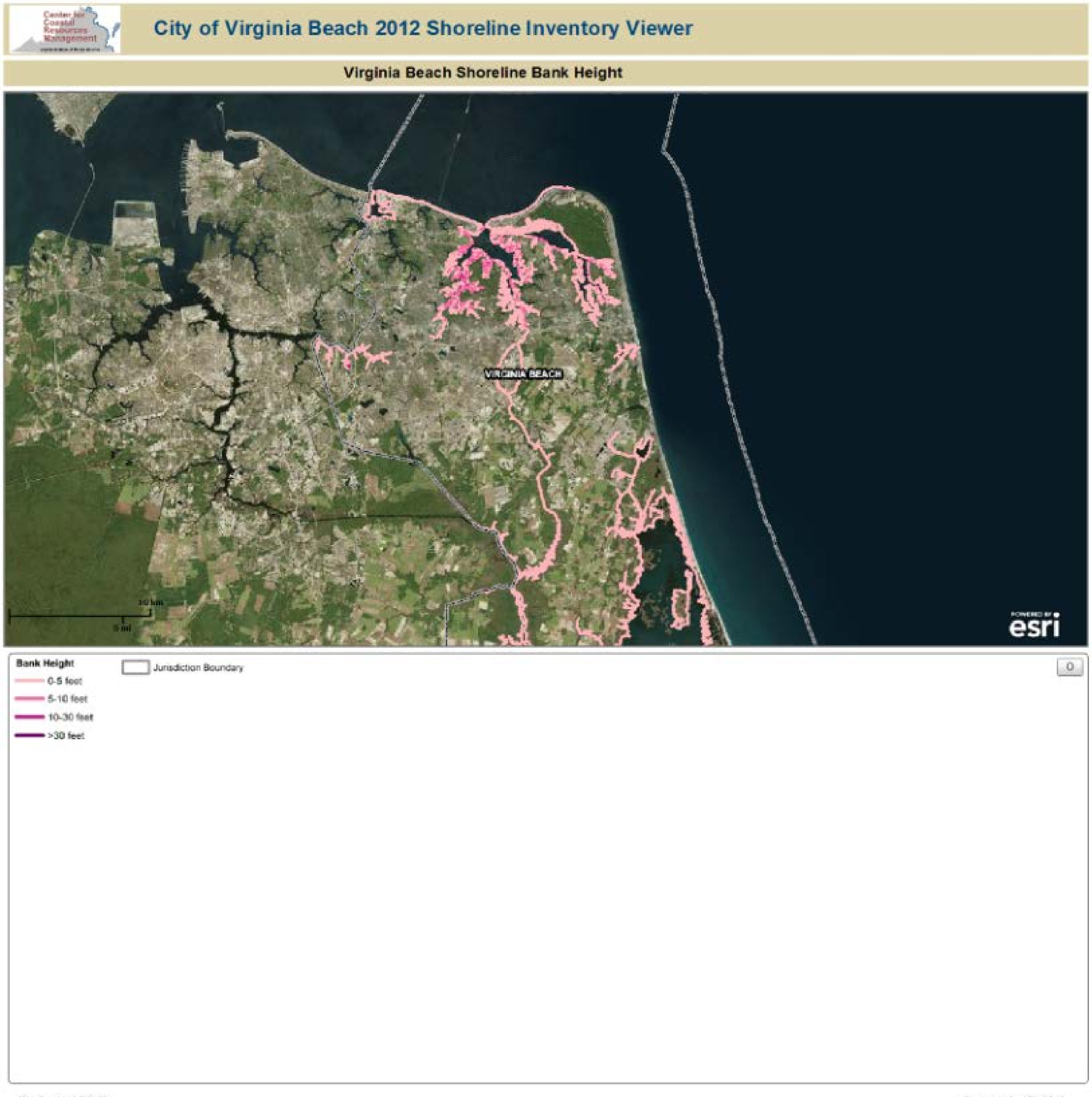

Figure 4. Map showing the height of the bank for the shorelines in Virginia Beach (Center for Coastal Resource Management, 2016).

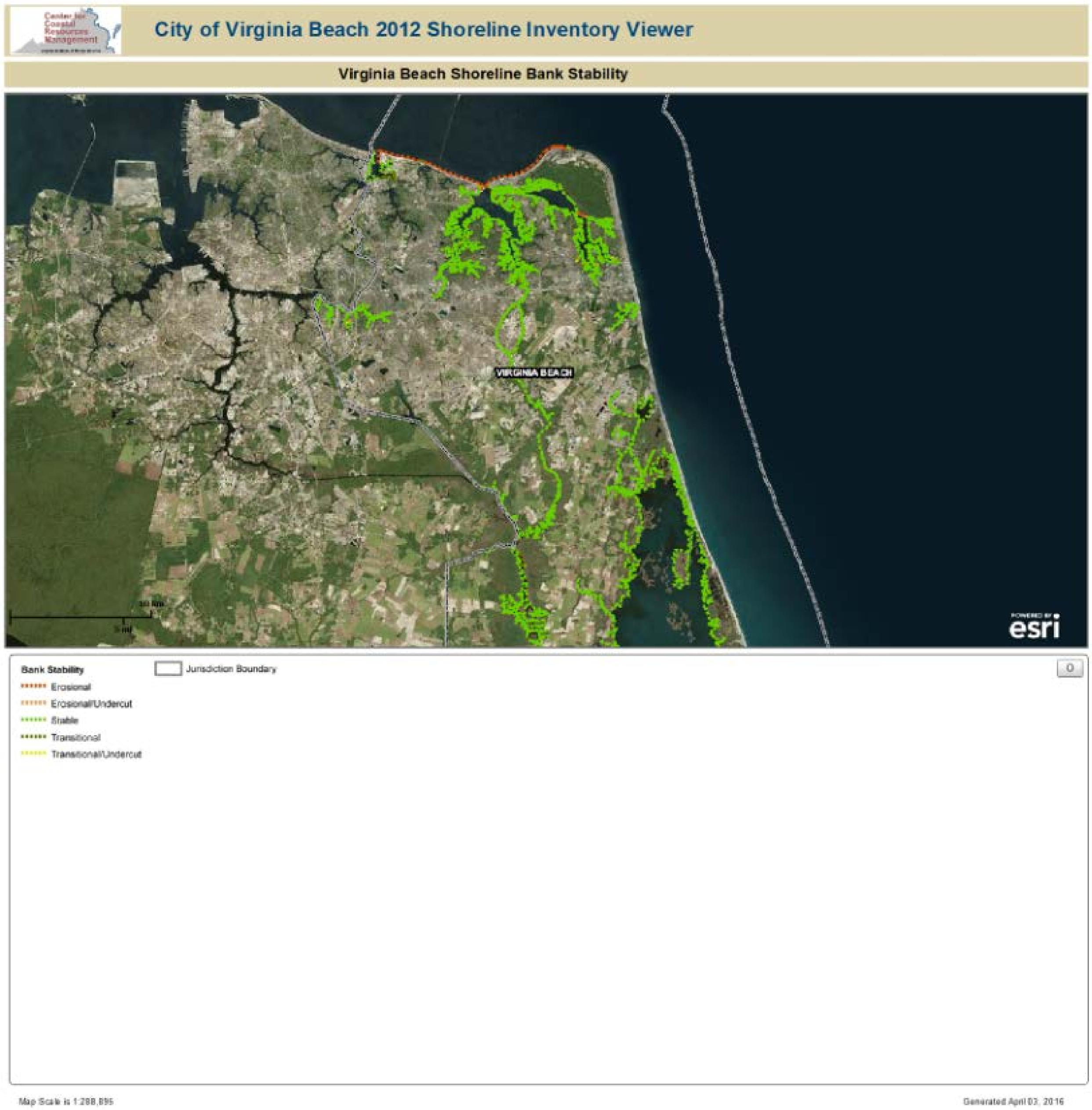

Figure 5. Map showing the stability of the shoreline in Virginia Beach (Center for Coastal Resource Management, 2016).

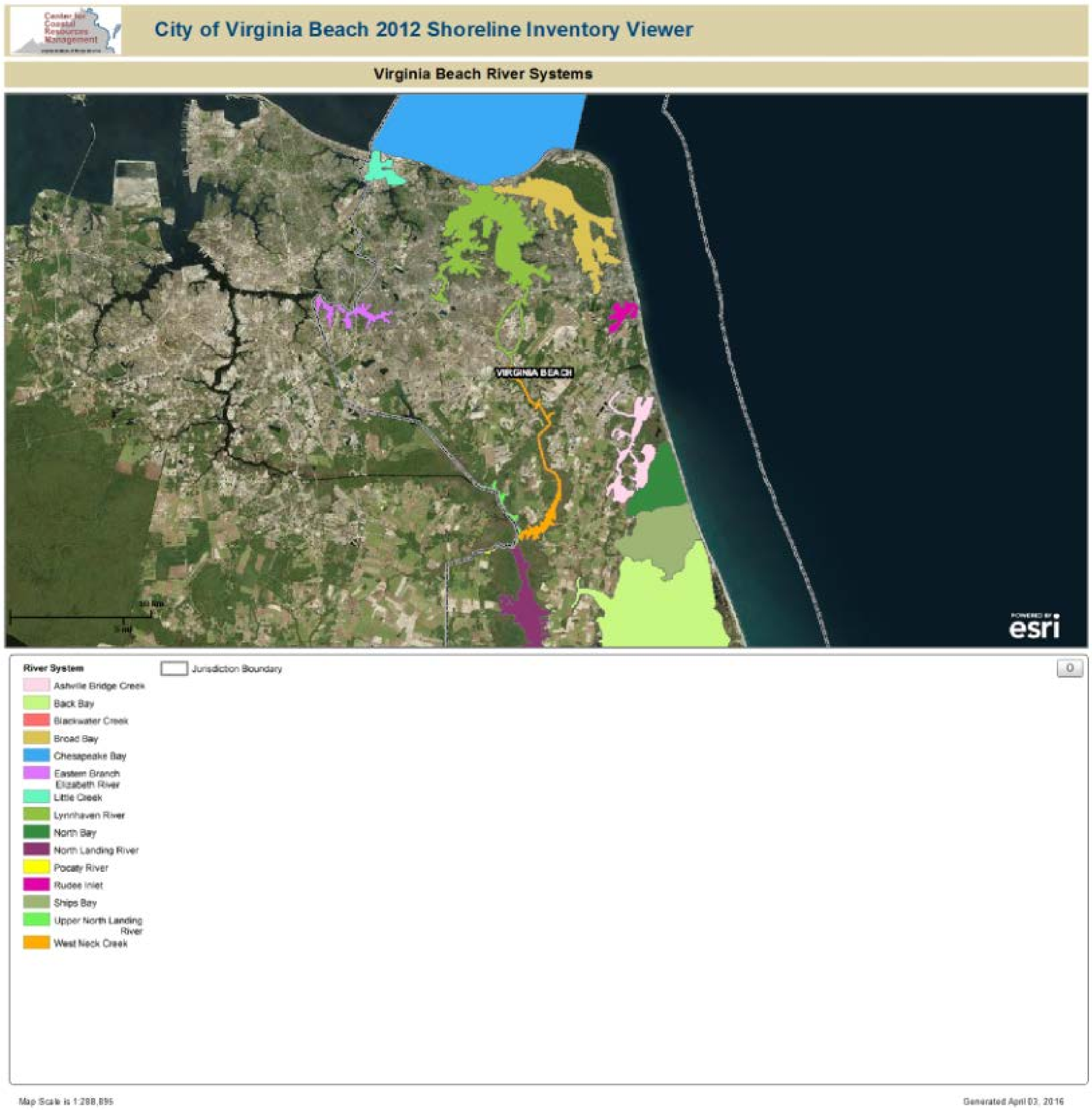

Figure 6. Map showing the river systems in Virginia Beach (Center for Coastal Resource Management, 2016).

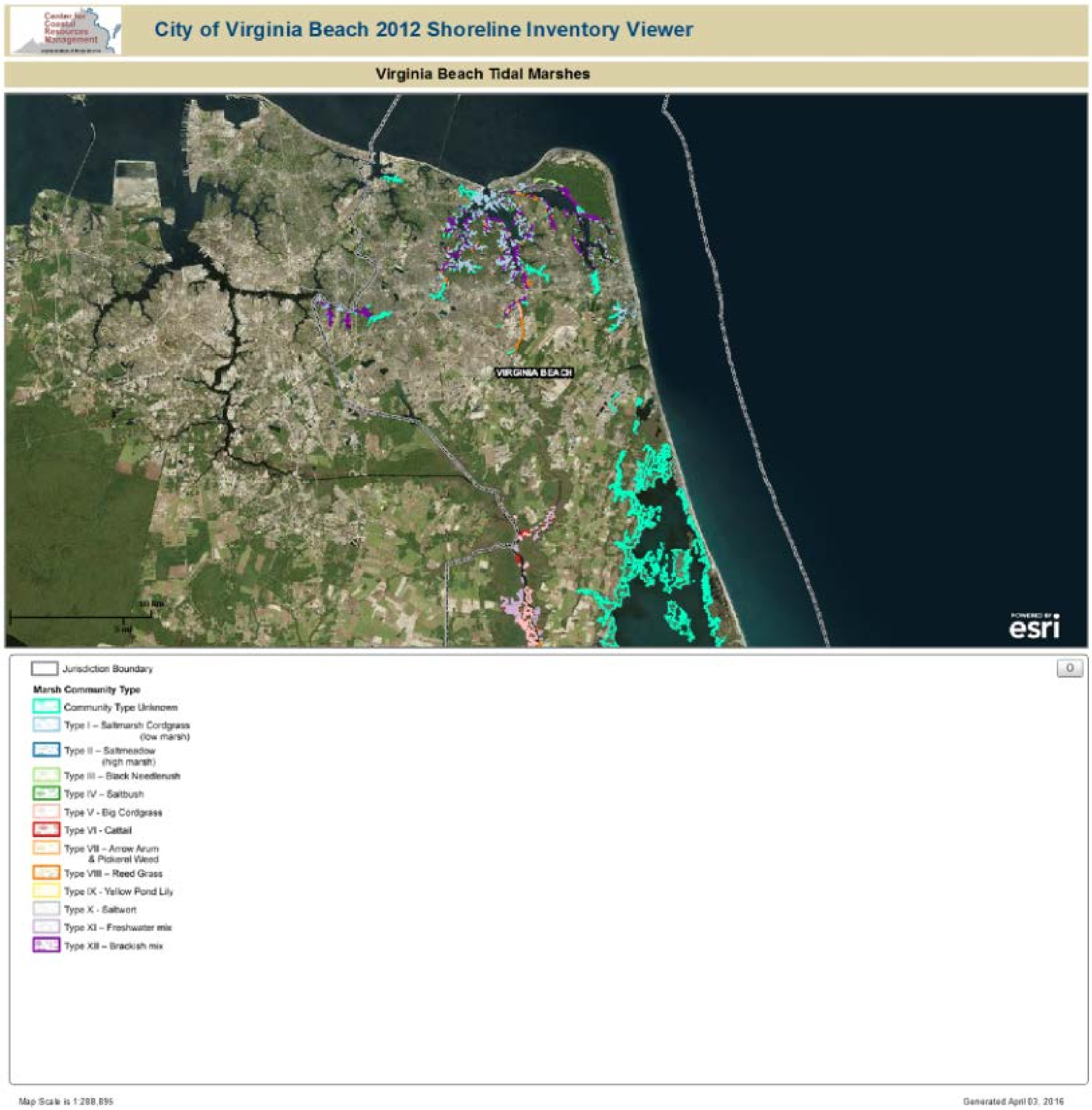

Figure 7. Map showing the tidal marsh in Virginia Beach (Center for Coastal Resource Management, 2016).