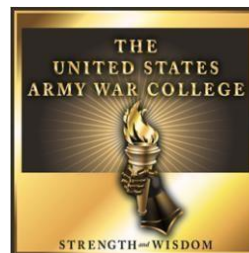


# On the Rise: Sea Levels, Interest, and Risk

by

Colonel Jason E. Kelly  
United States Army



United States Army War College  
Class of 2015

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USAWC STRATEGY RESEARCH PROJECT

**On the Rise: Sea Levels, Interest, and Risk**

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Colonel Jason E. Kelly  
United States Army

Professor Albert Lord  
Department of Military Strategy, Planning, and Operations  
Project Adviser

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U.S. Army War College  
CARLISLE BARRACKS, PENNSYLVANIA 17013



## **Abstract**

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Despite scientific data, tough talk from the White House and development of viable adaptation measures, efforts to increase coastal community resiliency remain stalled. This study investigates sea level changes in a strategically important coastal community and the impact of these changes on U.S. national interests. For many reasons, the country is developing a keen interest in adaptation and resiliency. Norfolk, Virginia is the second-most vulnerable city to sea level rise in the U.S. behind New Orleans. The risks posed to military facilities in this vibrant coastal community demand a response to climate consequences that are already affecting the area. This paper explores the science of rising seas, the significance of American ports, the strategic importance of Norfolk, and the potential role the U.S. Army Corps of Engineers could play in adaptation and resiliency.





## **On the Rise: Sea Levels, Interest, and Risk**

Sea level changes in strategically important coastal communities impact American national interests. Sea levels are rising at alarming rates. Scores of coastal communities in the United States are experiencing more frequent tidal flooding and scientists predict sea levels will continue to rise over the next 15-30 years.<sup>1</sup> It is anticipated that flooding from high tides will go further inland and occur much more frequently. This flooding will redefine how people in affected areas live, work, and otherwise go about their daily lives.<sup>2</sup> Locations vulnerable to tidal flooding include small towns, working class neighborhoods, military installations, tourist destinations, and vacation communities.<sup>3</sup> For many reasons, the country has a keen interest in infrastructure adaptation and resiliency. The United States Army Corps of Engineers (USACE) has long rendered technically sound and responsive solutions to national environmental challenges while focusing on public safety and collaborative partnerships. USACE is well-suited to initiate adaptation efforts and improve the resilience of communities and water resources infrastructure.

Norfolk, Virginia, home of multiple military installations, the world's largest naval base, and the Norfolk Naval Shipyard, is the second-most vulnerable city to sea level rise in the United States behind New Orleans. The risks posed to military facilities in this vibrant coastal community demand a response to climate consequences that are already affecting the area. A U.S. Army Corps of Engineers (USACE) led response is a practical national solution to the domestic and international threat posed by rising seas in Norfolk. The science of rising seas, the significance of American ports, the strategic importance of Hampton Roads, public-private partnerships, and the potential role USACE could play in adaptation and resiliency warrant exploration. An analysis of

national security, globalization, crucial nodes of the U.S. economy, and Norfolk as a potential proving ground for international infrastructure adaptation offer additional examination foci.

### The Science of Rising Seas

Sea level rise prediction is a fickle endeavor. Scientists cannot predict, with any degree of certainty, what future levels will be. Even sophisticated climate models that accurately represent the earth's physical processes cannot simulate rapid changes in ice sheet dynamics, and are likely to underestimate future sea level rise.<sup>4</sup> Despite the recent development of sophisticated methods that attempt to project future rise based on the statistical relationship between past rates of globally averaged temperature change and sea level rise, prediction remains a challenge.<sup>5</sup> Models suggest a range of additional sea level rise from about 2 feet to as much as 6 feet by 2100, depending on the emissions scenario.<sup>6</sup> There exist conflicting views on the causes of climate change and rising seas. The greenhouse effect, variations in the sun's energy reaching the earth, changes in the reflectivity of the earth's atmosphere and surface, perhaps human activity, are all potential causes. All are debatable. There are, however, irrefutable aspects of this phenomena that we do know.

Since the late 1800s, based on tide gauges throughout the world the global sea level has risen approximately 8 inches.<sup>7</sup> Historical data suggests that this rise is much greater than any other time in the past 2000 years.<sup>8</sup> Nearly 5 million people in the U.S. live within 4 feet of the local high-tide level.<sup>9</sup> In the next several decades, storm surges and high tides will combine with sea level rise and land subsidence to further increase flooding in many coastal regions.<sup>10</sup> As the debate rages, change in coastal communities throughout the United States is underway.

Scientists Virginia Burkett and Margaret Davidson submit that current sea level rise observations are cause for concern because:

- 1) Population densities have increased greatly and coasts have undergone significant development during a period of relatively stable sea level over the past century. Although, in theory, people could relocate landward to accommodate rising seas, human infrastructure, private land ownership, and current policy tend to prevent such adaptation measures.
- 2) Coastal landforms such as barrier islands, wetlands, and deltas are already dynamic and therefore highly vulnerable to sea level rise. Many coastal urban areas including Boston, New York, Washington D.C., Norfolk, Charleston, Miami, New Orleans, San Francisco, and Honolulu are also at high risk, yet few coastal communities and states have plans for adaptation.<sup>11</sup>

Society is, rightfully, developing an acute interest in the impact of rising seas. Strong scientific consensus suggests that sea levels are going to continue to rise. This will significantly impact the United States and the world.

#### Department of Defense Acknowledgement, Analysis, and Assessment

The Department of Defense and the Armed Services are taking sea level rise seriously in their strategic planning. The Department of Defense's Quadrennial Defense Review (QDR), the National Academy of Sciences' National Security Implications of Climate Change for U.S. Naval Forces, the Strategic Environmental Research Development Program's Assessing Climate Change Impacts on Coastal Military Installations, and the U.S. Navy's Climate Change Roadmap all acknowledge this threat. The 2010 QDR recognized that climate change was a threat to national security and the 2014 QDR reaffirms the Department's position: "The impacts of climate change may increase the frequency, scale, and complexity of future missions, including Defense Support to Civil Authorities, while at the same time undermining the capacity of our domestic installations to support training activities."<sup>12</sup> It is generally accepted that rising sea levels are going to play a significant role in the Department of Defense's

ability to fulfill future missions. Both built and natural infrastructure will be affected. Readiness and environmental stewardship responsibilities at hundreds of installations across the nation will be impacted.<sup>13</sup> As the climate change debate rages, multiple defense departments and agencies are starting to develop the understanding and tools necessary to identify vulnerable assets, assess impacts, and determine appropriate responses. Climate-related effects are already being observed at installations in every region of the United States and its coastal waters.<sup>14</sup> These physical changes include rising temperatures and sea levels, increases in both heavy downpours and the extent of drought, thawing permafrost, shifts in growing seasons, lengthening ice-free seasons in the oceans and on lakes and rivers, earlier snowmelt, and altered river and stream flows.<sup>15</sup>

In the introduction to the Department of Defense 2014 Climate Change Adaptation Roadmap Secretary of Defense Chuck Hagel emphatically states, “rising global temperatures, changing precipitation patterns, climbing sea levels, and more extreme weather events will intensify the challenges of global instability, hunger, poverty, and conflict.”<sup>16</sup> While elected representatives and members of the scientific community continue to disagree on global warming and its potentially catastrophic consequences, Secretary Hagel unambiguously acknowledges the serious implications for national security and prosperity. It is his perspective that the potential consequences of climate change are so dire that politics or ideology must not get in the way of sound military planning. Secretary Hagel refers to climate change as a “threat multiplier” because it has the potential to exacerbate many of today’s challenges – from infectious disease to terrorism.<sup>17</sup> “In places like the Hampton Roads region in Virginia, which

houses the largest concentration of U.S. military sites in the world, we see recurrent flooding today, and we are beginning work to address a projected sea-level rise of 1.5 feet over the next 20 to 50 years.”<sup>18</sup> The Climate Change Adaptation Roadmap is the Department of Defense’s response to Executive Orders 13514 and 13653. Executive Order 13514 directs all federal departments and agencies to evaluate climate change risks and vulnerabilities, to manage both the short- and long-term effects of climate change on the agency’s mission and operations, and include an adaptation planning document as an appendix to its annual Strategic Sustainability Performance Plans.<sup>19</sup> Executive Order 13653 notes that “building on these efforts, each agency shall develop or continue to develop, implement, and update comprehensive plans that integrate consideration of climate change into agency operations and overall mission objectives and submit those plans to the Council on Environmental Quality and the Office of Management and Budget for review.”<sup>20</sup> With the foundation that former Secretary Hagel established, the Department of Defense is well-postured for action.

#### The Intersection of Politics, Commerce, and Security

There exists a longstanding link between coastal communities, security, and prosperity. As the 19<sup>th</sup> Century drew to a close, Alfred Thayer Mahan published his seminal work, *The Influence of Sea Power upon History 1660-1783*. Mahan understood and articulated the historic linkage of prosperity and control of the sea. Resultant of its navy, Great Britain was able to establish an empire of dominions and colonies, monopolize trade, and access resources which were then denied to other powers. Mahan argued that “when a nation’s prosperity depends upon shipborne commerce, and the amount of trade is limited, then competition follows, and that leads to a naval contest to protect trade.”<sup>21</sup> He further posited that the combination of maritime

commerce, overseas possessions, and privileged access to foreign markets produces national wealth and greatness. The United States' turn of the century policy shift from simple self-sufficiency to commercial extension and influence in distant regions required a shift in military posture as well. It generated a national requirement to protect commercial interests and coasts in the east and west. This requirement compelled investment and the acquisition of a fleet capable of advancing and protecting U.S. interests.

Such a fleet required developed ports. Ports serve as major hubs and intermodal connections between marine transportation systems and intercontinental surface transportation networks. These ports have become vital national access points and satisfy important roles in both the commercial and military transportation structure of the United States. In this era of globalization, millions of products arrive and depart American ports every day. One of the most widely anticipated events in the maritime transportation industry is the opening of the expanded Panama Canal in 2016. Ports around the country, especially on the east coast, are attempting to position themselves to attract the larger ships that will soon be able to transit that waterway.<sup>22</sup> The race is on. The expansion of the Panama Canal will permit Post Panamax vessels to traverse the canal.<sup>23</sup> New locks will double the canal's capacity. The almost century old canal is currently operating at near full capacity.<sup>24</sup> Based on estimates provided by the Panama Canal Authority, five or six operational ports on the eastern coast of the United States will satisfy the increased throughput.<sup>25</sup> The ports of Savannah, Miami, New York, Norfolk, Baltimore, Jacksonville, and Houston are all vying to attract the larger Post

Panamax ships but some are more prepared than others. Norfolk and Baltimore are ready now to handle the larger ships.<sup>26</sup>

In addition to Post Panamax vessel preparation, port cities have invested heavily in post-9/11 security. Increased security concerns prompted the nation's ports to reevaluate the design of points of entry. Port security is a prominent issue among policymakers, security officials, and private industry. Throughout the country, civil engineers are attempting to develop safe and efficient layouts for vehicular ingress and egress. Following the terrorist attacks of September 11, 2001 ports have become much more vigilant and given greater emphasis to security improvement efforts. To date, these initiatives have focused on providing the infrastructure, equipment, and personnel necessary to impede the international movement of terrorists and prevent the sabotage of maritime facilities and the destruction of transportation infrastructure.<sup>27</sup> The port community is investing considerable time and treasure to secure national waterfronts. The effort is collaborative. The U.S. Coast Guard, the U.S. Customs Service, the Department of Justice, and the Immigration and Naturalization Service, as well as local port and city police forces have all contributed. With massive volumes of new government regulations, guidelines, and other information pouring out of Washington and the availability of new security technologies, port designers continue to balance client needs with current and anticipated U.S. port security policy.<sup>28</sup> Absent action, they will be forced to contend with rising seas as well.

The opportunities and challenges associated with military installations, Post Panamax ships, and port security are especially relevant in Norfolk, Virginia. Hampton Roads is one of the most heavily used complexes of harbors in the world and home to

the world's largest naval base, multiple military installations, and the Norfolk Naval Shipyard. Situated on the Elizabeth River, a tributary between the James River and the Chesapeake Bay, Norfolk has suffered near-total devastation twice in its history; during the American Revolution and the Civil War. Both times its resilient residents rebuilt, and today Norfolk is again in the midst of an ambitious rehabilitation.<sup>29</sup> Norfolk is also the second-most vulnerable city to sea level rise in the United States behind New Orleans. A third devastation is not outside the realm of possible.

### Lessons from New Orleans

As a nation, we are very familiar with the challenges associated with natural disasters and a lack of preparedness. When Hurricane Katrina whirled toward the Gulf Coast in the summer of 2005, a contingent of citizens from Mississippi, Alabama, and Louisiana scrambled to evacuate. The residents of New Orleans were relieved when the storm's fierce winds finally subsided and spared the Crescent City.<sup>30</sup> The relief, however, was temporary. One day after the storm, the 137 year old city was submerged in floodwaters.<sup>31</sup> The physical devastation caused by the hurricane severely compromised the precious cultural communities of the French colonial Gulf Coast. Hurricane Katrina damaged the local economy, obliterated entire neighborhoods, dispersed populations, and severely impaired basic public services.<sup>32</sup>

Much of New Orleans resides below sea level in a bowl-shaped area between two bodies of water: Lake Pontchartrain on the city's north side and the Mississippi River on the south.<sup>33</sup> Levees and pumps have long protected New Orleans and kept Lake Pontchartrain and the Mississippi from spilling into the city. Scientists attribute the great flood of 2005 to both the city's location and its loss of natural defenses. The latter of which is the result of misprioritization and neglect.



There was a time when New Orleans did not depend exclusively on its levees and pumps for protection. The coastal parts of the city were once comprised of marshes that soaked up the water that was pushed ashore. In 2005, however, the marshes were not much help. Prior to the construction of concrete levees, the Mississippi River would wash onshore and leave behind sediment. This sediment piled into the marshes and helped keep them sturdy and in place.<sup>34</sup> Man-made levees now prevent the Mississippi from flooding and leaving sediment behind. As a result, the marshes eroded and annulled flood protection redundancy. Levees and pumps became the city's sole defense. Plans to improve the levees and restore the barrier of wetlands around New Orleans have been a topic of discussion since 1998, but the federal dollars required to implement them never arrived.<sup>35</sup>

The residents of New Orleans have three adaptation options. They can retreat, accommodate, or enact protection measures. They no longer need to ponder the consequences of doing nothing. Because vacating New Orleans and deeming the region uninhabitable is highly unlikely, pursuance of management actions that fall short of a mass exodus are much more plausible. Risk avoidance measures such as zoning policies intended to prevent development in high risk areas may apply in some cases, but will not work for the entire city. Accommodation actions are most commonly applied and are, without doubt, appropriate in this case. Raising buildings and roads above flood levels, establishing evacuation routes, investing in warning systems, and enhancing storm water system capacity are all viable, but very expensive options. Protection measures, perhaps the most expensive of all, require some form of engineering to protect existing land use.<sup>36</sup>

In response to the loss of natural defenses in New Orleans, scientists recommended a second round of protection measures. They proposed raising the height of the existing levees, building a second ring of levees inside the city, and importing sediment to rebuild the marshes.<sup>37</sup> To provide further protection, a mobile dam system, much like the elaborate Maeslantkering, or Maeslant Storm Surge Barrier, in the Nieuwe Waterweg waterway between the towns of Hoek van Holland and Maassluis, Netherlands, was proposed to close off the mouth of Lake Pontchartrain.<sup>38</sup> Despite restored wetlands and new levees, the combination of geologic collapse and rising sea levels will likely sink New Orleans another meter by 2100.<sup>39</sup>

New Orleans' recovery from the damage caused by Hurricane Katrina reflects a long, complex, and contentious process that remains a work in progress. Disaster recovery offers a rare opportunity to rebuild damaged communities and make them more resilient.<sup>40</sup> New Orleans is still engaged in an extended recovery process and still struggling with recovery issues. Bold promises made by federal, state, and local officials immediately after the storm to “bring New Orleans back” have proven far more difficult to keep and far more complex than policy makers anticipated.<sup>41</sup>

#### The Combination of Rising Tides and Sinking Ground in Virginia

The sea level along the coast of Virginia is affected by three factors: the volume of water in the ocean, the elevation of the shoreline, and the movement of water in the ocean.<sup>42</sup> Changes in these factors greatly alter the water level at the shoreline. As glaciers, ice caps, and ice sheets in Greenland and Antarctica melt, the volume of water increases. This additional water, which was previously stored on land, gets added to the ocean's basins.<sup>43</sup> In addition to retreating glaciers, the residual effect of a meteor's impact more than 35 million years ago and the removal of large volumes of deep

groundwater also affect the elevation of the shoreline in Virginia.<sup>44</sup> Lastly, the circulation pattern of water in the north Atlantic is also a contributing factor. Data suggests that this pattern, the Atlantic Meridional Overturning Circulation, has decreased its velocity. Slower moving water results in less pressure to move water away from the coast.<sup>45</sup> In light of these influences, sea level rise is projected to continue.

Tidewater Virginia is particularly vulnerable as it is low-lying and subject to considerable flooding when major storms pass through the region. Projections for sea level rise in coastal Virginia range between 1.5 and 7.5 feet over the next 20 to 50 years.<sup>46</sup> It is reasonable to anticipate that sea level rise in this region will be at least 1.5 feet higher than it is presently in the next two decades.<sup>47</sup> This is a time frame that makes the consideration of potential impacts relevant for military facilities, ports, and densely populated coastal communities.

In a 2013 report submitted to the Virginia Assembly, the Center for Coastal Resource Management identified recurrent flooding issues throughout Tidewater Virginia, examined predictions for future flooding challenges, and evaluated potential adaptation strategies for reducing the impact of flood events. A key finding of the report suggests that it is possible for Virginia to effectively respond to rising sea levels and increasing flood issues, but it will take time to plan and implement effective adaptation strategies.

There are a wide variety of adaptation strategies used throughout the world, many of which are suitable for use in some parts of Tidewater Virginia. The optimal strategy is going to be development of flexible plans that match adaptation options to the unique circumstances of each coastal locality and link option implementation to the evolving risks. This is the strategy now employed by an increasing number of states and localities in the United States. It requires serious planning, commitment of resources, and careful analysis of evolving conditions. It reduces unnecessary

expenses, ensures development decisions are informed, and recognizes the long lead times required for effective implementation of many adaptation options.<sup>48</sup>

The implementation of adaptation strategies is a time consuming endeavor. In recognition of the time required for implementation, scientists and elected officials are actively planning and championing “no regrets” policies.

### The Strategic Importance of Norfolk and Hampton Roads

The risks posed to military facilities in strategic coastal cities demand a response to climate consequences that are already in motion. Norfolk, Virginia is, but one such city. In addition to its huge Navy footprint the region hosts major Air Force, Army, Marine Corps, and Coast Guard facilities. The deep channel of the Elizabeth River and its multiple harbors led to the development of Norfolk on the east bank and Portsmouth on the west bank.<sup>49</sup> The advent of Post Panamax Ships and the instant readiness of the Port of Norfolk further solidifies the region’s strategic value. The Norfolk Naval Base, the world’s largest, is located on the east side of the Elizabeth River opposite Craney Island in Norfolk. The much-older Norfolk Naval Shipyard is on the west bank of the Southern Branch of the Elizabeth River, eight miles south of the naval station. Despite its name, the shipyard is actually located in the city of Portsmouth. The shipyard is an important catalyst for growth in Hampton Roads, to include Portsmouth Naval Hospital.<sup>50</sup> The military facilities in Hampton Roads are major parts of the local economy. Six percent of adults aged 25-64 are in the Armed Forces, a much higher proportion than statewide (2%) and nationwide (less than 1%).<sup>51</sup> “More military men and women live in the Hampton Roads metropolitan area than anywhere else in the country. The vast majority of those military men and women are in the Navy -- roughly 80 percent -- and the vast majority live in Virginia Beach and Norfolk, in nearly equal portions.”<sup>52</sup> Every proposal to

relocate one of the aircraft carriers based at Norfolk to Florida or San Diego has been doggedly fought by Virginia's elected Representatives and Senators in Congress, regardless of their political party affiliation.

Rising sea levels could eventually put vast stretches of Navy docks and military installations under water in Hampton Roads. Norfolk is the potential proving ground for universal infrastructure resiliency and adaptation. Effective implementation presents an opportunity to establish credibility abroad via innovation and renovation at home. While addressing peers at the Conference of Defense Ministers of the Americas in Arequipa, Peru, Defense Secretary Chuck Hagel called on other nations to join the Pentagon in its effort to mitigate and adapt. The risks posed by rising seas to military installations in Norfolk present an opportunity to lead by example.

In his 2015 State of the Union Address, President Barack Obama emphatically stated, “No challenge--no challenge--poses a greater threat to future generations than climate change.”<sup>53</sup> For additional emphasis he further posited:

The best scientists in the world are all telling us that our activities are changing the climate, and if we don't act forcefully, we'll continue to see rising oceans, longer, hotter heat waves, dangerous droughts and floods, and massive disruptions that can trigger greater migration and conflict and hunger around the globe. The Pentagon says that climate change poses immediate risks to our national security. We should act like it.<sup>54</sup>

Impacts from rising seas are real and now. The full measure of adaptation options, to include pricey accommodation and protection actions, should be topics of discussion among our elected leaders. Long-term infrastructure may be in order. Long-term infrastructure, however, requires long-term funding streams.

## Public-Private Partnerships

In Annapolis, Maryland, along the vulnerable Chesapeake Bay coastline, a partnership between the United States Navy and local authorities has produced what some scientists consider the most forward thinking adaptation approach to rising seas. In response to the many challenges posed by climate change, the Navy created Task Force Climate Change. The Task Force's purpose is to inform policy and resource decisions via science, cooperative partnerships, and informed risk assessments. For maritime forces, sea level rise directly impacts readiness, strategic access, and influence. Navy installations are vulnerable. In 2003, the United States Naval Academy experienced significant flood damage following Hurricane Isabel. During the storm, Anne Arundel County sustained a record high number of power outages, numbering 196,000 out of 230,000 customers in the region. Scores of local businesses and more than 570 homes were declared uninhabitable from major flood damage. There were approximately 100 structural collapses throughout the county.<sup>55</sup> This partnership is the result of an acknowledgement that flooding is a serious threat in Annapolis.

The term public-private partnership became vogue in the late 1990s and early 2000s. In general, the term is used to denote government contracts in which the private contractor takes on more responsibility than has been customary in the past for the delivery of the services contracted for. With respect to long-term infrastructure, such as highways and bridges, the term refers to a family of relatively new contract types, actively promoted by the federal government for use on operations and maintenance or design-build-finance-operate-maintain contracts, by which the government is able to shift much of the financing, maintenance, and/or operating cost for public infrastructure to private contractors.<sup>56</sup> These private entities are then allowed to recoup their costs

through tolls or other user payments. This approach permits the government to use the market to accomplish its purposes and relieves public budgets of the financial burden associated with infrastructure upgrades and maintenance. By extension, the term is often applied broadly to all types of government service contracts, including such things as schools and prisons, provision of health care, and even the administration of state welfare programs and financial rescue of the economy.<sup>57</sup> These contractual agreements are not new. There exists an extensive history of similar government contracting, both with respect to long-term infrastructure and more broadly. Use of the term “public-private partnerships” appears to symbolize a new enthusiasm for privatizing traditional governmental functions.<sup>58</sup>

When managing large infrastructure and facilities portfolios, whether the perspective is owner, operator, service provider, or other stakeholder there is one objective that all share: effectively leverage scarce and dwindling resources to construct, sustain, restore, repurpose and/or modernize infrastructure and facilities public works as efficiently as possible.<sup>59</sup> As coastal communities throughout the nation wrestle with the challenge of financing adaptation measures in a fiscally constrained environment, public-private partnerships offer a creative resolution that is potentially favorable for all parties. Ideal public-private partnerships fund construction, operations, maintenance, services and often grant specified uses for revenue generation into a life-cycle business model that spreads costs over a fixed, predictable, multi-term arrangement.<sup>60</sup> In short, infrastructure and facilities are constructed at a fraction of conventional appropriations.

The Hampton Roads community has several initiatives underway that are intended to raise federal awareness and secure federal funding to develop a regional government and community-wide approach to sea level rise preparedness and resilience planning. The Hampton Roads Pilot Project is an intergovernmental exercise and a component of the National Exercise Program Climate Change Preparedness and Resilience Exercise Series, sponsored by the White House National Security Council, the Council on Environmental Quality, and the Office of Science and Technology Policy, and supported by the National Exercise Division.<sup>61</sup> This national pilot project will, without doubt, greatly aid the forging of relationships and help the country resolve how different levels of government, the private sector and academia can work together in Hampton Roads to combat the effects of sea level rise and climate change. The two-year initiative, despite White House support, includes no funds for work.

The Obama Administration appears committed, but coastal communities have yet to receive the means to develop significant resiliency and adaptation programs. A host of initiatives have commenced, but the challenge of rising seas continues to receive mere acknowledgment by most senior leaders. Decisive action remains elusive to at-risk locales. The risks posed to military facilities in strategic coastal cities demand a response to climate consequences that are already in motion. Norfolk, Virginia is one such city. Hampton Roads is one such region. The nation is amassing a wealth of information on the problem. All will be for naught unless funding streams that permit action are soon activated.

#### Resilience, Adaptation, and the United States Army Corps of Engineers

The United States Army Corps of Engineers (USACE), the federal government's premier engineer agency, is well-suited to put the nation's adaptation and resiliency



efforts in motion. USACE operates, maintains, and manages approximately one-third of the nation's water resource assets.<sup>62</sup> River and coastal navigation are central elements of the USACE civil works mission, but over time Congress has incrementally expanded USACE's responsibilities.<sup>63</sup> The Corps portfolio also includes national flood risk management. "USACE assets range from small boat launches to massive dams, extensive levee systems, and complex locks, all of which contribute to the nation's economy, safety, and security. Many of these vital assets, built decades ago, are reaching or exceeding their original design lives."<sup>64</sup> Over the last few years, USACE senior leaders and external finance experts have pondered funding and alternative financing arrangements.

USACE assets generate revenue through lease income and a variety of user fees. Some, but not all, of this revenue is reinvested in capital projects and ongoing operations and maintenance through annual Congressional appropriations. USACE also shares cost with state and local government partners for capital investment projects. Current levels of appropriations and cost share contributions must keep pace with pressing capitalization as well as operational and maintenance needs. To bridge the gap, USACE is considering innovations in revenue generation, project finance, asset management, and the leveraging of federal investment through expanded partnerships with public and private entities.<sup>65</sup>

USACE has an extensive history taking on and solving some of our nation's toughest challenges. Since inception, USACE has remained an organization that responds to national emergencies in a timely and efficient manner.

USACE's Engineer Research and Development Center (ERDC) prides itself on solving the most challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, Department of Defense, civilian agencies, and our nation's public good."<sup>66</sup> Given the best available scientific evidence, ERDC assesses that sea levels are rising at unprecedented rates

and pose a threat to military operations and readiness. Researchers are investigating comprehensive, science-based approaches to reduce risk and increase the resiliency of military installations. In a recent study, ERDC's Environmental Laboratory quantified coastal storm and sea level rise risks to Naval Station Norfolk. The study's purpose was to quantitatively evaluate natural hazard risks to military assets, specifically infrastructure and associated mission capabilities. Elaborate modelling permitted inference regarding the resiliency of the infrastructure. The inquiry investigated probabilities of asset damage, loss in capability, potential losses in mission performance, and alternative designs. ERDC is prepared to present a risk management approach to the challenges in Hampton Roads that manages regrets and permits decisions based on return on investment.<sup>67</sup>

President Obama signed the Water Resources Reform and Development Act (WRRDA) of 2014 into law on June 10, 2014. WRRDA is the primary legislation by which Congress authorizes the Corps of Engineers' key civil works missions, including navigation, flood risk management and environmental restoration.<sup>68</sup> WRRDA is strictly an authorizing legislation; it does not include funding. The funding of WRRDA-authorized studies and projects is accomplished separately as part of the annual appropriations process.<sup>69</sup> In his remarks at the signing of the legislation, President Obama stated, "this bill will help towns and cities improve their commerce, but it's also going to help them prepare for the effects of climate change -- storms, floods, droughts, rising sea levels -- creating more adaptability, more resilience in these communities."<sup>70</sup> WRRDA is helpful, but because it does not include funding, creative solutions are still required to finance the full measure of required national adaptation actions.

## Conclusion

In the 1995 film *Apollo 13*, actor Tom Hanks starring as astronaut James Lovell famously quips, “Houston, we have a problem.” In reality, it wasn’t Lovell, it was fellow astronaut Jack Swigert and he said, “Houston, we’ve had a problem here.”<sup>71</sup> Swigert’s report is germane to the Department of Defense and the nation, writ large, regarding rising seas. To date, elected leaders have been hesitant to act despite possession of actionable data. Energy invested in postmortem efforts to rebuild and remediate, as is the case in New Orleans, can be avoided via preemption and proactivity. Perhaps more advice from *Apollo 13* is in order. Actor Ed Harris, as flight director Gene Kranz, when presented with the direness of the astronauts’ predicament decreed, “Failure is not an option.”<sup>72</sup> This is, most certainly, the case in Hampton Roads. In the face of an increasing threat, adaptation is vital and the need to act is immediate.

Greater Norfolk houses the largest concentration of military sites in the United States, to include the world’s largest naval base. Post Panamax vessel readiness, improved port security, and continued harbor development further characterize the region’s worth. The military facilities, the ships, and the shipyard could move. The nation could invest and establish ports in protected areas, but the cost would be mammoth. At its core, sea level rise adaptation in Hampton Roads is a risk/reward proposition. If the projections are correct and the nation invests in adaptation, the region is prepared. If the projections are correct and the nation fails to invest, the results are catastrophic. If the projections are erroneous and the nation invests, the region increases its resiliency. If the projections are mistaken and the nation does not invest, the status quo prevails. Hampton Roads’ military significance and economic import warrant a strategy with a high rate of return. The status quo is untenable.

Despite an accumulation of data, tough talk from the White House and a scientific offering of viable adaptation measures, efforts to increase coastal community resiliency remain stalled. In response to rising seas and the inherent risks posed to Norfolk, a strategically important coastal community, the federal government should task the United States Army Corps of Engineers, the federal engineer agency, to do what it has done for the nation since 1775. For well over 200 years, engineers have contributed to the development of this nation and other developing nations. In war, U.S. Army engineers are fighters and builders of those things needed to sustain the battle.<sup>73</sup> In peace they construct and maintain those things required to sustain the nation. As elected officials debate the causes and effects of climate change and the size and role of the peacetime Army, sea levels are rising and threatening national security. The time for action is now. A USACE-led public-private venture is an appropriate response and Norfolk is an appropriate place to get started.

## Endnotes

<sup>1</sup> Erika Spanger-Sigfried, Melanie Fitzpatrick, and Kristina Dahl, "Encroaching Tides: How Sea Level Rise and Tidal Flooding Threaten U.S. East and Gulf Coast Communities over the Next 30 Years," October 2014, <http://www.ucsusa.org/sites/default/files/attach/2014/10/encroaching-tides-full-report.pdf> (accessed October 28, 2014).

<sup>2</sup> Ibid.

<sup>3</sup> Ibid.

<sup>4</sup> 2014 National Climate Assessment, <http://nca2014.globalchange.gov/> (accessed December 16, 2014).

<sup>5</sup> Ibid.

<sup>6</sup> Ibid.

<sup>7</sup> Ibid.

<sup>8</sup> Andrew C. Kemp, Benjamin P. Horton, Jeffrey P. Donnelly, Michael E. Mann, Martin Vermeer, and Stefan Rahmstorf, "2011: Climate related sea-level variations over the past two millennia," *Proceedings of the National Academy of Sciences* 108, no. 27, March 25, 2011) <http://www.pnas.org/content/108/27/11017.full.pdf+html> (accessed December 16, 2014)

<sup>9</sup> 2014 National Climate Assessment.

<sup>10</sup> Benjamin Strauss, Remik Ziemiński, Jeremy L. Weiss, and Jonathan T. Overpeck, "Tidally adjusted estimates of topographic vulnerability to sea level rise and flooding for the contiguous United States," *Environmental Research Letters* 7, [http://m.iopscience.iop.org/1748-9327/7/1/014033/pdf/1748-9326\\_7\\_1\\_014033.pdf](http://m.iopscience.iop.org/1748-9327/7/1/014033/pdf/1748-9326_7_1_014033.pdf) (accessed December 16, 2014).

<sup>11</sup> Virginia Burkett and Margaret Davidson, "Coastal Impacts, Adaptation, and Vulnerabilities: A Technical Input to the 2013 National Climate Assessment," (2012) [http://www.ssec.wisc.edu/~kossin/articles/NCA\\_Coasts.pdf](http://www.ssec.wisc.edu/~kossin/articles/NCA_Coasts.pdf) (accessed December 16, 2014).

<sup>12</sup> Department of Defense 2014 Climate Change Adaptation Roadmap, <http://www.acq.osd.mil/ie/download/CCARprint.pdf> (accessed December 25, 2014).

<sup>13</sup> Ibid.

<sup>14</sup> Strategic Environmental Research and Development Program (SERDP) Environmental Security Technology Certification Program (ESTCP) homepage, <https://www.serdp-estcp.org/Program-Areas/Resource-Conservation-and-Climate-Change/Climate-Change> (accessed December 21, 2014).

<sup>15</sup> Ibid.

<sup>16</sup> Department of Defense 2014 Climate Change Adaptation Roadmap.

<sup>17</sup> Ibid.

<sup>18</sup> Chris Rose, "US Defense Secretary Hagel Outlines Military's Response to Climate Change "Threat Multiplier"," *DESMOGBLOG.COM*, <http://www.desmogblog.com/2014/10/13/us-defense-secretary-hagel-outlines-military-s-response-climate-change-threat-multiplier> (accessed December 25, 2014).

<sup>19</sup> Department of Defense 2014 Climate Change Adaptation Roadmap.

<sup>20</sup> Ibid.

<sup>21</sup> A.T. Mahan, *The Interest of America In Sea Power, Present and Future* (Boston: Little, Brown, and Company, 1918).

<sup>22</sup> Kent Gourdin, ed., "Port Development in the United States," *Defense Transportation Journal* (Apr 2011): 9,144 in ProQuest (accessed December 27, 2014).

<sup>23</sup> Panamax ships are mid-sized cargo ships that are capable of passing through the lock chambers of the Panama Canal which are 1,050 ft (320.04 m) in length, 110 ft (33.53 m) in width, and 41.2 ft (12.56 m) in depth. These limits have greatly influenced ship building since the opening of the Panama Canal in 1914. In 2009, the Panama Canal Authority published the

dimensions for New or Post Panamax ships. The authority has initiated the construction of the third lane of locks having bigger dimension of 427 m (1400 ft) in length, 55m (180 ft) in width and 18.3 m (60 ft) in depth, in order to accommodate larger ships.

<sup>24</sup> Randy Hilarsky, "The Race is on in the USA to Prepare Post Panamax Ports," *Panama Simple*, April 4, 2013, <http://www.panamasimple.com/post-panamax-ports-us/> (accessed December 27, 2014).

<sup>25</sup> Ibid.

<sup>26</sup> Ibid.

<sup>27</sup> David Cruz and Larry Nye, "Protecting the Ports", *Civil Engineering* (Jul 2002): 62-65 in ProQuest (accessed January 14, 2015).

<sup>28</sup> Ibid.

<sup>29</sup> Fred Schultz, *History Abounds at Hampton Roads*, Naval History (Apr 2007) 34-37, in ProQuest (accessed January 14, 2015).

<sup>30</sup> Jacqueline Adams, "Sunken City," *Super Sciences* 17 no. 3, (Nov/Dec 2005): 12-14 in ProQuest (accessed January 16, 2015).

<sup>31</sup> Ibid.

<sup>32</sup> Jerry McKernan and Kevin V. Mulcahy, "Hurricane Katrina: A Cultural Chernobyl," *Journal of Arts Management, Law, and Society* 38, no. 3 (Fall, 2008): 217-230 in ProQuest (accessed February 11, 2015).

<sup>33</sup> Adams, "Sunken City," 13.

<sup>34</sup> Ibid.

<sup>35</sup> John Bohannon and Martin Enserink, "Scientists Weigh Options for Rebuilding New Orleans," *Science* 309, no. 5742 (Sep 16, 2005): 1808-1809 in ProQuest (accessed January 16, 2015).

<sup>36</sup> For background on adaptation options, see Carl Hershner and Molly Mitchell, "Rising Tides, Sinking Coast: How Virginia's coastal communities can adapt to surging sea levels," *Virginia Issues and Answers* 17, no. 2: 22-27, <http://www.via.vt.edu/winter13/Rising-Tides-Sinking-Coast.pdf> (accessed January 21, 2015).

<sup>37</sup> Adams, "Sunken City," 13.

<sup>38</sup> Bohannon and Enserink, "Scientists Weigh Options for Rebuilding New Orleans," 1808-1809.

<sup>39</sup> Ibid.

<sup>40</sup> Louise K. Comfort, Thomas A. Birkland, Beverly A. Cigler, and Earthea Nance. "Retrospectives and Prospectives on Hurricane Katrina: Five Years and Counting," *Public*

*Administration Review* 70, no. 5 (Sep, 2010): 669-678 in ProQuest (accessed January 16, 2015).

<sup>41</sup> Ibid.

<sup>42</sup> Carl Hershner and Molly Mitchell, "Rising Tides, Sinking Coast: How Virginia's coastal communities can adapt to surging sea levels," *Virginia Issues and Answers* 17 no. 2: 22-27, <http://www.via.vt.edu/winter13/Rising-Tides-Sinking-Coast.pdf> (accessed January 21, 2015).

<sup>43</sup> Ibid.

<sup>44</sup> Ibid.

<sup>45</sup> Ibid.

<sup>46</sup> VIMS Recurrent Flooding Study for Tidewater Virginia (2013) [http://ccrm.vims.edu/recurrent\\_flooding/Recurrent\\_Flooding\\_Study\\_web.pdf](http://ccrm.vims.edu/recurrent_flooding/Recurrent_Flooding_Study_web.pdf) (accessed January 21, 2015).

<sup>47</sup> Ibid.

<sup>48</sup> Ibid.

<sup>49</sup> "Norfolk Naval Shipyard," <http://www.virginiaplaces.org/military/norfolknavalshipyard.html> (accessed January 28, 2015).

<sup>50</sup> Ibid.

<sup>51</sup> "The Military in Virginia," <http://www.virginiaplaces.org/military/index.html> (accessed January 28, 2015).

<sup>52</sup> Marc Davis, "Hampton Roads Retains the Title: The Military Capital of America Census Bureau Says 91,615 Men and Women in Uniform are Here," *The Virginia Pilot*, May 30, 2002, <http://www.highbeam.com/doc/1G1-86509270.html> (accessed January 28, 2015).

<sup>53</sup> Barack Obama, "Remarks by the President in the State of the Union Address," *Office of the Press Secretary*, January 20, 2015 <http://www.whitehouse.gov/the-press-office/2015/01/20/remarks-president-state-union-address-january-20-2015> (accessed January 22, 2015).

<sup>54</sup> Ibid.

<sup>55</sup> D. Frank Smith, "Remembering Disastrous Hurricane Isabel: 10 Years Later," *Annapolis Patch*, September 18, 2013, <http://patch.com/maryland/annapolis/remembering-diastrous-hurricane-isabel-10-years-ago> (accessed January 24, 2015).

<sup>56</sup> Dominique Custos and John Reitz, "Public-Private Partnerships," *The American Journal of Comparative Law* Vol. 58, Supplement: Welcoming the World: U. S. National Reports to the XVIIIth International Congress of Comparative Law (2010):555-584 <http://www.jstor.org.ezproxy.usawcpubs.org/stable/20744554> (accessed January 24, 2015).

<sup>57</sup> Ibid.

<sup>58</sup> Ibid.

<sup>59</sup> Joe Calcara, "Inside Public-Private Partnerships," *The Military Engineer* 107, no. 693, (January-February 2015): 38-41.

<sup>60</sup> Ibid.

<sup>61</sup> "Fact Sheet: 16 U.S. Communities Recognized as Climate Action Champions for Leadership on Climate Change," *Office of the Press Secretary*, December 3, 2014 <http://www.whitehouse.gov/the-press-office/2014/12/03/fact-sheet-16-us-communities-recognized-climate-action-champions-leaders> (accessed January 27, 2015).

<sup>62</sup> Institute for Water Resources, "Potential and Implementation of Alternative Funding and Finance of the USACE Civil Works Mission," June 2013, <http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/2013-R-06.pdf> (accessed January 27, 2015).

<sup>63</sup> Ibid.

<sup>64</sup> Ibid.

<sup>65</sup> Ibid.

<sup>66</sup> U.S. Army Corps of Engineers, "Engineer Research and Development Center," <http://www.erd.usace.army.mil/About/MissionandVision.aspx> (accessed January 28, 2015).

<sup>67</sup> Information on U.S. Army Engineer Research and Development Center, Environmental Laboratory Risk-Based Portfolio Assessments relies on a Kelly A. Burks-Copes presentation, "Risk-Based Portfolio Assessment and Management for Informing Sustainable Military Installation Readiness in Consideration of Global Change," Environmental Laboratory, U.S. Army Engineer Research and Development Center, Vicksburg, MS, November 26, 2013.

<sup>68</sup> U.S. Army Corps of Engineers, "Water Resources Reform and Development Act (WRRDA) of 2014," <http://www.usace.army.mil/Missions/CivilWorks/ProjectPlanning/LegislativeLinks/wrrda2014.aspx> (accessed January 27, 2015).

<sup>69</sup> Ibid.

<sup>70</sup> President Barack Obama, "Remarks by the President at Signing of the Water Resources Reform and Development Act and the 65th Infantry Regiment Congressional Gold Medal," *Office of the Press Secretary*, June 10, 2014 <http://www.whitehouse.gov/the-press-office/2014/06/10/remarks-president-signing-water-resources-reform-and-development-act-and> (accessed January 27, 2015).

<sup>71</sup> James A. Lovell, "Houston, We've Had a Problem," in *Apollo Expeditions to the Moon*, ed. Edgar Cortright (Houston: National Aeronautics and Space Administration, 1975), <http://history.nasa.gov/SP-350/ch-13-1.html> (accessed September 27, 2014).



<sup>72</sup> Ron Howard, *Apollo 13*, DVD, (Los Angeles: Universal Pictures Home Entertainment, 1995).

<sup>73</sup> Larry Roberts, "The Corps of Engineers," *Engineer* 30, no. 4 (October, 2000): 29-31 in ProQuest (accessed January 29, 2015).