COASTAL RESILIENCE CENTER
A U.S. Department of Homeland Security Center of Excellence

Coastal Resilience Center of Excellence
Research Lead

based at

The University of North Carolina at Chapel Hill

YEAR 2 ANNUAL REPORT

Reporting Period:
July 1, 2016 – June 30, 2017

Award Number 2015-ST-061-ND0001-01

submitted to:

The Office of University Programs
Science & Technology Directorate
U.S. Department of Homeland Security

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Nov. 20, 2017

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Theme 1: Coastal Infrastructure Resilience

Theme 2: Building Resilient Communities

Theme 3: Disaster Dynamics

Theme 4: Education and Workforce Development

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DHS S&T Coastal Resilience Center of Excellence
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Year 2 Annual Report Summary

I. INTRODUCTION AND CENTER OVERVIEW

This report provides a description of the activities and accomplishments of the U.S. Department of Homeland Security (DHS) Coastal Resilience Center of Excellence (CRC) that occurred during the Center's second year of operations (July 1, 2016, to June 30, 2017). With funding through a five-year Cooperative Agreement between DHS Science and Technology Directorate and the University of North Carolina at Chapel Hill (UNC-CH), the CRC is a mature organization with roots in the former Coastal Hazards Center, which was funded by DHS S&T from 2008 to 2015.

Like the CHC, the CRC operates as a consortium of universities, private companies and government agencies focused on addressing natural hazard threats to coastal communities through applied research, education and transition of research findings to practice. The CRC also considers future climate trends and their impacts on coastal resilience. During the period covered by this report, the CRC consisted of 22 projects carried out by partners located at 21 academic institutions in 12 U.S. states and one U.S. territory. Seven projects focus on maintaining and enhancing education programs at partner universities and one college; of these partners, four are classified as Minority Serving Institutions (MSIs). The remaining 15 CRC projects focus primarily on conducting research in a variety of disciplines, including coastal hazards modeling, social and behavioral sciences and engineering.

The first two sections of this annual report summary describe the administrative and management structure of the CRC, along with selected activities that were undertaken at the Center level during Year 2. The third section of the summary provides a snapshot of some of the achievements made by Principal Investigators who lead CRC-funded research and education projects. Following this summary is a section containing individual progress reports from each of the CRC PIs, grouped by theme. The PI reports describe in detail their research and education activities; progress in achieving project milestones; efforts towards transition of project outputs; interactions with end-users and stakeholders; and student activity.

By the Numbers

Between July 1, 2016, and June 30, 2017, PIs at the CRC made steady progress on their projects, as demonstrated by the following aggregated figures:

- PIs taught **32 courses** to **520 students** across seven campuses, including class offerings in multiple categories, such as majors, minors, concentrations, certificate programs, seminars, electives and practica.

- Students were involved in more than **40 internships** related to Homeland Security.

- **40** students received **Homeland Security-related degrees**, including 10 at the graduate-level.

- **Nine** students secured **employment in Homeland Security**-related fields.

- **22** journal articles were published.

- PIs gave more than **200** project-related **presentations** in a variety of settings, including professional conferences, visiting lecture series, panel discussions and outreach events, among others.

- Center partners reported more than **$1.3 million in leveraged support** and nearly **$8.6 million in non-OUP funding**. Funding came from a variety of sources, such as government agencies, foundations and internal institutional programs, including: NSF, NOAA, FEMA, ONR-Navy, USACE/ERDC, NIST, Sea Grant, NC Emergency Management, Google, Glaxo Smith-Kline and the William R. Kenan, Jr. Charitable Trust STEM Motivation Initiative, among others. Institutional support included no-cost office, classroom and meeting space; reduced charges and return of indirects; student support; release of teaching loads; and free or low-cost use of supercomputing resources on multiple campuses, including LSU, UNC/RENCI, UCF, UNF, UT-Austin, and SDSC.

CRC Administration and Management

The structure and associated roles and responsibilities of the CRC remained unchanged from the original organization chart established in Year 1, with the notable exception that Thomas Richardson took on the role of Associate Director (see Figure 1). This change was implemented to enable Director Gavin Smith to devote more of his time and effort conducting research and service activities at the behest of the Governor of North Carolina, with the mandate to help communities in the eastern part of the state recover from the impacts of Hurricane Matthew, and to become more resilient to future hazard events. Dr. Smith has carried out this directive by leading the Hurricane Matthew Recovery and Resilience Initiative (HMDRRI) (more information about HMDRRI can be found in section III of this report summary).

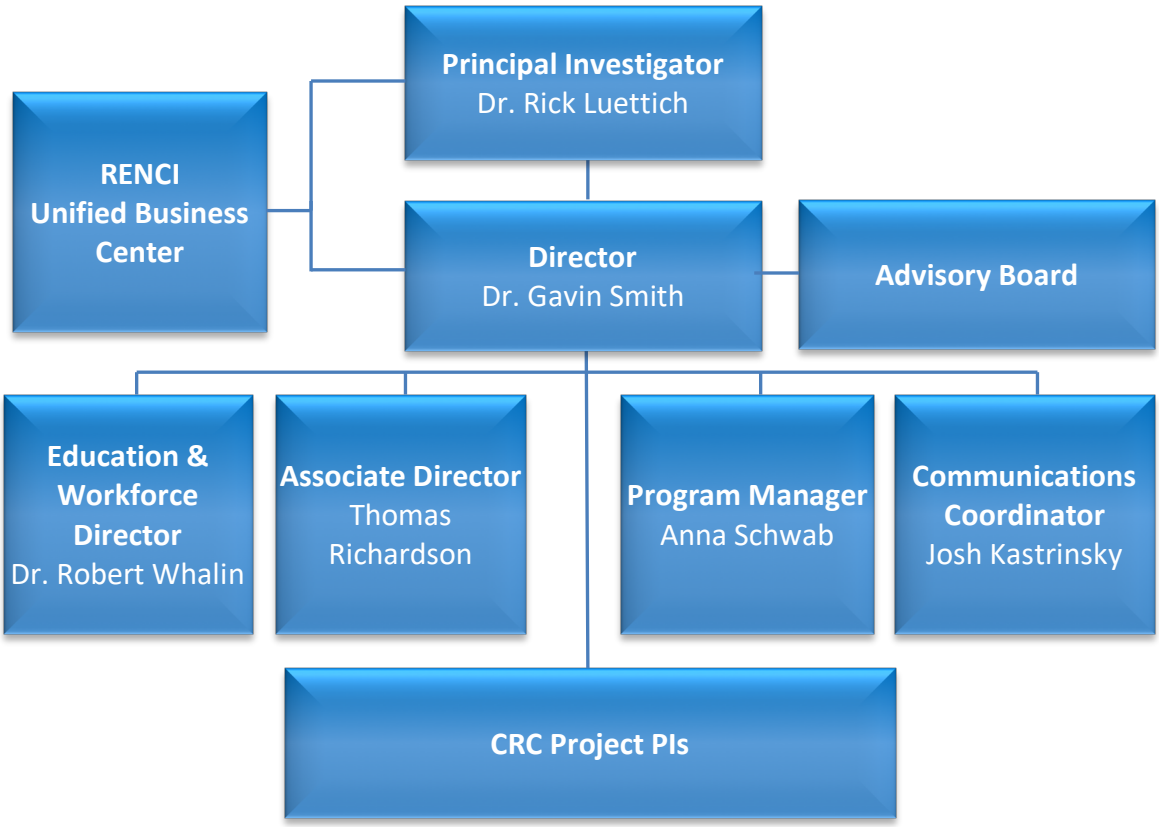

Figure 1: The CRC organizational chart

CRC Advisory Board

Many members of the CRC Advisory Board who served during Year 1 continued to be involved in the Center through Year 2 as well. Board members helped the Center by reviewing and providing feedback on overall Center activities, evaluating current projects and identifying transition partners, among other services. The primary mechanism for transmitting Board recommendations was the closed-door session immediately following the Center's Annual Meeting, as well as through separate communications with individual Board members.

The following members served on the CRC Advisory Board during Year 2:

- **Doug Bellomo,** Institute for Water Resources, US Army Corps of Engineers
- **Chad Berginnis**, Executive Director, Association of State Floodplain Managers
- **Curtis Charles,** Vice President for Research, Development, and Innovation, RLM Communications
- **Dr. John Cooper, Jr.,** Associate Professor of Practice, Landscape Architecture and Urban Planning Department, Texas A&M University
- **Todd Davison**, Manager, NOAA Gulf Coast Services Center
- **Dr. Reginald DesRoches**, Dean's Professor and Chair, Civil and Environmental Engineering, Georgia Institute of Technology
- **Dr. Billy Edge,** Professor of Civil, Construction, and Environmental Engineering, North Carolina State University

- **Dr. Gerald Galloway**, Glenn L. Martin Institute Professor of Engineering, University of Maryland
- **Dr. David Godschalk**, Stephen Baxter Professor Emeritus, Department of City and Regional Planning, The University of North Carolina at Chapel Hill
- **Dr. Diana Harrington**, Distinguished Professor of Finance, Babson College
- **Dr. William Hooke,** Senior Policy Fellow and Director of Policy Programs, American Meteorological Society
- **Dr. Gary LaFree**, Director, National Consortium for the Study of Terrorism and Responses to Terrorism (START)
- **Dr. James Martin**, Professor and Chair of Civil Engineering, Clemson University
- **Dr. Jae Park**, Recovery and Hazard Mitigation, AECOM
- **Dr. John Pine**, Director, Research Institute for Environment, Energy & Economics, Appalachian State University
- **Anthony Pratt,** Shoreline and Waterway Administrator, State of Delaware
- **Dr. Linda Rimer**, Region IV Liaison for Climate Resilience, U.S. Environmental Protection Agency
- **Ellis Stanley**, Executive Vice President, Hammerman & Gainer International and former General Manager, City of Los Angeles Emergency Preparedness Department
- **Dr. Lee Weishar,** Senior Scientist, Woods Hole Group, Inc.
- Special Advisory Board Liaison to the US Coast Guard: **Dr. Joseph DiRenzo**, Director of Research Partnerships, US Coast Guard Research and Development Center

II. CENTER-LED ACTIVITIES

Over the course of Year 2, the CRC administrative and management team carried out multiple activities on behalf of the Center, as summarized below.

CRC Annual Meeting

The second annual CRC meeting was held February 1-3, 2017, at the Center's main offices in Chapel Hill, N.C. Attendees included all research and education PIs, students, transition partners, DHS headquarters personnel and constituent agency staff, Center management and staff, Advisory Board members, Federal reviewers and invited guests. Over the course of the meeting, PIs presented on progress made to date, as indicated by milestone accomplishments and funding expenditures. During their presentations, research PIs identified committed customers within the Homeland Security Enterprise (HSE), and outlined plans to get their research products into actual use. Education PIs focused on how their projects' course content is kept current, their level of engagement with HSE professionals, and plans for courses to continue post-project. As a result of evaluations by the Federal reviewers at the Annual Meeting, three CRC research projects were removed from consideration under the Biennial Review (see Biennial Review section that follows).

In addition to PI presentations, the annual meeting agenda included a panel discussion about possible business strategies for the CRC, moderated by Shannon McKeen of the UNC-CH Kenan-Flagler Business School. The panel was followed by breakout sessions where meeting attendees discussed and reported back to the group about various models for a self-sustaining center. The discussion was carried into the closed-door Advisory Board meeting.

CRC Sustainability Plan

DHS S&T generally funds individual Centers of Excellence (CoE) for a maximum of two 5- or 6-year awards. Because CRC in effect operates as a continuation of its predecessor, the Coastal Hazards Center, DHS funding for CRC will likely cease in 2020, with the expectation that the Center will be self-sustaining by that point.

In order to meet this expectation, CRC hired Mr. Shannon McKeen, a business development expert at the UNC-CH Kenan-Flagler School of Business, to assist in drafting a sustainability plan for the Center. With input from CRC staff, Mr. McKeen conducted research to identify best practices and collect data on CRC's prospects for sustainability. Activities included:

- Secondary research on Center sustainability;
- Survey of coastal resilience stakeholders, including surveys of CRC PIs, Advisory Board members, members of the Federal Coordinating Committee, among others; and
- Interviews with thought leaders in coastal resilience and sustainability.

Based on initial findings of the research, the CRC will consider developing a plan to leverage its success by focusing on the development of tools to support stakeholders in community resilience. Possible action by the CRC includes:

- Narrow its focus to research and development of tools and techniques for communities:
    - Reach out to commercial entities or not-for-profit organizations to distribute products;
    - Engage in licensing, partnerships or consortia.
- Invest time and personnel to build partnerships and communicate what makes CRC valuable in the broad context of community resilience.
- Find a platform or network to join so CRC output is not a point solution but part of a larger effort to support resilient communities.

These and additional ideas will be further refined and deliberated during Year 3.

Biennial Review

Each Center of Excellence funded by DHS S&T must undergo a biennial review, an intensive examination of the Center's research and education portfolio, as well as the effectiveness of the CoE leadership team. The review is conducted by the CoE's Federal Coordinating Committee (FCC) in coordination with the CoE's DHS Program Manager. During Year 2, the CRC provided input to Phase I – the "Letter Review" of the biennial review process, which involved developing and submitting written materials about each project. CRC provided extensive guidance to PIs to assist them in preparing their Phase 1 review materials, including a two-page Project Summary, a Literature Review, an NSF Biosketch, a Stakeholder Point of Contact List and additional information to help the reviewers evaluate the projects' scientific quality or educational merit.

Phase II, an in-person presentation to the FCC about each research and education project, is scheduled to take place during Year 3 in Washington, D.C.

SUMREX: Summer Research Experience

Eight students who are enrolled in CRC-supported courses at partner universities were hosted by CRC research PIs through the second annual SUMmer Research EXperience (SUMREX), a unique home-grown program of the CRC that is funded by individual PIs' project budgets. As part of the program, CRC Education partners arrange for one or more students to visit the home institution of participating CRC researchers for a summer research internship lasting between six and 10 weeks. Students receive support from the host PI in the form of funding for travel and a stipend, instruction in research techniques, application of knowledge learned in their coursework,

and above all – one-on-one mentoring. Key to the program's success is making the best match between the student interns and the research PIs, so that the students have the opportunity to become fully immersed in a meaningful research project. Students come largely from Minority-Serving Institutions, in furtherance of the CRC's efforts to increase diversity in research environments. Stories of SUMREX students narrated in their own words are shared in the CRC News section and on the Students page of the CRC website.

During the summer of 2017, the following pairings of student and CRC PIs were made:

- Sabrina Welch (in photo), a PhD candidate at **JSU**, and Diego Delgado, a graduate engineering student at **UPRM** visited Dr. Stephen Medeiros at **UCF** and Dr. Scott Hagen at **LSU** where they developed and improved their skills using the ADCIRC storm surge model.
- Hector J. Colon and Peter Rivera, undergraduate students in engineering at **UPRM** were hosted by Dr. Dan Cox at **Oregon State University**, where they learned about extreme surge/wave forces during hurricanes.
- Stephen Kreller, a graduate student in Geography at **LSU** spent several weeks with Dr. Brian Blanton at **RENCI/UNC-CH**, whose project involves developing enhancements to the ADCIRC model.
- **URI** hosted three undergraduate students from **Tougaloo College**: psychology major Courtney Hill and biology majors Rosalie Cisse and Kierra Jones. Ms. Hill worked with co-PI Pam Rubinoff on the CRC project examining how the 2010 floods of Rhode Island led to specific reforms and policies; Ms. Cisse worked on a project identifying species of toxic plankton bloom present in the Narragansett Bay and Rhode Island Sound. Ms. Jones worked on a project analyzing the role of phytoplankton to temperature changes.
- In a one-day exchange, nine students from **JCSU** visited the **NCSU** Department of Civil, Construction and Environmental Engineering, where CRC PI Dr. Casey Dietrich arranged presentations and discussions with faculty members in the department's computing and systems groups.

RETALK

The Research Talk program, or *RETALK*, began in Year 1, and involves research PIs delivering an in-person talk to students at a CRC education partner. The talk may be a lecture, seminar or other type of presentation where visiting PI's discuss the details of their research projects as they relate to courses taught at the host institution. Guest speakers may also engage the students in new and different ways of thinking about resilience issues by exposing them to expanded scientific or technical concepts. The RETALK program has grown in scope since it began, as evidenced by the following exchanges made during Year 2:

- Dr. **Wie Yusuf** of Old Dominion University (ODU) gave a lecture at Johnson C. Smith University on 'Lessons Learned the Hard Way and Tales of Engagement' in October 2016.
- Dr. **Joshua Behr** (ODU) visited Dr. **Rachel Davidson**'s lab at the University of Delaware in February 2017.

- On March 31,2017 Dr. **Casey Dietrich** (NCSU) visited Johnson C. Smith University (JCSU) and presented a seminar about current research in storm surge modeling and forecasting. The seminar was attended by a combination of graduate students and faculty members from JCSU. The first half of the seminar was a summary of the last decade of PI Dietrich's research, with a focus on storm surge modeling along the northern Gulf coast, including examples of his experiences in graduate school and beyond. The second half of the seminar was an introduction to and preliminary results from Dietrich's CRC project. The seminar was well-received with many questions from the audience. The presentation has been archived on PI Dietrich's institutional website.
- Dr. **Don Resio** presented a lecture on March 17, 2017, at LSU titled, "The Effect of Natural Structure on Storm Surge Probabilities".
- **Sandra Knight** visited LSU and discussed with **Barry Keim** the process, successes and setbacks of establishing a research program at LSU. This was further shared with UMD faculty from across the colleges when **Robert Twilley** visited the campus to discuss how he established the Coastal Sustainability Studio at LSU.
- The Minor in Disaster Coastal Studies program at Tougaloo College hosts a research symposium each academic year which showcases the DCS student activities. Dr. **Gavin Smith**, from UNC-CH attended the Symposium as a guest lecturer. His talk was entitled "Post Hurricane Mathew Disaster Recovery Assistance: Linking Research, Practice and Community Engagement."
- Dr**. Dan Cox** (OSU) visited Puerto Rico from March 5- 9, 2017, at the invitation of Professors **Ismael Pagan** and **Ricardo Lopez**. On March 7, Dr. Cox visited the campus of the University of Puerto Rico- Mayaguez where he met with students and faculty in civil engineering and marine sciences, toured the facilities, and gave a seminar on coastal hazards engineering and resilience. His talk was titled "Tsunami Inundation Modeling for Risk-Based Decision Making to Increase Community Resilience." On March 8 and 9, Dr. Cox gave a keynote presentation on his research project at the research symposium organized by Profs. Pagan and Lopez in San Juan. Dr. Cox also met with engineering practitioners from Puerto Rico and researchers from the USACE.

Career Development and Workforce Development Grants

With funding from the DHS Office of University Programs, CRC and its predecessor, the CHC, have sponsored a total of four fellowships at UNC-CH through the DHS Career Development Grant (CDG) and the Science and Engineering Workforce Development Grant (WFD). The first CDG recipient, Lea Sabbag, graduated with a Master's in City and Regional Planning in Spring 2016 after fulfilling her CDG requirements. Ms. Sabbag is currently employed full-time at the NC Division of Emergency Management, where she coordinates housing-related policy issues following Hurricane Matthew.

Ms. Ashton Rohmer completed the requirements for the CDG program upon graduating from UNC-CH with a Master's in City and Regional Planning in the Spring of 2017. Ms. Rohmer participated in internships with the National Park Service working on climate adaptation, and with the NC Division of Emergency Management working on Hurricane Matthew recovery. In September 2017, Ms. Rohmer accepted a position with ASI Government as a consultant based out of FEMA headquarters, supporting the National Flood Insurance Program. Ms. Rohmer's final CDG report is included in the Student Activity Appendix.

With funding from the DHS OUP Science and Engineering Workforce Development grant, two Masters' candidates -- Colleen Durfee and Darien Williams -- enrolled in the Department of City and Regional Planning at UNC-CH in the in the Fall of 2016, with an expected graduation date of 2018. During the fall and spring semesters, both WFD students worked on the CRC-funded Resilient Design Education Study, a research project lead by Dr. Gavin Smith. They both fulfilled the first of two required internships in the summer of 2017 by working on the Hurricane Matthew Recovery and Resilience Initiative, a program funded by the NC Division of Emergency Management and UNC to help six communities in eastern North Carolina recover from Hurricane Matthew. Mr. Williams and Ms. Durfee's WFD annual progress reports are included in the Student Activity Appendix.

DHS Summer Research Team Program for Minority Serving Institutions

CRC partners at Old Dominion University (ODU) hosted a summer research team led by Norfolk State University (NSU) faculty Dr. Camellia Okpodu and Dr. Bernadette Holmes as part of an interdisciplinary, multi-institution collaborative summer research project. The exchange was funded by the DHS Summer Research Team Program for Minority Serving Institutions (MSI).

The project was titled "A Systems Approach: Developing Cross-Site Multiple Drivers to Understand Climate Change, Sea-level Rise and Coastal Flooding for an African American Community in Portsmouth, VA." Dr. Okpodu, Professor of Biology, led biological and ecological aspects of the project, while Dr. Holmes, Professor of Sociology and Criminal Justice, led the sociological part of the project. The project included five students, three from NSU and two from ODU. The ODU researchers provided assistance and feedback, served as a resource for engaging the local community, provided guidance on data management and supervised ODU graduate students participating in the multi-institutional project teams. The summer research project builds on work done by other researchers at ODU on the disproportionate impact of flooding on low-resource communities, and their adaptation to flood events.

Norfolk State University students Mikel Johnson and Raisa Barrera participated in a summer research team project at Old Dominion University.

DHS Flood Apex Study / Floyd-Matthew Study / Flood Analytics Colloquium

The DHS Science & Technology Directorate First Responder Group initiated the Flood Apex program with the goal of saving lives, reducing property loss and enhancing community resilience to disruptive flood. CRC plays a supporting role in the Flood Apex project, and carried out the following tasks during Year 2 with the CRC Associate Director Tom Richardson in the role of Co-PI:

- Planned and hosted four Flood Apex Research Review Board meetings, including:
  - Two virtual meetings by WebEx in September 2016 and January 2017, and
  - Two in-person meetings in Washington, D.C. in October 2016 and May 2017.
- Completed the Decision Support Landscape Survey through a contract with the RAND Corporation.
- Initiated the Floyd-Matthew study through a contract with AECOM. The purpose of this study is to evaluate how well hazard mitigation and other programs and policies put in place following Hurricane Floyd -- an event which caused massive flooding in eastern NC in 1999 -- reduced the impacts of Hurricane Matthew, which was a similar flooding event that occurred in 2016.
- Began the planning process for the "Rethinking Flood Analytics Colloquium" in collaboration with CRC PI Dr. Sandra Knight (UMD), and the Renaissance Computing Institute (RENCI) at UNC-CH. The Colloquium will be held during Year 3.

Resilient Design Education Project

As part of the Obama administration's recognition of the role of resilient design education for a resilient future, DHS S&T provided funding for a CRC study led by Director **Gavin Smith** and faculty at the Department of City and Regional Planning at UNC-CH. The purpose of the study is to understand how universities throughout the country and across different disciplines teach resilient design. With research assistance provided by graduate students in the CRC's Career and Workforce Development grant programs, the study involves a review of existing college and university education programs in planning, architecture, landscape architecture, building sciences and engineering that incorporate design approaches to address natural hazards, disasters and climate change adaptation into the curriculum. The study receives guidance and feedback from an advisory board made up of academics, private sector industry groups, professional associations and government agency representatives.

The research methodology includes a literature review and internet search of institutions and programs involved in the area of resilient design; semi-structured telephone interviews with 16 identified academics and practitioners; and case studies of universities and college programs that show innovation in teaching resilient design. During CRC Year 2, the research team completed approximately six case studies, and developed a list of recurring themes emanating from interviews conducted to date. Tasks for Year 3 include completing all scheduled interviews, finalizing case studies and writing a final report that describes the current state-of-the-art in resilient design education, identifies best practices and discusses some of the obstacles and barriers to teaching resilient design.

Maritime Risk Symposium

The Coastal Resilience Center, in collaboration with the US Coast Guard, hosted the 7th Annual Maritime Risk Symposium on Nov. 14-15, 2016, at the University of North Carolina at Chapel Hill. The theme of the gathering was "Integrating Maritime and Coastal Resilience." Structured in a workshop format, the event consisted of a series of panel presentations, plenary sessions and breakout discussions that tackled some of the most challenging issues associated with resilience in the maritime and coastal sectors. Topics included: enhancing resilience of the Nation's ports and

maritime facilities, including the Houston-Galveston complex; vulnerable coastal and maritime infrastructure; resilience in the coastal system of the Norfolk/Hampton Roads communities; and cyber resilience concerns in the Maritime Transportation System [MTS]. The primary goals of the 2016 Symposium were to expose gaps in current knowledge and areas of operational inefficiencies, and to identify innovative research opportunities that might be pursued via the Department of Homeland Security Science & Technology Centers of Excellence.

Throughout the discussions during the 2016 MRS, a recurring theme addressed the linkages between the MTS and the physical, ecological, built and human systems found in many coastal regions. Among the key outcomes of the Symposium, meeting participants provided guidance for designing resilience studies across the maritime and coastal sectors, including:

- Consider projects that take a regional approach, rather than attempting to address national or international scales;
- Seek interdisciplinary research project teams (e.g., engineering, ecology, planning & design, social and behavioral sciences – geography, economics) working with mixed-methods approaches (quantitative and qualitative);
- Seek participation or partnership with stakeholder-driven end user groups that represent important sectors of the coastal and maritime community (e.g., federal agencies, port authorities, shippers, tenants, local government, environmental groups, community groups); and
- Incentivize researchers working in this space to share results, experiences and lessons learned.

In addition, the MRS proceedingS highlighted numerous examples of operational needs and research questions related to resilience in the maritime–coastal system. From these, the final report of the MRS identified the following eight overarching research areas, with questions for possible future research activities:

- Understanding Interdependency of Maritime and Coastal Systems
- Understanding Impacts of Disruption to Maritime and Coastal Systems
- Understanding Threats to Maritime and Coastal Systems
- Understanding Costs of Implementing Resilience
- Understanding the Transfer of Risk to Stakeholders of Maritime and Coastal Systems
- Understanding the Value of Infrastructure Across Maritime and Coastal Systems
- Understanding Existing Data and Developing New Tools to Identify Areas of Investment for Resilience
- Assembling Examples of Resilience Implementation in Maritime and Coastal Systems

Additional details and specific findings from the MRS are captured in the MRS final report, which is available on the CRC website at http://coastalresiliencecenter.unc.edu/wp-content/uploads/2017/08/CRC_2016-MRS_FINAL-REPORT_07-28-2017_.pdf.

NSF PIRE Program

During Year 2, Dr**. Robert Whalin** (JSU) was engaged in the National Science Foundation (NSF) Partnerships for International Research and Education program (PIRE) through an award made to Texas A&M University. The project, titled "Coastal Flood Risk Reduction Program: Integrated, multi-scale approaches for understanding how to reduce vulnerability to damaging events," included exploration of flood-reduction approaches in The Netherlands. During Year 1, three JSU graduate students were part of a 12-student PIRE team led by Texas A&M-Galveston that spent two weeks in May, 2016 in the Netherlands working with students and experts at Delft University

on various aspects of planning, designing, and implementing integrated flood risk reduction. During Year 2, one PhD candidate from JSU was part of a 16-person student team that worked in The Netherlands.

Hurricane Matthew Infrastructure Study

During Year 2, the CRC provided assistance to a study conducted by the Community and Regional Resilience Institute (CARRI) and the Center for Resilience Studies at Northeastern University. The study is funded by the DHS National Protection and Programs Directorate, Office of Infrastructure Protection.

Based on an earlier DHS-funded study of the 2015 flooding event in the South Carolina midlands that was performed by CARRI, the Hurricane Matthew Infrastructure study is collecting observations and lessons learned that can help communities become more resilient and that policymakers can use to shape national support for community infrastructure resilience and recovery programs. Throughout the study, Drs. **Gavin Smith** and **Rick Luettich** provided insight and guidance, including the provision of contact information for people in their extensive networks of federal, state and local officials working in Hurricane Matthew-impacted communities in eastern North Carolina. The information was used by CARRI researchers to conduct telephone and in-person interviews with federal, state and local community leaders and stakeholders to record their perceptions of the characteristics and actions which impact and support rapid and healthy community recovery. A final report is expected in 2018.

III. RESEARCH AND EDUCATION PROJECT HIGHLIGHTS

Selected highlights from the reporting period are included in the section below. Detailed progress reports about individual projects follow this overview of accomplishments.

Hurricane Matthew Activity

Hurricane Matthew made landfall in the U.S. in early October 2016. In the days leading up to and during the storm, several CRC partners were involved in tracking the storm and predicting storm surge along Matthew's path up the coast from Florida, to Georgia, the Carolinas and Virginia. A team of Center researchers, including partners from the University of North Carolina at Chapel Hill (UNC-CH), Louisiana State University (LSU), North Carolina State University (NCSU) and Seahorse Coastal Consulting performed storm surge and wave forecasts using the ADCIRC modeling system as the storm tracked up the southeast coast.

The CERA website shows Matthew's projected storm path and surge on October 6, 2016

ADCIRC results for Hurricane Matthew were displayed on the Coastal Emergency Risks Assessment (CERA) website, which is developed and managed by CRC partners at LSU. The results were shared with local emergency managers, to help local leaders make informed decisions related to road closings, evacuations and search and rescue. During Hurricane Matthew, the computing power to run several ADCIRC simulations every six hours was provided by the UNC-CH Renaissance Computing Institute (RENCI), a partnership with Duke University and NCSU, and the Center for Computation and Technology (CCT) at LSU. Four current CRC projects are investigating improvements to the model to make it faster and more detailed.

Interest was high and widespread during Hurricane Matthew's path up the East Coast. The CERA website was accessed from 45 states, with the highest concentration in North Carolina, and the next highest along the East Coast and Gulf states. Website traffic between Oct. 2-10 peaked at close to 2,000 unique hits per day, a roughly tenfold increase in the traffic generated during Tropical Storm Hermine in late August and early September, 2016. CRC also saw a spike in social media activity during Hurricane Matthew; in particular, the CRC Twitter account showed a sharp rise in activity between Oct. 3-9. During a typical month, @CoastalResilCtr experiences between 15,000-20,000 unique impressions. In contrast, during the week of Hurricane Matthew coverage the account had more than 14,000 impressions in just 7 days.

ADCIRC Used at NC Emergency Management Operations Center

In addition to local governments, state officials relied on ADCIRC results to make decisions about preparedness, response and recovery actions related to Hurricane Matthew.

The CERA website was used during Hurricane Matthew preparedness action at the NCEM Emergency Operations Center. Photo by Casey Dietrich.

Dr. **Casey Dietrich** of NCSU, whose CRC project focuses on improving the speed of ADCIRC modeling, visited the North Carolina Emergency Management (NCEM) State Emergency Operations Center to see NCEM's operation and workflow during Hurricane Matthew storm response, which relied in part on data provided by ADCIRC predictions. NCEM officials used both the CERA site and shapefiles generated. The shapefiles were combined manually with other datasets to determine the potential flood damages, in terms of both number and cost of buildings and infrastructure, a critical component of storm damage assessment.

In addition to local and state emergency management agencies, the National Oceanic and Atmospheric Administration (NOAA), U.S. Coast Guard, U.S. Army Corps of Engineers and Federal Emergency Management Agency (FEMA) are among the federal agencies that factor ADCIRC modeling into their operations.

Tracking Damage and Recovery from Hurricane Matthew

In addition to the use of ADCIRC to predict storm surge and flooding from Hurricane Matthew, CRC researchers initiated several other projects to help coastal communities respond to and recover from the storm.

- **Don Resio** of the University of North Florida, whose CRC project incorporates precipitation into hazards modeling, began a study of storm surge and flooding impacts on the Atlantic Coast of Florida following Hurricane Matthew's impact. Dr. Resio was part of a team taking aerial photography and gathering in-situ on-ground data on high-water marks and damages in coastal areas of St. Augustine and Jacksonville.

- Dr**. Phil Berke** of Texas A&M University, whose current CRC project focuses on the coordination of local plans to better address hazards, examined the effects of local implementation efforts of hazard mitigation programs after Hurricane Matthew. The sample of communities in the study is drawn from a prior DHS-supported project on hazard mitigation planning in coastal areas of Florida, Georgia and North Carolina. The sample covers those communities that sustained impacts from Hurricane Mathew.

The previously collected data provides a unique opportunity to assess the effectiveness of plans designed to reduce vulnerability.

- Researchers at Louisiana State University who are part of CRC PI **Robert Twilley**'s project worked with PI Dr. **Casey Dietrich** (NC State University) and CRC Lead PI **Rick Luettich** (UNC-Chapel Hill) to add measurements from real-time water level stations located along the Atlantic and Northern Gulf coasts to enhance the Coastal Emergency Risks Assessment (CERA) website. The addition of these measurements will allow the researchers to improve the accuracy of the ADCIRC storm surge model by validating the water levels predicted by ADCIRC during Hurricane Matthew and the water levels recorded by several agencies. LSU researchers are in contact with the National Oceanic and Atmospheric Administration's (NOAA) Lower Mississippi River Forecast Center to gather data for this time period and to provide general station information.

- **Hurricane Matthew Recovery and Resilience Initiative:** Following the storm, the services of CRC Director Dr**. Gavin Smith** were requested by the North Carolina Division of Emergency Management (NCEM) to advise the Division and Governor Roy Cooper's office on state and federal disaster recovery policy and programs. In short order, Dr. Smith was detailed to lead the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI), which focuses on assisting local communities prepare disaster recovery plans.

  HMDDRI encompasses six North Carolina communities affected by Hurricane Matthew: Lumberton, Princeville, Kinston, Seven Springs, Fair Bluff and Windsor. Through the HMDRRI partnership, NCEM personnel, N.C. universities, representatives of the Governor's office, private sector consultants and FEMA officials are working together to assess municipal capacity to recover from and plan for the next disaster. The project involves nearly two dozen students and faculty from North Carolina universities, including NC State University School of Design, and UNC-CH Department of City and Regional Planning. Along with Dr. Smith, many of the students were embedded in the Hurricane Matthew Joint Field Office (JFO) located in the Research Triangle Park, where they worked directly with state and federal emergency management professionals. Among the full-time state personnel working at the JFO on Hurricane Matthew recovery efforts is a former DHS Career Development Grant recipient who was mentored during her matriculation by Dr. Gavin Smith before receiving her Master's degree in City and Regional Planning from UNC-CH in 2016.

  HMDRRI is funded through three primary sources: NCEM, the North Carolina Policy Collaboratory and DHS S&T. Direct support is provided by DHS S&T through funds that support research and education connected to HMDRRI, including an empirical analysis of post-Hurricane Floyd statewide mitigation actions and their effects on the level of resilience in the six HMDRRI communities. This study, managed through CRC, is funded by the DHS S&T Flood Apex Program.

Additional 2016 Hazards

In addition to efforts dealing with Hurricane Matthew, CRC research partners turned their attention to several other hazards that occurred during Year 2:

- **Tropical Storm Hermine**: CRC partners at **Louisiana State University** provided storm surge guidance for Hurricane/Tropical Storm Hermine in late July and early August 2016. Using an ADCIRC mesh that was developed by NOAA, results were visualized on the CERA website. The CERA website was visited by 180 users per day during Sept. 1-2, 2016, to access information about the predicted storm surge and inundation.

- **Louisiana Floods:** CRC researchers at LSU responded to the historic flooding event in Louisiana in August 2016. **Brant Mitchell**, Director of the Stephenson Disaster Management Institute at LSU, and co-PI on **Robert Twilley**'s CRC project, met with staff from the Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) and the head of the Coastal Protection and Restoration Authority (CPRA). During the meeting Mitchell gave an overview of the CERA website, LSU's efforts to continuously improve the ADCIRC model mesh for Louisiana, and the results of the consequence model that Stephenson Disaster Management Institute is developing. An additional meeting with the Louisiana National Guard resulted in potential additions to the consequence model to improve search and rescue efforts for major flooding events.

Training, Exercises, Workshops and Outreach

Throughout the 2016-17 reporting period, CRC research and education partners sponsored workshops, partnered and presented at conferences, and engaged in a variety of training and outreach activities. Many of these efforts included direct student involvement.

- **2017 ADCIRC Week and Boot Camp hosted by CRC researchers**: Researchers and students interested in coastal modeling gathered on May 1-5, 2017, in Norwood, Massachusetts to hear the latest developments in ADCIRC storm surge modeling, meet with peers and learn the state of the art in predicting flooding impacts on coastal communities. 2017 ADCIRC Week included the ADCIRC Boot Camp followed by the Users Group Meeting. The Boot Camp, an intense, three-day information and training session for new and returning ADCIRC users was organized by co-PI Dr. **Jason Fleming** of Seahorse Coastal Consulting. The ADCIRC Users Group Meeting was supported by FM Global.

ADCIRC Bootcamp 2017 Participants

Among those participating in the training were state and local government officials, students, academic researchers and private sector consultants. In addition, more than a dozen federal employees registered for the event including DHS, NOAA, NASA, NRC, Los Alamos National Laboratory, USACE and USCG.

- **URI Partners work with Rhode Island Emergency Management Agency:** CRC PI Dr. **Isaac Ginis** of URI, along with researchers on his coastal modeling team, conducted an *Integrated Emergency Management Course* from June 19-22, 2017. The event took place in partnership with the Rhode Island Emergency Management Agency (RIEMA), in lieu of RIEMA's Annual Preparedness Conference. The four-day exercise focused on response to hurricane scenarios and identified key actions to take before, during and after a hurricane. To create a realistic environment, the modeling team at URI partnered with RIEMA and FEMA to develop "Hurricane Rhody" scenarios and impact visualizations. The course provided RIEMA an opportunity to enhance overall preparedness, while actively testing the modeling outputs in various scenarios.

- **UPRM Coastal Resilience Conference:** PI Dr. **Ismael Pagan-Trinidad** and co-PI Dr. **Ricardo Lopez** hosted a conference called "Lessons Learned - Resilience of Coastal Infrastructure" in March 2017 at the University of Puerto Rico-Mayaguez. Among the 26 presenters were CRC PI Dr. **Dan Cox** of Oregon State University, representatives from U.S. Army Corps of Engineers, including the Engineer Research and Development Center (ERDC),, the Puerto Rico Department of Natural and Environmental Resources and the College of Engineers and Surveyors of Puerto Rico.

- **UNC-CH Speakers Series**: In partnership with the UNC-CH Department of City and Regional Planning, CRC sponsored a graduate certificate program in the study of Natural Hazards Resilience for the second year in a row. As part of this effort, Director **Gavin Smith** hosted a Speaker Series with invited talks by national and internationally recognized scholars and policymakers during the Spring 2017 semester. Among the wide range of topics presented, students learned about:
    - Ongoing efforts of the US Department of Housing and Urban Development following Hurricane Sandy;
    - How recent major bushfires may spark policy change in Australia;
    - The roles and experiences of the mayor of Hoboken, NJ in the wake of disaster;
    - The role of data and its analysis in the support of disaster recovery; and
    - Anthropological perspectives on resilience and climate change adaptation, among other timely and engaging issues.

- **Presentation to the AMS:** CRC Lead PI Dr. **Rick Luettich** made a presentation in January at the 2017 American Meteorological Society Annual Meeting in Seattle. Luettich spoke on "Representing Low Frequency, Spatially Varying Water Level Anomalies in Storm Surge Computations" in the session titled "Regional and Coastal Hydrodynamic Model Coupling, Including Hydrological Impacts - Part II." The talk was adapted from a paper written by Dr. Luettich and co-authored by CRC PI Dr. **Brian Blanton**.

- **CRC PIs present at American Society for Engineering Education Annual Conference**: CRC PI Drs. **Robert W. Whalin** of JSU and **Ismael Pagan-Trinidad** of UPRM, along with co-authors Evelyn Villanueva and David Pittman from ERDC, presented a paper entitled "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership" at

the Minorities in Engineering Division Technical Session on June 27, 2017. The paper is part of the Conference Proceedings. Dr. Pittman is Deputy Director at ERDC, and Ms. Villanueva is ERDC's partnership coordinator.

Providing Assistance and Expertise to Communities and Government Agencies

During Year 2, several CRC partners provided assistance to a variety of recipients:

- **CRC researchers present DHS work to Congressman's office:** Dr. **Austin Becker**, a co-PI on a CRC project led by Dr. **James Opaluch** at the University of Rhode Island, presented information on his DHS-funded work to staff of Rep. Alan Lowenthal (D-RI) in June 2017, in Washington, D.C. Dr. Becker's presentation, "Coastal infrastructure resilience to extreme events: Geoscience in planning, design and construction," was part of the Geoscience and the U.S. Economy Briefing Series.

- **National Preparedness Roundtable**: CRC Director Dr. **Gavin Smith** served on the National Preparedness Roundtable, sponsored by the National Security Council and White House staff in September, 2016. In recognition of National Preparedness Month, expert speakers, national professional associations, federal collaborators, state, local and tribal governments discussed recent advances in the National Preparedness System, what the federal government is doing to fill the gaps identified in the 2016 National Preparedness Report, and how FEMA's "Whole Community" approach can build on collective efforts to achieve national preparedness goals.

- **CRC PI helps Virginia city with resilience planning:** In January and February 2017, CRC researchers and students working on a project led by Dr. **Phil Berke** at Texas A&M University met with officials in Norfolk, Va., to assess the city's policies with regards to vulnerability to hazards by highlighting how local programs and plans may increase or counteract efforts towards resiliency. Norfolk, along with League City, Texas, serve as test cases for Berke's "Vulnerability Scorecard." Officials in Norfolk are using the standards developed by Dr. Berke and his team to compare vulnerability to natural hazards across neighborhoods. In League City, the team provided assistance to the community's mapping process.

- **Hurricane Matthew Design Week**: CRC Director Dr. **Gavin Smith** participated as a panelist and team advisor at Design Week, held in January, 2017 at North Carolina State University in Raleigh. Several students enrolled in Dr. Smith's CRC-supported courses participated in the event, which involved visits by student teams to sites affected by Hurricane Matthew in eastern North Carolina. Teams developed unique planning-based solutions for future flood resilience, which were judged at the conclusion of the event.

- **CRC PI work contributes to National Weather Service model:** PI Dr. **Isaac Ginis** and colleagues at URI contributed improvements to the National Weather Service's operational hurricane prediction models. The Geophysical Fluid Dynamics Laboratory and Hurricane Weather Research and Forecasting models adopted Dr. Ginis's inputs in July 2016. The upgrades will help track storms in the Northern Hemisphere basins, including the Central Northern Pacific, Western North Pacific and North Indian Ocean.

Student Activity

CRC Students were engaged in a wide variety of activities during Year 2, many of which were student-initiated:

- **Students organize research symposium:** The Carolina Hazards and Resilience Planners, a group led by students who are part of Dr. **Gavin Smith**'s education program at the University of North Carolina at Chapel Hill, hosted the Triangle Resilience Student Research Symposium in April, 2017, in Chapel Hill. The event provided a forum for graduate students from UNC-CH, Duke University and North Carolina State University to present their research, connect across the universities and prepare for a career in the field of natural hazards resilience.

- **Students at Johnson C. Smith present on summer projects:** Two Johnson C. Smith University students supported by Dr. **Hang Chen**'s CRC Education program presented their summer project work at the 2017 Emerging Researchers National Conference in STEM in February, 2017, in Washington, D.C. Student Jean Nshimiyimana presented on "Data Analysis of Haiti's Resiliency Post-2010 Earthquake," and student Desmond Taylor made a presentation on "A Comparative Analysis of Disaster Resilience in Ten Countries."

- **Disaster Coastal Studies (DCS) Symposium at Tougaloo College:** CRC PI Dr. **Meherun Laiju**, professor at Tougaloo College in Jackson, Mississippi hosted a research symposium in 2017. During the event, students enrolled in the interdisciplinary minor program in Disaster and Coastal Studie*s* shared their internship experiences, research, and training projects performed at end user agencies. Several end-users were in attendance and interacted directly with the students.

- **CRC students serve on panel at regional climate conference:** Students enrolled in Dr. **Gavin Smith'**s CRC-supported course served on panels during the Carolinas Climate Resilience Conference from Sept. 12-14, 2016, in Charlotte, NC. Ph.D. candidate Sierra Woodruff spoke on two panels: "Working Together for Climate Resilience: Linking Local Planning Efforts" and "Climate Adaptation Case Studies for Local Governments"; UNC graduate student and DHS Career Development grant recipient Ashton Rohmer spoke about "Buy-In for Buyouts: Buyout Best Practices and Their Implications for Hazard Mitigation and Climate Change Adaptation."

Awards

CRC PIs and students were recognized during Year 2 for a variety of accomplishments:

- **CRC Career Development Grant recipient wins awards for paper:** Ashton Rohmer, a graduate student at the University of North Carolina at Chapel Hill and a Career Development Grant recipient, was named Runner-Up at the Association of State Floodplain Managers 2017 Conference, "Flood Risk Management in the Heartland," held in Kansas City. Ms. Rohmer was awarded for her paper "Exercising Best Practices in Property Acquisition Programs and Open Space Projects." The same paper earned her a Weiss Best Colleague Award from the Department of City and Regional Planning at UNC-CH, where Rohmer recently received her master's degree.

- **Coastal Resilience Center shares award from high performance computing publication for storm surge modeling work:** The CRC was recognized, along with RENCI and the UNC Institute of Marine Sciences, in the annual ***HPCWire*** Readers' and Editors' Choice Awards, presented at the 2016 International Conference for High Performance Computing, Networking, Storage and Analysis (SC16) on Nov. 14, 2016, in Salt Lake City, Utah. The RENCI/CRC/IMS collaboration won Editors' Choice: Best Use of High-Performance Data

Analytics, based on their partnership on ADCIRC, which is used to model storm surge. The partnership is the focus of an ***HPCWire*** article written in October, **"RENCI/Dell Supercomputer Charts Hurricane Matthew's Storm Surge."**

- **CRC researcher honored by NOAA:** CRC Principal Investigator Dr. **Isaac Ginis** received a Certificate of Appreciation from the National Oceanic and Atmospheric Administration at the Tropical Cyclone Operations and Research Forum in Miami on March 15, 2017, for his contribution to improving hurricane forecasting. The recognition is for Dr. Ginis's "contributions to the development of the GFDL hurricane model, the model's successful transition to operations, and the continual operational support resulting in steady improvements over its lifetime."

- **Students use product of CRC project to win design awards:** Students at Texas A&M University won awards from the American Society of Landscape Architects – Texas Chapter for their proposed flood protection measures for vulnerable communities as identified through a tool developed by CRC PI Dr. **Phil Berke**. The students used the resilience scorecard that is the focus of Dr. Berke's project to envision changes to vulnerable League City, Texas. The scorecard helps local planners and emergency managers identify local plans that increase or decrease hazard vulnerability by examining the integration of all plans involved in land use and development decisions.

- **CRC PI receives grant for natural disasters studies:** CRC PI Dr. **Meheran Laiju** was one of two Tougaloo College faculty members to receive a grant from the Andrew Mellon Foundation in support of the college's minor in disaster resilience studies. The grant was given to conduct research and publication, supporting multiple students working on the project. The theme of Dr. Laiju's project is "A Global Issue: Natural Disaster and Child Trafficking," with the goal to advance national and global policy initiatives for child trafficking intervention in the context of contingency planning, which according to Dr. Laiju's research should ideally start in the response phase of disaster management.

Theme 1

Coastal Infrastructure Resilience

WALLACE, RPI

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Community Supply Resiliency (COMSURE)

2. **Principal Investigator / Institution:**
   William A. Wallace, Yamada Corporation Professor, Industrial & Systems Engineering (ISE), Rensselaer Polytechnic Institute (RPI)

3. **Other Research Participants/Partners:**
   John Mitchell, Professor, Mathematical Sciences, RPI; Thomas Sharkey, Associate Professor, ISE, RPI; Richard Little, Research Scholar, ISE, RPI

4. **Short Project Description ("elevator speech"):**
   The resilience of a coastal community to an extreme event depends upon the resilience of its critical infrastructures, one of which is the system of supply chains that provide the goods and services that make a community livable – Community Supply Resiliency.

5. **Abstract:**
   The capability of communities to withstand and recover from the disruptions of extreme events will determine, to a large extent, the degree to which the social, economic, and psychological impacts of these events can be reduced. It is well recognized that civil infrastructures (e.g., transportation, power, water supply and sewerage, and communications) are critical to the wellbeing of a community; our past work has focused on these systems. However, it is the social infrastructures (e.g., emergency response, banking, and food distribution) that play a crucial role in societal functioning; the availability of these systems following an extreme event is a key element in determining the resilience of a community. Therefore, the objective of the proposed research is to better understand, describe, and portray the supply chains that provide the goods and services needed to respond to and recover from an extreme event, such as a hurricane impacting a coastal community. With this knowledge, models and algorithms will be developed to support emergency management in planning, community development, training and education, thereby enhancing community supply resiliency.

6. **End users:**
   We envision the primary end users for our research to be local emergency managers and DHS analysts tasked with providing guidance on policies that effect community resilience to extreme events. We will collect data on the supply chains for the goods and services provided by the social infrastructures in this county; particularly the pharmaceutical and convenience industries. We will incorporate that information into our artificial coastal community of 500,000 citizens for our research and analyses. We have met with representatives of

HeathCare Ready and NACS, the Association for Convenience and Fuel Retailing to discuss possible joint projects and end user activities.

7. Unanticipated Problems:

Although the research necessary to develop and deploy MUNICIPAL/COMSURE has essentially been completed, this technology is not readily usable by the practitioner community. If the necessary funding were provided, this research could be translated into a readily deployable education and training tool for practitioners that will make the nation and its critical infrastructures more resilient in the face of multiple hazards. Two proposals have been submitted to secure this funding; one to the Critical Infrastructure Resilience Institute at the University of Illinois on in October, 2016 (not selected) and one in response to the NIPP 2017 Security and Resilience Challenge in May 2017 (pending).

8. Project Impact:

The MUNICIPAL/COMSURE technology has 3 potential levels of application that could be utilized by different cohorts of the EM community.

- An educational application designed for university-level curricula in emergency management that would make use of the CLARC community dataset
- A training application designed for working professionals in emergency management that would make use of the existing technology coupled with the HSIP Gold dataset specific to the location in question
- A field application to be used as a real-time decision-support tool in an actual emergency; it would also utilize the HSIP Gold dataset

All of these applications would produce usable tools for the education and practitioner communities to better understand the complex interactions that occur between interdependent civil and social infrastructures. The educational tool would make students more familiar with the complex interactions that occur between interdependent systems; the training tool would supplement or replace costly "boots on the ground" field exercises; and the decision-support tool would increase understanding of the important role of service restoration priorities in designing effective response and restoration activities.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Integration of supply chain activity	12/1/16	100%	
Incorporation of data into CLARC	2/1/17	100%	

Analysis of COMSURE	5/1/17	100%	
Research Milestone			
Research paper on modeling and analysis	6/30/17	90%	Paper under review
Dataset for augmented CLARC	6/30/17	90%	Incorporating suggestions form NACS

10. Transition Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Meet with NOAA officials at 2016 National Coastal Conference	10/28/16	100%	
Discussions with NIST: Center for Risk-Based Community Resilience Planning, Colorado State University	11/1/16	100%	
Investigate transitioning MUNICIPAL to an educational teaching aid for university training courses	12/1/16	100%	
Dataset for augmented CLARC	12/1/16	100%	
Network and associated mathematical representations for COMSURE	12/1/16	100%	
Exercising COMSURE to simulate impact of hurricanes on community supply chains to assess community resilience	4/30/17	100%	
Transition Milestone			

Paper on the role of Critical Commercial Services in Community Resilience	12/1/16	100%	
Paper on COMSURE	6/30/17	90%	Incorporated into research paper

11. Interactions with education projects:

Provided a White Paper entitled, "MUNICIPAL for Educators" as a basis for discussion with the CRC Education Leadership.

12. Publications:

Little, R.G., R.A. Loggins, J.E. Mitchell, T.C. Sharkey, and W.A. Wallace. "CRISIS: Modeling the Recovery of Interdependent Social Infrastructure Systems after an Extreme Event," *Natural Hazards Review*, submitted 4/23/2017 (in review).

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
NA	NA	NA	NA

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA	NA	NA	NA
Leveraged Support			
Description			Estimated Annual Value
10% time for Professor Wallace and R. Little salaries plus fringe benefits			$30,048

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	--	
Undergraduates provided tuition/fee support (number)	--	
Undergraduate students provided stipends (number)	--	
Graduate students provided tuition/fee support (number)	--	
Graduate students provided stipends (number)	1	2
Undergraduates who received HS-related degrees (number)	--	
Graduate students who received HS-related degrees (number)	--	
Graduates who obtained HS-related employment (number)	--	
SUMREX program students hosted (number)	--	
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)	--	
Journal articles submitted (number)	--	1
Journal articles published (number)	--	
Conference presentations made (number)	--	3
Other presentations, interviews, etc. (number)	2	1
Patent applications filed (number)	--	
Patents awarded (number)	--	
Trademarks/copyrights filed (number)	--	
Requests for assistance/advice from DHS agencies (number)	1	
Requests for assistance/advice from other Federal agencies or state/local governments (number)	1	1
Total milestones for reporting period (number)	3	
Accomplished fully (number)	2	2
Accomplished partially (number)	1	0
Not accomplished (number)	0	0

BENNETT, RPI

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Establishment of a Remote Sensing Based Monitoring Program for Performance Health Assessment of the Sacramento Delta

2. **Principal Investigator / Institution:**
   Victoria Bennett, Rensselaer Polytechnic Institute

3. **Other Research Participants/Partners:**
   - Tarek Abdoun, RPI
   - Mourad Zeghal, RPI;
   - Mohammed Gabr, NCSU
   - Brina Montoya, NCSU;
   - Cathleen Jones, NASA/Jet Propulsion Laboratory;
   - Joel Dudas, Department of Water Resources, Sacramento, CA;
   - Maureen Corcoran, USACE, Vicksburg, MS
   - Mike Sharp, USACE, Vicksburg, MS.

4. **Short Project Description ("elevator speech"):**

   As climate change progresses in the form of continuous land subsidence and rising sea water level, the integrity and reliability of flood-control infrastructure has become ever more essential components to homeland safety. This project employs a sensor-based (remote sensing with in-ground instrumentation for validation) and model-aided approach to provide engineers and decision makers with systematic tools to assess the health and provide early warning of deteriorating levees in the Sacramento Delta. The modeling tool integrates the use of measured data with the concept of performance limit states to effectively achieve a performance-based, network-level health assessment of the levee system. An artificial neural network tool labeled Risk Estimator for Earth Structures (REES) is developed for the transition of the research findings to the end users.

5. **Abstract:**

   As climate change progresses in the form of continuous land subsidence and rising sea water level, the integrity and reliability of earthen dams and levees become increasingly essential components of homeland security. The failure of levees during Hurricane Katrina in 2005 is a highly illustrative example of the criticality of these systems. But this distributed system of national flood-control infrastructure is aging and its structural health is deteriorating. Assessing the health, predicting the failure and implementing countermeasures are challenging tasks for any civil infrastructure in view of the complexity of the associated processes of long-term environmental degradation and wear. To efficiently maintain this infrastructure,

managing engineers should have access to fully automated programs to continuously monitor, assess the health and adaptively upgrade these systems. *A **validated** remote sensing-based (i.e., satellite or airborne radar) approach coupled with analyses to place the monitored data in context of performance parameters will be used to assess the health of this spatially distributed system. This innovative approach serves to identify weak sections and impending failures and can be used to help prioritize maintenance and upgrade efforts.* This project highlights the potential of a remote sensing-based monitoring system and health assessment tools that will enable early identification and warning of vulnerable levee or dam sections enabling prioritized repair work. This project will validate the use of satellite imagery to detect rate of deformation of a levee section on Sherman Island. Such data will be used and implemented in a numerical model for estimating the probability of exceeding a performance limit state. This probability will provide an indication of the likelihood of failure and the extent of damage from such failure. An artificial neural network tool labeled Risk Estimator for Earth Structures (REES) is developed for the transition of the research findings to the end users.

6. End users:

The work in this project is focused on developing an innovative platform for monitoring and condition assessment of the California Delta levees. A levee on Sherman Island is used for this purpose. The proposed approach couples the concept of deformation-based limit states (LS) with data collection from frequently employed remote sensing efforts to identify the levees' weak sections and possible impending failure modes. The modeling of the levee sections will provide condition assessment of their current state and will provide the context through which the monitoring data will be viewed to discern gradual and abrupt condition changes. The end users include the following:

i. California's Department of Water Resources (DWR);
ii. US Army Corps of Engineers (USACE);
iii. Federal Emergency Management Agency (FEMA);
iv. US Bureau of Reclamation (USBR); and
v. Levee Safety Boards.

DWR is engaged in this project by default because they own the section of levee containing the in situ instruments. They have been available for on-site support during the initial instrument installation and subsequent maintenance visits. They have provided boring locations and layouts, in addition to access to historic inclinometer readings of the Sherman Island setback levee test site. Joel Dudas, Senior Engineer with California's DWR FloodSAFE Environmental Stewardship and Statewide Resources Office, Mike Sharp, Technical Director of USACE Engineer Research and Development Center (ERDC), and Rich Varuso, Senior Program Manager at USACE – Risk Management Center, will consult with the research team throughout the two-year project and will serve as ambassadors for the transition to practice. Joel Dudas is also an incident responder with DWR. Joel McElroy, Superintendent with Reclamation District #341, is responsible for bimonthly levee inspections and is a first responder for levee breaches on Sherman Island. John Paasch, Program Manager for the Delta Flood Emergency Preparedness, Response and Recovery Program, will link our project to others in DWR Emergency Management and California Governor's Office of Emergency Services (CalOES) (http://www.caloes.ca.gov/). Brian Banning (ASIS Certified Protection Professional) and Mark Johnson at CalOES are interested in receiving monitored data and incorporating into the Flood Emergency Response Information Exchange (FERIX) data

management system (http://ferix.water.ca.gov/webapp/home.jsp). Kent Zenobia in the Flood Maintenance Office of DWR will facilitate the data sharing to the FERIX system. Jim Murphy, Head of Levee Condition Assessment Division of Risk Assessment, Mapping and Planning Partners (RAMPP), will help bring the project outcomes from FEMA Region IX to other critical coastal areas such as Louisiana (Region VI) and New York / New Jersey (Region II). Maureen Corcoran, Acting Technical Director of USACE ERDC, and Joe Dunbar, Research Geologist for USACE ERDC, are funding a pilot project at RPI, 'Historic InSAR Case History Study of New Orleans Risk Reduction Infrastructure, Louisiana.' Transition efforts will be enhanced by leveraging both projects.

7. Unanticipated Problems:

An artificial neural network (ANN) tool, Risk Estimator for Earth Structures (REES), is a product of this research project that will be provided to the end users. We have determined that the parameter to be used for training this tool should be the shear strain at critical locations within the earth structure rather than using the probabilities of exceedance. A scaled conjugate gradient backpropagation training function is implemented in MATLAB to train the ANN tool and we believe that the modified approach will lead to a lower mean square error.

8. Project Impact:

The work conducted so far includes the integration of a validated remote-sensing monitoring program and numerical modeling towards the development of protocol for assessing the integrity of levees. The Sherman Island levee section, within the California Sacramento Delta area, is used as a testbed for the development of the proposed technology. The Sacramento Delta levee system provides significant agricultural value to the State of California and economic value to the Nation in terms of protecting the freshwater aqueduct system and maintaining the freshwater head in the surrounding rivers.

Sherman Island levees were originally constructed around the 1870s. This implies around 147 years of peat layer decomposition for these levees (~50,000 days). Data (from literature) show the Sherman Island site to be underlain by highly fibrous peat. Satellite images and in-ground GPS sensors are used to collect displacement measurements at the study levee section. Three stand-alone, continuously monitoring GPS stations were installed on the setback levee on Sherman Island at locations shown in Figure 1a. Concrete pedestal foundations were used to anchor the station to the levee surface, Fig. 1b. Each station contains a Novatel ProPak 6 receiver and a dual-frequency GPS plus GLONASS pinwheel antenna (Fig. 1c). The ProPak 6 is a high performance Global Navigation Satellite System (GNSS) receiver capable of receiving and tracking different combinations of GNSS signal and integrated L-Band on 240 channels. The receivers have a built-in cellular modem and are connected to the AT&T network for remote data transmission.

The results from the three GPS stations are shown in Figure 2. Data shown herein was collected from April 2015 to January 2017. The data includes North, East, and Height measurements from top to bottom. North and East represent lateral movement of the levee surface and the height component is measuring settlement. The settlement accumulates to approximately 12 cm over a one year monitoring period. The data from August 2015 to April 2016 can be compared to satellite data collected in this area during that time period. Vertical lines have been added to Fig. 3 to indicate this time span. The displacement rates to be compared with satellite measurements are included on the right-hand side of the plots.

Satellite data was also collected over the levee test site in the same time period of the GPS data by the Japan Aerospace Exploration Agency. The Advanced Land Observing Satellite-2 (ALOS-2) uses L-band Synthetic Aperture Radar with a 1.2 GHz frequency range (22.9 cm wavelength). The Short Baseline Subset (SBAS) analysis technique was used with nine ALOS images of the setback levee on Sherman Island. The results of this analysis are shown in Figure 3. Time series plots for two points in the vicinity of the GPS station GNSS-2 are included. The cumulative settlement measurement is approximately 3.5 cm from August 2015 to April 2016 in the line of sight (LOS) of the satellite. This value could be roughly compared to 8 cm of settlement measured from GNSS-2 from August 2015 to April 2016. This favorable initial comparison will be improved by projecting the GPS measurement on to the LOS of the satellite (incidence angle of 32-35^{o}). In this projection, GNSS-2 measures 4.8 cm of displacement.

The GPS measurements are used for the calibration of a numerical model, using the finite element program PLAXIS 2D, with large deformation mesh updating. A fine 15-nodel element mesh was used with the domain having 1961 elements and 15,975 nodes. Locations of Global Navigation Satellite System (GNSS) in situ recordings of displacement (GNSS-1, 2 and 3) are shown in Figure 4. Points A and B along the levee landslide side slope are used to compare the data from the numerical model with monitored GNSS records. Flow and deformations boundary conditions were assigned appropriately.

The data from the model are used to establish fragility curves providing the probability of exceeding performance limit states including the influence of peat layer decomposition/aging with time. Peats with three degrees of decomposition, from fibrous (H1-H3) to hemic (H4-H7) to amorphous (H8-H10), are modeled and the corresponding deformation aspects are shown in Figure 5 at 10,000 days for the presumed three-peat decomposition cases.

Figure 5 shows higher deformation especially at the toe location for fibrous (H1-H3) peat compared to hemic and amorphous peats. As peat decomposition level increases, the deformation values decrease as the peat layer experiences less compression with time. Figure 6 shows the fragility curves for the three modeled peat layers. In this case, fragility is defined as the probability of exceeding a given limit state, given the decomposition rate of the peat layer with time. It should be noted that LSIII corresponds to a critical condition, defined as exceeding shear strain of 5% or higher at the landside toe area.

As shown in Figure 6, for fibrous (H1-H3) peat, shear strain exceeds a value of 1% (corresponding to LSI) at approximately 270 days. Probability of exceeding LSII increases around 9100 days when shear strain reaches 2.6% and the probability of exceedance keeps increasing to reach 95% at 50,000 days. For hemic (H4-H7) peat, it takes 10,000 days to reach 100% probability of exceeding LSI as the shear strain trend for this case does not exceed 1% until 1800 days. The use of amorphous peat (H8-H10) properties requires more time (around 300,000 days) to yield an indication of 100% probability of exceedance. The probability of exceeding LSII for both hemic and amorphous peat is very low, as the shear strain values did not reach close to 3% (LSII) by 50,000 days.

Within the context of modeling, the use of fibrous (H1-H3) peat yielded a shear strain value around 3.2% at 50,000 days, which corresponds to the approximate lifetime of the Sherman Island levee (Figure 3). This value of shear strain corresponds to 100% probability of exceeding LSI. As peat ages with time, more shear strain will be developed causing the probability of exceeding LSII to increase as well and therefore increases the vulnerability of the levee and its susceptibility to failure (reaching LSIII) under extreme flood events. However, it is important to note that several factors still need to be investigated, such as the

time needed in the field for peat to decompose, as the decomposition rate is influenced by temperature, aerobic and anaerobic activity, pH, etc. These analyses nonetheless demonstrate the value of condition assessment of levee health to place its vitality in the context of impending severe weather events.

Risk Estimator for Embankment Structures (REES) Tool Development

REES uses an Artificial Neural Network (ANN) model to assess the probability of exceeding a limit state without the need to conduct advanced numerical modeling. A graphical user interface (GUI) tool is developed to implement the ANN model and allows for a user friendly approach for estimating the probabilities of exceeding a given limit state. ***REES*** provides risk in terms of failure consequence as a function of fatality rates with distance away from the embankment structure using peak breach discharge (cubic feet per second) and 10-year discharge (cubic feet per second) values from the FEMA loss of life risk sheet (FEMA risk tool, 2008). However, the risk can be estimated in terms of economic impact and loss of functionality of critical infrastructure if the "impact" data are available. A user manual is developed to guide the user through operating the tool with examples.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Task a. Site Data Collection	6/30/2016	100%	
Task b. Model Calibration	6/30/2017	100%	
Task c. Baseline Case	6/30/2017	100%	
Task d. Probability of Exceeding Limit State and Uncertainty	6/30/2017	70%	*We had to revise the approach implemented in the Artificial Neural Network (ANN) REES software, which we use for estimating the probability of exceeding a limit state, and therefore the risk. The approach that was previously implemented in the ANN module was based on machine learning through training with data on "probability of exceedance." We discovered that these probability values are clustered at two extreme ends; in the low range (1 in 100,000) or in the high range (1-5 in 10; under very severe conditions). While performing the extensive parametric studies on*

			levees that is currently undergoing, we have discovered that a better parameter to use for training ANN is the shear strains within the embankment as these emerge as a function of flood loading. These values are well distributed in the range of .01% to 5% and therefore the training of REES software is more robust. We will then link the output of the ANN to an Excel worksheet for estimating probability of exceedance and the corresponding risk using REES. This "linking" process will be performed in the background, and the user interface will remain simple. We anticipate the software will be delivered by the end of the year for beta testing.
Task e. Field Comparison	12/31/2017	70%	
Research Milestone			
Characterization of the subsurface properties and possible constitutive relationship to use in the modeling effort	6/30/2016	100%	
Establishment of Levee Section fragility in terms of probability of exceedance versus flood cycle and level	6/30/2017	70%	See explanation for Task d above.
Establish the coupled model-monitored data approach as a means to identify vulnerabilities of the levee section studied herein.	12/31/2017	20%	

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Present preliminary findings of Task 1 at the CRC annual meeting	6/30/2016	100%	

Present modeling approach, and model results at the Geo-Frontiers annual meeting	3/12/2017	100%	
Present paper at Geo-risk 2017	6/4/2017	100%	
Submit a Journal paper documenting the findings of the 2-year study	12/31/2017	10%	
Transition Milestone			
Report on subsurface properties of the Sherman Island Levee section to be studied reviewed by DWR	6/30/2016	100%	
Calibrated model of the levee section with accurate description of section response	6/30/2017	50%	See explanation for Task d above.
Establishment of the levee section condition in terms of probability of exceedance the predefined limit states	6/30/2017	100%	
Successful demonstration of the coupled model-monitored data for identifying vulnerabilities of the levee section with variation in reservoir level and number of flood cycles	12/31/2017	20%	

11. Interactions with education projects:

The PIs engaged some CRC MSI education partners at the CRC Annual Meeting in February 2017. Unfortunately this did not result in a summer intern. While we have links to the University of Puerto Rico, Mayaguez through RPI graduate Ricardo Ramos, we do not have enough budget to fully host an intern from Puerto Rico for the summer. We will be happy to work with Tom Richardson to identify some domestic students that will be placed at RPI or NCSU in the future, if possible. If the intern is placed at RPI, undergraduate student activities in the Center for Earthquake Engineering Simulation (CEES) will be leveraged for this CRC intern as well. We have also identified an additional opportunity to leverage an existing educational project at Rensselaer Polytechnic Institute. Professors Abdoun and Bennett are currently developing a mixed reality and mobile (MR&M) game that will be integrated with traditional geotechnical engineering education but will provide an opportunity for students to experience the field work and testing necessary to instill practical skills. In order to educate a professional workforce who is properly trained in STEM, able to identify warning signs in advance of system failures, and capable of making the right decisions, undergraduate engineering education must be transformed to include the development of sense-making capabilities - the skills to recognize, report, diagnose, and assess risks. Educational games have the transformative potential to overcome the societal challenge associated with the deteriorating infrastructure, while also utilizing a technology that is familiar to today's students. The proposed game-based module is flexible and variations of the game can be scaled with little difficulty, depending on the targeted audience. The developed MR&M game can be made available to geotechnical engineering programs throughout the United States as well as used by practitioners, such as the Department of Water Resources in California and the

US Army Corps of Engineers. CA DWR has expressed interest in using the developed game to train its levee inspection personnel.

12. Publications:

- "***Monitoring and Modeling of Peat Decomposition in Sacramento Delta Levees***" Amr Helal, Victoria Bennett, Mo Gabr, Roy Borden and Tarek Abdoun. Geotechnical Frontiers 2017, Orlando, Florida.
- ***"Deformation Monitoring for the Assessment of Sacramento Delta Levee Performance"*** Victoria Bennett, Cathleen Jones, David Bekaert, Jason Bond, Amr Helal, Joel Dudas, Mohammed Gabr, Tarek Abdoun. Geo-Risk 2017 (Geotechnical risk from theory to practice), Denver, Colorado.
- ***"Use of remote-sensing deformation monitoring for the assessment of levee section performance limit state"*** Victoria Bennett, Chung Nguyen, Tarek Abdoun, Amr Helal, Mohammed Gabr, Cathleen Jones, David Bekaert, Joel Dudas. Proceedings of the 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul 2017.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
REES: Risk Estimator for Embankment Structures	Software	December 2017	Federal Agencies looking for an expedient means to assess performance of levees and earth dams

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Establishment of Sensor Driven and Model Based Health Assessment for Flood Control Systems	Tarek Abdoun	$61,595	US Army Engineer Research Development Center
New Faculty Startup Funds	Victoria Bennett	$241,500	Rensselaer Polytechnic Institute
10% of annual year salary and associated fringe benefits	Victoria Bennett	$11,780	Rensselaer Polytechnic Institute
Leveraged Support			

Description	Estimated Annual Value
Spare GPS equipment available from JPL to maintain instrumentation installed in Sherman Island setback levee.	$34,500
Field instrumentation recovered from V-Line Levee site in New Orleans	$25,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		

Undergraduate students provided stipends (number)		
Graduate students provided tuition/fee support (number)	2	3
Graduate students provided stipends (number)	2	3
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		2
Graduates who obtained HS-related employment (number)		
SUMREX program students hosted (number)		
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)		0
Journal articles published (number)		
Conference presentations made (number)	2	3
Other presentations, interviews, etc. (number)	1	3
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)		
Requests for assistance/advice from other agencies or governments (number)	4	2
Total milestones for reporting period (number)	3	3
Accomplished fully (number)	3	2 (REES being updated)
Accomplished partially (number)		1
Not Accomplished (number)	0	0

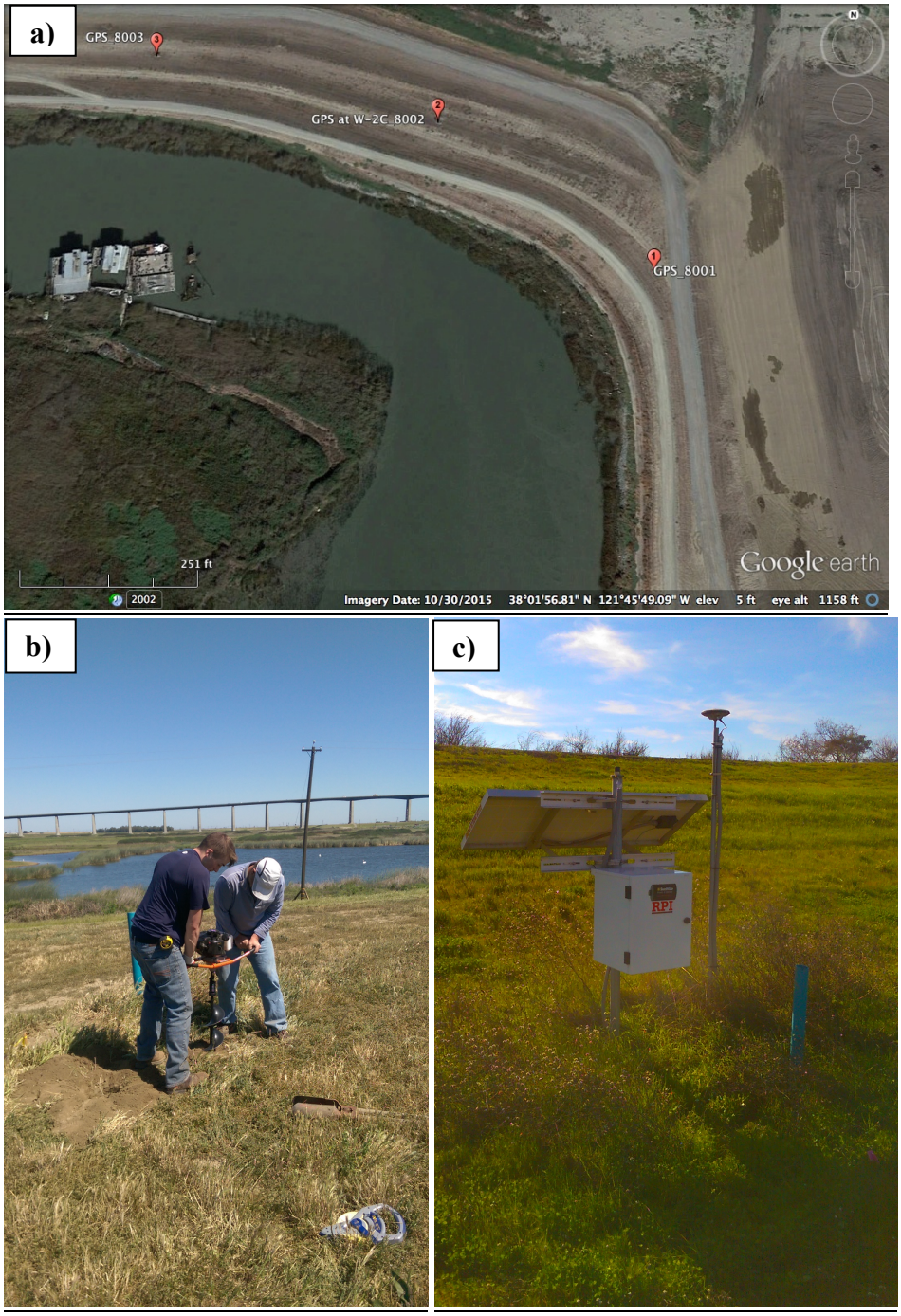

Figure 1. a) Location of in situ GPS stations (approximate coordinates: 38º01'56.81" N, 121º45'49.09" W); b) Installation of pedestal foundation for GPS station; c) completed autonomous GPS station (8003).

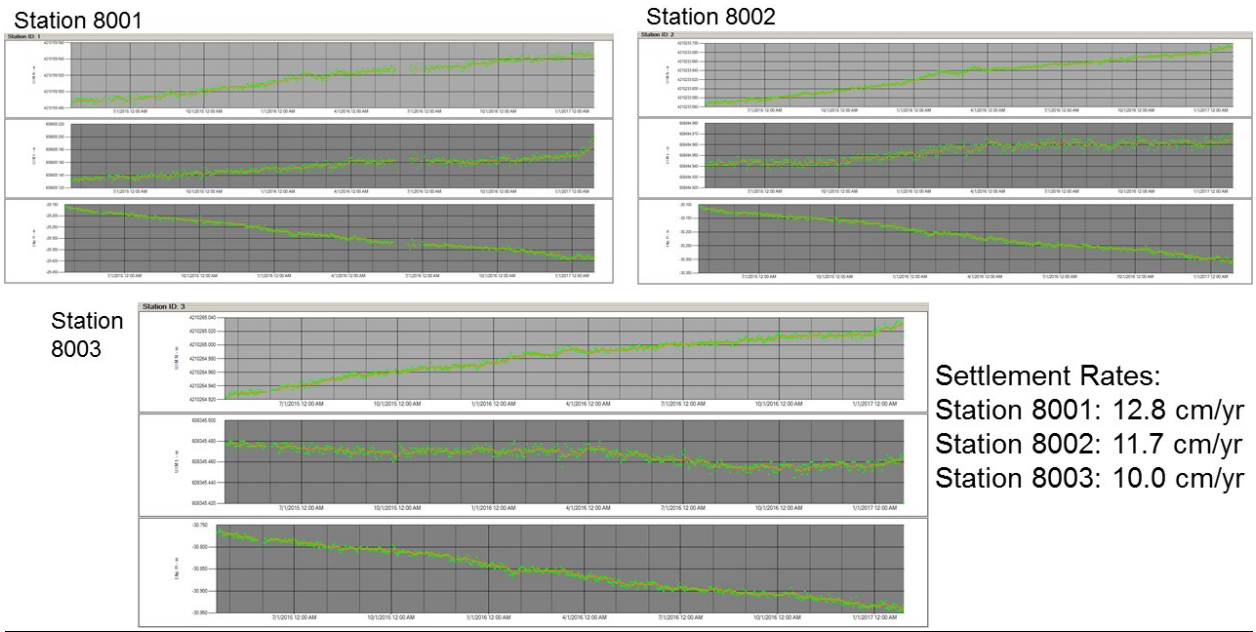

Figure 2. GPS time series at setback levee from April 2015 to January 2017.

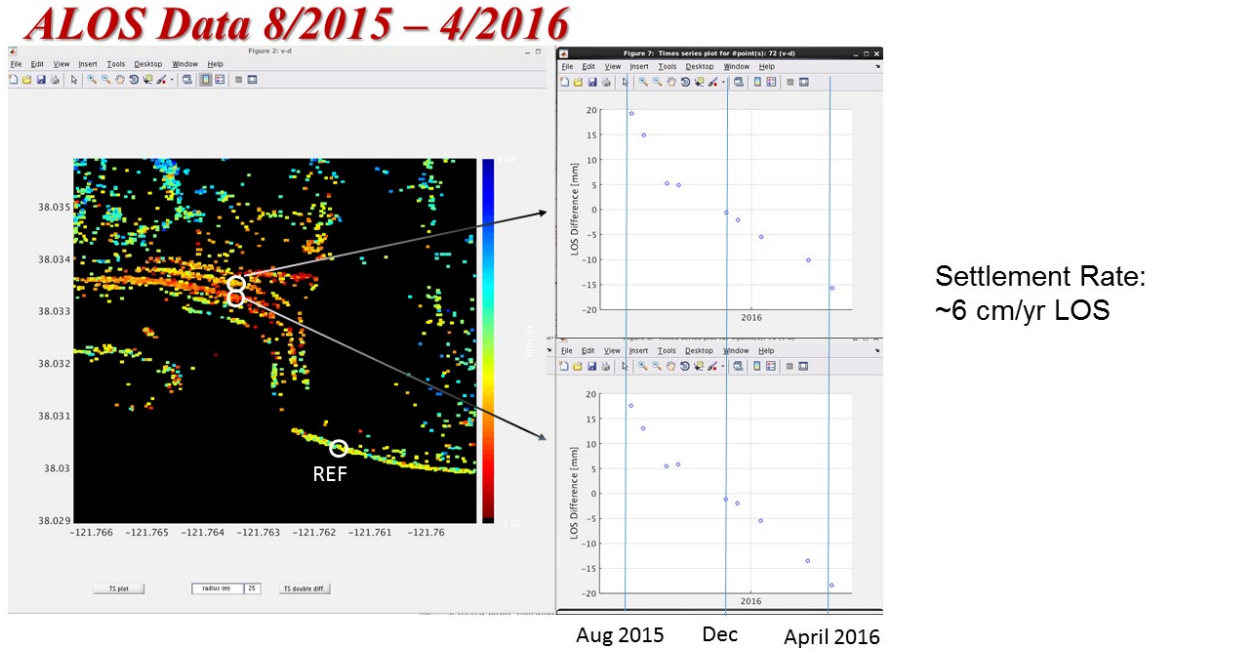

Figure 3. ALOS time series of setback levee from August 2015 to April 2016.

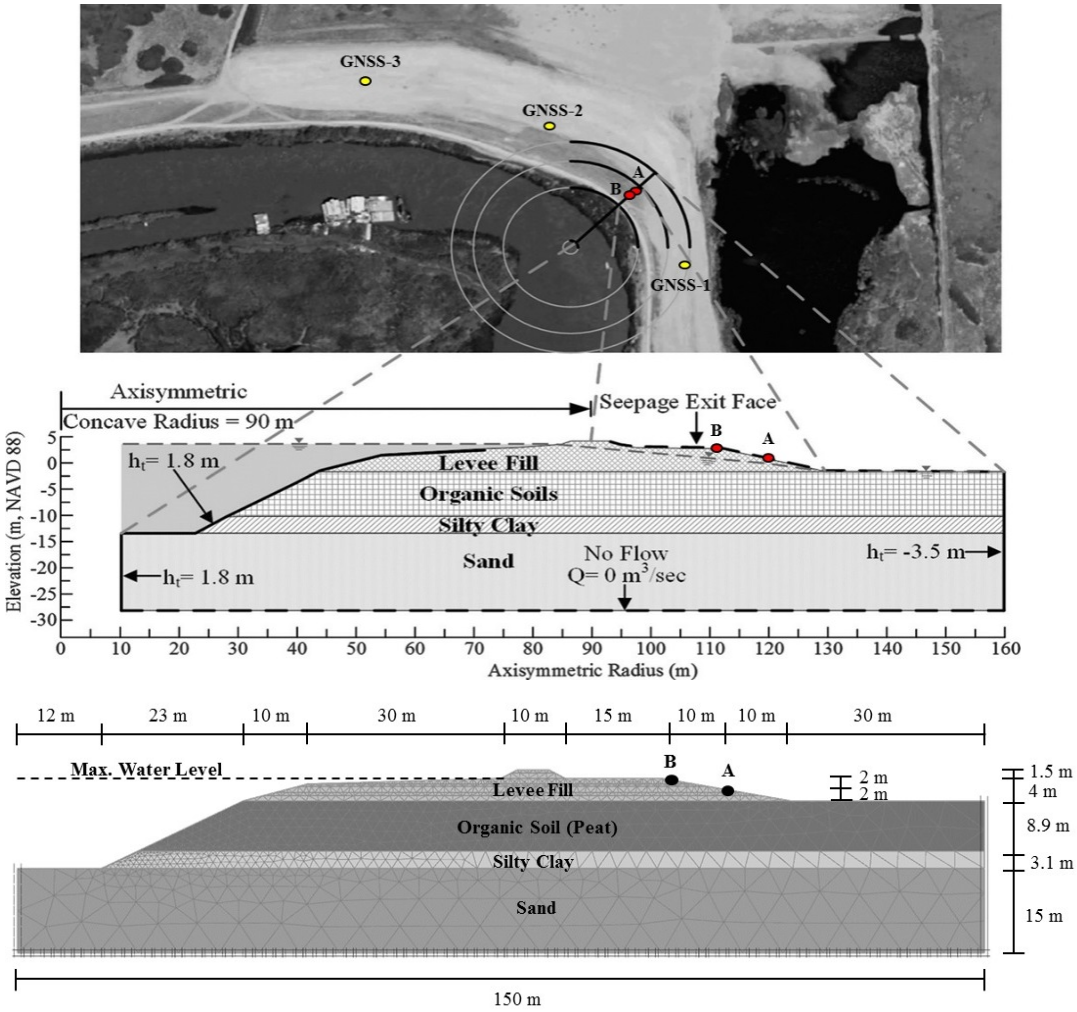

Figure 4. Finite element PLAXIS 2D levee mesh and boundary conditions.

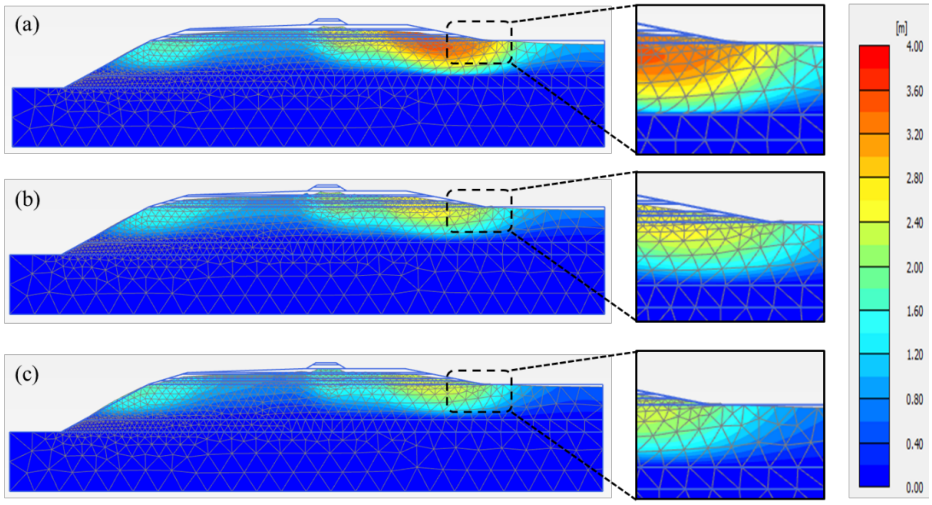

Figure 5. Deformation of levee for a) H1-H3 peat, b) H4-H7 peat, and c) H8-H10 peat at 10,000 days.

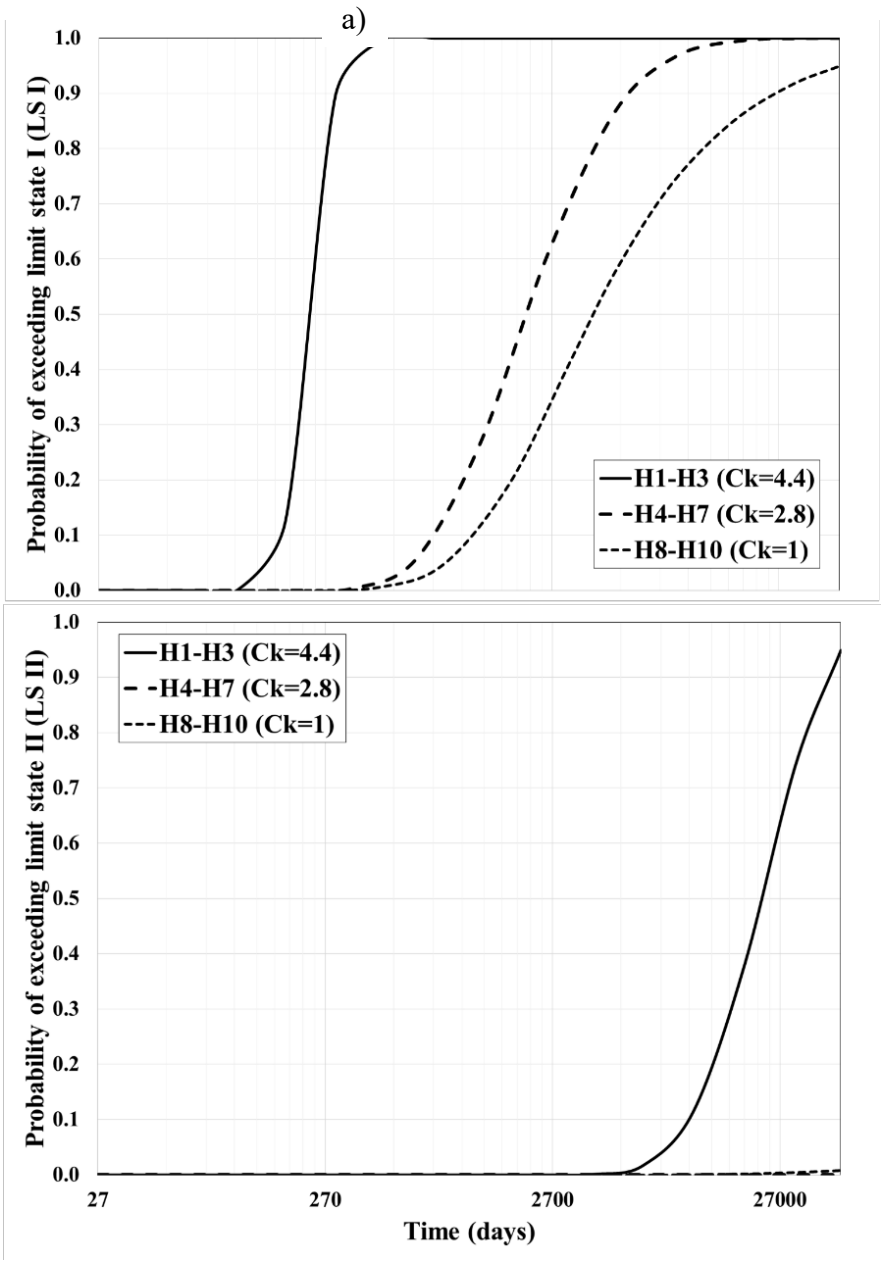

Figure 6. Probability of exceedance: a) LS I and b) LSII for shear strain for peat with different degree of decomposition.

COX, OSU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Experimental and Numerical Study to Improve Damage and Loss Estimation due to Overland Wave and Surge Hazards on Near-Coast Structures

2. **Principal Investigator / Institution:**
   Dr. Daniel Cox, (PI) Professor, Oregon State University
   Dr. John van de Lindt (co-PI), Professor, Colorado State University

3. **Other Research Participants/Partners:**
   - Bill Coulbourne, Applied Technology Council
   - Chris Jones, consulting coastal engineer; Chair, ASCE-7 Flood Loads

4. **Short Project Description ("elevator speech"):**

   This project will develop an accurate method to determine damage to buildings subjected to extreme surge/wave forces during hurricanes. The methodology will use large-scale hydraulic model testing combined with numerical simulations to improve existing risk software used by DHS/FEMA and to advance risk-based design methodologies to enhance coastal infrastructure resilience. The method will be consistent with other multi-hazard frameworks such as earthquake and wind engineering.

5. **Abstract:**

This project focuses on Theme 1 – Coastal Infrastructure Resilience; Topic 1a – Coastal Infrastructure Planning and Design. As building stakeholders seek to mitigate damage, risk to property and structure loss it is becoming apparent that exiting design methodologies such as those outlined in the FEMA Coastal Construction Manual are inadequate to incorporate the range of building types, storm conditions, and potential for resulting damage. More effective decision support tools such as FEMA's HAZUS-MH rely on a framework of multi-hazard fragility curves to relate the hazard and affected buildings to compute/predict an expected level of damage and subsequent losses. Although there have been significant advances in this correlation for wind earthquake loading and some preliminary work for tsunamis, the coastal surge and wave response of structures remains poorly defined, primarily due to a lack of large-scale data and the complexity of the fluid/structure interaction modeling. This project will significantly improve HAZUS input fragilities for surge and wave through a robust experimental and numerical study of the interaction of surge and waves with near-coast structures. The overall goal of this project is to develop accurate fragilities for near-coastal structures against overland surge and wave forces for input to HAZUS-MH such that they can be used in a design framework consistent with the risk-based methods used in wind and earthquake engineering We outline these specific objectives to be completed in two years in

order to provide (1) improved accuracy for surge and wave analysis in HAZUS-MH; and (2) innovative advances in risk-informed design methodologies to enhance coastal infrastructure resilience:

- ***Objective 1:*** Quantify wave forces on near-coast structures for a range of surge levels based on a mid-scale hydraulic model test program, and develop new predictive equations for horizontal and vertical forces.
- ***Objective 2:*** Develop the conditional probabilities (fragilities) for exceeding key thresholds which will be linked to damage levels available in HAZUS-MH.
- ***Objective 3:*** Illustrate next-generation risk-informed design for near-coast structures that have been shown to be vulnerable to hurricane surge and waves using the fragilities developed in (2). This will improve the ability of building occupants to return following the hurricane thereby improving the resiliency of the community.

This project will have a direct impact on estimating probable damage and loss of existing coastal infrastructure by providing improved load-response relationships to HAZUS-MH for surge and wave and develop a risk-informed framework for future engineering design of near-coast structures. While beyond the scope of this study, the results could also help improve the potential designs associated with the retrofit of existing structures funded through FEMA hazard mitigation grant programs and the implementation of improved coastal building codes.

6. End users:

In addition to these Research Participants, we will have the following people involved in the End-User Transition:

- Eric Letvin, FEMA HQ
- Jesse Rozell, HAZUS Program Manager, FEMA HQ Risk Management Directorate
- Casey Zuzak, Risk Analyst, FEMA Region VIII
- Ed Laatch, FEMA Building Science Division
- Chad Berginnis, ASFPM Executive Director and CRC Advisory Board Member

Additional possible end-users include the USACE:

- Ty Wamsley, USACE-ERDC, Vicksburg, MS
- Marc Gravens, USACE-ERDC, Vicksburg, MS
- Julie Rosati, USACE-HQ, Washington, DC

We have described our project to the end users during the CRC meetings in Washington DC (July 27, 2015) and at UNC (March 1, 2016). We will update our progress at the next center meeting. The benefit of this project will show how HAZUS software can be improved using new fragility curves developed in this project.

7. Explanation of Changes:

There have been no changes to the work plan. The hydraulic model tests (Task 1) are currently underway. Numerical modeling (Task 2) is also underway and limit states for failure of elevated buildings are being computed using detailed modeling approaches. Colorado State researcher Dr. Trung Do will be on site at Oregon State University to collaborate with Dr. Hyoungsu Park to work on integration of Task 1 and 2 from Aug 2 to Sept 2, 2016.

8. Unanticipated Problems:

There have been no unanticipated problems.

9. Project Outcomes:

A major limitation within HAZUS-MH when estimating damage and loss due to hurricanes is addressed in this stud: improving hazard-damage relationships for structures. Although the existing practice is to use flood depth as the intensity measure, this project will develop improved intensity measures derived from the wave climate. One example would be the modification of Goda's formula which has been used successfully for wave loads on coastal structures and has been adopted by the USACE for breakwater design. A second example is the momentum flux which is a parameter used for tsunami-structure interaction and has also be used to predict runup and stability of coastal structures. Finally, fragility functions to relate the hazard intensity to building damage are limited in HAZUS-MH for coastal surge/wave loading.

Although direct implementation of the research outcomes into HAZUS is beyond the scope for this project (and would have to be directed by FEMA through their contract with a consultant), this project will make direct comparison between existing HAZUS methodology and improvements that can be gained by implementing the new methodology and communicate it effectively to FEMA contacts described earlier.

10. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Experimental Design (OSU) – Task 1.1, develop wave/surge boundary conditions; bathymetry; specimen design and placement; test matrix and protocols.	3/31/2016	100%	Experimental design complete
Physical Model Testing (OSU) – Task 1.2, conduct physical model tests in Directional Wave Basin at HWRL; test setup, data acquisition, demobilization; initial data QA/QC	6/30/2016	100%	Experimental tests complete
Numerical Model (CSU) – Task 2.1, develop numerical model of a building and calibrate with existing experimental data	3/31/2016	100%	Numerical modeling complete
Fragility Formulation – Task 2.2, develop initial fragility limit states in cooperation with CRC, DHS/FEMA.	6/30/2016	100%	Fragility surfaces for several building archetypes complete

Research Milestone			
Progress Report 1: Detailed experimental work plan summarizing experimental plan (Task 1.1). Work plan to be developed with input from project partners and end users (Item 8).	3/31/2016	100%	Experimental work plan complete. Progress report is essentially the MS thesis work of Mr. W. Short and Mr. B Hunter.
Progress Report 2: Physical Model Data Base Report summarizing completed experiment. To be reviewed by project partners and end users.	6/30/2016	100%	Experimental work plan complete. Progress report is essentially the MS thesis work of Mr. W. Short and Mr. B Hunter. Experimental work was presented via webinar to partners and end users
Progress Report 3: Technical Brief summary of Task 2.1 calibration accuracy in a technical brief format and	3/31/2016	90%	A manuscript is being jointly written by Dr. T. Do and Dr. H. Park. Manuscript is being edited by project PIs.
Progress Report 4: Summary of the fragility formulation methodology (Task 2.2) to be used within this project. To be reviewed by project partners and end users.	6/30/2016	90%	Fragility work is nearly complete. Computer simulation is computationally slow due to the size of the analyses.
Progress Report 5: Illustrate next-generation risk-informed design for near-coast structures.	6/30/2017	50%	Work is ongoing to demonstrate the new methodology using Galveston, TX, as the test case.

11. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
End User Meeting #1:, Denver, CO. FEMA Region VIII. The meeting took place with Cox, van de Lindt and two end users, Jesse Rozelle, HAZUS Program Manager, FEMA HQ Risk Management Directorate, Actuarial and Catastrophic Modeling Branch, and Casey Zuzak, Risk Analyst, FEMA Region VIII. Cox and van de Lindt presented their project results and discuss possible implementations with HAZUS.	Tuesday April 25, 2017	100%	

End User Meeting #2:, Washington DC. FEMA HQ. The meeting was organized by Eric Letvin of FEMA HQ. Cox and van de Lindt gave a 1 hr presentation on the project to approximately 20 FEMA staff at the meeting and an addition 20 people participating via webinar. Question and answer session followed the presentation. A working lunch continued the discussion with about 3 FEMA personnel.	Friday May 19, 2017	100%	

12. Interactions with education projects:

We are hosting two SUMREX students from University of Puerto Rico - Mayaguez, **Hector Colon** and **Peter Rivera**. Hector and Peter were on the Oregon State University campus from June 18, 2017, to August 12, 2017. Both students are participating in an undergraduate research program with 17 other students and will complete a project report and presentation on August 9. Both students will work on hand-on experimental research projects related to coastal hazard engineering and are partially supported on grants from the National Science Foundation.

Visit to Univ. Puerto Rico – Mayaguez. Dr. Cox visit Puerto Rico from March 5 to March 9, 2017, at the invitation of Professors **Ismael Pagan** and **Ricardo Lopez**. On March 7, Dr. Cox visited the campus of the University of Puerto Rico Mayaguez campus, met with faculty in civil engineering and marine sciences, met with students, toured the facilities, and gave a seminar on coastal hazards engineering and resilience. On March 8 and 9, Dr. Cox attended the research symposium organized by Profs. Pagan and Lopez in San Juan. Dr. Cox met with engineering practitioners from Puerto Rico and researchers from the USACE. Dr. Cox gave a keynote presentation on this research project.

13. Publications:

1. Tomiczek, T., Park, H., Cox, D.T., van de Lindt, J.W., Lomonaco, P. "Experimental Modeling of Horizontal and Vertical Wave Forces on an Elevated Coastal Structure," *Coastal Engineering*, (submitted 1/2017).
2. Do, Trung, van de Lindt, J., Cox, D.T. (2016) "Performance-Based Design Methodology for Inundated Elevated Coastal Structures Subjected to Wave Load Engineering Structures," *Engineering Structures*, 117, 250 – 262.
3. William Short. *A laboratory study of horizontal and vertical regular wave forces on an elevated structure*. (2016). MS Thesis, Oregon State University.
4. Benjamin Hunter. *Exceedance Probabilities of Hurricane Wave Forces on Elevated Structures*. (2016). MS Thesis, Oregon State University.

14. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
NA			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Collaborative Research: Fundamental Mechanics and Conditional Probabilities for Prediction of Hurricane Surge and Wave Loads on Elevated Coastal Structures	Cox	$215,000	NSF CMMI-1301016
Collaborative Research: Fundamental Mechanics and Conditional Probabilities for Prediction of Hurricane Surge and Wave Loads on Elevated Coastal Structures	Van de Lindt	$140,000	NSF CMMI-1266101
Leveraged Support			
Description			Estimated Annual Value
NA			

15. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	2	2
Graduate students provided stipends (number)	0	2
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	0	0
SUMREX program students hosted (number)	2	2
Lectures/presentations/seminars at Center partners (number)	0	3
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	0	2
Journal articles published (number)	0	2
Conference presentations made (number)	0	1
Other presentations, interviews, etc. (number)	0	0
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0
Total milestones for reporting period (research activity/milestone)*	4	5
Accomplished fully (research activity/milestone)	0	2
Accomplished partially (research activity/milestone)	4	3
Not accomplished (research activity/milestone)	0	0

Theme 2

Building Resilient Communities

HORNEY, TAMU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Implementing the Disaster Recovery Tracking Tool

2. **Principal Investigator / Institution:**
   Jennifer Horney, Associate Professor, Texas A&M University School of Public Health, Department of Epidemiology and Biostatistics

3. **Other Research Participants/Partners:**
   Phil Berke, Professor, Texas A&M University, College of Architecture, Department of Landscape Architecture and Urban Planning

4. **Short Project Description ("elevator speech"):**

   Valid and reliable quantitative and qualitative measures of community disaster recovery are needed in order to be able to track recovery in different geographic locations, from different types of disasters, and over time. The Disaster Recovery Tracking Tool is a web-based tool that enables end users (e.g., planners, emergency managers, long-term recovery committees) to track the progress and quality of post-disaster recovery by comparing baseline and post-disaster data.

5. **Abstract:**

   Without monitoring recovery and comparing post-recovery status with pre-disaster benchmarks, it is difficult for communities to assess whether or not they are achieving a quality recovery, improving disaster resilience, or building back better. The Disaster Recovery Tracking Tool provides a framework for end users (e.g., planners, emergency managers, long-term recovery committees) to track progress on metrics of disaster recovery. These metrics were identified and content validated through a literature review, recovery plan review, case studies, focus groups, key informant interviews, and pilot tests with communities impacted by Hurricane Sandy. Practitioners using this tool can compare pre- and post-disaster status using baseline and current data. Reports generated by the tool can provide end users with a useful means of prioritizing recovery goals and activities and identifying elements important to include in recovery planning, potentially making recovery more effective and efficient and communities more resilient.

6. **End users:**

   The Disaster Recovery Tracking Tool (trackyourrecovery.org) currently has over 600 registered users. These include Federal (EPA, FEMA, NOAA (ERMA), Small Business Administration, US Air Force Academy, Cooperation for National and Community Service);

Regional (FEMA Regions 2, 6, and 8); Local Governments; Ga. Tech University; National Non-Profits (Red Cross, Natural Resources Defense Council); Other Non-Profits (SeaPlan.org); and private consultants. Additional end users include: 1) Municipal- and county-level planners, emergency managers, and members of long-term recovery committees; 2) FEMA national (Matt Campbell) and regional-level recovery division staff (Charlie Cook, Region 6; Marianne Luhrs, Region 2; Samuel Capasso, Region 2, Hazard Mitigation Division); 3) Department of Health and Human Services, Assistant Secretary for Preparedness, Office of Emergency Management, Recovery (Natalie Grant) 4) Los Angeles County Emergency Management (John Chung, Emergency Planner).

Liberty County, Texas and Bastrop County, Texas were recruited as pilot test communities. A recovery tool profile was created for each community and the collaborations are ongoing. Recovery planning checklists were completed for both Liberty County, Texas and Bastrop County, Texas. A pre-disaster recovery plan for Liberty County, Texas has been drafted. Data compiled using the checklist was incorporated into the draft plan. A manuscript describing the evaluation data collected from these pilots is being drafted. The anticipated date of submission is August 30, 2017.

Potential applications and opportunities to leverage the Tool were discussed previously with Alex Balsley, Project Manager at the U.S. Coast Guard R&D Center. However, the Coast Guard's Office of Research, Development, Test and Evaluation, located at Headquarters in Washington, DC, determined that the Tool would not be appropriate to meet established needs.

Lisa Schiavinato, Director of Extension at California Sea Grant, has agreed to connect us with an affiliated extension agent for advisement on natural resource data sources. We are working with Oil Spill Science Outreach and Extension Specialists at Texas Sea Grant College Program to determine whether the Disaster Recovery Tracking Tool could be used to measure recovery progress in oil spill-affected communities. Discussions with Alabama Sea Grant regarding potential applications for the Tool are ongoing. A conference call with Hank Hodde at the NOAA Disaster Response Center in Mobile, AL was also held.

We are working with the Texas A&M Engineering Extension Service (TEEX) to develop a Disaster Recovery Tracking Tool training course. The target audience for this course includes local government officials, city and county planners, and other community stakeholders. A course design document has been drafted and is under review by TEEX. We plan to investigate possible integrations with FEMA Higher Ed and the Emergency Management Institute if the present project is granted an extension.

To enhance the usefulness of the tool for local and federal end-users, the needs, insights, and expertise of FEMA partners have been incorporated throughout the decision-making process. Lessons learned will be incorporated into final marketing materials, a training module, and a user guide for additional end users. Final materials will also be shared with appropriate Federal partners, including FEMA / EMI Emergency Management Higher Education Program as well as TEEX, which provides training in emergency management and homeland security.

We have reached out to David Alexander, Program Manager of S&T Flood APEX, in hopes of scheduling a conference call. If successful, a meeting will be scheduled with FEMA Recovery HQ, S&T Flood APEX PM, Phil Berke, and CRC leadership team to discuss the long-term vision and transition plan.

7. Unanticipated Problems:

We have been unable to collect evaluation data from pilot communities, as communities have been engaged in nearly continuous response to multiple disasters over the grant period. By August 30, 2017, we will have either implemented the evaluation or developed another research milestone that is more acceptable to our partners, who have limited time to provide additional survey data. An example of this might be a paper or poster presented secondary analysis of the data that has been input into the tool, as this could be done by project staff, with less time required of project partners.

8. Project Impact:

The National Disaster Recovery Framework (NDRF) calls for communities to develop tools and indicators that can be used to assess progress toward achieving established goals, objectives, or milestones. The Disaster Recovery Tracking Tool provides an accessible means for resource-limited end users to readily measure and evaluate progress over time. The validated metrics that comprise the Tool's tracking function were developed in accordance with the Recovery Support Functions and Recovery Mission Area Core Capabilities that are defined in the NDRF. The Disaster Recovery Tracking Tool facilitates data collection and management, allowing systematic measurement of the disaster recovery process in various locations, across events, and over time.

The NDRF further recommends that measures of recovery be developed in tandem with pre- and post-disaster planning functions and activities. Data collected for the 84 recovery metrics may be used to guide the development of a recovery plan element as part of a larger plan, or the development of a stand-alone recovery plan. Results may also contribute to increases in the number and improvements in the quality of pre-disaster recovery plans. For example, one of the primary indicators of a high-quality plan is a strong community fact base. It often difficult for smaller communities with limited capacity for recovery planning to develop a robust fact base focused appropriately on high-priority issues. The integration of recovery metrics in community plans and planning processes can aid decision makers in identifying resilience-building opportunities and developing evidence-based policies and priorities. For this purpose, a recovery planning checklist based on the Disaster Recovery Tracking Tool's metrics has been drafted. This resource can be leveraged by practitioners to update plans or begin the process of developing a fact base for a pre-disaster recovery plan.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Complete pilot of tracking tool with at least one community	12/31/2016	100%	Liberty County, Texas was recruited as the first pilot test community. A recovery tool profile has been created and collaboration is ongoing.
Complete pilot of tracking tool with at least one additional community	06/30/2017	100%	Bastrop County, Texas was recruited as the second pilot test community. A recovery tool profile has been created and collaboration is ongoing.
Make a contact at Mayes Business School to recruit a students for marketing assistance; Draft marketing materials, training module, and user guide	03/31/2017	100%	Marketing materials, a training module, and user guide have been drafted.
Research Milestone			
Publication and or poster / presentation based on an analysis of the data collected as part of the pilot to determine which indicators are the strongest, most valid, and most useful predictors of recovery.	01/31/2016	100%	A research article describing the disaster recovery metrics was published in Volume 42 of the Carolina Planning Journal.
Publication and or poster / presentation based on an analysis of the evaluation data collected as part of the pilots	06/30/2017	0%	We have been unable to collect evaluation data from the pilot communities to date. We anticipate being able to update the plan to meet this Milestone in another way by August 30, 2017.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected

Recruit first pilot test community; Conduct training on Tool; Provide technical assistance	12/31/2016	100%	Liberty County, Texas was recruited as the first pilot test community. A recovery tool profile has been created and collaboration is ongoing.
Recruit second pilot test community; Conduct training on Tool; Provide technical assistance	06/30/2017	100%	Bastrop County, Texas was recruited as the second pilot test community. A recovery tool profile has been created and collaboration is ongoing.
Complete checklist with two pilot communities	06/30/2017	100%	Checklists were completed for both Liberty County, Texas and Bastrop County, Texas.
Transition Milestone			
Code complete release of the Disaster Recovery Tracking Tool website	06/30/2017	100%	The completed Disaster Recovery Tracking Tool website has been released for public access. More than 600 users are registered.
Evaluation summary data from pilot tests with end users	06/30/2017	75%	A manuscript describing the evaluation data collected from these pilots is being drafted. The anticipated date of submission is August 30, 2017.
Draft a pre-disaster recovery plan for a community based on data from the checklist	06/30/2017	100%	A pre-disaster recovery plan for Liberty County, Texas has been drafted. Data compiled using the checklist was incorporated into the draft plan.

11. Interactions with education projects:

No interactions with education projects occurred during this reporting period.

12. Publications:

Kirsch, K., & Horney, J. (2017). Steps toward recovery: A tool for disaster recovery planning, management, and tracking. *Carolina Planning Journal, 42,* 104-109.

Horney, J., Dwyer, C., Aminto, M., Berke, P., & Smith, G. (2017). Developing indicators to measure post-disaster community recovery in the United States. *Disasters, 41,* 124-149. doi: 10.1111/disa.12190

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Training Module	Guidance	6/30/2017	Local government officials, city and county planners, and other community stakeholders or web users
User Guide	Guidance	6/30/2017	Local government officials, city and county planners, and other community stakeholders or web users
Draft TEEX Disaster Recovery Tracking Tool Course	Course Document	6/30/2017	Local government officials, city and county planners, and other community stakeholders

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			
Leveraged Support			
Description			Estimated Annual Value
NA			

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	0	0
Graduate students provided stipends (number)	1	1
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	1	0
SUMREX program students hosted (number)	0	0
Lectures/presentations/seminars at Center partners (number)	0	0
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	1	1
Journal articles published (number)	1	1
Conference presentations made (number)	3	0
Other presentations, interviews, etc. (number)	4	7
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	1	?
Requests for assistance/advice from other agencies or governments (number)	3	?
Total milestones for reporting period (number)	3	
Accomplished fully (number)	3	
Accomplished partially (number)	0	
Not accomplished (number)	0	

ATKINSON, ODU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. Project Title:

Stakeholder/End User Engagement Support of Two CRC Projects (Formerly A Tool to Measure Community Stress to Support Disaster Resilience Planning)

2. Principal Investigator / Institution:

Larry Atkinson, Slover Professor and Eminent Scholar, Department of Ocean Earth & Atmospheric Sciences, College of Sciences

3. Other Research Participants/Partners:

Old Dominion University Co-PIs:

- Joshua Behr, Research Associate Professor, Virginia Modeling, Analysis, and Simulation Center (VMASC)
- Michelle Covi, Assistant Professor of Practice, Department of Ocean Earth & Atmospheric Sciences, College of Sciences and Virginia Sea Grant Extension
- Wie Yusuf, Associate Professor, School of Public Service, Strome College of Business

4. Short Project Description ("elevator speech"):

This project supported two Coastal Resilience Center projects, building on the project team's expertise in stakeholder engagement, and leveraging connections to stakeholders and possible end-users in Hampton Roads. We organized a panel for the Maritime Risk Symposium that addresses "Integrating Maritime and Costal Resilience;" and supported stakeholder engagement efforts of '*The Incorporation of Rainfall into Hazard Estimates for Improved Coastal Resiliency'* project. The ODU project team also represented the Coastal Resilience Center in a collaborative research project with faculty and students from Norfolk State University (NSU, a minority serving institution) as part of the DHS Summer Research Team Program. The NSU-ODU research team studied socio-ecological resilience using the case study of communities in Portsmouth, Virginia.

5. Abstract:

This project supported two Coastal Resilience Center projects, building on the ODU team's expertise in stakeholder engagement and utilizing existing connections to stakeholders and potential end-users in Hampton Roads. First, we co-organized a panel (with the U.S. Coast Guard) highlighting Hampton Roads resilience projects, including the Intergovernmental Pilot Project, for the Maritime Risk Symposium that addressed "Integrating Maritime and Coastal Resilience." This panel included Jim Redick (Director of Emergency Management, City of Norfolk), ADM Ann Phillips (U.S. Navy, ret.), Kit Chope (Vice President for Sustainability, Port of Virginia), and CAPT Richard Wester (Commander, U.S. Coast Guard Sector Hampton

Roads). Second, we hosted *a Hampton Roads Adaptation Forum on the topic of Sea Level Rise and Flooding Science,* in support of stakeholder engagement efforts of '*The Incorporation of Rainfall into Hazard Estimates for Improved Coastal Resiliency'* project (PI: Don Resio). For both projects, we connected our CRC partners with stakeholders and potential end-users, including managers and planners from local governments (e.g., in emergency management, coastal planning), regional organizations (e.g., Hampton Roads Planning District Commission, Hampton Roads Sanitation District), state agencies (e.g., Virginia Department of Emergency Management, Port of Virginia), federal and DoD agencies (e.g., Coast Guard, Navy, NOAA, National Weather Service), and non-profits (e.g., Chesapeake Bay Foundation, Wetlands Watch). We also conducted regular and periodic engagement events The ODU team also represented the CRC in a collaborative project with faculty and students from Norfolk State University (NSU, a minority serving institution) as part of the DHS Summer Research Team Program. The NSU-ODU research team studied socio-ecological resilience using the case study of communities in Portsmouth, Virginia.

6. End users:

Through the Maritime Risk Symposium, the following end-users directly participated as panelists:

- Jim Redick, Director of Emergency Management, City of Norfolk, VA.
- ADM Ann Phillips, U.S. Navy (Ret.)
- Kit Chope, Vice President, Sustainability, The Port of Virginia
- CAPT Richard Wester, Commander, U.S. Coast Guard Sector Hampton Roads

We co-organized the panel with LCDR Blair Sweigart, Operations Research Analyst, U.S. Coast Guard.

During the panel, the end-users highlighted challenges faced by the Hampton Roads region in terms of coastal and maritime issues. They also discussed some of the Hampton Roads resilience projects they have been involved in, including the Intergovernmental Pilot Project, and the partnerships they have participated in to build coastal and maritime resilience. By connecting stakeholders in maritime and port sectors with stakeholders in emergency management and resilience, the project supported efforts to address risk and improve coastal resilience in an integrated way. By bringing these issues to a wider audience through the Maritime Risk Symposium, the project increased the visibility of such issues and their connectivity to other related risk and resilience concerns.

The July 2016 Hampton Roads Adaptation Forum on the topic of Sea Level Rise and Flooding Science included participation by the following end-users as presenters:

- *Audra Luscher, NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS)*
- *Paul Fanelli, NOAA National Ocean Service (NOS) Center for Operational Oceanographic Products and Services (CO-OPS)*
- *Eric Seymour, Senior Hydrologist, National Weather Service, Wakefield Office*
- *Doug Marcy, Coastal Hazards Specialist, NOAA Office for Coastal Management*

Over 80 stakeholders and end-users attended the Hampton Roads Adaptation Forum to hear from Don Resio and ask questions about Don Resio on 'Risk of Extreme Events.' End-users included:

Michael	Anaya	City of Chesapeake Planning Department
Josh	Balisteri	Ecology and Environment
Mark	Bennett	USGS
Don	Berchoff	True Weather Solutions
Charles	Bodnar	City of Virginia Beach, DPW-Engineering
Justin	Burris	City of Norfolk
Shanda	Davenport	City of Virginia Beach
Stephen	DeVilbiss	DEQ
Gina	DiCicco	Virginia Department of Conservation and Recreation
Robin	Dunbar	Elizabeth River Project
Christy	Everett	Chesapeake Bay Foundation
Michelle	Hamor	USACE, Norfolk District
Gregory	Haugan	Northumberland Assoc for Progressive Stewardship
Gayle	Hicks	City of Hampton
John	Horne	James City County
Shereen	Hughes	Wetlands Watch
Kim	Hummel	Isle of Wight County
Caleb	Hurst	Clark Nexsen
Russell	Jackson	NOAA Coastal Storms Program
Whitney	Katchmark	HRPDC
Heather	Kerkering	MARACOOS
Scott	Kudlas	DEQ
Ronald	Lovell	Hampton Roads REALTORS® Association
Tavorise	Marks	VDEM
Robert	Martz	Hampton Roads Sanitation District
Elizabeth	Mayo	Verizon Wireless
Ben	McFarlane	HRPDC
Tom	McNeilen	McNeilen and Associates
Mary	Pohanka	US Navy
Mohammad	Shar	City of Newport News
David	She	ASCE
Mark	Slauter	VDEM
Brian	Swets	City of Portsmouth
Dave	Pryor	Clark Nexsen
Brian	Batten	Dewberry
Jenny	Reitz	HRSD
Zoe	Johnson	NOAA/ Chesapeake Bay

(Note: This is not an exhaustive list)

The involvement of end-users in this project facilitated flood modeling that incorporates different risks and that are more strongly connected to the needs of end users.

More information about the Hampton Roads Adaptation Forum is available here: https://sites.wp.odu.edu/HRAdaptationForum/the-latest-in-sea-level-rise-and-flooding-science/

In November 2017, the ODU team hosted Dr. Rachel Davidson (Univ. of Delaware) to present a lecture as part of the Center for Coastal and Physical Oceanography (CCPO)/ODU Resilience Collaborative (ODU-RC) Seminar Series. Her seminar title was 'An Integrated Scenario Ensemble-based Hurricane Evacuation Modeling Framework.'

In March 2017, the ODU team hosted Dr. Billy Sweet (NOAA National Ocean Service). Dr. Sweet gave a lecture titled '**Trends, Patterns and Scenario-based Projections of Relative Sea Level and Tidal Flood Frequencies along the US East Coast' as part of the CCPO/ODU-RC Seminar Series.**

End-users attending the seminars by Dr. Davidson and Dr. Sweet included regional planners from the Hampton Roads Planning District Commission, City of Virginia Beach, and City of Portsmouth. The seminars were open to the public and also available via WebEx. Recordings of the lectures are available here: http://vs.odu.edu/kvs/interface/?cid=201530_CCPOSeminarSeriesVS_96096

Following the seminar by Dr. Sweet, we hosted a 3-hour Roundtable Discussion for end-users to have a technical discussion with Dr. Sweet and the ODU research team about the needs of regional stakeholders with respect to nuisance and recurrent flooding and similar topics of interest. Representatives from the Hampton Roads Planning District Commission, National Weather Service, and local cities participated in the Roundtable Discussion.

For the NSU-ODU research project, we connected with end-users from the City of Portsmouth (Meg Pittinger, Environmental Manager and Brian Swets, Planning Administrator) to ensure that our research is relevant to the needs of the city and the communities served.

7. Unanticipated Problems:

There were no unanticipated problems during Year 2.

8. Project Impact:

By connecting end-users in the development of flood modeling, we can better ensure that the models incorporate different risks and are more strongly connected to the needs of end-users. Since end-users can provide input into development, such as by specifying how they would use modeling information or what risks they want incorporated into the models, they are more invested in using the models since they will be better tailored to their needs.
By having end-users involved in the conversation about integrating maritime and coastal risks in efforts to build resilience, we are raising the profile and relevance of the topic beyond the academic realm into world of practice.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Identify theme and potential maritime stakeholders as possible participants for the Maritime Risk Symposium panel	August 2016	100%	
Organize and submit Maritime Risk Symposium panel	August 2016	100%	
Participate in Maritime Risk Symposium	November 2016	100%	
Coordinate with Don Resio on stakeholder engagement needs	July 2016	100%	
Plan and host stakeholder engagement event for PI Don Resio as part of Hampton Roads Sea Level Rise/Flooding Adaptation Forum on 'Sea Level Rise and Flooding Science'	July 2016	100%	
Orientation meeting with NSU faculty and student researchers for DHS SRT	April 2017	100%	
Identify research experience opportunities for student researchers	May 2017	100%	
Identify ODU graduate students to participate in multi-institutional, NSU-ODU research team	May 2017	100%	
Conduct research in communities in Portsmouth, VA	July 2017	30%	Research is underway, expected to be completed by July 28, 2017.
Present research findings to ODU and NSU community, and end-users	July 2017	0%	Research presentation is scheduled for July 28, 2017.
Research Milestone			
Panel on 'Integrating Maritime and Costal Resilience' at the Maritime Risk Symposium	November 2016	100%	
Participate in Maritime Risk Symposium	November 2016	100%	

Stakeholder engagement event for PI Don Resio with 80+ stakeholders	July 2016	100%	
Create multi-institutional, NSU-ODU research team	May 2017	100%	
Complete research in communities in Portsmouth, VA	July 2017	30%	Research is underway, expected to be completed by July 28, 2017.
Present research findings to ODU and NSU community, and end-users	July 2017	0%	Research presentation is scheduled for July 28, 2017.
Annual report to CRC	June 2017	100%	

10. Transition Activity and Milestone Progress:

No translation activity were planned or undertaken.

Research Activities and Milestones: Progress to Date

(expand cell size / add rows as needed)

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Transition Milestone			

11. Interactions with education projects:

Dr. Wie Yusuf gave ReTALK lecture at Johnson C. Smith University on 'Lessons Learned the Hard Way and Tales of Engagement' in October 2016.

Dr. Joshua Behr visited Dr. Rachel Davidson's lab at the University of Delaware in February 2017.

Drs. Wie Yusuf, Joshua Behr, Michelle Covi and Larry Atkinson are working with a Summer Research Team (SRT) from Norfolk State University, a minority-serving institution on the research project 'A Systems Approach: Developing Cross-Site Multiple Drivers to Understand Climate Change, Sea-level Rise and Coastal Flooding for an African American Community in Portsmouth, VA.'

12. Publications:

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery
Table 2: Documenting External Funding and Leveraged Support

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
None	-	-	-
-	-	-	-
-	-	-	-

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Assessing Current and Future Risk Posed to Structural Assets at Norfolk International Terminal South Stemming from Sea Level Rise and Severe Storm Inundation	Behr	$68,000	Commonwealth of Virginia (Port of Virginia)
Assessment of Tourism Industry Resilience	Yusuf & Covi	$30,000	Commonwealth Center for Recurrent Flooding Resiliency
Hampton Roads Adaptation Forum	Covi	$15,000	NOAA
Virginia Sea Grant Climate Adaptation and Resilience Program	Covi	$113, 228	Virginia Sea Grant
Leveraged Support			
Description			Estimated Annual Value
Office and meeting space, telecommunication services			$3,000
Guest speakers and engagement events (CCPO/ODU-RC Speaker Series, Roundtable discussions)			$3,500
Hampton Roads Adaptation Forum corporate support			$3,000
Outreach support through Virginia Sea Grant Climate Adaptation and Resilience Program			$5,000
Student hours			$1,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	0	0
Graduate students provided stipends (number)	0	2
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	0	0
SUMREX program students hosted (number)	0	0
Lectures/presentations/seminars at Center partners (number)	0	1
DHS MSI Summer Research Teams hosted (number)	0	2
Journal articles submitted (number)	0	0
Journal articles published (number)	0	0
Conference presentations made (number)	0	0
Other presentations, interviews, etc. (number)	0	0
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	1
Requests for assistance/advice from other agencies or governments (number)		5
Total milestones for reporting period (number)	0	
Accomplished fully (number)	0	
Accomplished partially (number)		
Not accomplished (number)		

Photos:

Engineers and planners from the City of Chesapeake and City of Virginia Beach participating in roundtable discussion on nuisance flooding with Dr. Billy Sweet from NOAA.

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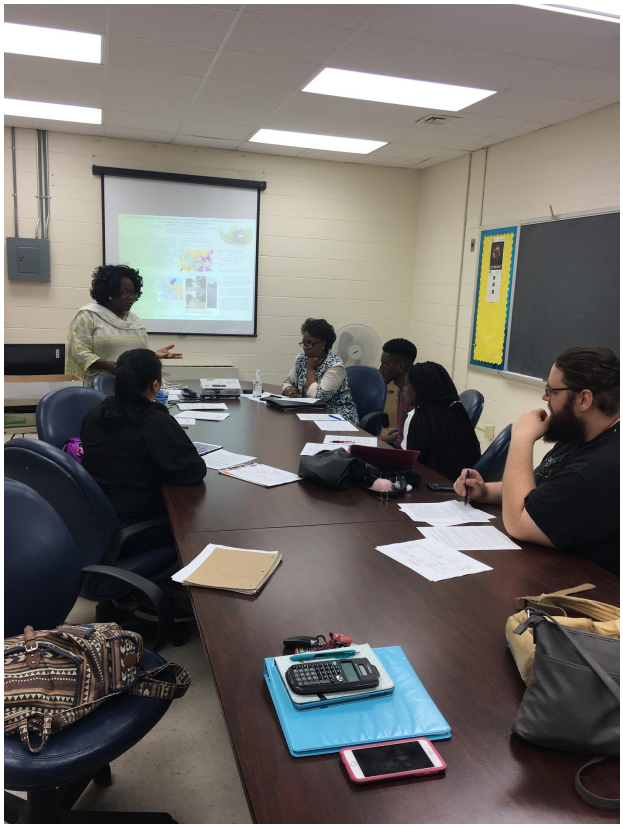
Panel on ‘Resilience in a Complex Coastal System’ at the Maritime Risk Symposium.

Dr. Wie Yusuf with Johnston C. Smith University students following her ReTALK lecture on ‘Lessons Learned the Hard Way and Tales of Engagement’



Norfolk State University undergraduate students Raisa Barrera, Bryan Clayborne and Mikel Johnson, along with ODU graduate student Isaiah Amos meeting with NSU faculty members Dr. Camellia Okpodu and Dr. Bernadette Holmes to kick-off the SRT project 'A Systems Approach: Developing Cross-Site Multiple Drivers to Understand Climate Change, Sea-level Rise and Coastal Flooding for an African American Community in Portsmouth, VA.'

Norfolk State University student Mikel Johnson learning more about modeling and simulation during a tour of the Virginia Modeling, Analysis and Simulation Center (VMASC) on June 8, 2017 as part of the SRT experience hosted by ODU (on behalf of the CRC).

Norfolk State University student Bryan Clayborne trying out simulation developed by Virginia Modeling, Analysis and Simulation Center (VMASC) researchers on tour of VMASC on June 8, 2017 as part of the SRT experience hosted by ODU (on behalf of the CRC).

BERKE, TAMU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Local Planning Networks and Neighborhood Vulnerability Indicators

2. **Principal Investigator / Institution:**
   Philip Berke/Texas A&M
   Galen Newman, Assistant Professor, Texas A&M; Supervise digital mapping, visualization.
   Walter Peacock, Professor, Texas A&M; Develop indicators, analysis of indicator data, report research; Texas Target Communities (engagement coordinator), Texas A&M University; lead and supervise all end user engagement activities.

3. **Other Research Participants/Partners:**
   Jaimie Masterson, Texas Target Communities at Texas A&M

4. **Short Project Description ("elevator speech"):**
   We develop a *plan integration for resilience scorecard* and user guidelines to assist local planners and emergency managers to integrate disaster risk into planning in all relevant sectors of urban development. Failure to coordinate networks of plans can significantly increase risks to disaster events. We apply the *scorecard* in nine coastal cities to evaluate the level of integration (and conflict) of local plans and the degree to which the network of plans targets areas most vulnerable to hazards.

5. **Abstract:**
   Problem**.** Fragmentation of mitigation among the diverse range of sectors of planning has led to siloes in which mitigation planning is isolated from other planning. When plans do not consistently integrate mitigation they can actually increase the vulnerability of people and the built environment to hazards and climate change. Failure to coordinate integration of multiple planning activities that govern land use in hazard areas has become a national policy concern. This was acknowledged by the Federal Emergency Management Agency director Craig Fugate's call for more integration of hazard mitigation efforts into all types of local planning and more cooperation between emergency managers and planners (see, Fugate, W. C. 2010 "Integrating Hazards into Local Planning," Foreword to Hazard Mitigation: Integrating Best Practices into Planning, James Schwab, editor, Planning Advisory Service Report 560, American Planning Association, Chicago, IL, 2010: iii-iv).

   Methods. We will initially review the literature in hazard mitigation planning to identify how mitigation can be supported thorough different types of local planning activities (economic development, land use, capital improvement programs, environment) that influence land use and development patterns in hazard areas. We then develop a conceptual framework to guide the creation of a *plan integration for resilience scorecard* (PIRS) that consists of two sets of indicators that measure the spatial variation of a community's social vulnerability and physical vulnerability, and how well a local network of plans are aimed at vulnerability reduction.

Next, we apply the scorecard to a set of nine demonstration coastal communities to test the applicability of the scorecard in determining how well the network of local plans support mitigation, and how well they are spatially correlated with variation in local vulnerability to coastal floods and projected sea level rise.

Deliverables

- A guidebook on application of the *plan integration for resilience scorecard* for local mitigation practitioners.
- Publications in peer reviewed journals.
- Research summary (2-3 pages) for each publication to be targeted to broad audience of end users.
- Conference presentations and webinars.
- Update of mitigationguide.org website supported by DHS to include the scorecard guidebook, and best practice examples of application of the tool in local jurisdictions.

6. End users:

We are engaging end-users through creation of a National Advisory Committee, direct contact with FEMA and NIST officials, and involvement of local government staff in the demonstration communities.

We have recruited and convened a National Advisory Committee to strengthen partnerships and collaborations with the practice community and to ensure the applicability of the scorecard for mitigation practitioners. Members include key leaders in the practice community:
-Chad Berginnis, Director, Association of State Floodplain Managers
-Matt Campbell, Nat'l Coordinator for Community Recovery Planning & Branch Chief for Community Planning and Capacity Building of the Interagency Coord. Div.,FEMA
-Jennifer Ellison, Community Development Coordinator, City of Urbandale, Iowa
-Allison Hardin, Urban Planner, City of Myrtle Beach, SC
-Barry Hokanson, Director, Hazard Mitigation and Disaster Recovery Division of the American Planning Association & Mitigation Planner, PLN Associates
-Darrin Punchard, Mitigation Planner, Hawksley Consulting
-Gavin Smith, Exec. Director, Coastal Resilience Center, University North Carolina
-Jennifer Ellison- City of Urbandale, Community Development
-Michele Steinberg, National Fire Protection Association, Wildfire Division Manager
-Rich Roths- URS Corporation, Principal Planner

The Committee meets about once every 4-months via teleconference with project investigators. To date the Committee has met five times. Committee members offer guidance to the development of the *plan integration for resilience scorecard* and guidebook for local mitigation practitioners, assist with dissemination of project results, and provide oversight and strategic advice to the research and translational activities. The Committee also serves to enhance communication between the project researchers and the practice community.

FEMA is the primary end user for this project. Our point of contacts are in the FEMA Risk Analysis Division, Assessment and Planning Branch, Mitigation Planning Program: Kathleen Smith, 202 646-4372, Kathlccn.W.Smith@fcma.dhs.gov; and FEMA Community Planning and Capacity Building Recovery Support Function, Matt Campbell, 202 870-4495, Matt.campbell@fema.dhs.gov. We informed Kathleen Smith and Matt Campbell of our

progress during the Hazard Mitigation and Disaster Recovery Division meeting at the American Planning Association Conference in May 2017. In addition, Matt Campbell of FEMA serves on our National Advisory Committee. We keep in regular communication with our OUP Program Manager (Eleanore Hajian at 202 567-1525 or eleanore.hajian@hq.dhs.gov) about progress of this study through emails, conference calls, and preparation of a brief research summary report.

We are conducting engagement efforts with three of the nine demonstration communities in League City, Texas (Key contact: Marc Linenschmidt, Planning and Development Department); Norfolk, Virginia (Key contacts: Paula Shea, Principal Planner; George Homewood, Director of Planning & Community Development); and San Luis Obispo, CA (Key contact: Michael Codron, Director of Community Development). It is the local community where all aspects of planning that influences land use and development come together. We engage local agency staff and in some cases non-governmental actors charged with responsibilities for planning. Local entities include, for example, emergency management, land use planning, housing, utilities, transportation, economic development, and environmental conservation. These end users are typically charged with preparing, updating and reviewing the diversity of local plans that influence land use and development in hazardous areas.

Finally, we have started the process of institutionalizing the plan integration scorecard. This fall-2017 we will initiate a fourth demonstration community – a collaborative project with NIST in Annapolis, MD, a HUD entitlement community, which we hope can be sustained in the long-term. We will work with NIST in combing NIST's *Resilience Planning Guidebook* and the Texas A&M *plan integration for resilience scorecard*. NIST is committed to our scorecard as part of its major program aimed at facilitating local government action in support of hazard mitigation (contact: Stephen Cauffman, stephen.cauffman@nist.gov). Presentation of the emerging partnership between NIST and Texas A&M investigators will be discussed on a panel this July at the Hazards Workshop in Broomfield, CO). If our project is extended, we will seek to strengthen our partnership with NIST based on additional community demonstration projects. We will also aim to build similar partnerships with other federal agencies, notably HUD's CDBG-Disaster Recovery program and FEMA's CRS program.

7. Unanticipated Problems:

No unanticipated major problems.

8. Project Impact:

We are working on two sets of impacts that focus on working with the demonstration communities and institutionalizing application of the scorecard at the national, state and local levels.

Demonstration Communities

Use of the plan integration scorecard by the three demonstration communities aims to improve planning for hazards by allowing planners from multiple community agencies to identify conflicts between plans and missed opportunities to mainstream mitigation into

multiple sectors of planning, and assess whether plans target areas that are most vulnerable.

In our work in applying the scorecard in the three demonstration communities we are tracking four types of impacts likely to occur at different stages of the plan review and implementation process (see Figure 1):

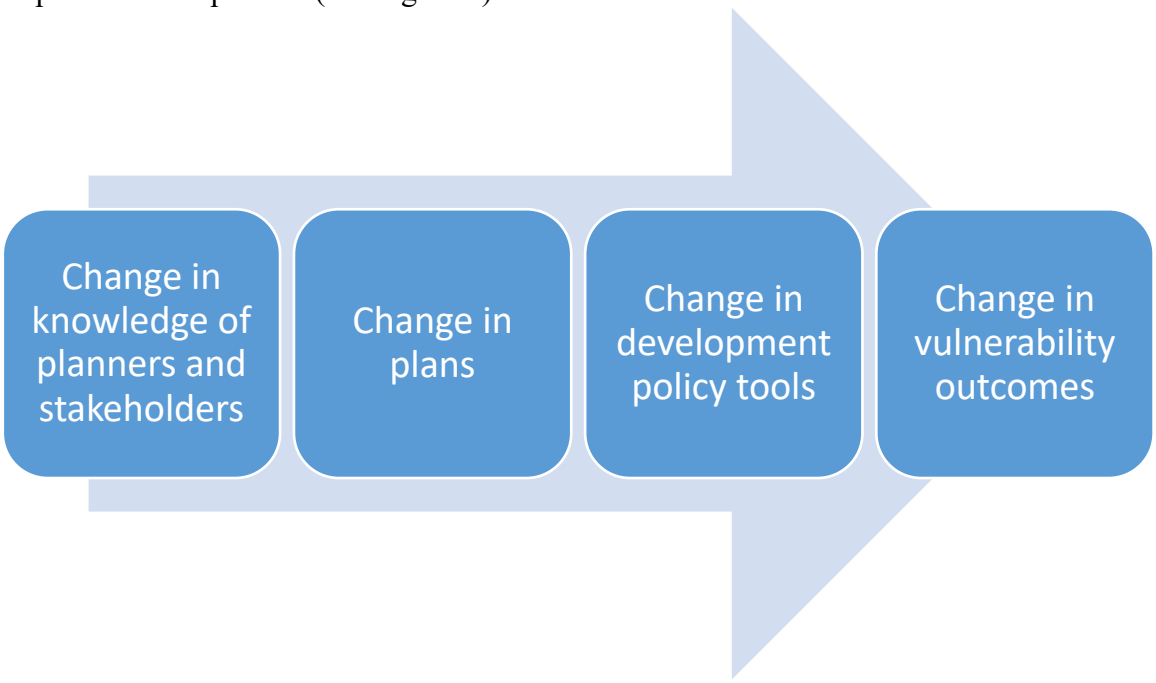


Figure 1 Impacts of PIRS

Impact #1: Changes in knowledge by urban planners, emergency managers and stakeholders about roles of alternative plans and how they can be better integrated to increase support for mitigation, reduce duplication of effort, and more efficiently use limited resources.

Impact #2: Revision and better integration of vulnerability reduction into a community's general plan, hazard mitigation plan, and other local plans.

Impact #3: Revision of a range of development policy tools that influence land use and development in hazard areas to be consistent with the revisions of plans. Examples of policies include development regulations (e.g., zoning and subdivision ordinances), incentives (density bonuses, property tax breaks), land acquisition strategies, and design and location of capital improvement projects (transportation, water, sewer).

Impact #4: Changes in vulnerability outcomes that limit or prevent new development (and population) in hazard areas, or reduce vulnerability of existing development (and population) in hazard areas in different geographic areas.

Impact #1 (change in knowledge of planners and stakeholders) begins soon after (1-3 months) a community starts to apply the scorecard. This impact indicates that plan review is not just about the scores. Based on our work with the demonstration communities to date, we are finding that a valuable contribution resulting from application of the scorecard is a collaborative process that yields information about how specific policies that influence public and private land use and

investments within a plan and the network of plans. Application of the scorecard provides a deeper understanding and comprehensive assessment of how multiple plans, that may not directly address hazard mitigation, are conclusively linked to mitigation and disaster loss.
Examples of comments by local officials in the demonstration communities indicate the high value they place in gaining a better understanding of their networks of plans through application of the scorecard:

- "We wanted to see the effect of all our policies on flood resilience because we had never taken such a comprehensive look our policies before. It was also an opportunity to see how different plans stacked up, particularly because we had not previously evaluated the hazard mitigation plan side by side with other community plans." –City of Norfolk;
- "We were very intrigued by the spatiality of our policies and hadn't thought about our policies spatially before. This was important to us because our Vision2100 document specifically designates areas of flood protection and retreat." –City of Norfolk;
- "We utilized this to update our comprehensive plan and zoning ordinances" –League City;
- "It is important for practice that you are tracing back to the policy." –League City

Impact #2 (change in plans) and Impact #3 (change in regulatory and investment policies) will likely occur in the mid-term (3-12 months) after completion of our engagement efforts in the demonstration communities this fall 2017. We will document these changes during the fall 2017, and continue to track changes if funding for this project is extended. To date, change in plans and policies have included amendments to several components of planning documents of the City of Norfolk. Staff planners indicate that applying the scorecard produced several benefits: a) the most comprehensive examination (but not time consuming) of the level of integration among different plans they had ever undertaken; b) allowed them to evaluate the degree to which policies from multiple plans decrease (or actually increased) vulnerability in different geographic areas of the city; and c) the new information supported deeper and more inclusive conversations about different stakeholder interests regarding the impacts of specific policies.

Action by the City of Norfolk was recently taken based largely on results of the scorecard evaluation process. On June 22, 2017 the planning staff presented a document to the Norfolk Planning Commission Public Hearing that details policy amendments across various plans. Following are examples of needed actions under two broad headings that are included in the public hearing document (see attached Planning Commission Public Hearing document):

I. The scorecard tool revealed weaknesses and inconsistencies throughout plans. Examples of improving plan integration include:
    a. Pg. 1: Land use, transportation, and facility location elements in the comprehensive plan (plaNorfolk 2030) need to be amended to incorporate resilience plan proposals (Vision 2100).
    b. Pg. 2: Amend comprehensive plan (plaNorfolk 2030) to incorporate specific design criteria for public facilities in the resilience plan (Vision 2100).
    c. Pg. 4: Revise land sales and acquisition policies in the affordable housing plan to be consistent with resilience plan (Vision 2100).
    d. Pg. 4: Update zoning regulations to be consistent with resilience plan land use strategies that vary across different geographic areas (red, yellow, green and purple districts, see pp. 10-11).
    e. Pg. 5: Location criteria for community facilities within the comprehensive plan did not account for resilience policies and metrics discussed in the resilience plan.

f. Pg. 5: Incorporate resilience policies in Vison 2100 into the capital improvement projects to determine major roadway improvements, rail, ferries, etc. (p. 5)
g. Pg. 5: Use Vision 2100 as a guide when reviewing development proposals and budgets for capital improvements.

II. Norfolk planning staff indicates they had not previously reviewed or evaluated the hazard mitigation plan. They have not consulted the hazard mitigation plan in the preparation of all other plans adopted by the city. They indicate that the scorecard provided a methodological tool to guide integration of the mitigation plan across other plans, and to make the mitigation plan better. Examples of integration of the mitigation plan identified on the attached Planning Commission Public Hearing document include:
    a. Pg. 2: Amend the comprehensive plan (plaNorfolk 2030) to incorporate actions in the hazard mitigation plan (Hampton Roads Mitigation Plan).
    b. Pg. 5: Integrate the mitigation plan and resilience plan (Vision 2100) guides to evaluate options to future development proposals.
    c. Pg. 7: Hazard mitigation plan contains policy actions that should more clearly specify "appropriate strategies to mitigate the impact of flooding to existing flood-prone structures." The resilience plan could be used to improve the mitigation plan, for example, since the resilience plan includes flood maps of locations of such structures, which can provide the basis for formulating more spatially specific policies in the mitigation plan.

Impact #4 (change in vulnerability outcomes) will likely be evident in the long-term (>2 years), but we will track any change outcomes during the duration of this study.

Institutionalizing the Plan Integration for Resilience Scorecard
The following activities will be initiated fall-2017 that are focused on disseminating and institutionalizing our *plan integration for resilience scorecard*, and thus increase multiple impacts related to our work:

-- As noted above, we anticipate that our new partnership with NIST will generate multiple outcomes. The NIST Community Resilience Planning Guide is a detailed guidebook for communities, which discusses the importance of plan integration, but does not give a tool or mechanism to do it. NIST guidance and scorecard are a natural fit and have spurred a panel discussion at the annual Natural Hazards Workshop in Broomfield, CO (July 2017). As noted, we have agreed to partner with NIST in Annapolis. NIST is also working to institutionalize their guidance and is committed to marketing and expanding use of its guidebook. We anticipate that our scorecard will be part of NIST's effort.

-- We are connecting with CRS as to embed the tool into their guidance and activities. We have reached out to Bill Lesser to set up a meeting to discuss the scorecard more. He has also suggested we reach out to Sam Brody and Wes Highfield at Texas A&M because of their work with CRS.

-- We have received invitations from Louisiana Sea Grant and Texas Sea Grant to collaborate. They are interested in a train-the-trainer program for their extension agents, coastal specialists, and coastal planners. Their network of agents would allow communities across the gulf coast to embed the tool into what they are already doing with communities. Louisiana Sea Grant (Robert Twilley, Director) and Texas Sea Grant (Heather Wade, Director) have agreed to support travel and accommodations.

-- Based on Matt Campbell's (FEMA) suggestions we are uncovering an opportunity to work with the CPCB Recovery Support Function and their communities in Louisiana to apply the scorecard for a more informed recovery. Additionally there is an opportunity to work with jurisdictions already a part of FEMA's Statewide Hazard Mitigation Pilot Program. They are working in four counties.

-- We will conduct webinars for the Association of State Floodplain Managers and the American Planning Association. We are working with Chad Berginis and Barry Hokanson to coordinate these. We will explore for other opportunities to host webinars for boarder reach.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Complete data analysis to determine how well a network of plans support mitigation, and how well they are spatially correlated with variation of social and physical vulnerability.	8/30/16	100%	
Research Milestone			
Produce draft manuscript for presentation at research conference (Association of Collegiate Schools of Planning, or some other national or international conference) to obtain feedback.	10/30/2016	100%	

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Analyze plans and work with local agency staff of demonstration communities in	8/30/2016	75%	We are still working with the demonstration communities. Most

developing a draft plan integration assessment tool (*Plan Integration for Resilience Scorecard*) and accompanying draft of user guidelines for mitigation planning practice.			of the work is completed, but we are dependent on the schedules of the teams of local government staff. We plan to complete this work in fall 2017.
Transition Milestone			
"Draft "of plan integration assessment tool and user guidelines.	9/30/2016	100%	

11. Interactions with education projects:

We offered our availability to participate, but have not been able to make arrangements to participate.

12. Publications:

Berke, P, Lee, J., Newman, G., Combs, T. Kolosna, C., Salvesen, D. 2015. Evaluation of Networks of Plans and Vulnerability to Hazards and Climate Change: A Resilience Scorecard, *Journal of the American Planning Association* 81(4): 287-302.

- 2016 Best Article Award, American Planning Association.

Berke, P., Malecha, M., Yu, S. and Masterson, J. 2017. Plan integration for resilience scorecard: Evaluating networks of plans in six coastal cities. *Journal of Environmental Planning and Management* (under review).

Malecha, M.L., Brand, A.D., & Berke, P.R. Spatially Evaluating a Network of Plans and Flood Vulnerability Using a Plan Integration for Resilience Scorecard: A Case Study in Feijenoord District, Rotterdam, the Netherlands. *Land Use Policy*. (under review).

-This paper applies the scorecard developed by our DHS project. The lead author is a doctoral student. The Rotterdam case study is supported by NSF.

13. Tables

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Plan Integration Scorecard Guidebook: How to Spatially Evaluate Networks of Plans to Reduce Hazard Vulnerability	Guidelines for integrating mitigation into local planning practice	Fall 2017	--National Institute of Science and Technology (to integrate with NIST resiliency planning guidelines) -FEMA (agreed to place guidebook on FEMMA's website as a resource for local hazard mitigation planners)

			-Hazard Mitigation and Disaster Recovery Division of the American Planning Association -Association of State Floodplain Managers -Louisiana and Texas Sea Grant programs

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NSF PIRE- Coastal Flood Risk Reduction Program: Integrated, Multi-scale Approaches for Understanding How to Reduce Vulnerability to Damaging Events, Sam Brody Lead at TAMU-Galveston, National Science Foundation, $250,000 sub-award to TAMU-College Station. (September 2016-20).	Berke	$250,000	NSF
Leveraged Support			
Description			Estimated Annual Value
Portion of university indirect returned to project			About $20,000

14. Metrics

Metric	Year 1 (1/1/16 – 6/30/16)	Year 2 (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	2	2
Graduate students provided stipends (number)	3	3
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	
Graduates who obtained HS-related employment (number)	0	
SUMREX program students hosted (number)	0	0
Lectures/presentations/seminars at Center partners (number)	0	3
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	0	2
Journal articles published (number)	0	0
Conference presentations made (number)	3	5
Other presentations, interviews, etc. (number)	1	6
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	1
Requests for assistance/advice from other agencies or governments (number)	0	9
Total milestones for reporting period (number)	2	2
Accomplished fully (number)	2	1
Accomplished partially (number)		1
Not accomplished (number)		

DAVIDSON, UDEL

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. Project Title:

An Interdisciplinary Approach to Household Strengthening and Insurance Decisions

2. Principal Investigator / Institution:

Rachel Davidson, Professor, Civil Engineering, University of Delaware

3. Other Research Participants/Partners:

- Jamie Kruse, Professor, Economics, East Carolina University
- Linda Nozick, Professor, Civil Engineering, Cornell University
- Joseph Trainor, Assistant Professor, Public Policy, University of Delaware

4. Short Project Description:

This interdisciplinary project will improve a developing policy analysis tool to help agencies explore the potential effects of policies related to household hurricane risk reduction. The project specifically focuses on better understanding the factors that influence homeowner insurance purchase and retrofit decision-making.

5. Abstract:

Two primary mechanisms to manage natural disaster risk— insurance and retrofit—are presently underutilized, suggesting a need to better understand how homeowners make retrofit and insurance purchase decisions. Future programs and policies intended to reduce coastal natural disaster risk will be more effective if designed to align with how homeowners actually make these choices.

This project is advancing understanding of (1) homeowner insurance purchase and retrofit decision-making and (2) the role it plays within the larger insurer-government-homeowner system of managing natural disaster risk. We are leveraging two products from a NIST-funded research project we undertook recently—phone survey data and a holistic framework comprised of interacting mathematical models of hurricane risk, and homeowner and insurer decision-making that can help policy makers consider how specific policy alternatives might affect different stakeholder groups.

In addition to advancing the scientific models and the broader mathematical framework and policy tool, we expect four main near-term outcomes: (1) discrete choice models that describe homeowner insurance and retrofit decisions; (2) a "system win-win" white paper that fully describes the larger mathematical framework this project contributes to, including description of the interacting models, the insights they produce when combined, the value that the system

will provide to practitioners, and the technical requirements for transitioning from the framework to a fully implemented policy tool; (3) a series of short policy briefs on the impact of low cost loans, grants, and insurance premium reductions on homeowner retrofit decisions; insurance adoption decisions; and the impact of hurricane experience on insurance purchases; and (4) analysis of the role of prior hurricane experience and risk perception on protective action decisions.

6. End users:

Five primary end users are involved in this project, representing both the mitigation and preparedness directorates of FEMA, state floodplain managers, and the NIST Community Resilience group (Table 1). As Acting Division Director of the Risk Analysis Division, one of the three main divisions of the FEMA Mitigation Directorate, Paul Huang focuses on identifying hazards, assessing vulnerabilities, and developing strategies to manage the risks associated with natural hazards in communities. In the FEMA Individual and Community Preparedness Division, Jackie Snelling works to promote preparedness and mitigation activities as adjustments to risk. Chad Berginnis represents the 17,000 members of the ASFPM, an organization dedicated to reducing flood losses nationwide. As a member of the Applied Economics Office and the NIST Community Resilience Group, Jennifer Helgeson works on economic analysis of individual and community resilience. Steve Cauffman is lead for Disaster Resilience at NIST. We have had multiple conversations with these partners before and during the project through a combination of in-person meetings, conference calls, and email exchanges. Through these interactions we have gained a good understanding of the challenges they face and how we can support their efforts to meet those challenges. In our previous NIST-funded research project, we worked with a reinsurance industry representative to gain input from that perspective.

Table 1. Primary end users involved in project

Name	Title	Organization	Role in project
Paul Huang	Acting Division Director	FEMA Federal Insurance and Mitigation Administration, Risk Analysis Division	Advisory Panel
Jacqueline Snelling	Senior Policy Advisor	FEMA Individual and Community Preparedness Division, National Preparedness Directorate	Advisory Panel
Chad Berginnis	Executive Director	Association of State Floodplain Managers (ASFPM)	Advisory Panel
Jennifer Helgeson	Research Economist	NIST Applied Economics Office/ Community Resilience Group	Advisory Panel
Steve Cauffman	Lead for Disaster Resilience	Materials and Structural Systems Division	Advisory Panel

7. Unanticipated Problems:

None.

8. Project Impact:

The longer-term aim of the project is to develop a fully operational policy analysis tool based on our current modeling framework. Risk management officials will be able to use the tool to identify and evaluate alternative public policies and private sector interventions aimed at effective, sustainable, win-win solutions to better manage natural disaster risk associated with existing buildings. A key, novel aspect of the tool is that by examining the system as a whole, solutions can be found that both reduce the societal risk and leave every stakeholder—homeowners, insurers, government agencies—better off. The policy analysis software tool will help officials both evaluate pre-defined policies under consideration, and recommend new policies based on government objectives. It will provide the sound scientific basis for natural disaster risk management policies. The system win-win paper that is a main outcome supports this real-world impact.

In the shorter term, the statistical analyses and policy briefs will inform risk managers about how homeowners make insurance purchase and retrofit decisions and the likely effects of different possible incentives on those decisions. As our end user partners and others continue to work to motivate risk management actions among homeowners and other stakeholders, this information will support their efforts.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Fit discrete choice models for decisions about insurance purchase.	8/16	100	
Write journal paper about homeowner hurricane-related insurance decision-making	11/16	100	
Write journal paper that explains the role of past hurricane experience on homeowner insurance purchase.	6/17	100	
Fit discrete choice models for decisions about homeowner hurricane-related retrofit decision-making, including consideration of incentives.	5/17	100	
Write journal paper about homeowner hurricane-related retrofit decision-making, including consideration of incentives	8/17	100	This was due 8/17, but we expect to complete it by the end of 6/17.
Research Milestone			
Submit manuscript to a peer-reviewed journal about homeowner hurricane-related	11/16	100	

insurance decision-making for protection against both wind and flood damage			
Submit manuscript to a peer-reviewed journal about the role of past hurricane experience on homeowner insurance purchase.	6/17	100	
Submit manuscript to peer-reviewed journal about homeowner hurricane-related retrofit decision-making for protection against both wind and flood damage, including consideration of incentives	8/17	100	This was due 8/17, but we expect to complete it by the end of 6/17.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Group conference call with research team and all end user partners to present progress and get input	7/16	100	
Begin System win-win white paper	3/17	100	
Begin Insurance decisions policy brief	11/16	50	With the completion of the research paper that forms the basis for this policy brief, this task will be much faster to complete now.
Begin Hurricane experience and risk perception policy brief.	12/16	50	With the completion of the research paper that forms the basis for this policy brief, this task will be much faster to complete now.
Group conference call with research team and all end user partners to present progress and get input	1/17	100	
Phone calls with additional end users to get feedback on the system win-win concept and what a useful policy analysis tool based on it would look like.	6/17	50	Due to scheduling issues, we plan to achieve this in the second half of the summer.
Transition Milestone			
Clear set of technical requirements for policy analysis tool	6/17	50	

11. Interactions with education projects:

In the Summer of 2016, we hosted two 8-week summer interns from our CRC partner, Tougaloo College, at the Disaster Research Center at the University of Delaware. The students are Irenia Ball and Taralyn Rowell, both African American Female Seniors. While at UD they contributed to this project by reviewing extant insurance literature and developing an inventory of mitigation programs currently being offered by states. These students also visited the Delaware Legislature and with a group of non-profit leaders in Wilmington. They also interacted more generally with UD social science and engineering students and faculty interested in disaster studies. We were able to bring the second student by identifying supplemental funds from the University of Delaware to support her.

12. Publications:

Wang, D., Davidson, R. A., Trainor, J. E., Nozick, L. K., & Kruse, J. 2017. Homeowner purchase of insurance for hurricane-induced wind and flood damage. *Natural Hazards*, 1-25. [published] (Wang, D. is a Ph.D. student)

Xu, K., Nozick, L., Kruse, J., Davidson, R., and Trainor, J. Affordability of Natural Catastrophe Insurance: game theoretic analysis and geospatially explicit case study, Chapter 15in *GEOValue: the socioeconomic Value of Geospatial Information*, ed. J. Kruse, J. Crompvoets, and F. Pearlman, Taylor & Francis Group, LLC Baton Rouge, FL. [in press] (Xu, K. is a Ph.D. student)

Yahyazadeh, Z., Davidson, R., Trainor, J., Kruse, J., and Nozick, L. Homeowner decisions to retrofit to reduce hurricane-induced wind and flood damage. *Journal of Infrastructure Systems*, in review. [submitted]

Journal paper that explains the role of past hurricane experience on homeowner insurance purchase is in final stage of editing and will be submitted by the end of June. Authorship and title still need to be finalized.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Insurance purchase paper	Journal paper	November 2016	Academic and professional community
Retrofit decision paper	Journal paper	June 2017	Academic and professional community
Experience, emotion, and insurance purchase paper	Journal paper	June 2017	Academic and professional community

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Collaborative Research: An Interdisciplinary Approach to Modeling Multiple Stakeholder Decision-making to Reduce Regional Natural Disaster Risk, National Science Foundation	Davidson	$306,555	NSF

Modeling natural disaster risk management: A stakeholder perspective	Davidson	$797,000	NIST
Leveraged Support			
Description			Estimated Annual Value
DRC support of interns			$1,000
UDEL School of Public Policy and Administration support of interns			$1,000
UDEL Vice Provost of Diversity support of interns			$3,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	2	2
Graduate students provided stipends (number)	2	2
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	1
Graduates who obtained HS-related employment (number)	0	1
SUMREX program students hosted (number)	2	0
Lectures/presentations/seminars at Center partners (number)	0	0
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	1	1
Journal articles published (number)	0	1
Conference presentations made (number)	0	0
Other presentations, interviews, etc. (number)	0	0
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0
Total milestones for reporting period (number)	1	3
Accomplished fully (number)	1	2
Accomplished partially (number)	0	1
Not accomplished (number)	0	0

PROCHASKA, URI

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Communicating risk to motivate individual action

2. **Principal Investigator / Institution:**

   Dr. James O. Prochaska, Cancer Prevention Research Center (CPRC), URI

3. **Other Research Participants/Partners:**

   - Additional Investigators: Dr. Andrea Paiva, CPRC, URI, Pam Rubinoff, CRC, URI.
   - Significant partner: Pro-Change Behavior Systems, Inc.

4. **Short Project Description ("elevator speech"):**

   Communicates risk to motivate action by tailoring communication to diverse populations. Participants receive individualized feedback via online coaching based on their readiness to take action, thereby encouraging them to move forward in the behavior change process to prepare and mitigate impacts of coastal storms.

5. **Abstract:**

Efforts to communicate disaster preparedness and risk messages lead to increased public awareness. However, FEMA surveys indicate that the public today is little more prepared to respond to a disaster than it was several years ago. This conundrum reflects the axiom in the science of behavior change that increasing awareness can start the change process, but cannot sustain it; reflecting a disconnect between theory and practice. Behavior change psychology indicates that: 1) the behavior targeted for change must be clearly defined and include specific achievable actions; and that 2) behavior change is an extended process where each stage is a small step on the way to permanent behavior change. While efforts at linking behavior change and preparedness have been shown to be successful (Miletti and Darlington, 1995) it is not common place for most emergency managers, communicators and planners to incorporate behavior change psychology when communicating with the public.

6. **End users:**

   The direct end users of this project are coastal residents in New England, Alabama and Florida. However, to ensure the continued use of this research in practice, it will also target local, state, and Federal emergency managers, and coastal planners, who can help us identify ways to incorporate and/or adapt the research findings to their communication programs. We are using Randomized Clinical Trials (RCTs) which include control groups that control for the

effects of secular trends and a broad range of variables that can affect outcomes, like demographics and severity of risks. RCTs are the gold standard for the science and practice of behavior change, but many organizations, like FEMA, often do not have the flexibility to use RCTs in their applied programs. The CTI or Computer Tailored Intervention system is comprised of risk communications that are tailored to dynamic variables, like stage of change, decision making, and self-efficacy, that drive behavior change. Brief reliable and valid assessments allow tailoring to each individual using algorithms that support normative feedback (how the individual's responses compares to peers who progress the most) and ipsative feedback (how the individual is progressing over time). Similar CTIs have been found effective across a broad range of risk behaviors and diverse populations who are at risk. The CTIs have also been delivered across a variety of IT platforms and communication systems. Our discussions with Karen Marsh, who is the IT lead for Jackie Snelling's team will evolve into meeting with a FEMA IT POC, as we integrate our innovative texting capability into our current CTI system. The texting and other CTI messages can be translated into different languages. Our practice has been to demonstrate effectiveness of a new program and then seek resources for translating it to serve diverse populations. We have reached out to the following individuals and received several commitments to engage in our end-user team:

National - Jacqueline Snelling from FEMA's Individual & Community Preparedness Program; Mary Culver from NOAA's Office for Coastal Management; Chad Berginnis ASFPM Executive Director; Kim Smail the Federal Alliance for Safe Homes)

Regional - Mark Landry, Federal Coordinating Officer and Disaster Recovery Manager for FEMA Region 1

Rhode Island – Jessica Stimson RI Emergency Management (to be confirmed); Igor Runge of the Rhode Island Floodplain Mitigation Association Board of Directors (Chapter of the ASFPM); Elizabeth Stone RI Department of Environmental Management and the RI Executive Climate Change Coordinating Council.

7. Unanticipated Problems:

We experienced delays in recruiting due heavily to the budget limitations and by generating leveraged funds we were able to resolve the issue. We were able to complete the baseline data collection rapidly and were able to increase our baseline recruitment from 1,000 participants to 3,000 participants. Due to our close discussions and collaborations with FEMA and with leveraged funds we now have an investigator who is spending more time to engage more end users, like those named above.

8. Project Impact:

This project develops and assesses a state of-the-science and innovative disaster preparedness communication intervention program. Addressing Topic 2c (Communicating Risk to Motivate Action), it identifies and uses messages that motivate individuals and groups to prepare in advance for disasters, and to take action when disasters threaten. Participants will be linked to key information sources, such as the National Oceanic and Atmospheric Administration (NOAA), FEMA, and the project's recent Waves of Change (RIClimatechange.org) website, which is organized to help visitors move through the stages of behavior change. This proposed

project will take this one step further and provide coaching by text messaging to increase efficacy of behavior change.
This computer tailored intervention identifies resident's readiness to prepare for such disasters and provides them with the tools, education, and behavior change strategies that empower them to take action on this important issue. In doing so, we focus on, and work closely with key members of the community, including governmental agencies, nongovernment organizations, and the private sector. Our innovative reliance on digital communications including texting, is directly related to FEMA Administrator Fugate's interest in the use of texting and other digital modalities to communicate information that can reach at-risk populations and increase their preparedness and mitigation behaviors (Haldeman, 2013).

The Transtheoretical Model in itself is a population based theory, in that it reaches out to people at all stages of readiness and not just those who are most ready to take action. This is particularly important in this area since those most ready for disasters are not always the people affected most by these storms. Coastal residents who are not ready or do not see the benefits of becoming prepared are likely to suffer the greatest consequences and may require greater levels of assistance after disasters. By engaging the entire population, we are able to make larger impacts on the community and conform to the core guiding principles of the DHS Whole Community approach (Department of Homeland Security, 2014):

(1) understanding and meeting the actual needs of the Whole Community;
(2) engaging and empowering all parts of the community; and
(3) strengthening what works well in communities on a daily basis.**Research Activity and Milestone Progress:**

9. Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017	
Research Activity	Completion Date
Receive Human Subjects Institutional Review Board approval	1/31/16
Develop statistical decision rules for text-based CTIs	3/30/16
Update/customize Internet CTI for each region	6/30/16
Create TTM-based text messages	7/31/16
Program text system	8/31/16
Test text system and fix bugs	9/30/16
Recruited census-based sample of 3000 coastal residents from the Survey Sampling Company;	10/2-11/30/16
Research Milestone	
Have completed, updated CTI system including text messages ready to disseminate	9/30/16
Analyze and report data on initial 3,000 coastal residents recruited into the study	12/31/16

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017	
Transition Activity	Completion Date
Ongoing collaborative conference calls with End-user Team	1/1/2016 – 6/30/2016
Build capacity of End-user team on TTM/CTI behavior change methods	1/1/2016 – 6/30/2016
Working with DHS & URI intellectual property offices to facilitate transition prior to making the purchase	1/1/2016 – 6/30/2016
Engage end users for collaborative input for tailored messages for texting	1/1/2016 – 6/30/2016
Ongoing collaborative conference calls with End-user Team	7/1/2016 – 6/30/2017
Continuing to engage end users for collaborative input for tailored messages for texting	7/1/2016 – 6/30/2017
Transition Milestone	
Completed one collaborative conference call with End-user Team	6/30/16
Webinar-based presentation with End-user team on behavior change methods	6.30/16
Participation of majority of targeted end-users on End-User Team for collaborative input for tailored messages for texting	6/30/16
Developed plan with DHS and URI intellectual property offices if DHS or any community want to use project's intellectual property	6/30/16
Completed two collaborative conference calls with End-user Team	6/30/17
Incorporate end user recommendations and feedback into our text messages.	7/31/16

11. Interactions with education projects: Undergraduates are coming to the University of Rhode Island for the summer from Tougaloo College. One student is a Psychology major and we are offering the student the opportunity to do a senior research project that can compare different states in their stage of readiness to adopt disaster preparedness behaviors.

12. Publications:

Mundorf, N., Redding, C.A., Prochaska, J.O., Paiva,A.L., & Rubinoff, P. (2017, in press). Resilience and Thriving in spite of Disasters: A Stages of Change Approach. In A. Fekete & Fiedrich, F. *Urban Disaster, Resilience and Security.* Berlin: Springer.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Expertise on the FEMA Household Survey	Survey	November 2016 and April 2017	FEMA
Results	Report	Expected Year 3	FEMA and other end users
Intervention Program	Software	Expected Year 3	DHS

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Rhode Island Science and Technology Advisory Council Collaborative Research Grant	Prochaska	$100,000	NSF
Leveraged Support			
Description			Estimated Annual Value
Foundation funding for Pro-Change software			$15,000
Indirect funds were used to allow Pam Rubinoff to connect with end users			$4,680
Free support staff office			$3426

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		
Graduate students provided tuition/fee support (number)	1	
Graduate students provided stipends (number)		
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)		
SUMREX program students hosted (number)		
Lectures/presentations/seminars at Center partners (number)	2	2
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)		
Journal articles published (number)		
Conference presentations made (number)		
Other presentations, interviews, etc. (number)		
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	2	2
Requests for assistance/advice from other agencies or governments (number)		
Total milestones for reporting period (number)	4	5
Accomplished fully (number)	4	3
Accomplished partially (number)	4	2
Not accomplished (number)		

OPALUCH, URI

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. Project Title:

Overcoming Barriers to Motivate Community Action to Enhance Resilience

2. Principal Investigator / Institution:

James Opaluch; Univ. of Rhode Island

3. Other Research Participants/Partners:

Austin Becker, Marine Affairs, Univ. of Rhode Island, Dawn Kotowicz, Donald Robadue, and Pamela Rubinoff, Coastal Resources Center, Univ. of Rhode Island

4. Short Project Description ("elevator speech"):

To date there is little quantitative information on the ability of communities to adapt to the threat of coastal hazards (e.g., Corps of Engineers, 2012). This project is designed to improve our understanding of the barriers that impede community adaptation to coastal storm hazards, and designs and designs interventions that can have potential to overcome these barriers. We combine individual interviews, group decision processes, a retrospective review of public dialog and policy simulation exercises to identify key barriers and to design interventions to overcome those barriers.

5. Abstract:

This research contributes to DHS programs by helping to improve the resilience of communities that face risks from coastal storm hazards. It is widely recognized that national preparedness for hazards is not simply the responsibility of the government, but rather preparedness is a responsibility that is shared by everyone—including citizens, the private sector, and communities (e.g., Department of Homeland Security, 2014; National Academy of Sciences, 2012). Yet recent studies have shown that individual preparedness has remained largely unchanged for at least a decade (e.g., FEMA, 2014).

The goal of this research is to improve our understanding of how we can increase "whole community" preparedness for coastal storm hazards. To do so, we apply insights from social science models of behavior change to help better understand how to increase the adoption of protective actions by individuals and communities. This research embodies the September 15, 2015 Executive Order "Using Behavioral Science Insights to Better Serve the American People" which encourages agencies to conduct behavioral research to "… review elements of their policies and programs that are designed to encourage or make it easier for Americans to take specific actions …" (White House, 2015).

The Behavioral Science literature demonstrates that simply providing information is not generally an effective means of bringing about behavior change (e.g., Velicer et al, 1998; Stern, 2000; Scott, 2002; Moser and Ekstrom, 2010), Rather, increasing the adoption rate of behaviors to mitigate storm effects is challenging (Kesete et al. 2014; Carson et al., 2013; Moser and Ekstrom, 2010). We adopt the lessons of theories of behavior change, that recognize the need for carefully planned and well-designed interventions that are tailored to the specific needs of various groups in order to help to expedite change (e.g., Velicer et al. 1998; Moser and Ekstrom, 2014; Lindell and Perry, 2012).

A key lesson of this scientific literature is that behavior change is not an event, but rather is a process that occurs over a series of stages. The most effective behavior-change programs will identify the specific barriers that impede progress through the various stages, and will apply interventions that are tailored to overcome these specific barriers.

Our project combines the following methods for identifying these barriers and designing interventions:

(1) Observing group decision processes,
(2) Carrying out semi-structured interviews of stakeholders,
(3) Carrying out a retrospective analysis of news reports and policy actions associated with storm events,
(4) Implementing a pilot survey to carry out a preliminary test of the effectiveness of interventions.

The primary project output is a report that provides recommendations for policy actions that show potential to increase the adaptation rate for protective actions by individuals and communities. These recommendations will be targeted to specific DHS programs, and tailored to specific stages of behavior change

The project outcomes also include development and testing of policy simulation tools, such as storm impact visualizations, that can be used to help improve decision making by helping end users better understanding the consequences action (or inaction). Our current project will test the potential of these policy simulation tools to help overcome barriers to increasing the adoption rate of protective actions. Note that development of some of the policy simulation tools are part of leveraged activities led by Dr. Austin Becker, and are being tested in this project, as discussed below.

Consistent with the spirit of the DHS "Whole Community" approach, we will disseminate project-related information as widely as possible. We will also transmit information to representatives of the private sector, and to federal, state, local government officials by leveraging ongoing planning activities in which project co-PIs routinely participate. Examples of these activities for September 2015 June 2017 are reported in the Appendix A.

6. End users:

End users for this project include a large number of community members at varying levels, from the local to the state and national levels. This is consistent with FEMA's "Whole Community Approach to Emergency Management" (e.g., FEMA, 2011), which "[e]mphasizes the need for the whole community to work together in a variety of ways and make the best use of resources" (Department of Homeland Security, 2014). "Recognizing that preparedness is a shared responsibility, it calls for the involvement everyone—not just the government—in preparedness efforts. By working together, everyone can keep the nation safe from harm and resilient when struck by hazards…" (Department of Homeland Security, 2014) Similarly, Presidential Policy

Directive calls for DHS to formulate a "… campaign to build and sustain national preparedness, including … community-based and private-sector programs to enhance national resilience". And a recent National Academy of Science report on disaster resilience concluded that "[d]isaster resilience is everyone's business and is a shared responsibility among citizens, the private sector, and government." (NRC, 2012)

The Table below contains a list of "Whole Community" participants in the research process, who are also included as end users for the project outputs. To date, the end users have provided critical input into the research project (see Tasks 1 and 2 in the Research Milestones below), and have been participants in planning meetings, some of which have been organized and/or facilitated by Project PIs Rubinoff and Becker. The dates, titles and purpose of these events are briefly summarized in Appendix A. These activities include both direct project-related efforts, and leveraged efforts of ongoing activities of co-PIs that the project capitalized upon (see Leveraged Activities in Table 2 below).

The meetings are designed to assist private and public officials in planning for coastal storm hazards, and for the coordination of protective actions across the various participants. Simultaneously, we used the events to (1) identify the barriers and interventions discussed above, (2) generate hypotheses to be further explored in interviews, (3) make recommendations to end users regarding actions that can be taken by stakeholder participants. We will continue interact with various officials as part of these ongoing efforts in order to obtain community perspectives on potential actions to make their community more resilient to coastal storm damages.

Individuals at the municipal level with whom the members of the research team are working include Pamela T. Nolan, Town Manager for Narragansett, City of Warwick Mayor Scott Avedisian, Warwick City Council Chair Donna Travis, Charlestown Town Council Member Virginia Lee, and Executive Director Daniel Beardsley of the Rhode Island League of Cities and Towns.

We have also identified the following end users who have been involved in the process to varying degrees:

- Tim Smail Federal Alliance for Safe Homes (FLASH)
- Jackie Snelling, FEMA HQ - Individual & Community Preparedness Division.
- Michelle Burnett and Jessica Stimson, RI Emergency Management Agency
- Mary Culver, NOAA Office of Coastal Management
- Elizabeth Stone. Office of the Director, RI Department of Environmental Management
- Board of Directors of the Rhode Island Flood Mitigation Association
- Stephen Cauffman, National Institute of Science and Technology
- Natalie Grant U.S. Department of Health and Human Services

The current Phase of the project has focused primarily on a Rhode Island-specific application, but later phases of the research will extend the methods, results and outputs obtained in Rhode Island to other geographic contexts.

”Whole Community” End Users	
Private Sector Associations, Educational Institutions and Nonprofits:	
RI Realtors Association RI Builders Association Westerly Economic Development Committee RI Independent Insurers Association Save-the-Bay Homeowners Associations of Block Island & North Kingstown Salt Pond Coalition (Nonprofit Advocacy Group RI Nursery and Landscape Association American Society of Civil Engineers Univ. of Albany	Quonset Development Corp ProvPort (Port Authority) Private firms on the waterfront FM Global (Global Insurer of Commercial & Industrial Property) Save-the-Bay CommerceRI (State of RI Business Promotion Agency) RI Marine Trades Association, Newport Maritime Association. Private Marinas. RI Sea Grant/Coastal Resources Center
Federal/State/Local Government Agencies	
RI Department of Environmental Management RI Coastal Resources Management Council RI Division of Statewide Planning RI Flood Mitigation Association RI Emergency Management Agency. South County Communities (Town Representatives) RI Green Infrastructure Project US Army Corps of Engineers	RI Coastal Resources Management Council RI Division of Planning Providence Department of Planning RI Emergency Management Agency US Marine Administration (MARAD) US Coast Guard US Army Corps of Engineers

7. Unanticipated Problems:

Year 2 funding was not made available until October 2016, which postponed progress in Year 2 of the project, particularly as co-PIs Opaluch and Becker have 9 month academic appointments, and their work on the project is concentrated in the summer months. We adjusted for this unanticipated delay by concentrating Year 2 work in May-June 2017, and by requesting a no cost extension through August 31.

8. Project Impact:

As discussed above, this project identifies barriers to creating more resilient coastal communities, and policy interventions that can help overcome these barriers. This information is of direct relevance to FEMA programs such as the Science and Technology Directorate Flood Apex Program, FEMA’s National Preparedness Directorate, and the Community Rating System, among others. The work is of particular relevance to the Individual and Community Preparedness Division and FEMA’s National Flood Decision Support Toolbox.

The information on barriers and interventions helps to answer questions asked by FEMA programs, including the Flood Apex program, which asks:

- "Why do property owners and renters not buy and hold flood insurance, especially when it is a mandatory requirement of a mortgage?"
- "How can developers, real estate companies and lenders contribute to decreasing flood risk and promoting insurance?
- How can FEMA better foster and promote products made by other public and private sources?" (FEMA, 2017)

Specific project impacts to date include the following:

PI James Opaluch participated in the Rhode Island State Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. The Number 1 recommendation of the report was for the State of Rhode Island to develop a process for providing storm vulnerability audits, and to seek funding to implement such a process (State of Rhode Island, 2016). The results of the audit would be given to the property owner with "…an evaluation detailing overall risk and flood preparedness along with specific resiliency measures available." The property owner "… could be eligible for certain financing measures to reduce costs in exchange for implementing these resiliency measures. This recommendation has led to the introduction of a bill in the Rhode Island Legislature to create a system of storm vulnerability audits. We see a system of storm vulnerability audits, with associated incentives to adopt recommended actions, as an effective tool increasing the adoption rate of protective actions.

This project leverages ongoing efforts by co-PI Pamela Rubinoff, who has participated in planning process for coastal resilience for several Rhode Island communities, and who has played a major role in development of Rhode Island Shoreline Change Special Area Management Plan (Beach SAMP). The Beach SAMP is a guidance document and a set of tools to help state and local decision makers prepare for, and adapt to the impacts of coastal storms, erosion, and sea level rise. The Beach SAMP develops official planning documents for the Rhode Island Coastal Resources Management Council. Consistent with the "Whole Community" philosophy, the intended audience for the documents include the Rhode Island Coastal Resource Management Council, as well as decision makers, planners, boards and commissions in Rhode Island's 21 coastal communities who are the main individuals responsible for coping with the impacts of storms, coastal erosion, and sea level rise. The Beach SAMP is also intended for other state and federal agencies with the responsibility of planning for coastal resources, assets and property in Rhode Island. (http://www.beachsamp.org/wp-content/uploads/2015/12/Beach-SAMP-Introduction.pdf). This project leverages activities of the Rhode Island Coastal Resources Management Council, and activities funded by Rhode Island Sea Grant and others by capitalizing on these planning processes.

Project co-PI Dr. Austin. Becker gave a Congressional Briefing hosted by Congressman Alan Lowenthal on June 12, 2017. The Briefing focused on planning coastal development and resilience to extreme events in order to enhance the quality of life and economic strength of coastal areas.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Task 1. Literature Review		100%	We have developed an annotated bibliography of several hundred publications and reports. We will continue to update the literature review throughout the project as we identify additional literature. We have also compiled an electronically searchable dataset of nearly 1,200 reports on coastal hazard issues.
Task 2. Group Decision Processes		100%	We have facilitated, observed and participated in a total of 35 group decision processes listed in the Appendix. We will continue to participate in this activity as opportunities arise through the project in order to obtain additional insights, to maintain 2-way communications and to deliver products to the various stakeholders.
Task 3. Individual Semi-Structured Interviews	12/31/17	75%	We have completed roughly 30 interviews of various stakeholder to follow up on hypotheses generated as part of Task 2, discussed above. Those interviews include private citizens, as well as local and state officials. We have also carried out a pilot survey on perceptions of storm risks and protective actions by private citizens to reduce storm vulnerability. Our initial task for semi-structured interviews is complete.. But we have extended our plan for semi-structured interviews to follow up on the timeline of actions (See the discussion of the timeline, below). This part of the task is scheduled for completion in Dec 2017.

Task 4. Initial Draft Policy Simulation Tools	12/31/17	50%	This Task is on schedule to be completed by Dec 31, 2017. We have carried out preliminary tests of some Policy Simulation Tools within the context of a pilot survey listed as part of Task 3, above.
Timeline of Storm Events and Protective Actions	12/31/17	75%	This Task searches for news items, reports and documentation of policy actions to develop a timeline for (1) barriers to resilience, (2) protective actions and (3) the temporal connections with major events (e.g. hurricanes). This task augments Tasks 1 and 2 by providing a longer-term perspective. We hypothesize that opportunities for change vary over time, so there may exist "windows of opportunity" when real change is more likely to occur. This task studies the dialog in news media and various reports to see whether we can identify particular times when barriers appear to be lowest, and when interventions become more feasible from political, economic and social perspectives. We also intend to follow up on this timeline with interviews to get the perspective of key participants with a long history of engagement in the public policy process on coastal hazards. This activity is on schedule to be completed by December 31, 2017
<u>Research Milestone</u>			
Plan for Coordination with Davidson Research Team	12/31/2016	100%	We held periodic conference calls with the Davidson team during 2016. This activity is now complete.

Updated Literature Review	3/1/2016	100%	As indicated above, we have compiled an annotated bibliography of several hundred publications, reports and other documents. However, this activity will continue throughout the project as addition literature is identified. As indicated above, we have also compiled a set of nearly 1,200 reports and policy documents that are in digital searchable form. This database is being used to develop a retrospective analysis and timeline of events and protective actions, as discussed above.
Facilitate, Observe and Participate in Group Decision Processes		100%	The goals of this activity were accomplished in Year 1 of the project. However, we have continued to participate in this activity as opportunities arise through Year 2 of the project in order to obtain additional insights, to maintain 2-way communications with end users, and to test and deliver project outputs to end users. We have facilitated, observed and participated in a total of 35 meetings involving group decision processes, listed in Appendix A (Note: Some activities in Appendix A involved more than one meeting).
Preliminary list of barriers and interventions	12/31/2016	66%	We have developed an initial list of barriers to adoption of protective actions and interventions to overcome those barriers using the results of Group Decision Processes and semi-structured interviews. We have carried out a preliminary test of some interventions using a pilot survey. We are preparing a report that links each barrier and intervention to specific DHS programs and reports, as well as to state and local programs.

Complete One-on-One Interviews	12/31/2016	75%	As indicated above, we have completed roughly 30 interviews of various stakeholder to follow up on hypotheses generated as part of the Group Decision Processes, discussed above. Those interviews include private citizens, as well as local and state officials. Additional interviews will be carried out to follow up on hypothesis based on the retrospective timeline. We have also completed an on-line survey that involved roughly 110 respondents regarding likelihood of a major storm event in the area, their storm vulnerability and actions that have been taken to reduce risks. This survey was also used to provide a pilot test of the effectiveness of storm visualizations.
Timeline of News Reports and policy documents	12/31/2017	75%	This work is to be completed in Year 3 of the Project, no later than June 2019, assuming the promised no-cost extension
Content Analysis of Interviews	12/31/2017	0%	Content analysis of interviews is set to begin once interviews are finished. Content analysis is on schedule to be completed in Dec 31, 2017.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Workshops on Coastal Resilience	12/31/2017	25%	We had proposed to organize and carry out one or more workshops to showcase tools developed by the various Rhode Island projects to end users. This activity is on schedule to be completed by Dec 31, 2017, as initially planned. See discussion below for current status.

			As noted in previous project reports, this project has no money budgeted for this activity, but we continue to seek to leverage events and other activities funded elsewhere. See the discussion on Transition Milestones, below.
Report on Barriers to Adaptation and Interventions to overcome barriers	12/31/2017	75%	We have compiled a preliminary list of barriers and interventions, and are developing a report to be released to end users. The report will also include specific programs of FEMA and other end users for which this information is of direct relevance. This work is on schedule to be completed in Dec 2017. Extensions and refinements may be carried out during the anticipated period of no-cost extension through June 30, 2018.
Transition Milestone			
FEMA Course on Coastal Resilience	12/31/2017	25%	We will participate in a FEMA course on coastal resilience held June 19-22 involving numerous Rhode Island state and town officials. This course will demonstrate several products being developed by the URI projects, including draft policy simulation tools. Following this event, we will determine whether there is a need for a follow up workshop showcasing more completed project tools, assuming adequate funds can be identified.
Presentation at Congressional Briefing	6/12/2017	100%	Dr. Austin Becker was a presenter at a Congressional Briefing on Coastal Resilience that was hosted by Congressman Alan Lowenthal

11. Interactions with education projects:

We have funded Courtney Hill from Tougaloo College to serve as a summer intern for our project. The goal of the internship is to expose Courtney to rich and varied educational experience centered on adaptation to coastal hazards. The primary project-related activity is participating in our retrospective review and timeline of community response to storm events by analyzing the content of various types of reports, data bases, interviews and news coverage of coastal hazards. This activity will develop a timeline of coastal storms and associate community response to

provide a longer terms perspective on barriers to adaptation and potential interventions. This review will utilize state agency permit data; reports of state and local policy responses; content analysis of newspaper coverage of post-storm events; and identification of patterns of decision making. The findings will be reported in the form of a timeline of events and associated responses. The student intern will participate in team meetings, and have the opportunity to engage in other coastal resilience meetings and activities of the URI-CRC project.

We have also carried out a separate set of educational activities on coastal storm hazards. In the spring 2017 semester we ran a Capstone Class with 27 students in the Department of Environmental and Natural Resource Economics. The Capstone is a senior-level class, in which students carry out a detailed case study of direct policy significance applying the methods that they learned throughout their undergraduate careers.

This year's Capstone focused on the issue of improving storm resilience in coastal communities, with a case study of Misquamicut, Rhode Island. Misquamicut is an excellent case study, as it is coastal beach community that is extremely vulnerable to inundation by coastal storms, and as has a repeated history of hurricane devastation including the Great New England Hurricane of 1938, Hurricanes Carol in 1954, Gloria in 1985, Bob in 1991, Irene in 2011 and most recently Sandy in 2012.

The Capstone project was coordinated with Capstone classes in the Ocean Engineering Department and the Landscape Architecture Department to create an interdisciplinary collaboration that focused on increasing the resilience of Misquamicut to coastal storm hazards. The students in the three Capstone classes met periodically throughout the semester, and shared research plans, project data and research findings. At the end of the semester the students from the three Capstone classes hosted an event with public presentations of their findings to a set of "whole community" end users.

The Ocean Engineering Capstone project analyzed potential physical damages to properties in Misquamicut for scenarios of varying hurricane intensity and sea level rise. Landscape Architecture students created different designs for communities to improve storm resilience. Environmental Economics students in our Capstone carried out three sets of analyses:

(1) A cost-benefit analysis of alternative structural solutions, including shoreline armoring, beach renourishment, elevating structures and retreat from hazard zones;
(2) A housing value assessment to see whether coastal storm threats are reflected in housing prices;
(3) A survey of the local public on risk attitudes and willingness to take protective actions.

The survey was used as a pilot test of the effectiveness of storm visualizations. Roughly 110 respondents were assigned to two groups: a treatment group that was shown visuals of storm impacts and a control group that was not shown visuals. Aggregate survey responses were compared across the control and treatment group to test the hypothesis that visualizations of storm impacts affected the respondents' perceived risk of coastal storms, and to compare stated intentions to take protective actions with vs without storm visualizations. We found that the visualizations show promise in preparing communities to adapt to storm hazards, both in terms of an increased perception of storm risks, and in terms of a stated willingness to take protective actions. Details of the findings will be included in the Biennial Review.

12. Publications:

Becker, Austin, Pamela Matson, Martin Fischer, and Michael D. Mastrandrea, Forthcoming. "Towards Seaport Resilience for Climate Change Adaptation: Stakeholder Perceptions of

Hurricane Impacts in Gulfport (MS) and Providence (RI)" *Progress in Planning*. Status: Accepted for Publication. Anticipated Publication Date November 2017.
Zhang, H., Ng, A., Becker, A. (In Press), "Institutional Barriers in Adaptation to Climate Change at Ports, Regions, and Supply Chains." North American Symposium on Climate Adaptation, New York, New York. Aug. 16-18, 2016. (Refereed Conference Paper)
Touzinsky, K, Rosati, J., Fox-Lent, C., Becker, A., Luscher, A., 2016. "Advancing Coastal Systems Resilience Research: Improving Quantification Tools through Community Feedback" *Shore and Beach* Vol. 84 No. 4 · November 2016.

13. Tables

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Coastal Storm Planning Tools	Visualizations and other information tools	Testing in June 2017, Revisions in Dec 2017	Products will be tested at a June 2017 FEMA course on Integrated Emergency Management for hurricane preparedness.
Barriers and Interventions to Adaptation	Report with guidance and program-specific recommendations	Dec 2017	FEMA, Individual and Community Individual and Community Preparedness Division; FEMA National Flood Decision Support Toolbox; RI Coastal Resources Management Council; RI Coastal Communities

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Measuring Climate Risk to Inform Resilience: Pilot Study for North Atlantic Medium and High-Use Seaports	Dr. Austin Becker	$280,000	US Army Corps of Engineers
Climate Change Community Resilience[1]	co-PI Pamela Rubinoff	$47,625	RI Sea Grant

[1] Our DHS project leverages ongoing efforts by co-PI Pamela Rubinoff and colleagues at the URI Coastal Resource Center to increase resilience of coastal communities in the face of climate change. Many of the group decision processes listed in the Appendix are organized by, or otherwise associated with this Sea Grant funded project. We add value to that effort by applying formal a social science based framework of behavior change, identifying barriers to adaptation and interventions to overcome those barriers.

Leveraged Support	
Description	Estimated Annual Value
Returned Indirect Cost	$4,328
Project Management and Coordination	$1,500

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		
Graduate students provided tuition/fee support (number)		
Graduate students provided stipends (number)		1
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)		
SUMREX program students hosted (number)		1
Lectures/presentations/seminars at Center partners (number)	2	3
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)	2	9
Journal articles published (number)		3
Conference presentations made (number)	13	18
Other presentations, interviews, etc. (number)	5	4
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	2	
Requests for assistance/advice from other agencies or governments (number)	5	
Total milestones for reporting period (number)	6	7
Accomplished fully (number)	4	5
Accomplished partially (number)		2
Not accomplished (number)		0

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Appendix A. Summary of Group Decision Meetings[2]

Meetings to Date

1. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. (September 24, 2015) Legislative Hearings on economic threats of sea level rise and coastal flooding.
2. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. (Oct 15, 2015) Legislative Hearings on economic threats of sea level rise and coastal flooding.
3. Municipal Adaptation Work Session, New Shoreham. (Oct 22, 2015). Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Increase awareness of tools, planning requirements and adaptation strategies.
4. Municipal Adaptation Work Session, Westerly. (Oct 29, 2015) Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Increase awareness of tools, planning requirements and adaptation strategies.
5. Municipal Adaptation Work Session, Charlestown. (Oct 29,2015) Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Increase awareness of tools, planning requirements and adaptation strategies.
6. Municipal Adaptation Work Session, North Kingstown. (Nov 11, 2015) Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Increase awareness of tools, planning requirements and adaptation strategies.
7. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding (Nov 19, 2015) Legislative Hearings on economic threats of sea level rise and coastal flooding.
8. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. (December 17, 2015) Legislative Hearings on economic threats of sea level rise and coastal flooding.
9. Town of South Kingstown, Municipal Adaptation Work Session. (January 20 2015) Purpose: Assist communities to understand exposure to coastal storm hazards, plan for action to reduce risk and implement plans. Increase awareness of tools, planning requirements and adaptation strategies.
10. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. (January 21, 2016) Legislative Hearings on economic threats of sea level rise and coastal flooding.
11. #ResilientPVD Community Workshop. A team of experts from around the country come to Providence for three days of charrettes, workshops, and community meetings to explore how Providence's infrastructure, buildings, and neighborhoods can prepare for the impacts climate change. (February 1-3, 20016)
12. Beach SAMP meeting, Meeting of State and Town leaders to discuss adaptation to sea level rise and coastal flooding threats. (February 4, 2016)
13. Meeting of Community Leaders to Discuss historic and potential future impacts of coastal flooding, and actions to mitigate impacts. (February 16, 2016)
14. Rhode Island Legislative Commission on Economic Impacts of Sea Level Rise and Coastal Flooding. Legislative Hearings on economic threats of sea level rise and coastal flooding. (February 25 2016)

[2] Note that some of these meetings are periodic events that involve attending multiple meetings.

11. BeachSAMP meeting. Meeting of State and Town leaders to discuss adaptation to sea level rise and coastal flooding threats. (April 6, 2016)

12. ANNUAL RIFMA CONFERENCE - "Incentivizing Actionable Resilience to Flooding" - Join floodplain management and hazard mitigation professionals as we explore implementation tools and techniques, and share experiences and lessons learned from the past to improve resiliency in the present and future. (April 7, 2016)

13. Keeping History Above Water Conference, Newport, RI. One of the first national conversations to focus on the increasing and varied risks posed by sea level rise to historic coastal communities and their built environments. This is not a conference about climate change, but about what preservationists, engineers, city planners, legislators, insurers, historic home owners and other decision makers need to know about climate change—sea level rise in particular—and what can be done to protect historic buildings, landscapes and neighborhoods from the increasing threat of inundation. (April 10-13, 2016)

14. RI Silver Jackets (RIEMA, Cranston) - Meeting of Interagency coalition to reduce flood risk. State-led teams, implementation of USACE National Flood Risk Program (April 14, 2016)

15. DC DHS Presentation and discussion with DHS HQ and others on how to link with their efforts. (April 14, 2016)

15. RI Coastal Erosion Control Workshop (April 21, 2016)
http://www.crmc.ri.gov/news/pdf/2016_0421_Workshop_Flyer.pdf

16. Meeting with and presentation by Chris Landsea, NOAA's Joint Hurricane Testbed Director/Science and Operations Officer at the National Hurricane Center. Discussion of all three URI projects funded by DHS, and lecture "Inside the Eye: Improving Hurricane Forecasts". (May 3, 2016)

17. BEACHSAMP Stakeholder Meeting with presentation from Michael Oppenheimer, speaking about climate change and the IPCC. (May 3, 2016)

18. Estuarine and Coastal Modeling Conference (ECM14) at URI - Rick Luettich (UNC lead) will be a keynote, Meeting with Rick Luttich with our team and other key users, including Coast Guard, and possibly other DHS leaders. (June 12-15, 2016)

19. New England Climate Adaptation, Preparedness, and Resilience seminar - Organized by DHS Infrastructure Protection, EPA, FEMA, NOAA, NH Department of Safety. First in a series of New England seminars. (May 24 – 25, 2016)

20. Preparedness Conference (CCRI) - Series of presentations, trainings, and exhibits.
http://www.riema.ri.gov/resources/government/prepare/preparednessconference/index.php (August 10-11, 2016)

21. RI Shoreline Change Special Area Management Plan Meeting, (August 25, 2016)

22. Presentations on Misquamicut Storm Vulnerability. Presentations by Rhode Island Officials to Capstone Classes. (Feb 3, 2017)

23. Coastal Storm Vulnerability Case Study. Misquamicut beach storm vulnerability site visit to led by RI Coastal Resources Management Council. (Feb 3, 2017).

24. Rhode Island Association of Emergency Managers (RIAEM) - Monthly meetings of local emergency managers, Red Cross, RIEMA, and Dept of Health. Identify tangible and useable products. Obtain feedback on prototypes of hazard management tools.

25. RI Annual Conference on Building Flood Resilience, (April 6, 2017)

26. Improving Resilience to Coastal Storms: Misquamicut Capstone Presentations, Reporting of findings of Capstone Classes to Stakeholder Groups. (May 5, 2017).

27. RI Executive Climate Change Coordinating Council Meeting, Council created by RI Legislation to coordinate planning for climate change impacts into the duties of all state agencies. (June 14, 2017)

28. FEMA Integrated Emergency Management Course/Community Specific Public officials and other leaders are placed in a realistic simulation of a hurricane disaster scenario to enhance storm preparedness. (June 19–22, 2017).

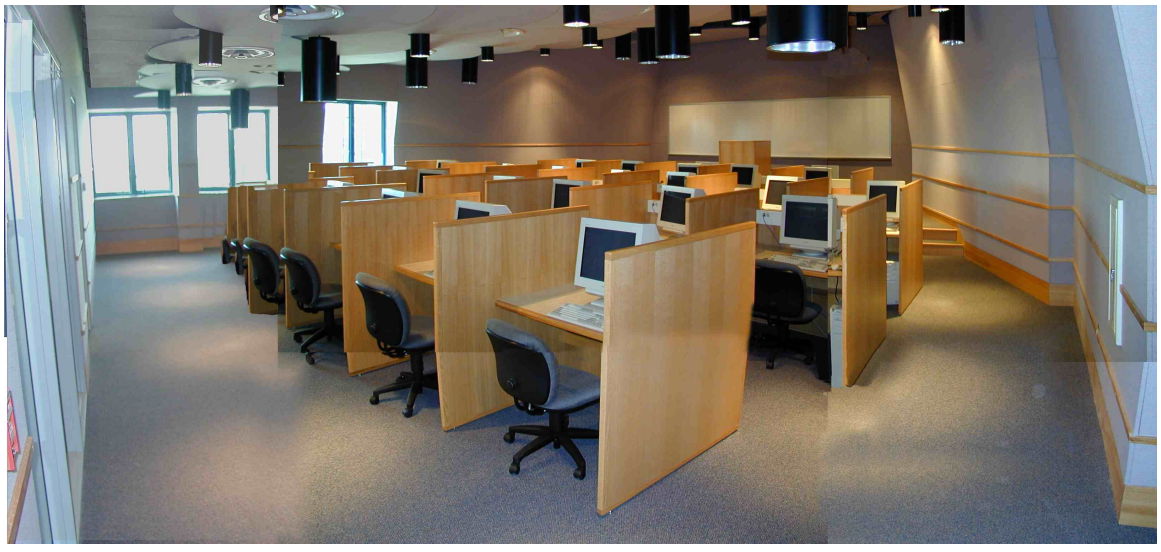
Appendix B. Policy Simulation Laboratory Facilities

Policy Simulation Laboratory. The URI Department of Environmental and Natural Resource Economics (ENRE) manages the Policy Simulation Laboratory (Sim Lab) and associated facilities. Dr. James Opaluch, project PI, is the Department Chair of ENRE, and is the Founder and Director of the SimLab. This will be the venue for social science-based laboratory experiments to be done in support of this project. The SimLab and associated facilitates is a group of electronically networked rooms that capitalize on emerging technologies to help citizens, policy makers and other interested parties better understand the consequences of actions.

What makes this facility unique is the close integration of the various system components to create a flexible, coordinated facility for studying decision making, and for helping communities or stakeholders to visualize the consequences of policy actions. All of the rooms are linked through the use of computer networks, so we can harness the power of modern technology to help communities make better decisions.

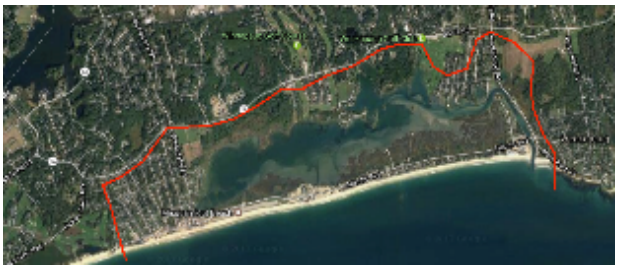
The facilities include the SimLab, two Group Decision Rooms, a Presentation Hall and a Large Conference room. The SimLab is a computer lab with 26 computer workstations and advanced audio-visual capabilities. The Group Decision Rooms are small conference rooms that seat up to 12 people who make decisions while interacting face-to-face. The Presentation Hall is a 125-seat auditorium with advanced audio-visual aids and in-seat voting capabilities.

3-D data-drive visualizations will be used to present storm scenarios to participants in policy simulations. Some preliminary examples of 3-D visualizations are presented below. As currently envisioned, hurricane simulation modeling work by other CRC projects is used to forecast storm effects for different storm scenarios, including wind speed and inundation. These data are used to identify likely storm impacts to structures. Maps are used to depict model forecasts for inundation and/or wind speeds from a given storm scenario. By clicking on locations on the map, 3-D visualizations representing those impacts are presented to participants in policy simulations to help them better understand likely vulnerability across the landscape.



Policy Simulation Laboratory

Appendix C. Example Policy Simulation Tools



Clicking on Map Locations Brings Up 3-D Visualizations of Representative Impacts to

Static Visualization (not 3D Model)

Theme 3

Disaster Dynamics

RESIO, UNF

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   The Incorporation of Rainfall into Hazard Estimates for Improved Coastal Resiliency

2. **Principal Investigator / Institution:**

   Don Resio, University of North Florida, 1 UNF Drive, Bldg 50/3204, Jacksonville, FL 32224.

3. **Other Research Participants/Partners:**
   Funded Directly By the University of North Carolina:
   Jackson State University - Tom Richardson (PI), former Director of the Coastal and Hydraulics Laboratory at ERDC and Bruce Ebersole, former Division Chief, US Army ERDC.
   ARCADIS - Hugh Roberts (PI), hydrodynamics specialist and ADCIRC modeler and Zachary Cobell ADCIRC specialist.

4. **Short Project Description ("elevator speech"):**

   Rising sea level, climate variability, and growing coastal populations increasingly threaten the immense investments in critical coastal infrastructure within the US, and could greatly impact the commercial and military value of coastal cities such as New York, New Orleans, Norfolk/Hampton Roads and many others. At the same time, natural coastal areas are essential to maintaining healthy ecosystems in these areas, since they provide much needed food and recreation and perform an important role in maintaining overall environmental stability. Decisions must be based on accurate quantification of factors which affect this balance between the natural and built environments in order to maximize resilience in these areas. A major factor known to be important in most coastal areas, interactions among rainfall, hydrologic flows and coastal surges is presently not treated within operational modeling systems. This project will develop a methodology for incorporating these interactions in a statistically and physically appropriate manner into FEMA's operational coastal modeling systems.

5. **Abstract:**

   This project will develop a method for including rainfall-runoff effects into FEMA-JPM studies, and evaluate the potential impacts of incorporating these effects into improved estimates of flooding hazards. There are two parallel efforts the project will be undertaking: 1) an improved understanding of the statistics of river/tributary discharges in terms of both antecedent conditions and the conditional probabilities of rainfall patterns and magnitudes given a tropical cyclone in a particular area and 2) a physics-based coupling of major tributaries into the ADCIRC model, including antecedent and rainfall effects during a surge event. The goal is to develop a model that is ready to be transitioned into realistic JPM

applications in areas where rainfall, hydrologic flows and surges are expected to interact strongly.

6. End users:

FEMA HQ: Jon Westcott, Tucker Mahoney; **FEMA Region I:** Kerry Bogdan**; FEMA Region II:** Alan Springett**; FEMA Region III:** Robert Pierson; **FEMA Region IV:** Christina Lindemer; and **FEMA Region VI:** Larry Voice have expressed support for this work and want to be directly involved in it. **USACE:** Mary Cialone has expressed support for this work and in interested in coordinating it with ongoing research at ERDC. **NOAA:** Andre van der Westheysen would like to see the coordination expand to include groups within NOAA besides the National Hurricane Center. **US Coast Guard:** LCDR Blair Sweigart is interested in using this approach to assist in the development of scenarios during and following disasters. NGA expressed a desire to incorporate our research into their maritime mission. We will involve all of these individuals, and others as become interested, in our project to plan to maximize the utility of this effort within ongoing work on resilience by government agencies within the US. These individuals will also be key advisors on developing end-user products and product delivery mechanisms and will provide advice on methods to certify final products for widespread FEMA use and for sustaining it following project completion. A significant project partner in the private sector (Arcadis) is experienced in performing RiskMap studies for FEMA. Arcadis involvement in the project will help ensure final products are useful and understood fully by the user community and work involved in these efforts. Collaboration with end users will be sought throughout the project as noted in our annual activities and the annual Center review will be critical to guide the project. Our team members include several individuals who have worked much of their professional career as bridges to the user community. Mr. Bruce Ebersole, former division chief at ERDC, (now at JSU) will take the lead in this area and form a small team of reviewers from the general stakeholder community to solicit ideas and feedback to the project development team. Planning groups in the Norfolk/Hampton Roads area are interested in coordinating, through Old Dominion University, with the project team.

7. Unanticipated Problems:

The primary unanticipated problem on this effort has been the lack of a readily available, open-source hydrologic model for routing rainfall overland and through streams into the ADCIRC model. NOAA's new National Water Center in Tuscaloosa, AL is developing a new system for this work; however, it is not ready for release at this time. In the interim, the team has tested an alternative means of incorporating the rainfall/streamflow effects and this method seems to work very well as a surrogate. Overcoming this impasse has been somewhat time consuming; however, now that we have a methodology that functions, we are proceeding with the development of efficient means to combine the new class of model runs with previous runs into a FEMA run suite.

8. Project Impact:

Adding the overland flow and precipitation to the surge models used in FEMA's simulations will produce significant increases along the area where the inland flooding and coastal

flooding approach equal magnitudes. Flood levels in many other areas where rainfall is locally concentrated will likely also be significantly raised. These changes will increase the number of people within areas exposed to flooding. In turn, this will both increase and redistribute the flood risks in these areas.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Obtain radar rainfall data set (from JSU source) for statistical analysis of patterns of rainfall relative to hurricane tracks and other parameters	June 2016	100%	Completed in January 2017 Delay due to delays in processing the data.
Development and test initial methodology for coupling rivers/tributaries and rainfall into ADCIRC in different geographic areas	June 2016	100%	Completed in March 2017. Delay due to delays in obtaining open-source hydrololgic model.
Interaction with JSU and user groups to develop a firm framework for effective user review of project accomplishments and future directions.	June 2016	100%	Completed July 2016
Establish overarching methodology for conducting a JPM analysis which includes two new dimensions: antecedent flows and rainfall/runoff during hurricane event	August 2017	80%	Expected: December 2017
Complete analysis of rainfall probability patterns and antecedent hydrologic flows and water levels	December 2017	50%	Expected December 2017
Complete validation of modeling system and its validation at a specific site for at least one historical event and determine the impacts of coupled versus uncouple estimates of inundation	December 2017	10%	Expected December 2017
Investigate expected impact of the coupled versus uncoupled approaches to coastal inundation hazards	December 2017	30%	Expected December 2017
Completion of analysis of rainfall probability patterns and antecedent hydrologic flows and water levels	December 2017	20%	Expected December 2017
Research Milestone			

Report on statistical approach for rainfall patterns and combining hydrologic effects into the JPM analysis	December 2016	100%	Delays in data analysis and quantification of methodology took longer than expected
Short Report on selected methodology for hydrologic-ADCIRC model coupling	July 2017	70%	Delays in hydrologic model component made it necessary to change our technical approach, but we will still meet the overall project deadline
Final Report on coupled methodology, validation of methodology, its application, its impact on flooding, and its impact on required runs for JPM execution plus delivery of documented modeling methodology and software	December 2017	10%	We expect to reach this milestone at our estimated date.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Development of technical guidelines for FEMA applications of coupled hydrologic-surge	No previous date proposed	10%	The R&D team had to concentrate on developing a strong technical basis for including rainfall and hydrologic effects into coastal surges. Now that we feel that we have achieved a methodology for this, we can begin to determine the best way to transition this methodology.
Transition Milestone			
Application of methodology to an area of interest	No previous date proposed	10%	The R&D team will being work with representatives of planning groups in the Norfolk/Hampton Roads area; but this is currently beyond the scope of the work that has been funded

11. Interactions with education projects:

Over the two year interval to date, UNF has supported an intern from the educational component of LSU's CRC program (PhD candidate Rudy Bartels) for 6 weeks, has given two seminars at LSU, and has met with a group of 12 graduate students at LSU to advise them on technical aspects of the MS and PhD efforts.

12. Publications:

Resio, D.T., Asher, T.G., and J.I. Irish, 2017: The effects of natural structure on estimated tropical cyclone surge extremes, J. Nat. Haz., currently available online, Nat Hazards, DOI 10.1007/s11069-017-2935-y\.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Rainfall Report	WORD Document	February 2017	FEMA
Journal Publication	Publication in J. Natural Hazards	December 2016	FEMA

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Guidelines to Electric Power Research Institute for Application of JPM to Coastal Surges	Resio/Salisbury	$67,000	EPRI
Development of Combined Storm Surge and Rainfall-Hydrologic modeling to the coast of Louisiana	Resio	$120,000	State of Louisiana
Leveraged Support			
Description			Estimated Annual Value
Free office space			$5,000
Free high-performance computer time			$15,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		
Graduate students provided tuition/fee support (number)	1	
Graduate students provided stipends (number)	1	2
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)	2	
SUMREX program students hosted (number)		1
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)	1	1
Journal articles published and Book Chapters (number)	1	1
Conference presentations made (number)		
Other presentations, interviews, etc. (number)	1	
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	1	1
Requests for assistance/advice from other agencies or governments (number)	1	1
Total milestones for reporting period (number)	3	2
Accomplished fully (number)	1	5
Accomplished partially (number)	2	6
Not accomplished (number)		

BLANTON, UNC

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:** A multi-tiered ADCIRC-based storm surge and wave prediction system
2. **Principal Investigator / Institution:** Brian Blanton, Renaissance Computing Institute, UNC-Chapel Hill
3. **Other Research Participants/Partners:**
    - Rick Luettich, Institute of Marine Sciences, UNC-Chapel Hill, co-PI
    - Jason Fleming, Seahorse Coastal Consulting, ASGS developer, ADCIRC Bootcamp organizer
    - Crystal Fulcher, Institute of Marine Sciences, UNC-Chapel Hill, ADCIRC grid development
    - Jess Smith, Masters student, UNC-Chapel Hill, Department of Marine Sciences. (100%, as of May 1, 2017)
4. **Short Project Description ("elevator speech"):** Decision makers need critical and helpful information delivered on time and in formats that are easily understandable. This is particularly true with dangerous and destructive natural hazards such as hurricanes and the resulting wind, storm surge, and wave impacts. Late and/or incomprehensible information is useless. This DHS CRC project is about reducing the time needed to deliver hazard information to end users by using advanced models for storm surge, very high performance computing resources, and statistical methods that can provide early guidance information in a matter of minutes as opposed to hours.
5. **Abstract:** We will enhance and extend a multi-tiered, ADCIRC-based storm surge and wave prediction system covering the US East Coast with highest resolution in North Carolina (NC) and southern Chesapeake Bay coastal waters. The system has two main components: (i) the ADCIRC Surge Guidance System (ASGS) that provides fully dynamic, deterministic, highly accurate ADCIRC-based storm surge and wave predictions ~1-2 hours following the release of meteorological forecasts and (ii) ADCIRC-Lite, which utilizes a response surface method (Taflanidis et al, 2013, Rapid assessment of wave and surge risk during landfalling hurricanes: Probabilistic approach, Journal of Waterway, Port, Coastal, and Ocean Engineering, 139**,** 171–182.) with a pre-computed database of ADCIRC surge and wave solutions to provide rapid (e.g., within minutes) probabilistic or deterministic surge and wave predictions for hurricanes using either forecast meteorological input or end user specified storm parameters. A graphical interface will facilitate user interaction and provide an important tool for risk assessment, education and outreach. Additional components to this project include conducting both the ADCIRC Annual User Group meeting and the ADCIRC BootCamp, and a hurricane track generator for probabilistic storm surge analysis.
6. **End users:** *Dr. Joe DiRenzio, LCDR B. Sweigart*, US Coast Guard, will provide essential usability feedback on project outcomes. USCG uses ADCIRC-based information routinely, but generally do not have the resources to either run the model or create derived products themselves. Instead, they rely on the products generated by ASGS and accessed through the

nc-cera.renci.org website, not the ASGS output itself. We will hold several WebEx meetings with USCG to demonstrate the project activities, particularly for ADCIRC_Lite. We will specifically request feedback as to the user interface and general functionality. We will then update the application.

Sergei Vinogradov, NOAA, Coast Survey Development Lab, Silver Spring, MD, leads the ADCIRC-related efforts for NOAA. CSDL uses ASGS to run ADCIRC operationally, and will be providing ADCIRC output to the National Hurricane Center during active tropical cyclone events in the western Atlantic. CSDL has provided their new comprehensive coastal grid for us to use in the operational ASGS system. As we work with this grid, we will provide feedback to CSDL

***Tucker Mahoney*, *Jonathan Westcott,* FEMA HQ, advisors on federal level coastal hazards and risk. Both Westcott and Mahoney are acquainted with ADCIRC, primarily from the federal NFIP perspective. Mahoney was previously in Region 4, and oversaw most of the technical aspects of the recent coastal Flood Insurance Study that RENCI conducted (with the State, Dewberry and Davis, Applied Research Associates, and US ACE). With our FEMA end users, we will be particularly interested in how they view ADCIRC_Lite as a potential outreach and education tool. Thus, being able to extend ADCIRC_Lite to more areas will be critical. We will invite FEMA to participate in the WebEx meetings to get a "multi-user" perspective on our project.**

***Christina Lindamer*, Coastal Engineer, FEMA Region 4, Atlanta, GA, is knowledgeable of ADCIRC, having previously been a coastal engineer for Dewberry and Davis. Dewberry is the prime contractor for FEMA-related activities for the State of North Carolina, and Lindamer worked extensively on the coastal extra-tropical statistical problem for the comprehensive sea level rise impacts study recently completed. See above.**

Maxwell Agnew, USACE, MVN District, user of ADCIRC products for operational decision making for New Orleans area. Agnew is well acquainted with ADCIRC and ASGS, and will provide end-user critiques of product usefulness, accessibility, and confidence. Agnew typically engages with the UNC ADCIRC group during active tropical events that pose a threat to the New Orleans region. During those periods, we work extensively with him to ensure that the ASGS systems are producing needed output in a timely manner. Agnew frequently advises us as to functionality feedback, and we expect this to continue over the next Atlantic hurricane seasons, as well as interactions during the ADCIRC users group meetings.

7. **Unanticipated Problems:** As noted in the previous Annual Report, response surface methods are fundamentally interpolation methods. As such, the results are very sensitive to the input data. In our case, (the FEMA NC storm surge simulation database), the statistical distributions of dynamic hurricane parameters (radius to maximum winds, central pressure, etc.) are evenly sampled. However, the landfalling location is randomly drawn from a uniform distribution. For the intended purposes of the FEMA coastal flood insurance study, this is appropriate because, for larger storms that contribute more to low-frequency water levels (such as the 1% or 0.5% annual exceedance levels), the storms' radii are large enough to fill in unevenness in landfall location. However, for general interpolation problems, where it is necessary to compute a weighted response from a set of "nearest" neighbors, the interpolated results can be unexpected. For example, if the nearest neighbor set contains storms whose landfall location is to the left of the storm being predicted, the resulting water level will have unphysical higher water to the left of the storm. An example of this behavior is shown in Figure 1. The majority of the high water is to the left of the track (yellow line), which is not consistent with our expectations based on the mechanics of storm surge and hurricanes.

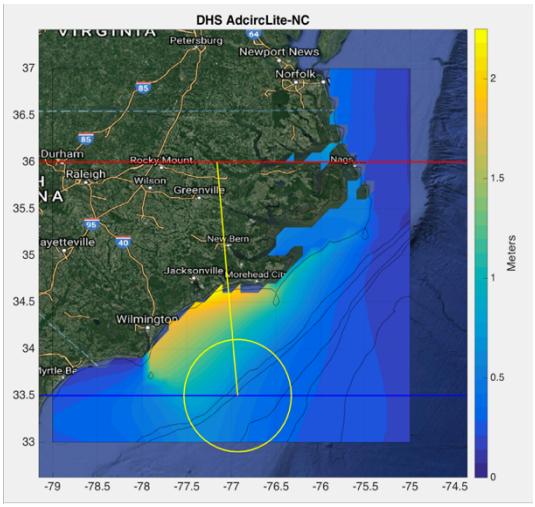


Figure 2. Example of interpolation behavior due to unevenly spaced parameter sampling.

We noted in the prior Y1 report that the remedy appears to be enforcing an even sampling of the landfalling locations. This cannot be done with the existing NC FEMA dataset, because of the sensitivity of storm surge to details of the coastline. We have thus abandoned the NC FEMA dataset and have computed a suitable set of training storms. To do this, we evenly sampled the primary dynamic hurricane parameters (central pressure, maximum wind speed, etc.) and then spaced this set of storm tracks at an along-coast distance increment proportional to the radius to maximum winds. This track set is shown in Figure 2. The track shape is determined by fitting Bezier curves from the starting location at (-70, 24) degrees to the landfall locations, constrained by the landfall orientation angle. Variations in the along-track central pressure are determined by analyzing historical storms and their pressures relative to landfall time. This analysis is summarized in Figure 3. Since the radius to maximum winds is correlated with the central pressure, this serves to provide realistic along-track variation in both parameters. Landfalling angle varies between -80 and 40 degrees (clockwise from true north). Storm surge for each track (a total of 5544 tracks) was computed on a coarse ADCIRC grid for testing purposes. Figure 4 shows the maximum storm surge across all tracks (maximum of

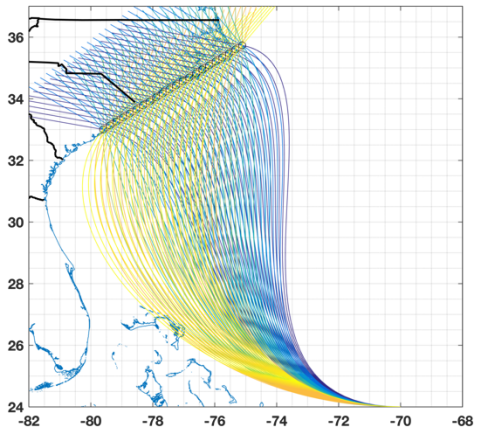


Figure 3. Synthetic hurricane tracks for North Carolina. The line colors serve to visually discriminate the different track paths and do not represent parameter variations.

maximums). We are currently modifying the response surface method code to accommodate this larger (in terms of the number of storms) dataset.

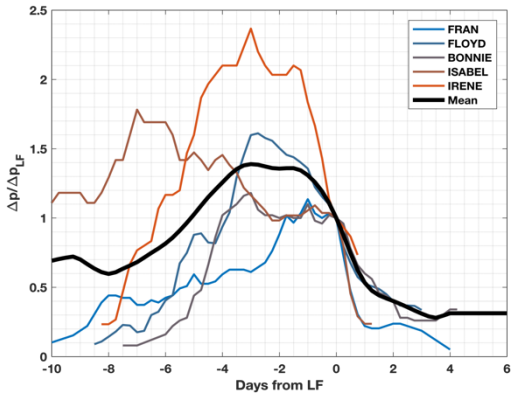


Figure 5. Along-track pressure variation scale relative to the central pressure landfall at t=0.

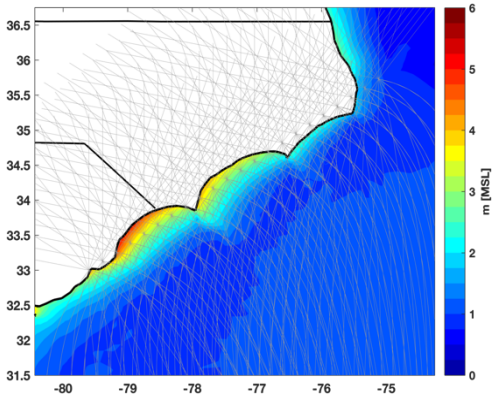


Figure 4. Maximum of maximums across all storms in the new storm population (gray lines), computed on a coarse ADCIRC grid.

Additional changes to the original plan: The original project plan included developing a comprehensive ADCIRC grid for the North Carolina and lower Chesapeake Bay region. However, in collaborating with NOAA's CSDL on this and other projects, we started using a new comprehensive coastal grid that CSDL has developed (HSOFS). This grid provides consistent coastal and near-coast land resolution for the entire eastern US and Gulf of Mexico coasts. We started using this grid during the Hurricane Matthew (2016) event, and have been evaluating this grid's performance for that event. A manuscript is in preparation describing the ASGS forecasting performance during Matthew and the implementation of a water level assimilation scheme.

8. Project Impact:

As detailed above, there are several aspects (or tiers) to this ADCIRC-based CRC project. At the technical/operational level, we continue to develop and extend the ASGS forecasting framework, the primary activity of Seahorse Coastal Consulting. Dr. Fleming has also developed extensive curricula for education and training activities for ADCIRC and ASGS, and these have been used at recent ADCIRC Annual Meetings and BootCamps. Dozens of graduate students, post-docs, and early career professionals attended the 2017 BootCamp in Norwood, MA. This constitutes a broad group of "end-users" of the software and technology developed, maintained, and supported by this project. Many of the students are conducting important research in coastal hazards, risk, and resilience, and whose research activities may have impacts in the near future. We note that one student (Mr. Stephen Kreller of LSU) attended the BootCamp specifically to be better prepared for spending the summer 2017 in residence at RENCI working with Dr. Blanton on his ADCIRC-related research.

This project also maintains the infrastructure at RENCI that hosts the nc-cera-renci.org website and the operational ASGS for North Carolina. This website is routinely used by many end-users, including the USCG, FEMA, NOAA, and USACE. Additionally, during active events that may impact North Carolina, the North Carolina Division of Emergency Management accesses ADCIRC forecast products through the RENCI data servers

(http://tds.renci.org:8080/thredds/asgs.html). Now that we have implemented the NOAA HSOFS grid in ASGS at RENCI, we will be able to provide additional guidance for any region threatened by tropical cyclone activity. This may substantially broaden the impact of ADCIRC, ASGS, and DHS's support of these activities.

Although not yet completely implemented, the ensemble track generator has the potential to provide new probabilistic storm surge information that is similar to NOAA's P-Surge information. While running thousands of simulations at high spatial resolution in near-real-time is not feasible, we hope to use the ADCIRC_Lite approach (with the new storm surge database) to make this tractable.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
~~Develop ADCIRC grid for NC and lower Chesapeake Bay by merging existing NC grid with portions of the existing FEMA Region III grid~~	03/30/2016	50	As noted above, the need for this grid has been superseded by the availability of NOAA CSDL's comprehensive coastal grid (HSOFS).
Test early grids with historical storms and in the ASGS	05/31/2016	75	The intent of this activity was to validate the regional NC/Chesapeake Bay grid. However, since adopting the NOAA HSOFS grid, we have focused
Continue operation of ASGS	Ongoing	100	RENCI continues to support the ASGS by providing computational resources to ASGS.
Develop parameter sampling for new storm surge database	03/31/2017	100	
Research Milestone			
Review of existing probabilistic track generation methods	05/31/2016	100	
Implement the new CSDL HSOFS grid in ASGS	10 /01/2016	100	
Develop new storm population that addresses the above-noted issue with the FEMA dataset.	03/31/2017	100	
Compute storm surge database using coarse ADCIRC grid	05/31/2017	100	

Status report on ASGS system upgrades and initial tests with new grid to NOAA and DHS	05/30/2017	100	ASGS progress/status and preliminary results with the NOAA HSOFS grid were presented at the DHS CRC Annual meeting in Chapel Hill, NC.
Presentation on project's ASGS activities to ADCIRC Annual Meeting	04/1/2017	100	Overview of ASGS updates and capabilities was presented by J. Fleming at the ADCIRC Annual Meeting and BootCamp.

10. Transition Activity and Milestone Progress:

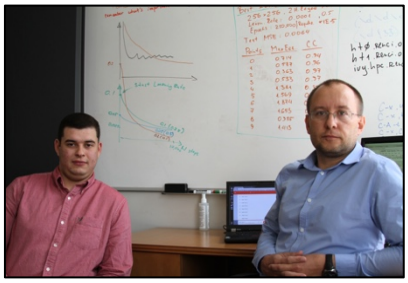
Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Attend 2017 American Meteorological Society meeting to present ensemble method development and results	01/31/2017	100	J. Smith presented a poster at the AMS 2017 meeting on her research into probabilistic storm surge simulations.
Develop report on ASGS enhancements and status to ADCIRC user community	03/31/2017		
Prepare for ADCIRC Annual Meeting and BootCamp	05/31/2017	100	
Incorporation of ASGS enhancements into the ASGS software repository. The software repository is the primary way that ASGS software is distributed.	05/15/2017	100	All new features developed by Seahorse Coastal Consulting have been committed to the ASGS repository for use by the community of ASGS users.
Transition Milestone			
Conduct ADCIRC Annual Meeting and BootCamp	5/31/2017	100	Seahorse Coastal Consulting organized, in conjunction with the host FM Global, the annual meeting and BootCamp, held in Norwood Mass. This was the largest BootCamp to date, attended by dozens of students and early career professionals.
HSOFS grid results in nc-cera.renci.org	10/31/2016	100	HSOFS grid results are posted to the usual nc-cera.renci.org website

			once the ASGS system posts the output to the data servers.
Present ensemble method results at AMS 2017	01/31/2017	100	
Provide update on ASGS status and enhancements at Annual ADCIRC Users Meeting and BootCamp	04/30/2017	100	
Aide NOAA in deploying ASGS prior to the hurricane season	05/31/2017	100	

11. Interactions with education projects:

While not a direct CRC education project interaction, we note the following. During the 2016 summer (which includes the early part of this Y2 project), the CRC hosted Anton Bezuglov (Associate Professor of Computer Science) and Reinaldo Santiago (rising senior in Computer Engineering) from Benedict College in Columbia South Carolina. This was through the DHS Summer Research Team for Minority Serving Institutions (SRT MSI). Bezuglov and Santiago were in residence at RENCI, where they developed an artificial neural network that uses hurricane parameters and storm surge responses from our FEMA North Carolina coastal flood insurance study to simulate storm surges at coastal locations. The network is an accurate and fast method and is a strong complement to ongoing CRC-funded research at RENCI on response surface methods for storm surge prediction. A manuscript describing the research and results is available in arXiv at this URL: https://arxiv.org/pdf/1609.07378. This summer research led to a follow-on proposal to the DHS SRT MSI program. This project was funded, but due to unforeseen circumstances, Prof Bezuglov was unable to accept the award.



DHS SRT researchers in residence at RENCI, a collaborator with the CRC. Mr. R. Santiago (left) and Prof. A. Bezuglov (Right).

RENCI is also hosting Mr. Stephen Kreller from LSU for the summer 2017 period, as part of the DHS SUMREX program. Mr. Kreller is a master's degree student of Prof Barry Keim (a CRC PI), and he is spending the summer at RENCI working with ADCIRC, including data processing and analysis, model setup and execution, and scientific communication skills.

12. Publications:

Storm Surge Probabilities for Hurricane Events, J. Smith, B. Blanton, R. Luettich, 2017.
This is a poster presented at AMS 2017 in Seattle WA (Jan 2017), DHS CRC Annual Meeting in Chapel Hill, NC (Feb 2017), and the annual Hurricane Awareness conference at East Carolina University (May 2017).

13. Tables

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
ADCIRC_Lite	Software	Dec 2017	Coast Guard, FEMA, other end-users as approriate
ASGS	Software	ongoing	ADCIRC forecasting and real-time users

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			
Leveraged Support			
Description			Estimated Annual Value
RENCI Computing Resources			30,000

14. Metrics

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	1	1
Graduate students provided stipends (number)	1	1
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	0	0
SUMREX program students hosted (number)	0	1
Lectures/presentations/seminars at Center partners (number)	1	0
DHS MSI Summer Research Teams hosted (number)	1	0
Journal articles submitted (number)	0	0
Journal articles published (number)	0	0
Conference presentations made (number)	2	2
Other presentations, interviews, etc. (number)	0	2
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0
Total milestones for reporting period (number)	7	7
Accomplished fully (number)	2	2
Accomplished partially (number)	3	3
Not accomplished (number)	2	2

HAGEN, LSU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Development of an optimized tide and hurricane storm surge model for the northern Gulf of Mexico (MS, AL, FL) for use with the ADCIRC Surge Guidance System.

2. **Principal Investigator / Institution:**

   Scott C. Hagen, Professor. Louisiana State University, Department of Civil & Environmental Engineering / Center for Computation & Technology.

3. **Other Research Participants/Partners:**

   Stephen C. Medeiros, Research Assistant Professor. University of Central Florida, Civil, Environmental & Construction Engineering Department, Coastal Hydroscience, Analysis, Modeling and Predictive Simulations Lab.

4. **Short Project Description ("elevator speech"):**

   This study will develop a semi-automated mesh de-refinement method designed to optimize a research grade tide, wind-wave, and hurricane storm surge model so that it can be used in real-time surge guidance operations. The resulting model will be capable of producing accurate predictions within the ADCIRC Surge Guidance System (ASGS) forecast time frames and will include advanced terrain analysis and lidar-based surface roughness parameterizations.

5. **Abstract:**

   This project will advance state-of-the-art model development by introducing novel terrain analysis techniques and lidar-based surface roughness parameterization at the regional scale. These advanced techniques will also be used to develop intelligent, stable, and semi-automated mesh de-refinement methods for optimizing a research grade (i.e., high resolution) storm surge model to reduce computational time to the point where it can be run within reasonable real-time forecast time frames (e.g., ~1-2 hrs). We will use a protocol based on emphasizing hydraulically significant embankment or valley features to optimize a research grade model of the MS, AL, and FL Panhandle. Since the purpose of ASGS is the provision of real-time hazard guidance, we will emphasize the accurate capture of the timing and magnitude maximum water levels. This will be achieved by employing mesh development techniques such as: running preliminary simulations to define active floodplain and removing unnecessary elements (relevant because the research grade model was developed to accommodate up to two meters of sea level rise); employing accelerated element relaxation moving outward from significant vertical features; and enforcing stricter criteria for vertical feature inclusion (especially for channels). Objective error metrics will be used to assess model

performance. The final outcome/deliverable will be an accurate, optimized hurricane storm surge model of the northern Gulf of Mexico (MS, AL, & FL Panhandle) that is suitable for use with the ASGS including improved surface roughness parameterization from our lidar-based technique. In addition, this high resolution ADCIRC+SWAN model will serve as a benchmark for validating future versions that may incorporate less resolution or smaller regional focus.

6. End users:

- Jerrick Saquibal, Northwest Florida Water Management District. Dr. Medeiros contacted him prior to CAT 1 Hurricane Hermine Landfall. Provided link to CERA and sample images from NGOM3 via email. Received positive feedback on the CERA product. Dr. Medeiros followed up with him regarding a possible CERA tutorial for NWFWMD staff. Mr. Saquibal was interested and also suggested two people from FDEM and FDOT that might be interested as well. To help facilitate this, Dr. Medeiros has tested the existing CERA tutorial on the CERA website by having 2 undergraduate research assistants go through it and provide feedback. We are also having this years SUMREX students run through the tutorial and provide feedback as well. We will assimilate all feedback and produce a revised tutorial in 2017. Mr. Saquibal continues to look forward to high resolution surge forecasts for the Florida Panhandle and Big Bend regions, as well as the value-added lidar products.
- David Kidwell, NOAA Northern Gulf of Mexico Sentinel Site Cooperative (NGOM SSC). Team has remained in constant contact with Mr. Kidwell and Renee Collini of NGOM SSC regarding the value of accurate coastal hydrodynamic modeling to the NGOM SSC mission. This partnership had been leveraged into a funded NOAA project. We anticipate presenting the CERA tutorial (once finalized during Performance Period 3) to the NGOM SSC as well as their invitees.

7. Unanticipated Problems:

The problems scaling the surface roughness parameter computations to model scale proved to be difficult on many fronts (compute, storage, spatial registration of results). To address this problem, Dr. Medeiros invested in lidar processing software (LAStools) in order to use its tools on some of the more routine lidar data processing tasks such as projecting, clipping, tiling, boundary shapefile production and point height computations. This has greatly sped up the progress of this aspect of the work. Dr. Medeiros also hired an established undergraduate research assistant, Alex Rodriguez, to work on the lidar data processing pipeline for 30 hours per week during the summer semester and plans to continue through Performance Period 3. To date, this has already accelerated the progress of the work. Lastly, Dr. Medeiros is planning to invest in additional compute allocation from the STOKES HPC at UCF in order to speed up the production of surface roughness parameters for the model domain.

8. Project Impact:

Our project will produce an accurate, optimized hurricane storm surge model of the NGOM that is suitable for use with the ASGS and CERA that includes improved surface roughness parameterization from our lidar-based evaluation technique. This will enable ASGS to provide emergency management personnel in the region with the highest resolution, most accurate

storm surge forecasts for real-time tropical cyclones as they approach. In turn, this will facilitate more efficient evacuation and better prediction of post-storm emergency resource needs.

The submission and subsequent publication of the surface roughness parameterization and mesh optimization methods in high-impact journals will validate the research pathways and document their acceptance by successful peer review. By achieving these milestones, the incorporation of this optimized model into ASGS will be justifiable by any measure and DHS S&T will have independent documentation in support of it. The incorporation of the optimized model into ASGS is also the best, most readily adoptable means for conveying the model results to the public in a meaningful way.

Our project will also train multiple end users (NWFWMD, NGOM SSC, possibly FDOT, FDEM and FEMA) in the use of CERA to receive updated surge forecasts. We are also coordinating with NWFWMD regarding the incorporation of CERA into an emergency management exercise (i.e. a table-top evacuation plan), although correspondence to date has indicated that they are less receptive to this; the CERA tutorial has gotten more traction with this end user.

Lastly, the impact of the SUMREX program needs little explanation other than stating the facts. Our pilot program in the summer of 2016 was a resounding success as the student, Felix Santiago of UPRM, had an outstanding experience and was able to leverage his participation into a PhD opportunity at LSU, which will be funded in part by an NSF Graduate Research Fellowship award (Drs. Hagen and Medeiros both provided letters of recommendation). Furthermore, the program was expanded to two students in 2017: Sabrina Welch of Jackson State University and Diego Delgado of UPRM. This impact of this program will be qualified, talented, and motivated students that will remain in this field either through advanced study or industry practice.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Develop scalable data processing pipeline for lidar-based surface roughness parameterization	06/30/2016	75%	Issues with magnitude of data, explained above in Section 7. Expect completion by 06/30/2018
Phase 2 of optimization procedure: Enforce stricter inclusion criteria for vertical features and document incremental performance improvements	10/31/2016	100%	

Phase 3 of optimization procedure: Accelerate relaxation criteria moving away from vertical features and document incremental performance improvements	12/31/2016	100%	
Research Milestone			
Submit a manuscript on Regional Scale Lidar Surface Roughness	06/30/2016	60%	Issues with magnitude of data, explained above in Section 7. Targeted journal will be PE&RS due to industry reach. Expect completion by 06/30/2018
Presentation of Mesh Optimization Progress at ADCIRC Workshop	04/30/2017	100%	Completed by Dr. Bilskie
Submit manuscript on mesh optimization	6/30/2017	25%	Currently spending time and effort to finalize the new forecast-grade optimized mesh for the 2017 hurricane system and its implementation into ASGS/CERA. Once the model is ready effort will then be put forth towards manuscript preparation. Expected Completion June 2018.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Meet (in-person or virtual) with technical team from Coastal Emergency Risks Assessment (CERA) to establish file format, tiling scheme, and transfer protocols for displaying model results on http://cera.cct.lsu.edu/	03/30/2016	100%	
Develop transfer protocol for NGOM model to ASGS including file naming convention, file compression, security keys, model update schedule, ADCIRC version control, etc.	07/31/2016	90%	This activity is nearly complete and is reliant on completion of the first version of the optimized forecast grade model. Expected Completion is 7/31/2017.
Participate in workshop (in-person or virtual) to discuss possible improvements to the interface at http://cera.cct.lsu.edu to	03/31/2017	50%	Made decision to have students conduct preliminary assessment of tutorial prior to presentation to end

facilitate both end-user experience and model output integration pipeline			users. Expect Completion by 12/31/2017
Transition Milestone			
Prototype integration of NGOM ADCIRC model output into CERA	06/30/2016	50%	This activity is nearly complete and is awaiting mock model run results for testing on the CERA platform. In-person meetings have been conducted between model developers and CERA technical personnel. Expected Completion is 7/31/2017.
Refined transition goals and plan with end user input	06/30/2016	75%	Consultations with end users are ongoing. We expect to keep an open dialogue with end users until end of project.
Implementation of preliminary optimized NGOM model in ASGS. Enables us to deliver surge imagery to NGOM Sentinel Site Cooperative and NWFWMD via email. This preliminary implementation sets up ASGS to automatically execute simulations of our optimized NGOM model using latest NHC storm tracks.	08/31/2016	25%	This activity is reliant on completion of the first version of the optimized forecast grade model. Expected Completion is 8/31/2017.
Full integration of NGOM ADCIRC model output into CERA. Enables NGOM Sentinel Site Cooperative and NWFWMD to view current surge forecasts on CERA. These surge forecasts will be generated by ASGS using the preliminary optimized NGOM ADCIRC model and latest NHC storm tracks.	05/31/2017	25%	This activity is reliant on completion of the first version of the optimized forecast grade model. Expected Completion is 8/31/2017. This activity will be released on the CERA development site and will not be a full release until the 2018 hurricane season to ensure a robust implementation of the optimized model into the ASGS/CERA framework.

11. Interactions with education projects:

This reporting period contains the latter part of the 2016 SUMREX (student: Felix Santiago, UPRM) and the entire 2017 SUMREX (students: Sabrina Welch, Jackson State University and Diego Delgado, UPRM). The students spend the first 3 weeks at UCF and the second 3 weeks at LSU.

At UCF, the students begin with a pre-test consisting of basic linear algebra and numerical methods problems designed to assess his level of competence in these topics and gage the need for further explanation on these topics. During the pre-test, the students engaged with Dr. Talea Mayo for assistance with the mathematical aspects of the pre-test. The pre-test also required the students to read a research paper in JGR-Oceans written by the LSU-UCF team, highlighting both concepts they did not understand, as well as concepts that they were interested in. For the remainder of the UCF phase of the SUMREX, the students worked

closely with Dr. Medeiros to learn the SMS software for ADCIRC mesh development (temporary software licenses provided at no cost by Alan Zundel of Aquaveo). They went through tutorials from past ADCIRC boot camps, working through the examples. They then used their knowledge to implement and run desktop ADCIRC tide simulations on an existing WANT mesh in SMS. Dr. Medeiros also took the students into the field on the UCF campus where they learned the basics of RTK-GPS topographic surveying, field methods for determining Manning's *n* bottom friction coefficients and effective aerodynamic roughness length by measuring the height, canopy width and other dimensions of trees and above-ground obstructions. Lastly, the students engaged with Dr. Thomas Wahl to discuss sea level rise, appropriate model scales, and how ADCIRC (or surge model output in general) is used by downstream researchers and policy makers. The students were given 3 questions to ponder after Dr. Wahl's presentation and given three days to develop responses.

- How can ADCIRC be used to identify and quantify non-linear interaction between different sea level components?
- How could you implement sea level rise in an ADCIRC model? Be specific.
- For which spatial scales is ADCIRC most suitable and why?

For the second three weeks (underway at the time of this writing), the students transitioned to LSU and began working with Dr. Matthew Bilskie to build on their ADCIRC knowledge by conducting storm surge simulations. The students will attend three virtual trainings entitled "Introduction to Linux" and High Performance Computer (HPC) User Environment Part 1 and Part 2". These trainings were provided by LSU HPC. They will also simulate several hurricanes using a coarse ADCIRC model on both their workstations and on the LSU HPC and document the difference in run-time. They will also learn how to generate presentation and publication quality graphics of storm surge model output using the FigureGen software program (developed by J. Casey Dietrich, NC State University, CRC PI). This experience is still underway and we look forward to Sabrina and Diego's final presentations.

12. Publications:

Tahsin, S., **S.C. Medeiros**, A. Singh, M. Hooshyar (2017), "Optical Cloud Pixel Recovery via Machine Learning", *Remote Sensing*, Accepted.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Lidar to Surface Roughness Processing Script	Software Code made available on Github	June 2018	The general coastal modeling community
CERA Tutorial for Coastal Stakeholders	Guidance	December 2017	NWFWMD, NGOM SSC, FDOT, FDEM, FEMA, Coastal Communities
ASGS NGOM Forecasts	Web Application	June 2018	NGOM SSC, NWFWMD, General Public

Lidar to Surface roughness processing paper	Journal Paper PE & RS	June 2018	General coastal resilience, remote sensing, and geospatial big data community
Paper on mesh optimization	Journal Paper Advances in Water Resources	June 2018	General coastal resilience and hydrodynamic modeling community
Paper comparing tide and surge results from mesh with standard (land cover) versus lidar based surface roughness parameterization	Journal paper Coastal Engineering	June 2018	General coastal resilience and hydrodynamic modeling community

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			
Leveraged Support			
Description			Estimated Annual Value
XSEDE High Performance Computing Allocation (Stampede) – Est. 13% of award to be used on this project (400,000 CPU hours)			$13,946.23
STOKES HPC at UCF – Est. 50% of Dr. Medeiros base monthly allocation equal to 40,000 CPU hours per month			$1,394.00
LSU/LONI High Performance Computing Allocation – 200,000 CPU hours			$6,973.11

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		1
Graduate students provided tuition/fee support (number)	1	1
Graduate students provided stipends (number)	1	1
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)		
SUMREX program students hosted (number)	1	2
Lectures/presentations/seminars at Center partners (number)		
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)		
Journal articles published (number)	1	1
Conference presentations made (number)		
Other presentations, interviews, etc. (number)	8	10
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)		1
Requests for assistance/advice from other agencies or governments (number)		2
Total milestones for reporting period (number)	3	4
Accomplished fully (number)	0	5*
Accomplished partially (number)	3	2
Not accomplished (number)	0	

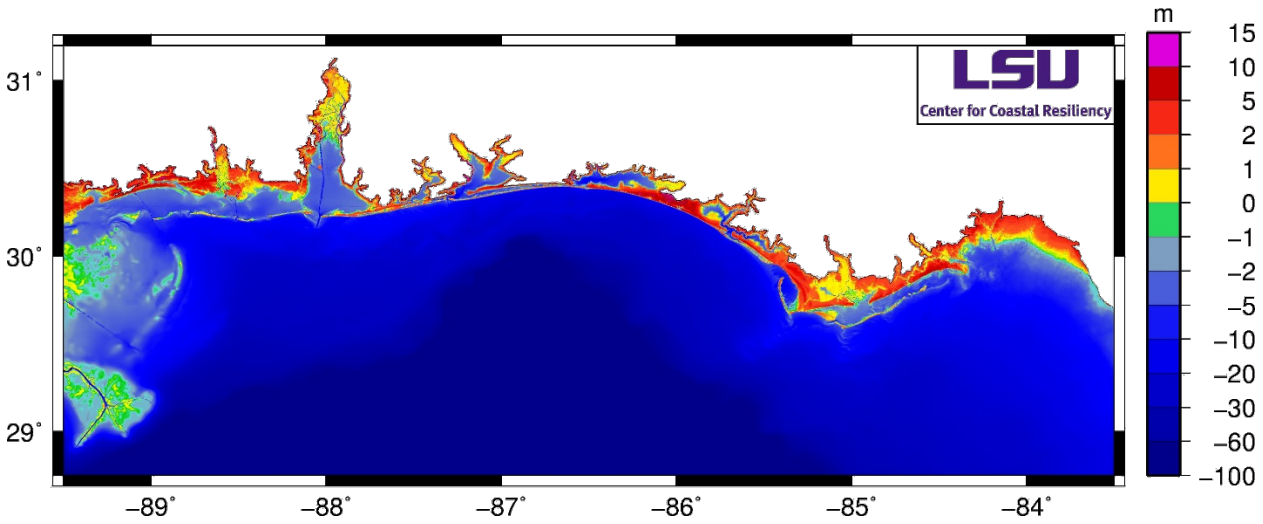


Figure: NGOM3 Mesh Elevations

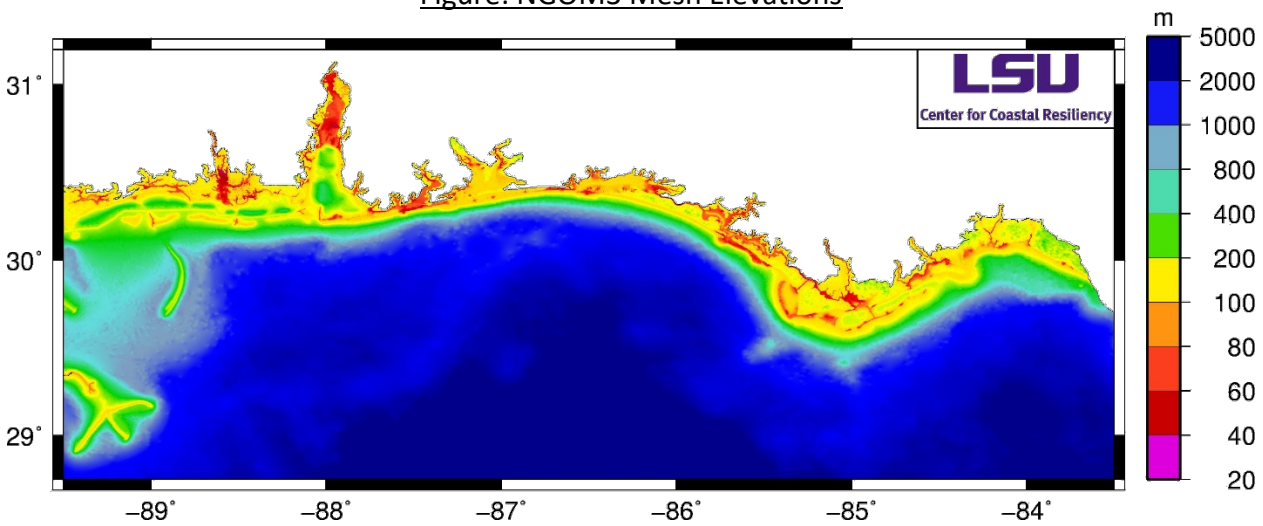


Figure: NGOM3 Mesh Resolution (Element Size)

DIETRICH, NCSU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Improving the Efficiency of Wave and Surge Models via Adaptive Mesh Resolution

2. **Principal Investigator / Institution:**

   Joel Casey Dietrich, Assistant Professor, North Carolina State University

3. **Other Research Participants/Partners:**

   Clint Dawson, Professor, University of Texas at Austin

4. **Short Project Description:**

   Coastal communities rely on predictions of waves and flooding caused by storms. These predictions are used during the storm to make decisions about resource deployment and evacuation, and these predictions are also used between storms for design and to establish insurance rates for local homeowners. Computational models are essential for making these predictions, but they can be costly. A typical prediction can require hundreds or even thousands of computational cores in a supercomputer, and several hours of wall-clock time. In this project, we will improve the performance of a widely-used, predictive model. Its representation of the coastal environment will adapt during the storm, to better utilize the computing resources and ultimately provide a faster prediction. This speed-up will benefit coastal communities, including emergency management personnel, who will have more time to make decisions during the storm event. It will also benefit long-range planners, such as flood mappers, who will be able to consider larger, more-accurate models in the same amount of time.

5. **Abstract:**

   Storm-induced waves and flooding can be predicted using computational models such as the ADCIRC+SWAN modeling system, which has been used by DHS and its constituent agencies for mapping of floodplain flood risk and forecasting of storm surge and inundation. This modeling system has been shown to be efficient in parallel computing environments. It is implemented on static meshes and with a static parallelization, and thus it does not evolve as a storm approaches and inundates a coastal region. This implementation can be inefficient when large portions of the mesh remain dry during the simulation.

   In this project, we will optimize the parallel implementation of ADCIRC by using a large-scale adaptivity, in which a mesh will be refined by incorporating entire portions of another, higher-resolution mesh. Instead of subdividing an individual element, we will increase resolution by

adding elements from a pre-existing mesh that has been well-validated. This procedure will leverage the existing suites of meshes for the same geographic region. The adapted mesh will be rebalanced among the computational cores so that geographic regions with increased resolution will not be concentrated on a disproportionally-small number of cores, and so that the time spent on inactive regions is minimized. These technologies will decrease the computational cost and better utilize the available resources.

This project will develop technologies to improve the efficiency of ADCIRC+SWAN simulations, thus allowing for more model runs in ensemble-based design applications, and for faster simulations in time-sensitive applications such as operational forecasting. These outcomes will increase the accuracy of flood risk products used in building design and the establishment of flood insurance rates, and thus lessen the impact of a disaster. These outcomes will also improve the communication and understanding of potential hazards.

6. End Users:

The proposed enhancements to efficiency will benefit all model users, including several DHS agencies with missions related to coastal flooding. In its development of Flood Insurance Rate Maps (FIRMs), FEMA will benefit because the probabilistic guidance requires a large number of deterministic simulations, and the approach described in this project will require fewer computational resources. For example, if a flood mapping study would see an efficiency gain of, say, 10 percent, then the study could be completed in a shorter time. Alternatively, that efficiency gain could be reinvested into increasing the mesh resolution and/or considering a larger suite of storms, and thus increasing the accuracy of the model results. At FEMA, **Jon Westcott**, **Tucker Mahoney**, **Christina Lindemer**, and **Rafael Canizares** have agreed to participate as transition partners. The project will also help to speed the delivery of projected flood inundation levels associated with coastal storms, thereby assisting FEMA as well as state and local emergency managers to plan for coastal evacuations and deployment of resources and personnel. In addition, the Coast Guard will benefit from faster guidance about waves and surge and therefore be able to make operational decisions about the possible relocation of assets in advance of an oncoming storm. The project personnel will continue to work with the transition team to identify additional end-users in these and other DHS constituent agencies.

With the Texas State Operations Center, the project personnel will work with **Gordon Wells** and **Teresa Howard** to transition the analysis products that are used for guidance by the emergency management leadership. They have worked with forecast guidance for the Texas coastline in previous seasons, and are supportive of the proposed work to improve the speed of the forecasts. This partnership is important because it will connect the products with end users at the state and local levels.

The proposed work will also benefit ADCIRC model users at other federal agencies. With the USACE Engineer Research and Development Center, **Ty Wamsley** and **Mary Cialone**, with the NOAA NCEP, **Andre van der Westhuysen**, and with the NOAA West Gulf River Forecast Center, **Derek Giardino** have agreed to participate as transition partners. In some cases, and especially for partners who are focused on operational modeling with ADCIRC, these activities will take the form of guidance about development with the goal of transitioning products to their work in the long term.

The project personnel will also work closely to transition the project outcomes to the ADCIRC modeling community. These transition activities will connect with **Jason Fleming** and **Carola Kaiser**, who are key members of the Coastal Emergency Risks Assessment (CERA) group. They operate the forecasting systems for regions along the U.S. Gulf and Atlantic coasts, and

they visualize and communicate the forecast guidance via a Google Maps application. Dr. Fleming also manages the software repository for the development of ADCIRC. The project personnel will work with these partners to ensure that the new modeling technologies can be incorporated within the forecasting system and the release version of ADCIRC.

During this project year, the research team facilitated the transfer of research products to these transition partners via two methods:

A. Progress reports via videoconference, during which the research team shared interim results from our activities, and our transition partners provided guidance about future directions. Their feedback and suggestions are valuable as we move our research products into something useful for production.

B. We are working with Jason Fleming to transition a static load balancing into the ADCIRC version used for forecasting in North Carolina, so it can benefit from a gain in efficiency. The latest development version of ADCIRC was modified so its static domain decomposition will account for the relative costs of dry and wet computational points. Preliminary tests, even with this most-basic of changes, have shown a speed-up of 10-20 percent compared to the existing release version of ADCIRC. We continue to work on more-sophisticated methods that will offer enhanced efficiency gains.

Thus, we are working with our transition partners, and information is flowing in both directions. They have identified some future directions for our research, and we are sharing our technologies with them. The project technologies will be shared as they become available, and our transition partners will be trained and then test the technologies for applications ranging from operational forecasting to engineering design. The technologies developed in this project will also be released to the ADCIRC modeling community. This work will require the development of extensive documentation and example files, which will be hosted online, and the integration of the software into the release version of ADCIRC.

7. Unanticipated Problems:

This project has not had any unanticipated problems or challenges.

8. Project Impact:

This project is developing technologies to improve the efficiencies of the ADCIRC modeling system in parallel computing environments. It is developing automated routines for an adaptive, multi-resolution approach to employ high-resolution, unstructured meshes for storm surge applications, and it is developing automated routines for the efficient re-balancing of the computational workload via parallelized domain decomposition. These routines better utilize the available computing resources by ensuring that every core is busy during the entire simulation. These routines will be shared (with extensive documentation and examples) with the ADCIRC modeling community, including the ASGS for operational forecasting.

These technologies will decrease the time required for an ADCIRC simulation, thus allowing for more model simulations in ensemble-based design applications, and for faster simulations in time-sensitive applications such as operational forecasting. These outcomes will increase the accuracy of flood risk products used in building design, land use planning and the establishment of flood insurance rates, and thus lessen the impact of a disaster. These

outcomes will also improve the communication and understanding of potential hazards to individuals, community officials, the insurance industry, and government agencies.

The project has progressed in two key areas. First, we have focused on code modifications to ADCIRC to improve its load balancing. A new routine was added to its source code to perform the domain decomposition at the start of the simulation, so each computational core is now responsible for developing its own set of input files. This new routine can also be called periodically during the simulation, to re-perform the domain decomposition, and thus re-balance the workload among the cores. Preliminary results are promising. We have been able to tie the re-balancing to the workload, so the code will re-balance only when it needs to do so. In our initial tests, the efficiency gain is about 25 percent. This speed-up is significant because it will lead to shorter simulations in real-time forecasting, and thus more time for the guidance in each forecast cycle to be interpreted by end users. We are working now to further improve the re-balancing by implementing a new library that will allow for computational points to be migrated between neighboring sub-domains, instead of starting each decomposition from scratch. This implementation should provide further speed-ups in the wall-clock time.

Second, we are developing techniques to map solutions between meshes with varying levels of resolution. By using the interpolation techniques within the Earth System Modeling Framework (ESMF), the solution from one mesh (e.g. a coarser mesh) is mapped onto a different (e.g. finer) mesh, in a way that is fast and conservative. The simulation may start with the coarser mesh, then add resolution in regions near where the storm is projected to make landfall, and then continue on this finer mesh until new information becomes available. The results from the coarser mesh will be used to hot-start the continued simulation on the finer mesh. During the first half of this year of the project, we developed a prototype framework and tested it on meshes with no flood plains. We developed an automated tool called ADCIrpolate to map the results between meshes, and we performed initial testing of the system by using results from a coarser mesh to hot-start a simulation on a finer mesh of the East Coast of the U.S. The comparison of the results has shown a near-identical match between simulations on interpolated meshes and fine-scale meshes. Furthermore, the solution obtained through the interpolation was computed in about 60 percent of the time needed to compute a fine-mesh solution. Next, we extended the algorithm to account for wetting and drying. The wetting and drying logic when interpolating from one mesh to another is challenging, but we have an initial algorithm that works for some simpler test cases. The next step is to test the algorithm on realistic meshes with hurricane force winds. This is a necessary step toward a multi-resolution adaptivity during storm forecasts.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Dynamic load balancing for a static ADCIRC simulation	12/2016	100	N/A
Automation of interpolation routines	12/2016	100	N/A
Demonstration of adaptive approach with single target mesh	06/2017	100	N/A
Research Milestone			
Presentation at national conference	12/2016	100	N/A
Presentation at ADCIRC workshop	04/2017	100	N/A
Submission of manuscript about dynamic load balancing	06/2017	25	While we could write-up our progress to date, we are waiting to do so until we implement a new library that will allow more flexibility in the load balancing, and thus allow the consideration of more research questions related to how and when to re-balance. We expect to submit a manuscript on this work during Fall 2017.

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Integrate dynamic load balancing into release version of ADCIRC	03/2017	25	The dynamic load balancing has been added to a development version based on the ADCIRC repository, but we are still testing and improving these additions. While we will be sharing the code with targeted users, it will not make it into this year's release version of ADCIRC. We will push it into the version released in Spring 2018.
Transition Milestone			
Quarterly progress updates, feedback from transition partners	09/2016 12/2016 03/2017 06/2017	75	We shared progress updates in Aug and Dec 2016, and again in May 2017. We will update again before the end of summer.
Testing of dynamic load balancing with J Fleming and C Kaiser	12/2016	25	We have shared our research progress with our transition partners. As we finalize the dynamic load balancing, we will connect with targeted partners for testing and implementation.
Release of software to transition partners, training with examples	03/2017	25	The documentation of the dynamic load balancing will be finalized and shared widely when the code changes are mature and stable.

11. Interactions with Education Projects:

This project has initiated involvement with the CRC's MSI education partners in several ways. First, PI Dietrich visited Johnson C. Smith University (JCSU) and presented a seminar about current research in storm surge modeling and forecasting. The seminar was on 31 March 2017, and it was attended by a combination of graduate students and faculty members from JCSU. The first half of the seminar was a summary of the last decade of PI Dietrich's research, with a focus on storm surge modeling along the northern Gulf coast, and with an emphasis on experiences in graduate school and beyond. The second half of the seminar was an introduction to and preliminary results from this CRC project. The seminar was well-

received with many questions from the audience. The presentation has been archived on PI Dietrich's institutional web site, and notice of the seminar was shared with CRC leadership.

PI Dietrich will be hosting a visit from JCSU students on 14 June 2017. The JCSU students will visit NC State for a day, meet with PI Dietrich and his graduate students, and learn more about their recent research in modeling of coastal hazards. Because the JCSU students have backgrounds in computer science and engineering, much of the discussion during their visit will be focused on the applications of computational techniques and models into our research program. PI Dietrich has invited several faculty members from inside his department to meet the JCSU students and describe their research, too. Hopefully this interaction will be another building block to connect JCSU students with research at NC State.

Co-PI Dawson hosted a PhD student from Jackson State University (JSU) at UT-Austin during last summer under the CRC SUMREX program. Xuesheng Qian is a PhD candidate in coastal engineering, and he visited UT-Austin to learn the SWAN+ADCIRC wave and surge models. Qian learned how to run the model on the HPC machines at UT Austin, how to use the Surface Water Modeling System to generate/modify finite element meshes and data used in the models, how wind files are generated and used, and worked with Dawson and JSU researcher Bruce Ebersole to run the model for storms in the Texas Gulf Coast area. With this training, Qian will be able to teach other researchers at JSU how to run the model.

12. Publications:

This project does not yet have any articles submitted for publication.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
ADCIRC forecast guidance for Texas	Guidance	June-Nov 2017	G Wells and T Howard, Texas State Operations Center

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			
Leveraged Support			
Description			Estimated Annual Value

NSF XSEDE allocation of 6.6M CPU-hours combined for supercomputers at UT-Austin and SDSC	$ 282,311.86

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	3	2
Graduate students provided stipends (number)	3	2
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	0	0
SUMREX program students hosted (number)	1	0
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)	0	1
Journal articles submitted (number)	0	0
Journal articles published (number)	0	0
Conference presentations made (number)	2	4
Other presentations, interviews, etc. (number)	1	4
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	1
Requests for assistance/advice from other agencies or governments (number)	0	1
Total milestones for reporting period (number)	6	7
Accomplished fully (number)	6	3
Accomplished partially (number)	0	2
Not accomplished (number)	0	2

TWILLEY, LSU

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Integrated Modeling Approaches with Application to Pre- and Post-Disaster Planning for Creating More Resilient Communities

2. **Principal Investigator / Institution:**

   Robert R. Twilley, Louisiana Sea Grant/Oceanography & Coastal Science, LSU

3. **Other Research Participants/Partners:**

   Jeff Carney, Coastal Sustainability Studio, LSU
   Traci Birch, Coastal Sustainability Studio, LSU
   Carola Kaiser, Center for Computation and Technology (CCT), LSU
   Brant Mitchell, Stephenson Disaster Management Institute (SDMI), LSU

4. **Short Project Description ("elevator speech"):**

   We propose a unique combination of research centers (Coastal Sustainability Studio (CSS) and Stephenson Disaster Management Institute (SDMI)) and a research and outreach organization (Louisiana Sea Grant College Program (LSG)) to develop pre- and post-disaster planning and adaptation tools for coastal communities to increase resilience. These efforts will enable vulnerable communities to plan, react, and recover more quickly and effectively in areas facing repetitive disturbance. The goals of the program are to improve emergency response with regard to protecting vulnerable infrastructure and populations, and to reduce repetitive loss by providing accurate impact data to community planners in the immediate aftermath of an event. This program focuses on significant reduction in risk with the use of high-fidelity storm surge data and impact scenario viewers during the pre-disaster planning and rapid reaction to storms, and accurate information useful to post-disaster recovery planning. Together this group will provide (1) planning tools that visualize aggregated risks to include hurricane force winds, storm surge, and inland flooding along with vulnerable populations based on socio-economic status; (2) modeling and visualization tools to communicate flood risks during a tropical cyclone event by identifying vulnerable populations and structures that are susceptible to storm surge; (3) provide post-landfall search and rescue grid system with prioritization based on socio-economic vulnerabilities; (4) develop methodology for helping community planning departments and recovery planning teams effectively utilize and implement changes to their built environment through effective resilience based planning. The CERA planning tool will incorporate many NOAA and other federal products (e.g., NOAA National Ocean Service, NOAA's River Forecast Centers, NOAA's National Centers for Environmental Information (NCEI), NOAA's Weather Prediction Center, and the NOAA National shoreline data, along with USGS, and USACE) to inform local consequence model results. User groups and Sea Grant outreach program will be organized to facilitate awareness

of products generated from this project, with focus on how to communicate vulnerable infrastructure and populations to regional planners.

5. Abstract:

We propose that an integration of coastal modeling tools linked to innovative design/planning approaches, together with effective outreach to both emergency managers and land use planners is needed to provide crucial community-level data for effective pre- and post-disaster planning. Beyond large-scale models or those that only demonstrate one aspect of hazard impact (e.g. storm surge), communities need clear guidance on exactly which vulnerable infrastructure and populations may be threatened and/or protected (pre-disaster planning and rapid response), and accurate post-event impact in order to make crucial land use and redevelopment decisions quickly. The ability to leverage this type of community-specific data provides the opportunity to avoid loss and rebuild for maximum future risk reduction. The trans-disciplinary LSU partnership builds on the strengths of each research center and outreach institution, and will provide transformational products to vulnerable communities to actively address improved flood prediction, protection, and response. We will incorporate established modeling outputs into a new consequence model showing how flood risk (both from storms and SLR) will impact people, industry, and infrastructure. This much-needed information will be used to enhance pre- and post-disaster planning for efforts. Louisiana Sea Grant and CSS will engage federal, state and local planners and emergency managers to incorporate these products into planning efforts. Beyond the targeted work being undertaken with established partner community(ies), the products will be tested at annual FEMA-lead hazard preparation workshops (i.e. Res/Con and LEPA) to engage end users directly in the development process, and will be leveraged to develop integrated approaches for university-based design studio courses and design/outreach entities addressing these issues.

6. End users:

This project, starting with the establishment of a focus group of federal, state and local planners and emergency managers, will determine what variables should be tracked in terms of consequences of storm surge to people, homes, and infrastructure to assist them in making critical decisions during and immediately following storm events. End users involved in this process will include: Federal Emergency Management Agency (FEMA), Department of Homeland Security (DHS) Federal Protective Services, the National Weather Service (NWS), Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP), the Louisiana Coastal Protection and Restoration Authority (CPRA), the Louisiana Department of Wildlife and Fisheries (LDWF), the Louisiana Office of Community Development (OCD), the US Department of Housing and Urban Development (HUD), the Louisiana Emergency Preparedness Association (LEPA), the Louisiana National Guard, US Coast Guard (8th District), the Mississippi Emergency Management Agency

(MEMA), The Coastal Protection and Restoration Authority (CPRA), local planners, emergency managers, and others. Each of the agencies described above have already been involved in the development of CERA and its use during several recent hurricane events, such as Hurricane Isaac. These agencies have made commitments through attendance at workshops dedicated to training on CERA products, and technology updates prior to hurricane season, that demonstrate the partnerships that exist to the project proposed. In addition, SDMI Has established relationships with local partner communities that will serve as case studies for the Consequence Model production and targeted planning efforts.

The CSS has a track record and established relationships with coastal communities throughout the MRD. In the wake of Hurricanes Gustav and Ike, CSS worked with 30 communities across the state to develop the Louisiana Resilience Assistance Program. This ongoing program connects architects, scientists, citizens and coastal managers to provide resilience planning assistance to communities across the coastal zone. Building on these established relationships and processes, CSS will engage coastal planners, emergency managers, and other stakeholders in the initial focus group, as well as later in the process to test the Consequence Model and planning framework. CSS will conduct workshop(s) directed at engaging communities through the use of case study scenarios to pilot the planning framework and Consequence Model. Tools and expertise developed through this project would be available to communities in Louisiana and beyond through the LRAP website www.resiliency.lsu.edu.

This project, starting with the establishment of a focus group of federal, state and local planners and emergency managers, will determine what variables should be tracked in terms of consequences of storm surge to people, homes, and infrastructure to assist them in making critical decisions during and immediately following storm events. End users involved in this process will include:

- Federal Emergency Management Agency (FEMA) - Randy Meshell, Federal Preparedness Coordinator
- Department of Homeland Security (DHS) Federal Protective Services - Philip Constantin, Protective Service Advisor
- National Weather Service (NWS) – Ken Graham, Slidell/New Orleans Forecasting Office
- Louisiana Governor's Office of Homeland Security and Emergency Preparedness (GOHSEP) – Christopher Guilbeaux, Deputy Director for Preparedness, Response and Interoperability-
- Louisiana Coastal Protection and Restoration Authority (CPRA) – Chris Ellis, Director
- Louisiana Department of Wildlife and Fisheries (LDWF) – Patrick Banks, Deputy Director
- Louisiana Office of Community Development (OCD) – Pat Forbes, Secretary
- Louisiana National Guard, - MAJ Robert Fudge
- US Coast Guard – Sector New Orleans - Roy Ford, Port Security Specialist
- Local Planners –
  - Bob Rivers, Planning Director – City of New Orleans
  - Louisette Scott, Planning Director – City of Mandeville, LA
  - Chris Pulaski, Planning Director – Terrebonne Parish, LA
  - Doug Burguires, Assistant Planning Director, Lake Charles, LA
  - Jennifer Gerbasi, Terrebonne Parish Recovery Planner
  - Dexter Accardo, Director - St. Tammany Parish OHSEP
- Emergency Managers –
  - John Rahaim, Director – St. Bernard Parish
  - Earl Eues, Director, Terrebonne Parish

- Sea Grant Agent - Kevin Savoie, Camaron Parish
- National Sea Grant Office – Dr. Dorn Carlson

7. Unanticipated Problems:

A huge effort was made to automate the workflow for the Consequence model. The scripts have been updated and produce now results down to the municipal level. The outcome was carefully tested and validated. This, however, took longer than expected so that the full integration with the CERA website could not be completely achieved. The CERA Planning website (cera-planning.cct.lsu.edu) shows some intermediate results for Vermillion parish. We will soon be able to show the final results from the Consequence model on this website and the CERA website for the Northern Gulf.

The full-scale development and deployment of a digital tool has not come together in a way that has allowed the pool to be fully engage in a design studio course. A studio was taught that utilized the existing CERA website to assist with research and design for a coastal residential development. Further, this has delayed follow up outreach with the end user groups to test the Consequence Model and planning framework

8. Project Impacts:

Many of the accomplishments listed below for research activities and milestones were actually accelerated due to the Louisiana Flood in August 2016. Several products requested by emergency managers and flood response agencies in planning for potential complicated flood impacts associated with the remainder of the 2016 hurricane season. There was particular concern that a hurricane following the August 2016 precipitation flooding would complicated inland flooding in the event of a coastal storm surge. These scenarios brought attention to the tools that are being developed as part of the CRC.

We are confident to integrate the final products of the Consequence Model into the CERA real-time web mapping interface in the next couple of weeks. They will be available for the peak of the hurricane season 2017. This is a major accomplishment and will be a tremendous asset to GOHSEP, local emergency managers, and planners in Louisiana.

9. Research Activity and Milestone Progress:

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Link CERA website with consequence analysis of SDMI. Complete cyberinfrastructure development to transfer information from CERA to GIS platforms to expand the utility of products associated with critical infrastructure along the coast.	June 2017	80 %	100% in completion the cyberinfrastructure to transfer the data to GIS platforms and to the consequence model. Speed improvements for the consequence model still planned. Link to the CERA website will be available in ~ 6 weeks.

Design and build an automated model in ArcGIS to interpret outputs of ADCIRC to analyze the consequences of expected storm surge.	Jan 2017	100%	
Test Model utilizing 143,000 point infrastructure database for the State of Louisiana and historical storms to determine effectiveness of consequences.	June 2017	100%	Now that the scrips are in place we can add and modify layers as needed. We are finishing a full output run for Hurricane Isaac this week which is integrating the database.
Determine most effective means to present results of the consequence model on the CERA website.	June 2017	100%	Links will be provided on the CERA website to access directly the results from SDMI.
Integrate available data into a Consequence Model that can analyze storm surge impacts to build SSVI for pilot parish(es)	June 2017	100 %	
Link Consequence Model and SSVI with recovery/adaptation planning model to expand the resilience of industry, critical infrastructure, and communities along the coast.	June 2017	10 %	We anticipate a substantial level of accomplishment on this particular task in the next six weeks.
Use HAZUS to augment the actual CI/KR structures that will be part of the Consequence Model output and to provide estimates on actual damages	June 2017	70%	This task is behind as a result of upgrading our computers earlier in the year. There was an unknown conflict with HAZUS and Windows 10. Portions of HAZUS-MH 4.0 were being tagged by Windows Defender as a virus prohibiting HAZUS from completely installing. In addition, a patch was recently released for ArcGIS 10.4 that was required for HAZUS to run properly. The fix was just provided to us on the 12th and we will continue working on this milestone over the next two months.
Research Milestone			
Conduct model usability testing with identified stakeholders	June 2017	100%	
Present integrated CERA Consequence Model at professional conference	June 2017	100%	
Develop final SSVI for pilot parish(es)	June 2017	100%	
Conduct recovery planning/CERA integration workshop at LEPA/GOHSEP conference	June 2017	0 %	We missed a window to submit a proposal for this workshop in early spring 2017 and will have to wait for the spring 2018 LEPA conference. (Louisiana Emergency Preparedness Association meets first week of May each year)

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Compile results of Consequence Modeling workshop into CERA capability. The development of CERA has always been driven by suggestions and requirements by our clients and users. Feedback and workshop results are always considered and carefully reviewed. If appropriate, such results will be incorporated into the CERA software.	June 2017	70%	Delayed due to continued script writing for the consequence model. Will be completed in approximately six weeks prior to the peak of the 2017 Hurricane Season.
Conduct research studio in designing integration of CERA consequence tool with SSVI application tool to develop visualization and informatics.	Aug 2016	25%	Two courses have been taught engaging the tools from this grant but have yet to be implemented fully as a course focus due to lack of tool completion in time for course development
Partner with GOHSEP and the LA National Guard as part of the hurricane planning exercise by developing products for the exercise in preparation for 2017 hurricane season.	June 2017	100%	This milestone was accelerated to meet requirements for the 2016 Hurricane Season as a result of the August 2016 floods.
Transition Milestone			
Completion of course that includes advisors from federal and state agencies to assist students in developing an integrated communication tool	June 2017	25%	Two courses have been taught engaging the tools from this grant but have yet to be implemented fully as a course focus due to lack of tool completion in time for course development
Provide maps and flooding scenarios as part of the GOHSEP and LA National Guard planning exercise	June 2017	100%	Completed in August 2016 during the August floods in which an exercise for the Governor and his Unified Command Group. Scenario was developed using ADCIRC and the Consequence Model for a hurricane impacting Louisiana during the recovery from the August 2016 floods.

11. Interactions with education projects:

None during this reporting period.

12. Publications:

None during this reporting period.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
CERA	Software	June 2017	See list of users in item #6 above
Consequence Model	Software addition to CERA	December 2017	See list of users in item #6 above

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Improved Algorithms for Computing Storm Surge (STORM)	Twilley, co-PI	$206,560	NSF
Coastal SEES Project on Accelerated Flood Risk with Delta Degrdation	Twilley, PI	$298,683	NSF
Cyber SEES – Simulation Management System for Flood Modeling	Twilley, co-PI	$75,000	NSF
Port Resilience Index	Twilley, PI	$20,000	NOAA
Louisiana Community Resilience Institute I	Carney, PI Birch, Co-PI	$50,000	Kresge, Sea Grant
Louisiana Community Resilience Institute II+III	Carney, PI Birch, Co-PI	$150,000	FEMA, NOAA

Leveraged Support	
Description	Estimated Annual Value
Free office space	$14,000
Portion of university indirect returned to project	$13,240
Reduced rates on high performance computer	$25,000
Support for ASGS development by Louisiana Sea Grant	$25,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)	1	1
Graduate students provided tuition/fee support (number)	1	1
Graduate students provided stipends (number)	1	1
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Graduates who obtained HS-related employment (number)		
SUMREX program students hosted (number)		
Lectures/presentations/seminars at Center partners (number)	1	2
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)		
Journal articles published (number)		
Conference presentations made (number)	5	3
Other presentations, interviews, etc. (number)	6	2
Patent applications filed (number)		
Patents awarded (number)		
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	7	6
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5	4
Total milestones for reporting period (number)	8	
Accomplished fully (number)	3	
Accomplished partially (number)	5	
Not accomplished (number)	0	

GINIS, URI

DHS Coastal Resilience Center

Research Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

Modeling the combined coastal and inland hazards from high-impact hypothetical hurricanes

2. **Principal Investigator / Institution:**

PI: Isaac Ginis, University of Rhode Island
Professor Co-PIs:

- Chris Kincaid, University of Rhode Island, Professor
- Tetsu Hara, University of Rhode Island, Professor
- Lewis Rothstein, University of Rhode Island, Professor
- David Ullman, University of Rhode Island, Marine Research Scientist
- Wenrui Huang, Florida State University, Professor

3. **Other Research Participants/Partners:**

- Kevin Rosa, URI/GSO, Graduate Student
- Xuanyu Chen, URI/GSO, Graduate Student
- Xiaohui Zhou, URI/GSO, Graduate Student
- Pam Rubinoff, URI/CRC, Senior Coastal Manager
- Austin Becker, URI/Marine Affairs, Assistant Professor
- Peter Stempel, URI/Marine Affairs, Architect, Graduate Student
- Robert Witkop, URI/Marine Affairs, Graduate Student
- M Reza Hashemi, URI/Ocean Engineering, Assistant Professor

Key Partners:

- NOAA/NWS/NCEP Environmental Modeling Center (EMC), Arun Chawla, Marine Modeling Branch
- NOAA Northeast River Forecast Center (NERFC), David Vallee, Director
- NOAA NWS, Taunton, MA, Robert Thompson, Meteorologist-in-Charge
- NOAA NWS, Taunton, MA, Matthew Belk, Hurricane Program Leader
- FEMA Region 1, Paul Morey, Hurricane Program Manager
- RIEMA, Stephen Conard, Training & Exercise Specialist
- DHS Office of Cyber and Infrastructure Analysis, Marilee Orr, Senior Analyst

4. **Short Project Description ("elevator speech"):**

This project will advance modeling capabilities for assessing the potential impacts of landfalling hurricanes on critical infrastructure and communities, exacerbated by the effects of climate change. The primary focus is on extreme hypothetical, yet plausible high-impact

hurricane scenarios in the Northeastern United States by combining multiple hazard impacts, including coastal flooding due to storm surge and inland flooding due to rainfall. This project will allow DHS and other agencies to better understand the consequences of coastal and inland hazards associated with extreme high-impact landfalling hurricanes in specific regions and to better prepare coastal communities for future risks.

5. **Abstract:**

The major goal of this project is to comprehensively investigate the hazards in the focus region using the most advanced coupled hurricane-ocean prediction, coastal ocean circulation/storm surge, wave, climate, and hydrological models. To attain this goal, the following specific tasks will be accomplished: 1) Create physically consistent, hypothetical high-impact scenarios that combine widespread, multiple hazard impacts (e.g. storm surge and rainfall-induced flooding); 2) use a multi-model ensemble approach to integrate 2D and 3D coastal models with watershed and 1D river models to provide the best possible coastal and inland flood guidance; 3) implement the URI air-sea coupling module, developed for NOAA operational hurricane models, for coupling storm surge/wave models; 4) provide hazard model output in a format suitable for HAZUS, HURREVAC or other risk modeling software and decision support tools used by DHS and other agencies; and 5) utilize the most advanced tools for sharing, visualizing and communicating the hazard model simulations with end users.

6. **End users:**

Rhode Island Emergency Management Agency (RIEMA)

Emergency Management Institute (EMI)

The URI team provided modeling products and collaborated with Rhode Island Emergency Management Agency (RIEMA) and the Emergency Management Institute (EMI) to conduct an Integrated Emergency Management Course (IEMC) as part of a statewide preparedness exercise on June 19 – 22, 2017. The four-day exercise focuses on the response to hurricane scenarios while identifying key actions taken before, during, and after a hurricane. The modeling team developed scenarios and impact visualizations of a high-impact hurricane (Hurricane Rhody) for use in the exercise. Outcomes from the course will provide RIEMA with an opportunity to enhance overall preparedness, while actively testing modeling outputs during various parts of the course.

In this effort, the URI team worked closely with Stephen Conard at RIEMA, Douglas Kahn and Sabrina Bateman at EMI, and Marilee Orr and Thomas Reis at the DHS Office of Cyber and Infrastructure Analysis in developing the impact analysis on critical infrastructures in Rhode Island.

Stephen Conard, Training & Exercise Specialist, stated: “The information and modeling provided by URI will be used within RIEMA sponsored trainings and exercises to update the scientific data and modeling used. Also, RIEMA can use this information within the State Emergency Operations Center for catastrophic planning. The information given from URI can also be used in long-term planning to deal with the effects that sea level rise plays on 21 of RI's 39 communities.”

This provides an opportunity to share this type of capability and products to FEMA Region 1, for application on a broader scale. It also provides an opportunity to see if the EMI training can incorporate these types of models into exercises in other regions.

FEMA Region 1
Paul Morey, Hurricane Program Manager, implemented the Hurricane Rhody scenario into HVX decision support tool administered by FEMA for the Integrated Emergency Management Course on June 19 – 22, 2017.

NOAA NWS, Taunton, MA
Robert Thompson, Meteorologist-in-Charge, and Matthew Belk, Hurricane Program Leader developed tropical storm advisories and hazard graphics for the weather briefings during the Integrated Emergency Management Course based on the Hurricane Rhody scenario and output from the URI HBL model wind simulations.

NOAA/NWS/NCEP Environmental Modeling Center
The URI team conducted an evaluation of the new operational (ST4) version of the WAVEWATCH 3 wave model in hurricane conditions and communicated the results to the NCEP wave modeling group (Arun Chawla) and via conference calls and WW3 developer meetings (Jessica Meixner), providing recommendations to adjust/recalibrate the source term in WW3 in high wind conditions. Our team will conduct this effort with potential transition to operations at NCEP.

RI Flood Mitigation Association
Participated in the RI Flood Mitigation Association Annual Meeting to network with state emergency managers. Presentation of initial model outputs provided our team with feedback from local end users. These inputs have been incorporated into the model and outputs as feasible.

RI Coastal and Resources Management Council
Coordinated with this state regulatory agency on modeling and visualizations as a tool for planning, response and permitting. Discussions on integrating the models and programs (i.e. Shoreline Change Special Area Management Plan) is underway. This coordination also provides an example of how to link with 33 coastal states as well as NOAA's Office of Coastal Resources Management.

Rhode Island Environmental Management Agencies
Significant efforts have been made to transfer technological advances and multi-modeling tools to those relevant RI management agencies that are tasked with protecting RI marine resources. Organized a meeting/workshop that included DHS team members Chris Kincaid, David Ullman and Lew Rothstein, along with Jim Boyd, (Coastal Policy Analyst, RI CRMC), David Beutel, (Aquaculture Coordinator, RI CRMC) and Conor McManus (RI DEM, Fisheries Management Section). Also present were Professors Dale Levitt and Scott Rutherford, researchers from Roger Williams University with extensive experience with RI Shellfishing activities, communities, outreach, and research. Grover Fugate (Head of RI CRMC) and Jason McNamee (Chief of RIDEM Marine Resource Management) were copied on all emails where DHS-supported research was summarized and the workshop agenda was set, but could not attend. They were briefed by their representatives. The outcome of the meeting was the consensus agreement that our DHS-funded modeling tools on the mobilization and transport of hazardous materials from the urban source regions in the north, through the sensitive and valuable fisheries resource regions of the mid-lower

estuary, should be developed into planning and training activities similar to the IEMC.

7. **Unanticipated Problems:**

None.

8. **Project Impact:**

- The project advanced current technologies and capabilities by developing end-to-end model simulations capable of representing extreme hurricane events from the open ocean, onto the shelf, through coastal estuaries and tributaries, and into coastal watersheds based on multiple, independent models that contributed to an ensemble of model solutions for DHS stakeholders in the Rhode Island region.

- The project conducted detailed assessment of the performance of state-of-the-art coastal circulation, watershed rainfall and river flood models in representing the hurricane and other extreme weather hazards in the RI region.

- The project conducted detailed assessment of the performance of two ocean surface wave models under hurricane forcing and communicated the results to operational wave modeling centers.

- The project created reasonable hypothetical worst case scenarios (low probability, high impact) by combining multiple hazard impacts, including coastal flooding due to storm surge and inland flooding due to rainfall, based on a combination of historical storm elements.

- The project developed multi-model strategies and methodologies for testing the benefits and unintended consequences of utilizing engineered structures (hurricane barriers) under a range of storm characteristics, and conducted detailed evaluations of the Fox Point Hurricane Barrier in Rhode Island.

- The project transitioned the results from the physical modeling scenarios to DHS end users that helped to inform the impact on infrastructure and losses and the associated challenges in managing multiple threats with limited resources, and used this as a pilot for other emergency preparedness and response trainings.

- The project designed a computationally efficient framework that combined multi-model ensemble output with interactive 3D visualization tools for training and real-time hazard impact analyses. These products are a substantial advancement of the existing tools that will maximize the utility of outputs from complex numerical models. They are produced in forms that are most useful for emergency managers, first responders, and other professionals from all levels of government and the private sector.

- By contributing models and outputs (visualizations and impact scenarios) to RIEMA/FEMA training for their Integrated Emergency Management Course (EMI-IEMC), the trainees of the statewide preparedness exercise are able to envision (and practice) and respond to “exercises that update our materials to current threat standards, instead of slightly outdated, unrealistic thresholds that growth has easily surpassed.” (Stephen Conard, RIEMA). These materials are already being considered for more trainings and exercises in the state and the Northeast region.

- Three students from Tougaloo College are actively working with researchers to advance and apply their knowledge in natural and social science.

9. **Research Activity and Milestone Progress:** Details of the project activities and main accomplishments are provided in Appendix, which includes 8 chapters:

   1. Hurricane Boundary Layer Model

   2. R-CLIPER Hurricane Rainfall Model

   3. Hurricane Rhody

   4. ADCIRC Storm Surge Simulations

   5. Multi-model Storm Surge and Post-Hurricane Environmental Impact Simulations: ROMS vs. ADCIRC and 2D vs. 3D

   6. Wave Modeling Under Hurricanes in Coastal Regions

   7. Rainfall Runoff and Coupled Inland/Coastal Flood Simulations in Woonasquatucket and Pawtuxet River Basins

   8. Developing 3D Visualization and Impact Analysis Methods and Tools

Research Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Research Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Configure and implement high-resolution ADCIRC in Narragansett Bay and Rhode Island coastal waters.	11/30/2016	100%	This activity was expanded, after the previous report, to include the uniform refinement of the ADCIRC mesh (minimum mesh size 30 m) within Narragansett Bay and Southern New England coastal waters. Summary is provided in Appendix
Configure and implement high-resolution WAVEWATCH III and SWAN wave models in Narragansett Bay and Rhode Island coastal waters.	11/30/2016	100%	This activity was expanded to include the investigation of the wave model performance under hurricanes, and the investigation of the model sensitivity to spatial resolutions. Summary is provided in Appendix
Calibrate and verify ROMS, ADCIRC, HEC-HMS and HEC-RAS models for selected historic hurricane events.	11/30/2016	100%	Summary is provided in Appendix

Conduct initial simulations of Hurricanes Bob (1991), Floyd (1999), and Carol (1954).	11/30/2016	100%	Summary is provided in Appendix
Implement the URI air-sea coupling module (ASCM) into the ADCIRC/SWAN and ROMS/SWAN models coupled with the new, unstructured grid version of WAVEWATCH III.	6/30/2017	70%	Implementation of ASCM into ROMS has been postponed. Instead, sea state dependent drag coefficient was investigated.
Simulate the impact of hypothetical Hurricane 'Rhody' on coastal and inland flooding and compare it to the historical events.	12/31/2017	100%	This activity is accomplished ahead of schedule. Summary is provided in Appendix

Develop a new Hurricane Boundary Layer model	6/30/2017	100%	This activity has been added in the course of the project. Summary is provided in Appendix
Implement the R-CLIPER rainfall model for hurricane rainfalls	6/30/2017	100%	This activity has been added in the course of the project. Summary is provided in Appendix
Refined ADCIRC mesh to provide uniformly high resolution (30 m minimum cell size) over Narragansett Bay and the adjacent southern New England shelf	6/30/2017	90%	Summary is provided in Appendix (work continues to further refine the mesh to better resolve very narrow inlets between RI coastal ponds and the ocean).
Perform ADCIRC simulations of Hurricanes Bob (1991) and Carol (1954) on refined and prior meshes and compared with observations.	6/30/2017	100%	Summary is provided in Appendix
Perform ADCIRC simulations of Hurricane Rhody on refined mesh with and without the presence of the (closed) Providence Hurricane Barrier and with and without the inclusion of river inflows north of Providence.	6/30/2017	100%	Summary is provided in Appendix
Run ADCIRC in idealized experiments to begin to determine the impact of dunes on coastal and inland flooding.	6/30/2017	100%	Summary is provided in Appendix

Setup and calibrate rainfall runoff model for Woonasquatucket River Basin and Moshassuck River Basins. Modify HEC-RAS model for unsteady model simulations in Woonasquatucket River.	6/30/2017	100%	Summary is provided in Appendix
Perform rainfall-runoff and river flood simulations caused by 2010 storm and Hurricane Carol (1954) events under hurricane barrier open and close conditions.	6/30/2017	100%	Summary is provided in Appendix

Perform rainfall-runoff and river flood simulations caused by Hurricane Rhody with hurricane barrier closed.	6/30/2017	100%	Summary is provided in Appendix
Perform rainfall runoff simulations of Hurricane Rhody in the Pawtuxet River Basin	6/30/2017	100%	This activity has been conducted by our URI partners sponsored by RI Coastal Resources Management Council. Summary is provided in Appendix
Refine ROMS mesh for Narragansett Bay to better include primary tributary, Seekonk/Blackstone Rivers.	6/30/2017	100%	Summary provided in Appendix
Perform simulations of Hurricanes Bob, Carol, Floyd and Rhody on refined ROMS mesh for both ROMS 3D and ROMS 2D. Compare solutions to all available data, and ADCIRC model runs.	6/30/2017	100%	Summary provided in Appendix
Initiate tests of mesh nesting capabilities in ROMS, for use in DHS simulations. Focus on defining benefits of enhanced resolution in the most sensitive regions of the estuary (e.g. Port of Providence, Fox Point Hurricane Barrier, etc.).	6/30/2017	80%	Summary provided in Appendix
Developing total storm impacts through multi-model approach: preliminary simulations of after hurricane environmental impacts. Fate/impacts of a) chemical releases from Port of b) mobilized debris.	6/30/2017	a. 25% b. 25%	This activity has been added in the course of the project based on feedback from end users. Summary provided in Appendix

Run ROMS tests of key differences in 2D versus 3D predictions for transport of chemical fields and debris for Hurricanes Carol and Bob.	6/30/2017	80%	Summary provided in Appendix

Research Milestone			
Applied the Hurricane Boundary Layer Model and R-CLIPER rainfall model for the ADCIRC, ROMS and hydrological models simulations.			Summary is provided in Appendix
Presented the results of the wave modeling studies at the NOAA/NWS/NCEP Environmental Modeling Center, July 2016, and at the WW3 Developers Meeting, February 2017.			Summary is provided in Appendix
Completed all planned ADCIRC and ROMS simulations of Hurricanes Bob and Carol and hypothetical Hurricane Rhody.			Summary is provided in Appendix
Completed all planned hydrological simulations for Woonasquatucket River Basin and Moshassuck River Basins of Hurricane Carol and hypothetical Hurricane Rhody.			Summary is provided in Appendix
Completed all necessary ROMS mesh upgrades and re-runs of all 2D/3D ROMS simulations for each Hurricane case (Bob, Carol, Floyd, Rhody).			Summary is provided in Appendix.

10. **Transition Activity and Milestone Progress:**

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Developed tools and products for Statewide preparedness exercise in coordination with RIEMA, FEMA's National Emergency Training Center, and the Emergency Management Institute to conduct an Integrated Emergency Management Course (EMI-IEMC)	6/30/2017	100%	Summary is provided in Appendix
Identified points of concern for facilities and communities through semi-structured interviews in person, over the phone, and through email with emergency and facility managers from Coventry, Providence, Westerly, Pawtucket and Middleton, RI	6/30/2017	100%	Summary is provided in Appendix
Developed new methods to create engaging 3d visualizations of storm impacts based on hurricane hazard modeling	6/30/2017	100%	Summary is provided in Appendix
Engaged with NOAA National Weather Service to share models and model results.	6/30/2017	100%	
Engaged with and initiated response plan for points of concern from Waste Water Treatment Facility managers through 2016 Silverjackets meeting and 2017 briefing workshop to the Narragansett Bay Commission.	6/30/2017	100%	
Held workshop to educate RI management agencies RI-DEM and RI-CRMC on potential applications of DHS multi-model tools for planning and response actions related to assessing hurricane generated impacts to estuarine-based natural resources.	6/30/2017	100%	
Transition Milestone			

Organized a breakout session at RI Preparedness Conference, for local and state emergency managers, to get input and validate model. August, 2016.			
Transitioned tools and products to RIEMA, FEMA's National Emergency Training Center, and the Emergency Management Institute for an Integrated Emergency Management Course (EMI-IEMC)			
Participated in training, with modeling products, sponsored by the National Emergency Training Center, and the Emergency Management Institute to conduct an Integrated Emergency Management Course (EMI-IEMC) as part of a statewide preparedness exercise on June 19 – 22, 2017.			
Organized a meeting/workshop with RI CRMC and RIDEM, presented DHS-funded modeling tools for mobilization and transport of hazardous materials from the urban source regions into sensitive and valuable fisheries resource regions of the estuary, March, 2017.			
Provided the Hurricane Rhody scenario to FEMA Region 1 for implementation into the HVX decision support tool. May, 2017.			
Provided the Hurricane Rhody scenario to NOAA NWS for developing hurricane advisory for the Integrated Emergency Management Course, May 2017.			
Provided model output from Hurricane Rhody simulations to DHS Office of Cyber and Infrastructure Analysis for infrastructure impact analysis in Rhode Island			
Participated in the RI Flood Mitigation Association Annual Meeting network with state emergency managers, April 2017			

Met with Narragansett Bay Commission (NBC) to brief them on DHS modeling advancements, including Hurricane Rhody, effects of Hurricane Barrier open/closed for flooding at their site and ROMS simulations of long term transport of chemicals, including nutrients from their plant. Discussed organizing a workshop for linking DHS modeling tools to planning activities that involved all Narragansett Bay waste water treatment facilities/managers, April, 2017.			

11. **Interactions With Education Projects:**

URI has 3 undergraduate summer interns from Tougaloo College. The URI team took advantage of an opportunity presented when Tougaloo College approached us with the need to place students. We identified one project, under PI Jim Opaluch, to fund and work with his team's project related to Obstacles and Barriers to Adaptation.

Beyond this, PIs Ginis and Rubinoff, coordinated with the long-time program at the URI Graduate School of Oceanography's (URI-GSO) Summer Undergraduate Fellowship in Oceanography (SURFO), a partnership of URI and the National Science Foundation. This supported two additional students from Tougaloo College to become a new model for incorporating diversity in the SURFO program, that of cultural and racial diversity, as well as natural and social science integration.

Visualizations have been supported by a URI PhD candidate and a Masters student, working under the leadership of Dr. Austin Becker and the Marine Affairs Visualization Lab. The work on visualizations has been beneficial as an educational approach, as well as a true contribution to the project.

This project motivated a new URI-GSO minor (PODS-Proficiency in Ocean Data Science), a 4 course sequence with a capstone internship. The program involves all DHS Faculty PI's, with the fourth, or capstone course covering the multi-model hurricane-surge approach developed on this project. All courses and the PODS minor approved by general education and curriculum affairs committees and URI Faculty Senate.

Results from this research project have been used in class teaching and student's course projects at FSU: CWR4201, Hydraulic Engineering I, Fall, 2016, 20 students and a course project for CWR4201, Hydraulic Engineering I, Spring, 2017, 23 students

Results from this research project have been used in class teaching and student's course projects in URI's large general education course, The Ocean Planet, OCG 110, Fall, 2016.

12. Publications:

Blair, A., I. Ginis, T. Hara, and E. Ulhorn, 2017: Impact of Langmuir Turbulence on Upper Ocean Response to Hurricane Edouard: Model and Observations, submitted, April 2017.

Chen, X, I. Ginis, and T. Hara, 2017: Ocean surface wave modeling under tropical cyclones: sensitivity to spatial resolutions, *Ocean modelling,* to be submitted in August 2017.

Gao, K. and I. Ginis, 2016: On the equilibrium-state roll vortices and their effect in the hurricane boundary layer. *J. Atmos. Sci.*, 1205- 1222.

Gao, K., I. Ginis, J.D. Doyle, Y. Jin, 2017: Effect of boundary layer roll vortices on the development of the axisymmetric tropical cyclone *J. Atmos. Sci.*, in press.

Fei ,T., W. Huang, I. Ginis, Y. Cai, 2016. Characteristics of River Flood and Storm Surge Interactions in a Tidal River in Rhode Island, USA. Proceeding of IUTAM Symposium on Storm Surge Modelling and Forecasting, Oct 17-19, 2016, Shanghai, China

Fei T., W. Huang, I. Ginis, Y. Cai, 2017. Hydrological modeling of storm-induced runoff and snowmelt in Taunton River Basin. Submitted for review to the journal of Natural Hazards.

Fei T., W. Huang, I. Ginis, D. Ullman, Y. Cai, 2017. Integrated rainfall runoff and river hydrodynamic modeling for flood analysis in Woonasquatucket river basin. In preparation for submission the journal of Frontiers of Civil and Structure Engineering.

Liu, Q., L. M. Rothstein, Y. Luo, D. S. Ullman, and D. L. Codiga, 2016. Dynamics of the periphery current in Rhode Island Sound, *Ocean Modelling*, 105, 13-24.

Liu, Q., L. Rothstein, and Y. Luo, 2016. Dynamics of the Block Island Sound estuarine plume. J. Phys. Ocean., Accepted for publication.

Reichl, B. G, D. Wang, T. Hara, I. Ginis,, T. Kukulka, 2016: Langmuir turbulence parameterization in tropical cyclone conditions*. J. Phys. Oceanogr.,* 46, 863-886.

Reichl, B. G., I. Ginis, T. Hara, B, Thomas, T. Kukulka, and D. Wang, 2016: Impact of sea-state dependent Langmuir turbulence of the ocean response to a tropical cyclone, *Mon. Wea. Rev*, (in press).

Rosa, K., and C. Kincaid, 2017: Modeling and observations of mixing, circulation and exchange in Narragansett Bay and Rhode Island Sound during Hurricane Floyd, manuscript in preparation for submission to J. Geophys. Res.

Rosa, K., C. Kincaid and D. Ullman. Comparing 2D and 3D ROMS models of historical and hypothetical hurricanes storm surge in Narragansett Bay, manuscript in preparation for submission to J. Geophys. Res.

Sun, Y., C. Chen, R. C. Beardsley, D. Ullman, B. Butman, and H. Lin, 2016. Surface Circulation in Block Island Sound and Adjacent Coastal and Shelf Regions: A FVCOM-CODAR comparison, *Progress in Oceanography*, 143, 26-45.

Ullman, D. S. I. Ginis, B. Thomas, X. Chen, and W. Hwang, 2017. Storm Surge/Rainfall Impacts of a Major Hurricane in Southern New England (Rhode Island), in preparation for submission to Natural Hazards.

Whitney, M. M., D. S. Ullman, and D. L. Codiga, 2016. Subtidal Exchange in Eastern Long Island Sound, . *J. Phys. Oceanogr*. 46, 2351-2371.

13. Tables:

Table 1: Documenting CRC Research Project Product Delivery

Product Name	Product Type	Approx. Delivery Date	Recipient or Anticipated End Users
Hurricane Rhody scenario	Digital track files and model output	May 2017	NOAA NWS, Taunton FEMA Region 1, Boston
WAVEWATCH III	Hurricane Evaluation Analysis	July 2016	NOAA NCEP
Hurricane Rhody impact analysis	Damage spread sheets	April 2016	EMI, RIEMA
Hurricane Rhody visualizations	3D graphics	May 2017	EMI, RIEMA
Hurricane Rhody Master Scenario List (MSEL)	Digital tables aligning with storm timing	June 2017	EMI, RIEMA
WAVEWATCH III	Analysis of hurricane waves	February 2017	NOAA NCEP

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Improving NOAA's HWRF Prediction System through New Advancements in the Ocean Model Component and Air-Sea-Wave Coupling	Ginis	$260,000	NOAA
GFDN operational tropical cyclone model maintenance and support	Ginis	$134,000	Navy
Advancing tropical cyclone models through explicit representation of boundary layer roll vortices	Ginis	$260,000	ONR-Navy
Langmuir turbulence under tropical cyclones	Hara, Ginis	$376,000	NSF
Airflow separations over wind waves and their impact on air-sea momentum flux	Hara	$355,000	NSF
4D physical models of migrating mid-ocean ridges: Implications for shallow mantle flow	Kincaid	357,000	NSF
Collaborative Research: 3D Dynamics of buoyant diapirs in subduction zones	Kincaid	442,000	NSF
NOAA/RISG: Quahog Larval Dispersion and Settlement in Narragansett Bay	Kincaid Ullman	199,000	RI Sea Grant/NOAA
Authentic Data and Visualization Experiences and Necessary Training (ADVENT): An undergraduate model for recruiting students to STEM careers in the U.S. Navy	Pockalny Kincaid	750,000	ONR-Navy
Rhode Island Sound as a Potential Source of HAB Toxins for Narragansett Bay	Ullman	140,000	RI Sea Grant

MARACOOS: Preparing for a Changing Mid-Atlantic	Ullman	75,000	NOAA, Rutgers Subcontract
Optimizing Seaweed and Shellfish Integrated Multi-Trophic Aquaculture: Developing a Spatially Explicit Ecosystem Model	Humphries, Ullman, Kincaid, Thornber	300,000	NOAA
Summer Undergraduate Research Fellowship in Oceanography (2 students from Tougaloo)	Rubinoff	12,000	NSF

Leveraged Support	
Description	Estimated Annual Value
Returned Indirect Cost [1]	$10,000
Graduate Student tuition	$15,000
Microsoft Azure Research Award, a one-year grant that allows our project to utilize cloud computing technology.	$20,000
Support for graduate students Peter Stempel and Robert Witkop from URI Coastal Institute and RI Sea Grant	$40,000
Support for graduate students Kevin Rosa and Christina Wertman from State Funded TA's.	$40,000

[1]The University of Rhode Island's Coastal Institute (CI) has generously agreed to return 66% of their share of indirect cost return back to the project. The CI obtains 17% of the indirect cost, so roughly 11.3% of indirect cost is being returned to the project.

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	0	0
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	2	3
Graduate students provided stipends (number)	2	3
Undergraduates who received HS-related degrees (number)	0	0
Graduate students who received HS-related degrees (number)	0	0
Graduates who obtained HS-related employment (number)	0	0
SUMREX program students hosted (number)	0	2
Lectures/presentations/seminars at Center partners (number)	1	3
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	2	7
Journal articles published (number)	7	8
Conference presentations made (number)	15	14
Other presentations, interviews, etc. (number)	12	22
Patent applications filed (number)	0	0
Patents awarded (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	3
Requests for assistance/advice from other agencies or governments (number)	5	13
Total milestones for reporting period (number)	11	21
Accomplished fully (number)	9	17
Accomplished partially (number)	2	4
Not accomplished (number)	0	0

Theme 4

Education and Workforce Development

WHALIN, JSU

DHS Coastal Resilience Center

Education Project:

Year 2 Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. Project Title:

PhD in Engineering (Coastal Engineering and Computational Engineering concentrations) at an HBCU.

2. Principal Investigator / Institution:

Robert W. Whalin, Ph.D., P.E., D.CE Professor of Civil Engineering; Co-Director, Coastal Hazards Center of Excellence-Education (July 1, 2008-Dec. 31, 2017); Education Director, Coastal Resilience Center of Excellence (Jan. 1, 2016- June 30, 2020).

3. Other Education Participants/Partners:

US Army Engineer Research and Development Center (ERDC), University of North Florida and Texas A&M University at Galveston

4. Short Project Description:

This project establishes the first HBCU PhD in Engineering degree with concentrations focusing on coastal natural disasters. It will help increase workforce diversity (over 80% of students are minorities) in the Homeland Security enterprise. The PhD Engineering degree will have two coastal natural disaster related concentrations: Coastal Engineering (focusing on hurricanes and floods) and Computational Engineering (focusing on computational fluid dynamics) and continues to nurture the BS/MS education programs of the Coastal Hazards Center of Excellence (July 1, 2008-Dec. 31, 2015). End user (employers) relationships with ERDC, Mississippi Department of Transportation (MDOT), Corps of Engineers Districts, Mississippi Emergency Management Agency (MEMA) and local emergency management offices across the southeastern US are strengthened even further.

5. Abstract:

This project will formulate and implement a concentration in Coastal Engineering for the PhD Engineering degree and will promote the approved Computational Engineering Concentration. These two PhD concentrations will have a pipeline of graduates from the MS Engineering (Coastal Engineering and Computational Engineering concentrations) plus government and industry employees within the commuting area as a steady source of students. The BS and MS programs were formulated and implemented during the DHS Coastal Hazards Center of Excellence (July 1, 2008-Dec. 31, 2015) at Jackson State University and will continue to be nurtured and strengthened as part of the academic foundation for the CRC. This is the only natural disaster focused coastal engineering and computational engineering graduate (or undergraduate) program at an HBCU and is a direct result of DHS Office of University programs support for Centers of Excellence. Jackson State University has a minority student population exceeding 80% which directly supports

the DHS Strategic Plan Goal to Enhance the DHS Workforce, especially the Objective to Increase Workforce Diversity and Priority Goal 3 to Enhance Resilience to Disasters. Leverage of federal assets is assured by the Education Partnership Agreement (authorized by Public Law) between the Engineer Research and Development Center and Jackson State University that facilitates ERDC engineers serving as Adjunct Faculty, providing student internships and potential use of ERDC experimental and computational facilities for graduate research. An outstanding record of DHS End User involvement and transition of graduates to end users has been established during the seven and one-half years of the Coastal Hazards Center of Excellence at Jackson State University and will continue to be strengthened throughout the five year Coastal Resilience Center of Excellence program. Research staff and graduate students have a direct participation in at least one research partners project and in highly relevant hurricane barrier projects nationwide (funded by others) including the Ike Dike concept for protecting Galveston Island and the greater Houston metropolitan area from devastating, albeit low probability, hurricane surges. Coastal Engineering programs nationwide have been on a decline for the past two decades and United States leadership in the coastal engineering profession has declined relative to other nations. This project will help ameliorate that trend while increasing the supply of minority coastal and computational graduate level engineers focused on the field of coastal natural disasters.

6. End users:

End User	Agency/Employer	Project Role
Dr. Christina Lindemer	FEMA Region IV	Transition, employer
BG (Ret) Robert Crear Chairman, Free Flow Power Development, LLC	Free Flow Power	Collaborator (guest lecturer), Transition (helps students with internships/employment).
Mr. Mark Sanders GIS Specialist	MEMA	Collaborator, Transition (employer and co-author).
Dr. Tooran Enami Assistant Professor USCG Academy	USCG Academy	Collaborator, potential co-author & intern employer
Mr. Henry Dulaney Branch Chief, Vicksburg District	USACE	Transition (employer)
Ms. Jennifer Constantine, Senior Association Coordinator	Louisiana Emergency Preparedness Association	Collaborator (potential employer).
Mr. John T. Weeks, PE Vice President	SDW	Transition employer
Commander Zeita Merchant, Special Assistant to Vice Commandant	USCG	Collaborator, coordinator with Commandant Office
Jocelyn Pritchett, PE President	Pritchett Engineering and Planning, LLC	Transition, employer of interns and graduates.
Dr. David Pittman, Director	ERDC	Transition, signatory for ERDC Education Partnership Agreement with JSU
Dr. James R. Houston Director Emeritus, ERDC	ERDC, Retired	Collaborator.
Mr. Jose Sanchez Director, Coastal and Hydraulics Laboratory (CHL)	ERDC	Transition; CHL is source of Adjunct faculty, graduate

		students and employs JSU interns and graduates
Dr. Reed L. Mosher Director, Information Technology Laboratory (ITL)	ERDC	Transition; ITL employs interns & graduates. Approver for Computational assets/use
Mr. Bart Durst Director, Geotechnical and Structures Laboratory (GSL)	ERDC	Transition; GSL employs interns & graduates.
Dr. Gary Anderton Director of Human Capital	ERDC	Transition, Key person in strategic recruitment
Dr. Lihwa Lin Research Engineer	ERDC	Graduate Adjunct Professor
Mr. Mark B. Gravens	ERDC	Undergraduate Adjunct Professor.
Dr. Chris Massey	ERDC	Graduate Adjunct Professor
Dr. Gaurav Savant	ERDC	Graduate Adjunct Professor
Dr. Jeffrey A. Melby	ERDC	Transition; Guest Lecturer

7. Unanticipated Problems:

Jackson State University experienced severe unanticipated fiscal challenges and leadership changes during Year 2. Our President resigned in November 2016 amid very public media reports of an 89% decrease in operating funds from ($37M to $4M) over a four year period and a less than two week backlog of operating funds. To further accelerate the fiscal challenges the Governor decreased university funds (all state universities) three times during Year 2. An interim President was appointed (retired Dr. Rod Paige, former US Secretary of Education) and a new President was announced the first week of June 2017, effective July 1, 2017. These challenges caused numerous university wide fiscal limitations and typical blanket policy responses that are impossible to challenge. It was deemed unwise to submit documentation requesting a new PhD concentration among the Year 2 fiscal turbulence even though the cost to the university for the program is, for all practical purposes zero. The plan to address this challenge was/is to delay submission of documentation for the PhD Coastal Engineering concentration until July 2017. This strategy should not impact the Year 4/5 goals relating to PhD graduates. We already have two PhD students enrolled in the PhD Civil Engineering concentration that will change their concentration to coastal engineering immediately on approval. At least one additional PhD student will begin in Fall 2017.

***8.* Project Impact:**

The major impact of this project on current workforce capabilities will be to start providing a relatively steady supply of, mostly minority, graduate coastal engineers for the greater Homeland Security (HS) enterprise. Four graduate students who completed all required Coastal Engineering concentration courses were awarded MS Engineering degrees during year 2, and all four are continuing their graduate education and pursuing a PhD Engineering degree. A fifth (African American) engineer will receive his MS Engineering (Coastal Engineering concentration) degree in Year 3 in December 2017. He is employed full time in the HS enterprise by the U.S. Army Corps of Engineers, Vicksburg District. At or before, as scheduled, the conclusion of year 5, we project that one or more PhD Engineering degrees

will be awarded. At the current time I have three PhD students enrolled and taking classes and one more will enroll in fall 2017. There are very, very few African American coastal engineers in the United States. This project will make a substantial contribution to resolving that shortage.

Almost all universities use slight variations of the following processes to ensure courses incorporate pertinent literature advances in the field and contain state of the art content. The very strict ABET engineering accreditation process reviews each engineering degree program every six years (or sooner if weaknesses were detected). The review process includes a review of a large 3 ring binder (can be electronic) for each class which contains, lectures, homework assignments, final exams, required technical papers/presentations, notes; quizzes; tests electronic media if used and all material used or provided the students. Three samples of student work on every assignment (excellent, average and below average) are requirement. The ABET evaluators have an entire day to review this material uninterrupted. Evaluators interview each professor that teaches in the program. This process forces an update of each course syllabus at least every six years. Practically speaking, each course is likely revised every two or 3 years. The other independent Accreditation process is the SACS (Southern Association of Colleges and Schools) that accredits every university in the southeastern US every ten years. While quite rigorous and trending, more and more to duplicate ABET accreditation processes it is less often and less intense out of necessity since it covers every program (undergraduate and graduate) at a university. Beyond these, each professor is expected to keep current in their area of expertise and to keep current in their field. In addition to annual evaluations, this includes five year post tenure reviews, to determine if they remain tenured professors or are placed on a performance improvement plan. This includes five year reviews for tenured professors. In order to maintain a Professional Engineer License (all Civil Engineering professors at Jackson State University are Registered Professional Engineers in at least one state), an average of 15-20 Professional Development Hours (PDH) are required annually (two hours must be engineering ethics hours). There are slight variations in the number of hours from state to state. In my specific case, I have been granted the status of Diplomate in the specialty of Coastal Engineering by the Academy of Coastal, Ocean, Port and Navigation Engineers (ACOPNE). This particular Certification was granted on June 5, 2014 and must be renewed every two years with at least 32 PDH hours. ABET accreditation is by far the most intensive and most rigorous degree program accreditation of any university major.

9. Education Activity and Milestone Progress:

The university fiscal challenges caused numerous actions including a hiring freeze, temporary policy to have no Adjunct Professors teach classes, a reversal of granting out of state tuition waivers for STEM majors, salary freezes, and reductions in force. It was deemed (by the PI) to not be a prudent time to submit documentation for a new degree concentration. A new President has been hired effective July 1, 2017. Documentation submittal for the Coastal Engineering concentration of the PhD Engineering degree program was delayed until July 2017. It will not progress past the college until after the 2017-2018 school year begins during the fall semester and it is envisioned that it should proceed in an orderly manner at that time. This delay will not impact PhD degree award milestones in Years 4 & 5.

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Prepare Coastal Engineering concentration documentation	12/30/16	100%	
Submit Coastal Engineering documentation for approval	1/1/17	0%	Although preparation was completed 100%, the submittal date was delayed to July 2017 by PI due to university fiscal challenges described above that likely would have precipitated an undesired response.
Continue to Teach BS/MS classes	6/30/17	100%	
Seek research funds from outside sources	continuous	100%	
Education Milestone			
Continue to graduate students enrolled in BS/MS Coastal Engineering classes	5/30/17	100%	
Receive approval for Adjunct professors	12/30/16	100%	
Receive approval for PhD Coastal Engineering concentration	6/30/17	0%	Completion expected 05/15/18 due to university fiscal challenges described previously.
Schedule first PhD level new class	6/30/17	100%	CIV 632 Tides and Long Waves is being offered for the first time in Fall 2017 (8 students enrolled)

10. Transition Activity and Milestone Progress:

Enrollment of students in the BS/MS coastal engineering courses continued. Two enrolled BS students graduated and two enrolled MS students graduated. Mr. Rahmatullah Faizi graduated in Dec. 2016 and Ms. Mireille Tchuisseu graduated on April 30, 2017. Both students graduated with a MS Engineering (Coastal Engineering concentration) degree. Each are working fulltime in the greater Jackson Metropolitan area. One is working in the greater Homeland Security enterprise with a local civil engineering industrial firm and the other is a rising employee of Nissan Inc. Both graduates were recipients of scholarship funds provided by the DHS Education and Workforce Development Program managed by Ms. Stephanie Willett, DHS. Each applied for admission to the JSU PhD Engineering program and each has been accepted. They will be part time PhD graduate students in Fall 2017 and are enrolled in two courses each for the Fall 2017 semester. I am their graduate (PhD) advisor. We had two other MS Engineering degrees awarded in Dec. 2016 where the graduates completed all requirements for the Coastal Engineering concentration; however, they chose to graduate in the Civil Engineering concentration. I was/am a member of their Graduate committee; although not the Chair. These students were Mr. Xuesheng Qian and Ms. Lei Bu. Both are pursuing their PhD Engineering degree.

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Continued enrollment of students in BS/MS programs	6/30/17	100%	
Transition Milestone			
Graduation of BS/MS students and employment in the greater HS enterprise or continued graduate school enrollment.	6/30/17	100%	

11. Interactions with research projects:

During the summer of 2016 (June 1 thru Aug. 10), Mr. Xuesheng Qian, a Civil Engineering (Water Resources Engineering concentration) PhD student was a JSU CRC SUMREX (Summer Research Experience) student at the University of Texas working with Dr. Clint Dawson and his team performing ADCIRC hurricane surge modeling research in the Gulf of Mexico. Mr. Qian has taken every coastal engineering and computational engineering graduate course offered at JSU and has honed his computational fluid dynamics skills quite remarkably. He is projected to graduate in Dec. 2017. Ms. Sabrina Welch is a JSU SUMREX student during the summer of 2017 working with Dr. Stephen Medeiros and his teaching assistant at the University of Central Florida (May 21 to June 10) and with Dr. Scott Hagen and his research team at LSU (June 11 to June 30) in the ADCIRC modeling SUMREX program they started last summer. Ms. Welch is joined by another graduate student from University of Puerto Rico, Mayaguez in this excellent UCF/LSU SUMREX program.

Ms. Welch attended the ADCIRC Boot Camp and Users Group meeting held in Boston, MA (May 1 to May 5, 2017) and had the opportunity to meet Dr. Leuttich, CRC PI and Dr. Chris Massey, ERDC and other key researchers and graduate students using the ADCIRC modeling system. This summer's activities for Ms. Welch and her year 2 coursework are a very deliberate plan to prepare her to use the ADCIRC modeling system as part of her PhD dissertation. Ms. Welch was admitted directly to the PhD Engineering graduate program based on her exemplary undergraduate Civil Engineering degree performance (Summa Cum Laude).

The talents of our CRC Senior Research staff member, Br. Bruce Ebersole, were utilized to help mentor Ms. Sabrina Welch in her learning process of applying ADCIRC to the Houston/Galveston, TX area. Leveraged funds from the first two research projects in Table 2 were used to fund Mr. Ebersole plus some funds from the CRC research project of Dr. Resio at University of North Florida.

We plan to incorporate an ADCIRC oriented computational fluid dynamics class as an elective in our PhD Coastal Engineering concentration in either year 3 or year 4 of the CRC. The course would be taught by Dr. Chris Massey, ERDC, who is an approved Adjunct Professor at JSU.

Dr. Gavin Smith, CRC Director gave a seminar at Tougaloo College on April 7, 2017 at which a number of JSU CRC professors, staff and graduate students attended. All coastal engineering staff, graduate students and professors were invited.

In summary, students in this Education Project have benefitted from research project interactions at University of Texas, University of Central Florida, Louisiana State University, University of North Florida and University of North Carolina. Additional student research interactions occurred with renowned engineers at ERDC (a partner) and students and professors from Texas A&M, Texas A&M Galveston, Rice and Technical University, Delft in The Netherlands (leveraged interactions from the first project in Table 2).

12. Publications:

- Whalin RW. HBCU Engineering Faculty and Graduates: Implications for Race, Retention and Graduation Linkages, NAAAS & Affiliates 2016 National Conference Proceedings, Baton Rouge, LA, published Oct. 2016.

- Whalin RW, Pang Q, Latham J, Lowe LN. Assessment of a Summer Bridge Program: Seven Years and Counting, 2017 ASEE National Conference Proceedings, Columbus, OH, June 24-28, 2017.
- Whalin RW, Brody SD, and Merrell WJ. The Galveston Bay Region as an International Test Bed for Flood Risk Reduction, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016.
- Ebersole B, Richardson TW, and Whalin RW. Modeling Coastal Storms: Past, Present and Future, 8th Texas Hurricane Conference, University of Houston, Houston, TX, August 5, 2016

13. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by Jackson State University under Project PhD in Engineering (Coastal Engineering and Computational Engineering concentration) at an HBCU						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
CIV631	Linear Theory of Ocean Waves	T	T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		6	5			
CIV637	Advanced Design for Breakwater Rehabilitation	T	-			
Offering: Elective (E), Concentration (C), Minor (M)		C	-			
Enrollment		3	-			
CIV642	Prestressed Concrete Design	T	-			
Offering: Elective (E), Concentration (C), Minor (M)		E	-			
Enrollment		4	-			
CIV698	Independent Study (4 separate courses)	T/R (4 courses)	T/R (4 courses)			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		1 each	1 each			
CIV538 Spring 17	Coastal Structures	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	C			
Enrollment		-	6			
CIV636 Fall 16	Spectral Wave Analysis	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	C			
Enrollment		-	5			
CIV539	Advanced Coastal Engineering Design	-	T			

Fall 16						
Offering: Elective (E), Concentration (C), Minor (M)		-	C			
Enrollment		-	6			
CIV520	Advanced Engineering Analysis	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	C			
Enrollment		-	9			
CIV535	Pavement Design	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	E			
Enrollment		-	8			
CIV542	Advanced Design of Concrete Structures	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	E			
Enrollment		-	9			
CIV544	Advanced Design of Steel Structures	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	E			
Enrollment		-	8			
CIV544	Advanced Design of Hydraulic Structures	-	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	E			
Enrollment		-	9			
Total		17	69			

Table 2: Documenting External Funding and Leveraged Support

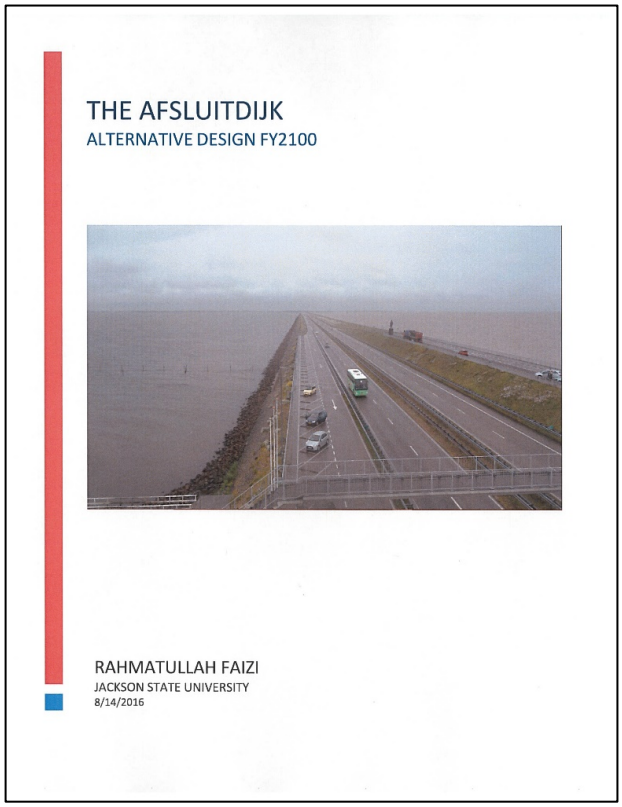
External Funding			
Title	PI	Total Amount	Source
Coastal Flood Risk Reduction	Robert W. Whalin	$99,514	Texas A&M University, Galveston (NSF PIRE)
Hurricane Storm Surge Study for Galveston Bay, TX	Robert W. Whalin	$26,524	Texas A&M University
Maritime Transportation and Education Center (MarTREC)	Feng Wang (PI) Robert W. Whalin (Co-PI)	$185,000	University of Arkansas (Tier 1) UTC
Southeastern Transportation Research, Innovation Development and Education Center (STRIDE)	Feng Wang (PI) Robert W. Whalin (Co-PI)	$112,150	University of Florida (Regional) UTC
Total		$423,188	
*UTC- US Department of Transportation, University Transportation Center			
Leveraged Support			
Description			Estimated Annual Value
High Performance Computer Time (No Cost)			$36,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	5	4
Undergraduates provided tuition/fee support (number)	1	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	4	7
Graduate students provided stipends (number)	2	6
Undergraduates who received HS-related degrees (number)	2	3
Graduate students who received HS-related degrees (number)	0	4
Certificates awarded (number)	0	0
Graduates who obtained HS-related employment (number)	1	2
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number) (includes peer-reviewed conference proceedings)	2	0
Journal articles published (number) (includes peer-reviewed conference proceedings)	2	4
Conference presentations made (number)	2	4
Other presentations, interviews, etc. (number)	5	3
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	4
Requests for assistance/advice from other agencies or governments (number)	0	3
Total milestones for reporting period (number)	3	4
Accomplished fully (number)	2	3
Accomplished partially (number)	1	0
Not accomplished (number)	0	1

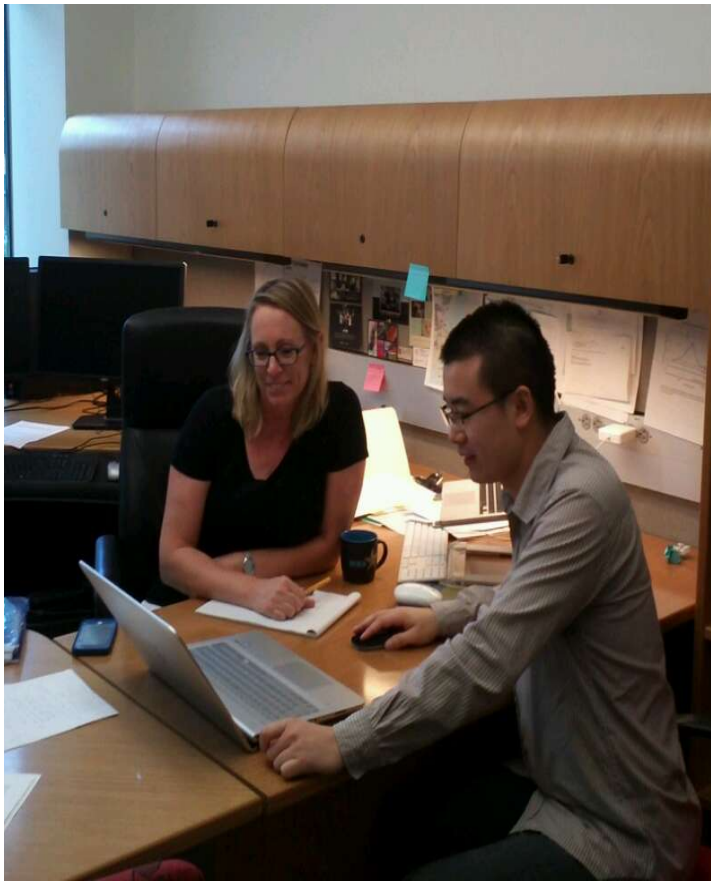
Project Title: PhD in Engineering at an HBCU.

Images for Year 2 Annual Report: 2016 and 2017 Netherlands Research



Project Title: PhD in Engineering at an HBCU.

Images for Year 2 Annual Report: 2016 and 2017 SUMREX Activities



2016 SUMREX University of Texas

2017 SUMREX University of Central Florida

CHEN, JCSU

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Preparing Tomorrow's Minority Task Force in Coastal Resilience through Interdisciplinary Education, Research, and Curriculum Development

2. **Principal Investigator / Institution:**

   PI, Dr. Hang Chen, Johnson C. Smith University

   Other Education Participants/Partners: UNC-Chapel Hill, UNC-Charlotte, and Jackson State University (major partners)

3. **Short Project Description:**
   We focus on the integrative, interdisciplinary nature of real-world problems and strive to bridge traditional academic programs to develop solutions to coastal resilience and its related problems facing our nation. The proposed program will build an undergraduate education framework to prepare tomorrow's minority task force in coastal resilience (approximately 80% of students are minorities), which presents tailored courses in coastal resilience, applied research experience, knowledge transfer activities, scientific seminars, and summer camps.

4. **Abstract:**

   Given the national need to prepare future coastal resilience professionals with educational and research experience, this proposed program supports a critical mission. Most existing coastal resilience related curriculum currently either target graduate programs or vocational education. We will develop an undergraduate education framework that meets the needs and standards for excellence in undergraduate education.
   The project is designed around the following aims:
   1) **Aim 1**: Develop a curriculum to prepare undergraduate students for careers in coastal resilience;
   2) **Aim 2**: Create partnerships to conduct applied research in the area of coastal resilience;
   3) **Aim 3**: Create ongoing opportunities for the transfer of skills, knowledge, people and ideas between JCSU and the community at large.

   To help reach these goals, we define the following objectives:
   1) **Objective 1**: Develop four new courses to educate students with demonstrated interests and aptitudes in coastal resilience study;
   2) **Objective 2**: Design and deploy interdisciplinary coastal resilience seminar series;
   3) **Objective 3**: Establish and develop Faculty/Student research collaborations in coastal resilience;
   4) **Objective 4**: Design and offer a summer camp to expose and increase the awareness of undergraduate students in coastal resilience study.

5. **End users:**

End User	Agency/Employer	Project Role
Dr. Rick Luettich	Principal Investigator & Director, the U.S. Department of Homeland Security's Coastal Resilience Center of Excellence UNC-Chapel Hill	External Advisor
Dr. Gavin Smith	Director, the U.S. Department of Homeland Security's Coastal Resilience Center of Excellence UNC-Chapel Hill	Collaborator (guest lecturer); Transition (helps students with internships/employment).
Dr. Robert W. Whalin Thomas Richardson	Jackson State University	Collaborator; Transition (Graduate study pipeline)
Wie Yusuf Associate Professor, Old Dominion University, School of Public Service, Strome College of Business	**Old Dominion University**	Transition (helps students with internships/employment).
Casey Dietrich **Assistant Professor, Department of Civil, Construction, and Environmental Engineering**	*NC State University*	Collaborator (guest lecturer, research project supervisor); Transition (Graduate study pipeline).
Elizabeth Austin	Society for Information Management-Charlotte region Chapter	Transition (helps students with internships/employment).
Dr. Mohamed Shehab	UNC Charlotte	Collaborator (guest lecturer, research projects supervisor); Transition (Graduate study pipeline).
Dr. Bei-Tseng Chu	UNC Charlotte	Transition (Graduate study pipeline).
Dave Canaan Mecklenburg County Water & Land Resources Director	Mecklenburg County	Collaborator (guest speakers); Transition (helps students with internships/employment).
Jeff Stovall Chief Information Officer at City of Charlotte	City of Charlotte	Collaborator (guest speakers); Transition (helps students with internships/employment).

6. **Explanation of Changes:**

Developed a new minor in sustainability. It will take effect in Fall 2017. It was not in the original plan. The recent literature and research argued that sustainability encompasses natural hazards. It is becoming increasingly clear that enhancing the capacity of social-ecological systems to cope with, adapt to, and shape change is central to building sustainable and resilient development pathways in the face of climate change. Natural disaster reduction and sustainable development are necessarily woven together. The Sustainability minor is a flexible program open to all majors. Students will be exposed to various concepts of sustainability and modern sustainable practices that can be used to address current issues affecting society, organizations, and the world. Therefore, our program is well aligned with DHS S&T Coastal Resilience Center of Excellence (CRC)'s research agenda, and supports the critical mission of DHS.

7. **Unanticipated Problems:**

None.

8. **Project Outcomes:**

There are numerous jobs in the DHS enterprise available for qualified candidates majored in Computer Science and Engineering. Nearly 70% of graduates with a master's degree in computer science are international students. Since candidates must be U.S. citizens to fulfill federal government jobs, many employers are facing a serious shortage of computer science and engineering professionals. Moreover, according to the data reported by the Computing Research Association, only 4.5% of all new recipients of bachelor's degrees in computer science or computer engineering are African American. It is critical to recruit and retain more underrepresented minority students into the STEM pipeline

All DHS end users who hire engineers, regardless of degree level, need engineers to have as much knowledge of coastal natural disasters as possible. However, most existing coastal resilience related curricula either target graduate programs or vocational education. No other computer science and engineering undergraduate program in the U.S. offers courses which focus on natural disaster resilience.

The education program we propose meets the needs and standards for excellence in undergraduate education. The curriculum and research experience will provide students a solid knowledge foundation and skills to conduct coastal resilience research. JCSU is a HBCU with an approximately 80% minority population. Studies suggest that building partnerships between research-intensive universities and undergraduate-focused, minority-serving institutions can go beyond merely supplying the pipeline. We work with partner intuitions to identify gaps in the undergraduate training of coastal resilience for DHS and other agencies to ensure their success in graduate school and future careers.

Year 2 (January 1, 2016 to June 30, 2016) Outcome highlights:

1. Developed a new course, Hazards Risk Management. Nine students enrolled in this course in Spring 2017 semester.
2. Develop a new interdisciplinary minor in Sustainability.
3. Leverage Funding received in 2016-2017: North Carolina GlaxoSmithKline Foundation $25,000 for Summer Sustainability Enrichment Program. Z. Smith Reynolds Foundation $25,000, Green to Green Project: Economic Development through Urban Agriculture. Google, Inc. Foundation, $45,000, Google Entice program. William R. Kenan, Jr. Charitable Trust, $555,000 STEM Innovation Initiative.
4. Nine students participate coastal resilience undergraduate research projects in fall and spring semester.

5. Nine students who participated DHS CRC research graduated in May 2017. One student is awarded full scholarship to attend Applied Computer Science Master program at East Tennessee State University.
6. Two students received NSF CyberCorps scholarship for service.
7. Twenty students participated coastal resilience one-week summer camp, May 15 to 19, 2017.
8. Nine students conducted four-week summer undergraduate research, May 22 to June 16, 2017.
9. Hosted Re-talks semester with CRC research partners from Old Dominion University, UNC Chapel Hill, and North Carolina State University.
10. Collaborated with Dr. Casey Dietrich, research partner PI at NCSU to develop a field trip at NCSU.

9. **Education Activity and Milestone Progress:**

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Develop one new course.	04/30/2017	100%	
Host Three Seminars.	04/30/2017	100%	
Select eight students to conduct research projects	01/30/2017	100%	
Design a one-week summer camp focused on Coastal Resilience	06/01/2017	100%	
Select nine students form the summer research teams.	07/01/2017	100%	
Education Milestone			
New course will be offered for spring semester.	05/01/2017	100%	
New Minor in sustainability is approved in spring semester	05/01/2017	100%	
Twenty Students complete the one-week summer camp.	05/30/2017	100%	
Nine students complete the four-week summer research projects.	06/30/2017	100%	

10. **Transition Activity and Milestone Progress:**

Transition Activities and Milestones: Progress to Date

Reporting Period 07/01/2016 – 6/30/2017			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
The students who participated in the research projects will be available for employment in the greater Homeland Security enterprise.	06/30/2017	On schedule	Employers feedback show that this research experience is valuable for job placement. Most graduates are working in private section. In year 3, we will emphasize on internships, graduate programs, and DHS career placements.
Dissemination of the undergraduate education and research education framework and results.	06/30/2017	On schedule	In year 2, we supported students to attend the Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM), and the National Society of Black Engineers Annual Convention. Two students presented their research on ERN conference.
Develop the collaboration with research partners.	06/30/2017	On schedule	
Transition Milestone			
Graduates are employed in greater HS enterprise or continued graduate school enrollment	06/30/2017	On schedule	Nine students who participated in this program graduated in May 2017. One student is awarded scholarship to attend graduate school.
Conference presentation and publications of the project results.	06/30/2017	On schedule	Two students presented their research on ERN conference. One research manuscript is submitted.

Students present research finding at regional and national conferences.	06/30/2017	On schedule	Nine students will submit their research posters to 2018 National Undergraduate research conference.

11. **Interactions with research projects:**
    1. Dr. Whalin reviewed our grant proposal for the DHS Scientific Leadership Awards for Minority Serving Institutions (MSI). Dr. Gavin Smith provided us a letter of support on behalf of CRC.
    2. Three research PIs visited JCSU in 2016-2017 to give the RE-Talk Seminars.
    3. Nine students in CRC's JCSU Summer Research Program visited NCSU Department of Civil, Construction, and Environmental Engineering hosted by Dr. Casey Dietrich. This field trip is well-planned and successful. The director of graduate program gave an overview of NCSU CCCE department, and summer and graduate programs opportunities. Dr. Dietrich arranged presentations and discussions with faculty members in their computing & system group. Ten faculty members presented their interdisciplinary research projects addressing problems throughout civil and environmental engineering using computational tools. The JCSU students also sit with Dr. Dietrich's graduate students at their workspaces and learned more about their research and workflows. This field trip provided our students opportunities to be cognitively engaged and challenged, as they explored areas of personal interest and curiosity and engaged in communication with graduate students and faculty members. It also allows us to know each other better and identify opportunities for future collaboration.

12. **Publications:**

Cody Byrd, Jean-Marie Nshimiyimana, Ehije Idehenre, Hang Chen (Faculty Advisor), "Data Analysis of Haiti's Resiliency Post-2010 Earthquake". Presented at the 2017 **Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM)**.

NyJae Dickerson, Adonis Tillman, Desmond Taylor, Awatif Amin (Faculty Advisor) "Using Data Mining to analyze Natural Disasters at 10 countries". Presented at the 2017 **Emerging Researchers National (ERN) Conference in Science, Technology, Engineering and Mathematics (STEM)**.

Ying Bai, Hang Chen, "Build a Real Time Optimal Evacuation Contraflow Model for Natural Disasters by Using a Fuzzy Inference System," Submitted for review.

Student has completed their research projects in summer 2017. The abstracts will be submitted in fall 2017 National Undergraduate Research Conference.

Aaron Smith, "Analyzing Mecklenburg County's Flooding Resilience."

Amyr Washington, Tendru Howell "Vulnerability Assessment: New Orleans, Louisiana vs. Savannah, Georgia."
Imyer Majors, Frandy Prince, and Djerhkea Epps Dukes, "Hurricane Vulnerabilibity Assessment: North Carolina Coastal Counties."

Thandiwe Balani, QUintavious Coleman, Ashenafi Tsaudu, "Using Fuzzy Interference System to Build Real Time Optimal Evacuation Contraflow Model."

13. **Tables:**

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed by Johnson C. Smith University under Project Preparing Tomorrow's Minority Task Force in Coastal Resilience through Interdisciplinary Education, Research, and Curriculum Development						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
CSC436	***Hazard Risk Assessment***	D	T			
Offering: Elective (E), Concentration (C), Minor (M)		-	-			
Enrollment			9			
	Community Resilience Summer Camp	D/T	T/R			
Offering: Elective (E), Concentration (C), Minor (M)		-	-			
Enrollment		20	20			
	Coastal Resilience Summer Research	T/R	T/R			
Offering: Elective (E), Concentration (C), Minor (M)		-	-			
Enrollment		9	9			
	Minor in Sustainability	-	D			
Offering: Elective (E), Concentration (C), Minor (M)		-	M			
Enrollment		-	-			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Summer Sustainability Enrichment Program	Terik Tidwell, Director of STEM Innovation	$25,000 We utilized the fund to support 1 faculty to develop community resilience summer camp for K-12 students.	North Carolina GlaxoSmithKline Foundation
Carolina Cyber Defense Scholarship	Hang Chen	$262,917 We utilized the fund to support undergraduate tuition and travel.	NSF
Google Entice program.	Terik Tidwell	$45,000, 2-week Computer Principle Training for two staff members.	Google, Inc. Foundation

		STEM summer camp. 30 Mac Laptops to support the program.	
STEM Innovation	Hang Chen	$555,000 Support students to attend conferences and faculty professional development activities.	William R. Kenan, Jr. Charitable Trust, STEM Innovation Initiative.

Leveraged Support	
Description	Estimated Annual Value
Reduced indirect cost of 8% (DHS negotiated rate of 34.4%)	$20,188
In-kind faculty time to supervise Summer Research for 4-weeks ($3,000 stipend)	$25,000

14. **Metrics:**

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	1	1
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	37	47
Graduate students provided tuition/fee support (number)	0	0
Graduate students provided stipends (number)	0	0
Undergraduates who received HS-related degrees (number)	9	20
Students who participated CBC Research		
Graduate students who received HS-related degrees (number)	0	0
Certificates awarded (number)	0	0
Graduates who obtained HS-related employment (number)	3	0(*)
Lectures/presentations/seminars at Center partners (number)	0	0
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	1	1
Journal articles published (number)	0	0
Conference presentations made (number)	0	2
Other presentations, interviews, etc. (number)	0	0
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	0	0
Requests for assistance/advice from other agencies or governments (number)	0	0
Total milestones for reporting period (number)	7	6
Accomplished fully (number)	4	6
Accomplished partially (number)	3	0
Not accomplished (number)	0	0

*: No 2017 graduates work with DHS agencies directly. But many work in insurance and financial institutions, whose companies must often retool their IT systems and data centers to cope with the possibility of power-grid problems, terrorist attacks and other unforeseen events. Additionally, two students are awarded CyberCorp Service scholarship. When they graduate in 2018, they are required to work with federal agencies.

LAIJU, TOUGALOO

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers Reporting Period July 1, 2016 – June 30, 2017

1. **Project Title:**
   Institutionalization, Expansion, and Enhancement of Interdisciplinary Minor: Disaster and Coastal Studies

2. **Principal Investigator / Institution:**
   Meherun Laiju, Ph. D. Associate Professor and Chair,
   Sociology Department; Tougaloo College

3. **Other Education Participants/Partners:**
   Interdisciplinary collaboration within Tougaloo
   College (Sociology, Psychology, Physics and Political Science Departments faculty members)

4. **Short Project Description ("elevator speech"):**

   The project goal is to offer curriculum at Tougaloo College, making it more relevant to education and workforce development in homeland security operations. Three initiatives has been done to reach the goal: a) Interdisciplinary Minor in Disaster and Coastal Studies (DCS) offered courses and research opportunity to train undergraduate students in interdisciplinary skills necessary to mitigate natural and man-made coastal hazards, b) Develop professional certificate program's to create a workforce for (DHS) and emergency management agencies, c) neighborhood outreach initiatives in collaboration with Mississippi Emergency Management Agency (MEMA), to facilitate education and training for local citizens in planning and implementing disaster strategies to build a more effective path to societal resilience and security.

5. **Abstract:**

   This project took initiatives to institutionalization, expand, and enhance the Interdisciplinary Minor: Disaster and Coastal Studies implemented during the Coastal Hazards Center of Excellence-Education (2008-2015). The minor provide students an opportunity to be trained in interdisciplinary fields across academic divisions (Natural Science and Social Science), which is uncommon in small historically black colleges. Faculty members from Sociology, Psychology, Physics and Political Science departments collaborated to teach and modify courses which includes adding GIS component, FEMA's Independent Study (IS) Training. Students pursuing the minor participate in faculty lead research in the field of community preparedness to enhance community resilience. Student receive training in the critical needs area through education, participating in research, and field experience by completing an internship with a local emergency management agencies. The exposure helps students to acquire highly portable skills necessary to succeed in high impact careers, thus creating a more diverse future workforce. Furthermore, the project addresses the acute underrepresentation of African American minorities in the Science, Technology, Engineering and Mathematics (STEM) areas. In addition, worked on developing a professional certificate

program which will prepare undergraduates to join in workforce related to DHS and emergency management agencies. The pilot program neighborhood outreach initiative in collaboration with MEMA offer opportunities for community leaders and interested citizens to be trained as first responders. The aim of this initiative is to facilitate DHS initiatives to build resilient community(ies) as a part of national preparedness in time of steady-state and natural and man-made disasters.

6. End users:

During the Spring 2016 academic session, an advisory committee was put together. The committee members are assisting in the designing the professional certificate program and neighborhood training. The committee members met at least once a semester, most of the time correspondence and meetings are conduct by email and phone. The participants and their roles are included in the following table:

End User	Agency/Employer	Project Role
Dr. Nicole Cathy	Political Science; TC	Coordinator
Dr. George Humphrey, CFM	Director (grants)MEMA	DCS Instructor, Place Intern
Mr. John Brown	Regional Manager; Red Cross	Serve on panel, place Intern
Ms. Loretta Thorpe, MEP	Bureau Director-Training State Training Officer, Office of Preparedness, MEMA	Serve on panel, Place Interns, & neighborhood training coordinator
Mr. Jesse Murphree	Emergency Preparedness Training Officer, MEMA	Conduct the neighborhood training
Ms. Marsha Manuel	Grant Director, MS office of Homeland Security	Serve on panel, Intern placement
Colonel Donnell Berry	MS State Trooper	Serve on panel
Mr. Ricky Moore	Director, Hinds County Emergency Management	Serve on Panel
Mr. Warren D. Miller	President, Mississippi Voluntary Organizations Active in Disaster(VOAD)	Serve on Panel, Intern Placement
Phyllis Parker	Director, Woodhaven Homeowners Association	Serve on Panel
Mr. Anderson	Pastor, United Methodist Church	Serve on Panel
Dr. Shaila Khan	Psychology Department, TC	DCS Instructor &Mentor student research
Dr. Santanu Banerjee	Physics Department, TC	DCS Instructor &Mentor student research

7. Unanticipated Problems:

The delivery method has been changed for the certificate program. Initially the non- credit bearing certificate program was commenced by the Tougaloo College Continuing Education Program for the community at large. The change of administration (Provost) during fall of 2015 and in spring of 2016 led to the administration decision to phase out the continuing Education Department and created a problem for the proposed certificate program. Anyhow, by March 2016, it was decided that the certificate program will be offered by Sociology Department in collaboration with the Political Science Department. Dr. Nicole Cathy, assistant professor of the Political Science Department, is assigned as a coordinator. We have contacted the local emergency management agencies and setup an advisory board to assist us in designing the certificate program. Unfortunately, we had to face another unanticipated challenge. In the fall of 2016, the new administration focused on restructuring the general education (common core) curriculum. The new curriculum reduces the general education requirements from 60 to 40 (credits hours) and plans to add professional certifications in different fields. These professional certificate program will provide an option for students who want to join in to workforce immediately after completing their undergraduate degree. Currently the proposed certificate program is selected to be part of one of the professional certifications which will prepare students for emergency management related workforce. Advisory committee members input and the existing DCS minor courses will be used to develop the certificate program. The courses will be taught by emergency management personnel, faculty and other relevant parties. The change in administration and their new initiatives put us slightly behind schedule to develop and launch the proposed certificate program.

8. Project Impact:

Tougaloo College is a private Historically Black College which offers undergraduate degree. The majority of the student body is comprised with 1st generation attending college. The main mission of the college is to prepare students for graduate school. The current project addresses the acute underrepresentation of minorities in the science, technology, engineering and mathematics areas (STEM). The project plans to diversify the future of DHS and S &T related workforce by training underrepresented minorities, mirroring some of the more vulnerable population impacted by disaster scenarios. The interdisciplinary minor: Disaster Coastal Studies (DCS) curriculum offers a multidisciplinary approach using social science perspective. The minor is designed to prepare students with skills and knowledge that are marketable in the field of disaster and emergency planning, management, response and recovery. Students pursuing the minor have opportunity to be trained in interdisciplinary fields across academic divisions (Natural & Social Science). The minor consisted of six courses including forty (40) hours of field placement (internship) with local, state, federal, and NGO'S which deals with emergency management. Students are trained in use of GIS and its function in the disaster management field, they also complete the FEMA's Independent Study (IS) Training. All of these are achieved through course work. Student participated in faculty lead research in the field of community preparedness to enhance community resilience. Student presents their research findings in the field of disaster preparedness and recovery at the yearend annual symposium which is attended by various stakeholders including students, faculty, staff, administration, program partners, homeland security related organizations, and community members. The course syllabi, field placement supervisor student evaluation, students' presentation at the symposium, conferences, dissemination materials and program evaluation documents are the medium used to ensure that students are gaining knowledge in state of the art content related to the field. In addition, the pilot

program neighborhood outreach initiative in collaboration with MEMA offered opportunities for community leaders and interested citizens to be trained as first responders. Which lend a hand to facilitate DHS initiatives in building resilient community (ies) as a part of national preparedness.

9. Education Activity and Milestone Progress:

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Offer 6 courses for DCS minor	August, 2016 January 2017	100%	
Select new students for research and training (GIS & Survey Construction and Analysis), develop questionnaire, identify areas to survey, IRB permission, etc.	August – December, 2016	100%	
Select existing courses to modify	September, 2016	100%	
Student/Faculty/staff certified training in GIS	October, 2016	0%	PI was not available during that time due to personal reason. Plan is to complete on October 2017
Select and place intern students to end – user hosting organizations	February, 2017	100%	
Design the certificate program	February 2017	In progress	Due to administration changes and curriculum restructure***
Host DCS Research Symposium	April 2017	100%	
Education Milestone			
Students working in GIS project& risk identification and perception awareness project present at Mississippi Academy of Science (MAS) conference	March 2017	100%	
Intern and DCS minor students present at DCS Symposium & TCMC Undergraduate Research Symposium	April 2017	100%	
Invite CRC partners & end-user agency personnel as guest speaker from partnering institute to present at DCS Symposium	April 2017	100%	

Approval of the certificate program	May 2017	0%	Explained earlier, Fall 2017 we will seek the approval
Expecting 2 students graduate with DCS minor. Encourage graduates to attend graduate program at CRC Institute /seek employment at end-user agencies	May 2017	100%	3 students graduated with DCS minor in May, & 2 will graduate in December 2017
Promote the new certificate program	June 2017	0%	*** see the explanation, possibility to complete by December 2017

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Recruit end-users to provide internships	July 2016 & January 2017	100%	
Recruitment for Certificate Program	January 2017	0%	*** Explained earlier, in progress plan is to launch by December 2017
Transition Milestone			
Internship with end-users organization	June 2017	100%	
Increase enrollment in Certificate Program	June 2017	0%	*** in progress, expected to complete by January 2018

*** The pilot study: Neighborhood outreach Initiatives – the first training was done on May 6, 2017 with the residence of the Woodhaven subdivision in Jackson, MS. This was done in collaboration with Mississippi Emergency Management Agency (MEMA) office of Preparedness. The goal is to strengthen the community resilience. A survey was conducted with the participants after the training. The survey results and the relevant suggestions will be incorporated for future training initiatives. **(Addition to Work Plan)**

11. Interactions with research projects:

The existing Minor in Disaster Coastal Studies hosts a research symposium each academic year. The symposium showcases the DCS students' activities. Dr. Gavine Smith, from the University of North Carolina-Chapel Hill attended the Symposium as a guest lecturer. His talk was entitled *Post Hurricane Mathew Disaster Recovery Assistance: Linking Research, Practice and Community Engagement*. This year, a collaborative working partnership was developed with the University of Rhode Island. Three Tougaloo students, Courtney Hill (Psychology), Rosaline Cisse (Biology), and Kierra Jones (Biology), have been offered summer internships with DHS – Coastal Resilience Center Supported Research at the University of Rhode Island. The students will spend at the institution from June 5 – August 11, 2017.

12. Publications:

Ball, I & Laiju, M. (2017) Sociodemographic Characteristics and Natural Disaster Preparedness among Mississippi Residence, abstract published in *The journal of Mississippi Academy of Sciences* (ISSN 0076-9436) April edition.

Senior paper:
Young, K, & Hunter, F. (2017) Hurricanes, Mudslides, and Drought: Considering the Publics Perceptions of the Role Governments Should Play in Providing Aid Using the NORC General Social Survey (GSS), presented at MCTC research Symposium

Hopkins, A. & Banerjee, S. (2017) Using ArcGIS to Map Natural Disasters in Mississippi presented at MCTC research symposium.

Presentation:
Laiju, M and Banerjee, S (2017) Innovative Interdisciplinary Curriculum in Homeland Security at a HBCU presented this at the 10th Anniversary Homeland Defense & Security Education Summit at George Mason University in Fairfax, Virginia, on March 23, 2017

Award:
Meherun Laiju, received fellowship to participate in the Pardee RAND Faculty Leaders Program in July, 2017 to work on project titled, A Global Issue: Natural, Manmade Disaster, and Exploitation of Children.

Instrument:
Hunter, F and Laiju, M. (2017) developed a survey *Preparing Today for Tomorrow: Neighborhood Outreach Initiative* to administer at May 6 training session. **[see end of this document]**

13. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by Tougaloo College under Project Institutionalization, Expansion, and Enhancement of Interdisciplinary Minor: Disaster and Coastal Studies						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
DCS201	Introduction to Natural and Manmade Disaster		R, T			
	Offering: Elective (E), Concentration (C), Minor (M)		M			
	Enrollment		10			
DCS211	Public Health Issues in Disaster Preparedness	T	T			
	Offering: Elective (E), Concentration (C), Minor (M)	M	M			
	Enrollment	1	10			
DCS 301	Political and Legal Issues in Disaster Preparedness	T	T			
	Offering: Elective (E), Concentration (C), Minor (M)	M	M			
	Enrollment	14	10			
DCS311	Psychological Dimension of Disaster					
	Offering: Elective (E), Concentration (C), Minor (M)	E, M				
	Enrollment					
DCS314	Economic Aspects of Disaster		T			
	Offering: Elective (E), Concentration (C), Minor (M)		E, M			
	Enrollment		14			
DCS 320	Emergency Preparedness, Response and Planning	T	R,T			
	Offering: Elective (E), Concentration (C), Minor (M)	M	M			
	Enrollment	16	8			
DCS 400	Internship	T	T			
	Offering: Elective (E), Concentration (C), Minor (M)	M	M			
	Enrollment	7	8			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			

Leveraged Support	
Description	Estimated Annual Value
Class room space and computer lab for GIS Training, space for hosting Symposium	$15,000
Portion of university indirect returned to project	$15,000
25% release time for PI	$11,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	7	8
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)	15	17
Graduate students provided tuition/fee support (number)	NA	NA
Graduate students provided stipends (number)	NA	NA
Undergraduates who received HS-related degrees (number)	3	5
Graduate students who received HS-related degrees (number)	NA	NA
Certificates awarded (number)	NA	NA
Graduates who obtained HS-related employment (number)		
Lectures/presentations/seminars at Center partners (number)	1	1
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	0	0
Journal articles published (number)	0	0
Conference presentations made (number)	1	4
Other presentations, interviews, etc. (number)	10	12
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	2	1
Requests for assistance/advice from other agencies or governments (number)	5	2
Total milestones for reporting period (number)	7	7
Accomplished fully (number)	4	5
Accomplished partially (number)	3	1
Not accomplished (number)	-	1

SPECIAL MOMENTS

Students and Instructor DCS 400 Internship

Interns with MEMA personnel and Dr. Humphrey

Irenia Ball: Mississippi Academy of Science (MAS) on February 23, 2017

GIS Training Course

DCS Students and Faculty research team

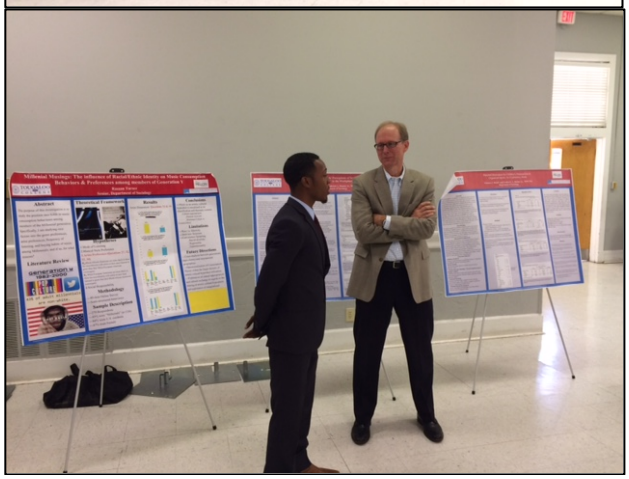
With instructors at Intro to Natural Disaster class

NEIGHBORHOOD OUTREACH TRAINING

Neighborhood Training Participants with MEMA Instructor and DCS faculty

DCS faculty after completing the Preparedness training

DCS RESEARCH SYMPOSIUM (April 2017)



SUMREX 2017 INTERNS FROM TOUGALOO COLLEGE
To
UNIVERSITY of RHODE ISLAND

Courtney Hill

Kierra Jones

Rosalie Cisse

Tougaloo College
Interdisciplinary Minor: Disaster Coastal Studies
Preparing Today for Tomorrow: Neighborhood Outreach Initiative
May 6, 2017
SURVEY

DIRECTIONS: Please complete the following questions to reflect your opinions as accurately as possible and to answer factual questions to the best of your knowledge. Your information will be kept strictly confidential. For the purpose of this survey, use the following definitions for the terms hazard and natural disaster:

- ***Hazard*** is defined as a situation that poses a level of threat to life, health, property, or environment and can create an emergency situation.
- ***Natural disaster*** is a major event that results in the natural process of the earth; for example, floods, hurricanes, tornados, and other geological processes. A natural disaster can cause loss of life or property damage, and typically leaves some economic damage in its wake.

Risk Awareness

How strongly do you agree with the following statements?						
		Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	I am aware of potential local hazards and/or natural disasters effecting my community/city.					
2	I am aware of local community systems and plans concerning local hazards and/or natural disasters.					
3	I am aware of the benefits of designing a plan for local hazards and/or natural disasters for me and my family.					
4	I am aware of local community organizations who participate in providing informational seminars and drills for local hazard planning.					
5	I believe that these types of hazards and/or disasters will occur in my community					
6	I believe that the effects of a hazard and/or disaster would be severe to me.					
7	I believe that preparing for a hazard and/or natural disaster now will help me in the future.					

8	I believe I will be able to successfully respond to a hazard and/or natural disaster.					

Beliefs About Risk and Efficacy

2

In the space provided to the right of the list below, please rank the following types of hazards and/or natural disasters based on their importance to your community (1 as the most important and 10 as the least important).

	Extreme Heat	a prolonged period of excessively hot weather, which may be accompanied by high humidity
	Flood	an overflow of water that submerges land which is usually dry.
	Tornado	a localized, violently destructive windstorm occurring over land
	Wildfire	a large, destructive fire that spreads quickly over woodland or brush
	Hazardous Materials Accident	potentially dangerous or harmful to waste that causes harm to human health or the environment
	Disease Outbreak	the occurrence of cases of disease in excess of what would normally be expected in a defined community, geographical area or season
	Hurricanes	a storm with a violent wind, in particular a tropical cyclone that may reach inland and cause damage
	Terrorism	the unlawful use of violence and intimidation, especially against civilians, in the pursuit of political aims
	Other Natural Disasters	Write in:

Preparedness Behaviors

Which of the following descriptions best captures your level of preparedness for local hazards and/or natural disasters **before** this outreach imitative?

3

1	Pre-contemplation	No intention to change at present, but intending to take action.
2	Contemplation	Not prepared to take action at present, but intending to take action.
3	Preparation	Actively considering changing my behavior in the immediate future.
4	Action	Recent overt behavior change, but the changes are not well established.
5	Maintenance	Have an established plan but will not make any modifications to the plan.

4

Which of the following descriptions best captures your level of preparedness for local hazards and/or natural disasters **after** this outreach initiative?

1	Pre-contemplation	No intention to change at present, but intending to take action.
2	Contemplation	Not prepared to take action at present, but intending to take action.
3	Preparation	Actively considering changing my behavior in the immediate future.
4	Action	Recent overt behavior change, but the changes are not well established.
5	Maintenance	Have an established plan but will not make any modifications to the plan.

5

What do you identify as perceived barriers to your local hazard and/or natural disasters preparedness (planning)? Please use the area to the right to further explain.

1	Too Expensive	
2	Unsure	
3	Time	
4	Barriers to Information	
5	Other	

Plan & Intervention

Following this outreach initiative, how likely are you to do the following:

6

		Very Likely	Somewhat Likely	Not at All
1	Develop a household emergency plan and discuss it with my household members.			
2	Get involved in local opportunities to volunteer for community safety and disaster response.			
3	Assists in a planning process for disaster relief in my community.			
4	I believe I will be able to successfully respond to a disaster.			

7

Considering your future plans, how important are the following for your community.

		Very Important	Moderately Important	Not Important
1	Community training exercises and simulations for planning preparedness.			
2	Community informational sessions with emergency responders, emergency operations centers, and state and federal level disaster management systems to coordinate community preparedness.			
3	Community informational sessions on short and long term federal, state, and local assistance programs, community recovery strategies and actions, and post disaster mitigation planning.			
4	The creation of a, free or low-cost, certificate program at Tougaloo College in disaster preparedness for residents of your community.			

Demographics

8

Pleae write in or circle the corresponding category to the right of the demographic characterisitc listed.

Age								
Gender	Man	Woman						
Housing Status	Rent	Own	Neither					
Ethnciity	White	Black	American Indian	Alaska Native	Asian	Native Hawaiian	Pasific Islander	Other

PAGAN, UPRM

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Education for Improving Resiliency of Coastal Infrastructure

2. **Principal Investigators / Institution:**

   Ismael Pagán-Trinidad (PI), Ricardo R. López (Co-PI), University of Puerto Rico at Mayagüez

3. **Other Education Participants/Partners:**

   ERDC-US Army Corps of Engineers, PR Emergency Management Agency, FEMA, PR Department of Natural Resources, Association of Professional Engineers of PR, UPRM partners (Marine Science Department, Sea Grant Program, CariCOOS NOAA project); NOAA (National Weather Service)

4. **Short Project Description ("elevator speech"):**

   This project will help educate the Coastal Resiliency community by transferring state of practice knowledge to stakeholders (students, faculty, professionals, first responders, and work force) through formal (curriculum, internships, student projects) and informal (workshops, seminars, lectures, short courses, webinars) learning experiences. It will serve as a vehicle to engage the community as a whole to understand and learn its members' roles and responsibilities in providing resilient coastal infrastructure systems. The project will help the community understand better various stages in coastal infrastructure hazard prevention, preparedness, response, recovery, and mitigation. It will also help create pipelines of students and professionals into CRI careers (graduate school and practice).

5. **Abstract:**

   The main goal of this project is to develop and offer formal and informal education through courses, workshops, seminars, lectures, and other educational means leading to advance knowledge on the state of practice on Resiliency of Coastal Infrastructure (built and natural). This initiative aims at creating a Certificate in Resiliency of Coastal Infrastructure. The focus of the project is to provide students and faculty, professionals and homeland security personnel, and affected citizens with capabilities to assess the effects of natural hazards on coastal infrastructure, the conditions of existing structures, and rehabilitation alternatives to mitigate future damage and potential risks. The educational content will focus on pre-incidents, incidents and post-incidents. New courses and existing course revisions will be evaluated in Civil Engineering and related disciplines dealing with estimates of causes and effects caused by of coastal flooding, storm surge, ocean waves, tsunami loads, earthquake effects, and strong winds. Courses will be alternatively offered in the form of conferences, workshops, and lectures. Lecturers from experts from CRC, ERDC, FEMA, and other

partners will be invited to participate. State of practice technology will be a priority, e.g., FEMA P646 publication for tsunami load estimates. The National Infrastructure Protection Plan and state infrastructure protection programs and plans will be addressed. Results of recent research work by UPRM, ERDC, and other CRC partner investigators regarding flood, wave, earthquake and tsunami, and hurricane wind effects on structures will be incorporated. Being a small and fully developed island, Puerto Rico offers the ideal setting to assess lessons learned of the effect of natural hazards on built and natural infrastructure including housing, commercial, industrial, institutional, transportation, communication systems, and others. The Island presents unique challenging settings like overdeveloped and exposed urban areas, vulnerable zones (flood prone, weak soils, hurricane wind exposure), highly concentrated and poorly planned urban communities, stressful tradeoff between urban development and natural ecosystems development and conservation, extreme economic development constraints and suboptimal first responders resources (e.g. funding, equipment, capabilities, training, and others) make the Island educational settings most challenging. All this setting will be available for first hand assessment and evaluation from the educational perspective. This program has also the goal to facilitate internships at CRC universities performing research in CRI and in government agencies and industry dealing with coastal hazards. Being a minority serving institution (MSI) with a high women's participation (near ⅓ in Civil Engineering) it is also our goal to create and capacitate minority Hispanic students, faculty, professionals, and affected citizens to warranty up to date level of competency in Coastal Resilient Infrastructure to this part of the community. Our MSI university has been providing well qualified Hispanic Engineers to US for many years and will benefit from the opportunity to collaborate with DHS and the community it serves.

6. **End users:**

End Users	Role of Participation in the Project
Students:	Trainee; Interns; Undergrad/grad research experiences on RCI topics SUMMER 2016 Oregon State University-Internship: (July) SUMREX 1. Kevin Cueto, MSCE (Struct) Oregon State Univ. 2. Diego Delgado, BSCE, Oregon State Univ., Intern University of Central Florida - Internship (July) SUMREX 1. Felix Santiago, MSCE (Environ.), Univ. of Central Florida, Intern Coastal and Hydraulic Laboratory - ERDC-US Army CoE Internship (July -September 2016) 1. Efrain Ramos, MSCE (Environ.) 2. Jaime Calzada, PHD (Marine Sc.) 3. Gabriela Salgado, MSCE (Environ.) 4. Jesús Otero, MSCE, (Water Resources) 5. Stefanía Quiñones, MSMS (Marine Science) University of Puerto Rico - Mayagüez (UPRM) -Undergraduate Research (July-August 2016) 1. Gabriela Buono, BSCE **FALL 2016 (UPRM)** 1. Kevin Cueto, MSCE (Structures), UPRM, Graduate Research assistant in this project. **SPRING 2017 (UPRM)** **Undergraduate and Graduate research** 2. Alexander Molano-MSCE, UPRM, Graduate Engineering Project (Transportation)

3. Giovani Seijo, BSPH (Physics), UPRM, Research Assistant
4. Paola E Martínez, BSCE (Geotechnical), Undergraduate Research
5. Mark Rivera, BSCE, (Geotechnical), Undergraduate Research
6. Felix Santiago, MSCE(Environmental), UPRM,
7. Kevin Cueto, MSCE (Structures), UPRM, Graduate Research assistant in this project.

Capstone Course: Civil Engineering Senior Design Experience

1. 32 students supervised by 5 professors and 5 graduate students participated in a 1-semester CE Senior Design Experience course. The course focused on training students on designing a coastal urban cluster (Hotel, Shopping Center, and Entertainment Center) considering coastal resilience risk and technology. Trainings were given by invited lecturers and speakers whose talks focused on coastal resilience technology. Community and professionals were opened to the community. Design Process: Founding a company; Feasibility Study; Conceptual; Preliminary and Final Design; Cost Estimate, Construction Management Plan, Sustainability

SUMMER 2017

UPRM

1. Ángel Alicea, PhD, UPRM, Research Assistant in the project
2. Juan Rodríguez, PhD, UPRM, Research Assistant in the project

Coastal and Hydraulic Laboratory - ERDC-US Army CoE Internship (June)

1. Gabriella Buono, BSCE, UPRM.
2. Nelson Cordero, MSMS, UPRM
3. Kevin Cueto, MCSE (Structures), UPRM.

University of Central Florida - Internship (SUMREX)

1. Diego Delgado, BSCE, UPRM.

Oregon State University - Internship (SUMREX)

1. Peter Rivera, BSCE, UPRM
2. Héctor Colón, BSCE UPRM

Faculty	Trainers/Teachers in courses, seminars, workshops; CRI leaders; Project Advisors; Course content evaluators; **Capstone Course: Civil Engineering Senior Design Experience** 1. Five Professors: J. Guevara (Structures), B. Camacho (Geotechnical), C. López del Puerto (Construction); A. Figueroa (Transportation), I. Pagán-Trinidad(Environmental) - Mentors/Supervisors **Faculty In-Charge of Offering Courses or Course Topics** 1. INCI 6066 Master Thesis: Ricardo López, Walter Silva, Luis Aponte 2. INCI 6995 Graduate Special Problems: Ismael Pagán Trinidad 3. INCI 6065 Graduate Civil Engineering Project: Ricardo López 4. INCI 5996 Civil Engineering Special Problems: Benjamín Colucci, Ismael Pagán Trinidad, Ricardo Ramos 5. INCI 4998 Undergraduate Research: Ismael Pagán Trinidad **Faculty In-Charge of Developing Courses or Course Topic and Modules** 1. A.Saffar: Reliability Based Design of Coastal Resilient Structures 2. J. Guevara - Rehabilitation of Coastal Infrastructure 3. W. Silva - Modeling of Riverine and Coastal Flooding
Professionals	Trainee; Trainers; Advisors; Providers of lessons learned; Survey responders for priority needs 1. 7 mentors and 5 mentees at 2016 and 3 mentors and 3 mentees at 2017 Summer Research Internship program at Engineer Research and Development Center of the US Army Corp of Engineers 2. 4 mentors and 3 mentees at OSU, UCF, and LSU 2016 SUMREX 3. 3 mentors and 3 mentees at OSU and UCF 2017 SUMREX Other professionals participated at these activities: 1. 9 professionals, 16 faculty and 6 students attended the Seminar “Earthquakes, Hurricanes and Other Disasters: A view from Space” presented by Mr. Ron Eguchi on February 23, 2017 at the Civil Engineering Auditorium. 2. 1 professional, 8 faculty and 36 students attended the Seminar “Tsunami Inundation Modelling for Risk-Based Decision Making to Increase Community Resilience” presented by Dr. Dan Cox of Oregon State University on March 7, 2017 at the Civil Engineering Auditorium. Dr. Cox is a Center researcher andhis visit is part of the ReTalk program. 3. 81 participants (59 professionals, 14 faculty, 8 students) attended the 2-day Conference “Lessons Learned and Best Practices: Resilience of Coastal Infrastructure”. Lecturers represented the US Army Corps of Engineers, UPRM, Sea Grant Program, PR Professional Engineers Association, Department of Natural Resources, Puerto Rico Climate Change Council. It was held March 8 and 9, 2017 at the Headquarters in San Juan of the Professional Engineers and Surveyors Association. Nine (9) Researchers from the US Army CoE and one from Oregon State traveled from the US to present their results and participate in discussions.

	4. 1 professional, 5 faculties and 38 students attended the Seminar "Coastal Resilience in Changing Climate" presented by Eng, José Sánchez, Director of the Coastal and Hydraulics Laboratory of the US Army Corps of Engineers on March 30, 2017 at the Civil Engineering Auditorium. The talk is part of the ReTalk program. 5. 1 professional, 37 students, and 6 faculties attended the 2 hour lecture "Coastal Management Program: PR Infrastructure Inventory, Risks and Vulnerability by Ernesto Díaz, Director of the PR Coastal Management Program Department of Natural and Environmental Resources and the PR Climate Change Council as part of the Capstone Design Experience Course on Jan 26, 2016.
Researchers from CRC	Advisors on course/seminar/workshop contents (breadth and depth); providers of internship opportunities; recruiters of students for graduate school; Trainers/lecturers; advisors · Dr. Dan Cox, Oregon State University-Mentor Internship, Lecturer · Dr. John van de Lindt, Colorado State University, Mentor, Internship · Dr. Stephen Medeiros, University of Central Florida, Mentor, Internship · Dr. Scott Hagen, Louisiana State University, Mentor, Internship · Dr. Robert Whalin, Jackson State University, Article coauthor and project Advisor
First responders (HLS Partners)	Trainee; Trainers/Lecturers; Survey responders of priority needs 1. 81 participants (59 professionals, 14 faculty, 8 students) attended the 2-day Conference "Lessons Learned and Best Practices: Resilience of Coastal Infrastructure". At least 15 can be classified as first responders. Lecturers represented the US Army Corps of Engineers, UPRM, Sea Grant Program, PR Professional Engineers Association, Department of Natural Resources, Puerto Rico Climate Change Council. It was held March 8 and 9, 2017 at the Headquarters in San Juan of the Professional Engineers and Surveyors Association. Nine (9) Researchers from the US Army CoE and one from Oregon State traveled from the US to present their results and participate in discussions. 2. 9 professionals, 16 faculty and 6 students attended the Seminar "Earthquakes, Hurricanes and Other Disasters: A view from Space" presented by Mr. Ron Eguchi on February 23, 2017 at the Civil Engineering Auditorium.

UPRM Partners	**Leverage; Support; Trainers; Collaboration** · Ruperto Chaparro, Sea Grant Director · Julio Morel, CariCOOS Director · Aurelio Mercado, Marine Sciences Researcher · Miguel Canals, Ocean Engineering Research Centre Director and Researcher · Sylvia Rodríguez, Materials Science and Engineering Researcher · Cecilio Ortiz, Social Science Research Center, Researcher · David Sotomayor, Agricultural Science Researcher · Raul Zapata, Assistant to Chancellor · Mrs. Lillian Ramírez, Puerto Rico Sea Grant Program · Juan González, CariCOOS Researcher · Patricia Chardón. CariCOOS Researcher · Various technical personnel
Government Agencies	Leverage; Support; Advice Various activities were coordinated with Government officials, programs and agencies, namely: Department of Natural and Environmental Resources-Coastal Management Program; the PR Sea Grant Program; the NOAA- Caribbean Coastal Oceanic Observatory Program (NOAA), the Transportation Technology Transfer Center sponsored by the Federal Highway Administration, FEMA, and municipalities.

7. **Unanticipated Problems:**

No changes from initially approved work plan.

8. **Project Impact:**

Ø Students: Training /Education through curriculum research and learning

· *Formal undergraduate and graduate research work experience (experimentation, modeling, simulation, programming, and analysis)*
· *Improve communications skills (oral, written, graphical, media) on RCI topics and literature*
· *Provide knowledge and tools on coastal hazards and its impact on coastal infrastructure*
· *Attract and motivate candidates into HS career with emphasis in RCI*
· *Provide access to state of the arts and practice in RCI*
· *Provide access to experts with RCI expertise*
· *Create a pipeline towards advanced degrees or work force on RCI and DHS priority job opportunities*
· *Develop maturity, confidence, satisfaction and expertise on new advances in RCI topics*
· *Support workforce through internships and summer jobs*

Ø Agencies: Trained, guided, and motivated workforce

· *Vision to new worldwide RCI challenges*
· *Provide human resources for workforce*
· *Upgrade human capital capabilities*

· *Trained professional with better capabilities to face new challenges in RCI*
· *Increase institutional expertise*
· *Provide continuing education on state of art and practice*
· *Facilitate institutional networking and collaboration*
· *Consultant to help regular work forces and advisors*

Ø Constituents: Continuing education RCI and HS advancements

· *Provide state of practice resources and tools, for example literature, software (GIS), databases (geospatial), guidelines, case studies, and examples that can be applied in their jobs.*
· *Advance expertise and confidence which help in career development and better opportunities.*
· *Orient and persuade potential professional to follow HS careers.*
· *Provide networking opportunities to engage in team work consultation and collaboration.*
· *Gain hands-on experience on new technologies.*
· *Become educators for other professionals in resilience topics.*

Ø Faculty: Scholar professional development

· *Provide scope of opportunities on Coastal Infrastructure Research to create new knowledge.*
· *Provide resources and expertise to be incorporated into formal curricula.*
· *Expand opportunities to team building and collaboration with scholars in the resiliency of coastal infrastructure.*
· *Advise on funding opportunities and funding agencies.*
· *Create opportunity for publishing.*
· *Expand the scope of expertise.*
· *Expand, update and upgrade existing programs on RCI.*

9. **Education Activity and Milestone Progress:**

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
1. Formulate and design content of Certificates for students, professionals, professionals, and other participants.	Dec 2016	100	
2. Offer first course on RCI, first Conference/Workshop, engage invited lecturers	May 2017	100	
3. Identify and participate in first Internship experiences	May 2017	100	
4. Formalize First Educational Partnerships with HS constituents and partners	Dec 2016	100	

Education Milestone			
1. Engage partners on RCI activities (Metric: number of partners participating)	June 2017	100	
2. Create first round of certificates for students, faculty, and professionals (Metric: No. of certificates awarded)	June 2017	100	
3. Allocate students in RCI related internships (Metric: No. of students)	June 2017	100	

10. **Transition Activity and Milestone Progress:**

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
1.Offer course, first local workshop/conference (proceedings, documentation, and certificates by …) **List:** a. Undergraduate Research (INCI 4998): Climate Change Impact on Coastal Communities – Flooding Scenarios in Puerto Rico b. Undergraduate Research: Effect of Climate Change on the Coastal Transportation Infrastructure of Puerto Rico c. Lecture: Coastal Management Program: PR Infrastructure Inventory, Risks and Vulnerability d. Lecture: Hurricanes, Tornadoes, Floods and Other Disasters: A view from Space e. Lecture: Tsunami Inundation Modeling for Risk Based Decision Making to Increase Community Resilience f. Conference: Lessons Learned and Best Practices: Resilience of Coastal Infrastructure g. Coastal Resiliency in Changing Climate	**June , 2017** **August 2016** **Dec. 2016** **Jan. 26 , 2017** **Feb. 23, 2017** **March 7, 2017** **March 8-9, 2017** **March 30, 2017**	100	

2. Seek and expand internship opportunities, identify, select and orient candidate students (Orientations, promotions, divulgation, selection, allocation, etc.)	**June 2017**	100	
Transition Milestone			
1. Provide first round certificates (Metric: Distribution of certificates)	**June 2017**	100	
2. Offer first local workshop/conference (Metric: Distribution of participants/ workshop; contents learned; action list proposed)	**June 2017**	100	

11. **Interactions with research projects:**

a. **SUMREX** participation has been successful for 2016 and 2017. This year opportunities were communicated by researchers from two institutions. Oregon State University (Dr. Dan Cox and Dr. John van de Lindt – two opportunities), and University of Central Florida/Louisiana State University (Dr. Stephen Medeiros/Dr. Scott Hagen- one opportunity). These initiatives were coordinated with Researchers during CRC meetings. Advertisements were posted including all requirements at the university. Interested students presented their credentials and we evaluated if students qualified. Students who qualified were advised to apply and referred directly to Research PI's for their evaluation. Two students were admitted at OSU (working at the O.H. Hinsdale Wave Research Laboratory (HWRL)) and one student was admitted to UCF/LSU (working on the ADCIRC model (setup and parameterization) and how to run simulations on a high-performance computing cluster). Last year SUMREX students were Kevin Cueto and Diego Delgado at OSU and Felix Santiago at UCF/LSU. Felix has now been admitted to study his PhD at LSU starting in January 2018, thanks in part to being awarded an NSF Graduate Fellowship to pursue the PhD, and to his research at UCF, LSU, and at UPRM with Dr. Walter Silva. The students selected for SUMREX this year are Peter Rivera and Hector Colón to attend OSU and Diego Delgado will attend UCF/LSU. All are currently in the middle of the internship.

b. **ReTALK** program at UPRM by CRC researchers was initiated with the visit of Dr. Dan Cox of OSU in March of 2017. Dr. Cox gave lectures at UPRM and at San Juan Professional Engineers Association. In Mayagüez, he also met with students and professors. Both his presentations were well attended. Other talks at UPRM given by distinguished researchers were offered by Mr. Ernesto Díaz, president of PR Climate Change Council and Director of the PR Coastal Zone Management Program at the Department of Natural and Environmental Resources Agency, by Mr. Ron Eguchi, president of ImageCat in California who was invited by the Earthquake Engineering Institute UPRM student chapter, and by Mr. José Sanchez,

director of the Coastal and Hydraulic Laboratory of the US ARMY Corps of Engineers in Vicksburg, MISS.

c. **Conference Lessons Learned and Best Practices: Resilience of Coastal Infrastructure** was a 2 day conference held in San Juan organized by our project with the cooperation of the Sea Grant Program, Engineers Association, Dept. of Natural and Environmental Resources, and the sponsorship of the US Army Corps of Engineers, who provided travel expenses for 9 researchers who shared their expertise with local researchers from UPRM and Dr. Cox from OSU.

12. **Publications:**

a. Digital proceedings of Conference **"Lessons Learned and Best Practices: Resilience of Coastal Infrastructure"** , organized by the project, can be found in the link http://engineering.uprm.edu/inci/?page_id=3522

The following two presentations were given by Dr. Ricardo López at the World Engineering Conference on Disaster Risk Reduction. More information at http://www.wfeo.org/events/world-engineering-conference-disaster-risk-reduction-wecdrr-2016/

b. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, Agustín Rullán, Oscar Perales-Pérez, John Fernández-Van Cleve, "THE ROLE OF UNIVERSITIES ON DISASTER RISK REDUCTION IN THE COMMUNITY: UPRM CASE STUDY", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016.
c. López-Rodríguez, Ricardo R., Pagán-Trinidad, Ismael, "Structural Vulnerability to Natural Hazards in Puerto Rico", World Engineering Conference on Disaster Risk Reduction, Peruvian Association of Professional Engineers, Lima Perú, December 5-6, 2016.

13. **Tables:**

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by **University of Puerto Rico at Mayaguez** under Project **Education for Improving Resiliency of Coastal Infrastructure (RCI)**						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
INCI6XXX INCI5XXX	***"Rehabilitation of Coastal Structures (under development)"***- Guevara Dual codes for undergraduates and graduates		D			
	Offering: Elective (E), Concentration (C), Minor (M)	E	E			
	Enrollment	-				
INCI6XXX INCI5XXX	***"Reliability of Coastal Infrastructures (under development)"***- Saffar Dual codes for undergraduates and graduates		D			
	Offering: Elective (E), Concentration (C), Minor (M)	E	E			
	Enrollment	-	-			
INCI6995	CE Special Problems (Graduate): ● ***"A Novel Boussinesq -Type Numerical Wave Model Development" - IPT*** ● ***"Stochastic Simulation of Tropical Cyclones for the Quantification of Uncertainty Associated with Storm Recurrence and Intensity: Phase II" - IPT*** ● ***"Analysis of a Ring Levee Breach Using Adaptive Hydraulic" - IPT*** ● ***"US Army Improved Ribbon Bridge" - IPT*** ● ***Feasibility of Using the Weather Research and Forecasting Model (WRF) as forcing to the Advanced Circulation Model (ADCIRC) - IPT***	T T T	T T T T			
	Offering: Elective (E), Concentration (C), Minor (M)	E	E			
	Enrollment	3	1			
INCI5996	CE Special Problems (Project) ● ***"Impact of Projected Sea Water Rise on Coastal Infrastructures"*** ● ***"Ship Simulation Study"- IPT*** ● ***Utilities and Building Inventory For Resiliency Analyses at the Mayagüez Municipality Coastal Zone - Dr. Ricardo Ramos*** ●	T	T T			
	Offering: Elective (E), Concentration (C), Minor (M)	E	E			

	Enrollment	1	4			
INCI6066	***MS-Thesis*** ● ***Structural Effects of Tsunami Loads on Coastal Infrastructure, by Kevin Cueto*** ● ***Computation of Gradually Varied Flow in Channel Networks with Hydraulic Structures by Felix Santiago*** ● ***Cost Analysis of the alternatives to Restore by Francisco Villafañe***		D D T			
INCI6065	***MS-Project*** ● ***Structural Analysis of Common Coastal Structures found on the West Coast of Puerto Rico using FEMA P-646 by Jorge Romeu***		D			
INCI8999	***PhD Dissertation*** ● ***Resistencia a Cargas de Tsunami de Estructuras Críticas en el Norte de Puerto Rico (Resistance to Tsunami Loads of Critical Structures in the North of PR) by Johnny Rosario***		D			
	Offering: Elective (E), Concentration (C), Minor (M)		R			
	Enrollment		3			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty Associated with Storm Recurrence and Intensity	Ismael Pagán Trinidad	$22K Summer-Fall 2016	CHL-ERDC-US ARMY Corps of Engineers
Hydro Model Validation and Surge/Wave Grid Development - Puerto Rico and Virgin Islands	Juan Gonzalez	$36K Fall 2016 - Spring 2017	CHL-ERDC-US ARMY Corps of Engineers

Leveraged Support	
Description	Estimated Annual Value
UPRM Release Load - 2 CE Researchers worked on CRC project (Pagán 6 crs. ; López 6 crs)	$55,000
Venue and promotion for the "Lessons Learned and Best Practices in Resiliency of Coastal Infrastructure" at PR CIAPR, Hato Rey Puerto Rico	$1,000
ERDC support to participant speakers at "Lessons Learned and Best Practices Conference in Puerto Rico"	$45,000
Sea Grant Program Collaboration - Promotional materials, arts, announcements	$2,000

Transportation Technology Transfer Program -Promotion	$500
Dr. Dan Cox - Oregon State University - RETALK Program	$1,000
UPRM Release Load - 3 CE Faculties worked on CRC research and teaching topics (Guevara-1 cr. ; Saffar-4 crs ; Ramos - 2 crs, Colucci - 2 crs	$40,000
Coastal Hydraulic Lab (ERDC) speaker on National Coastal Research and Development Speaker	$2,000
PR Climate Change Change Speaker -3 hours	$500

14. **Metrics:**

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	10	16 [1]
Undergraduates provided tuition/fee support (number)		1
Undergraduate students provided stipends (number)		2
Graduate students provided tuition/fee support (number)	5	9[2]
Graduate students provided stipends (number)	6	9[2]
Undergraduates who received HS-related degrees (number)		N/A
Graduate students who received HS-related degrees (number)		n/A
Certificates awarded (number)		245
Graduates who obtained HS-related employment (number)		2
Lectures/presentations/seminars at Center partners (number)		0
DHS MSI Summer Research Teams hosted (number)		N/A
Journal articles submitted (number)	1	0
Journal articles published (number)	1	0
Conference presentations made (number)	2	31
Other presentations, interviews, etc. (number)	2	8
Trademarks/copyrights filed (number)		0
Requests for assistance/advice from DHS agencies (number)		
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5	
Total milestones for reporting period (number)		2
Accomplished fully (number)	2	2
Accomplished partially (number)		N/A
Not accomplished (number)		N/A

Some Pictures of Project Activities

Oregon State SUMREX Participation (June -July 2016): Kevin Cueto and Diego Delgado

Announcement of Conference

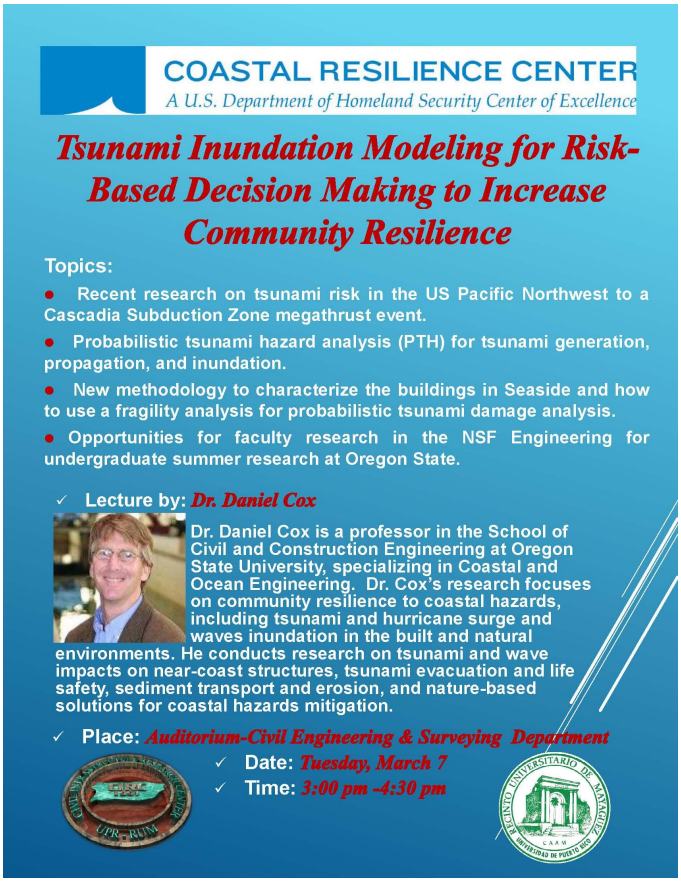
Lessons Learned and Best Practices: Resilience of Coastal Infrastructure March 7-8, 2017

Participants Photos: Conference Lessons Learned and Best Practices: Resilience of Coastal Infrastructure March 8-9, 2017

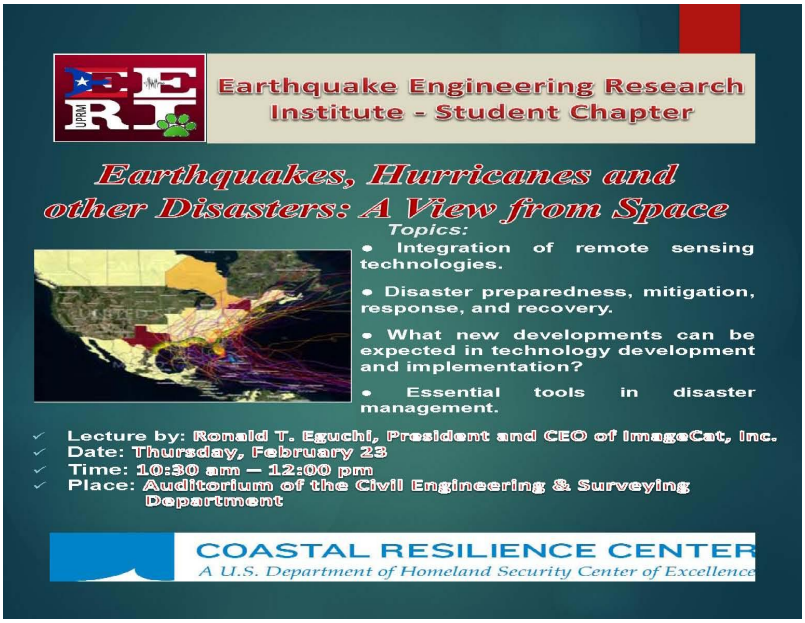
Participants from the ERDC- US Army Corp of Engineers at the

Conference Lessons Learned and Best Practices: Resilience of Coastal Infrastructure March 8-9, 2017

Agmus 2016 Summer Students Research Symposium Sponsored by NSF and Others where four of the students who participated in the 2016 ERDC Research Internship (in Coastal and Hydraulic Laboratory) at ERDC presented their Research work



Flyer Dan Cox Seminar



Flyer Ron Eguchi Seminar

Sample of UPRM Capstone Project – Coastal urban development

Figure 5 - Ocean-view terraces at front of structure.

Figure 3 - Front of lot will include other amenities and family and friends oriented activities.

KEIM, LSU

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Disaster Science and Management Program at LSU

2. **Principal Investigator / Institution:**

   Barry D. Keim, Professor in the Department of Geography and Anthropology and Louisiana State Climatologist.

3. **Other Education Participants/Partners:**

   - Baton Rouge Community College (BRCC)
   - NOAA's Southern Climate Impacts Planning Program.

4. **Short Project Description ("elevator speech"):**

   The Disaster Science and Management (DSM) Program at LSU was originally within the College of Humanities and Social Sciences (for 7 years), however, the educational structure of the program took place outside of any single Department. Under this Coastal Resilience Center of Excellence project, the DSM program is now fully integrated within the Geography degree program at Louisiana State University. Students may now major (BA or BS) in Geography with a concentration in DSM. A minor in DSM is also available to students with majors in other Departments. We have partnered with the Emergency Management Program at BRCC to develop curriculum, enhance program development and recruitment, and foster ease of credit transfer to LSU for those that want to continue to a Baccalaureate degree. We believe that students in DSM should develop experience and connections in the Homeland Security Enterprise through internships, and we have a strong and expanding internship program.

5. **Abstract:**

   Louisiana's propensity for natural disasters (e.g., Hurricanes Katrina, Rita, Gustav, Ike, and Isaac) demonstrates a clear need for a robust Disaster Science and Management Program in the region. The DSM program at LSU within the Department of Geography & Anthropology allows students to obtain either a BA or BS in Geography with a concentration in DSM, in addition to making the program available as a minor. A revised curriculum was implemented this year, including both on-campus, and on-line courses focused on hazard identification and assessment, geospatial techniques such as Geographic Information Systems (GIS) and remote sensing, emergency management courses, and student internships within the Homeland Security Enterprise.

6. End users:

End User/Agency	Project Role	Expected Return/Benefit
Ms. Joanne Moreau, Director Mayor's Office of Homeland Security and Emergency Preparedness	• Provided internship for DSM student during Spring 2016 semester. • Hired DSM student as a student worker.	Student gained real-world experience with employment in a homeland security enterprise position.
Ms. Amy Pinero, Chair Department of Social Sciences and History, Baton Rouge Community College (BRCC)	• Build curriculum at BRCC • Act as gateway to DSM program at LSU.	Increase student diversity at LSU as BRCC maintains a higher percentage of minority's vs LSU (45% at BRCC vs. 25% at LSU). Able to reach different sectors of the community more effectively than LSU alone
Mr. Garrett J. Romagossa, Disaster Program Manager American Red Cross, Baton Rouge Chapter	• Provided internship for DSM student during Fall 2016 semester. • Provided volunteer opportunities for DSM class	Student gained real-world experience with employment in a homeland security enterprise position.

7. Unanticipated Problems:

The DSM program had a change in personnel in November, 2016, when Dr. Alan Black replaced Nicole Coarsey as the Program Manager. Ms. Coarsey resigned to take a position with the Louisiana Department of Health and Hospitals.

While we have fully developed DSM curriculum for BRCC and both the "Fundamentals of Emergency Management" and "Hazards, Disasters, and the Environment" courses have been offered, neither had sufficient enrollment for the course to be taught. There is strong support at BRCC for these courses to be offered; therefore we will assist them in promoting the courses using promotional material and by attending student information fairs where we can promote the courses in person.

8. Project Impact:

The DSM program targets LSU students and professionals interested in the field of Emergency Management (EM). Students can earn a BA or the BS degree programs in Geography, whereby if they take the requisite core DSM courses, the student would earn a concentration in DSM along with their Geography degree. We also host a minor degree program through the Department. This concentration advances workforce capabilities by providing both classroom instruction and hands-on experience in the Homeland Security Enterprise (HSE) to students. Graduates of the program will be trained to immediately enter the Homeland Security Enterprise, locally (i.e., MOHSEP - the East Baton Rouge Mayor's Office of Homeland Security and Emergency Preparedness), regionally (i.e., the Louisiana Department of Environmental Quality and GOHSEP – the Louisiana Governor's Office of Homeland Security and Emergency Preparedness), and nationally (i.e., FEMA, DHS, FBI). The program manager (Dr. Alan Black) monitors the course content to ensure consistency of material across course sections and instructors. Course content is updated each semester to ensure that it incorporates new, pertinent literature and advances in the field. Finally, the PI and Program Manager regularly interface with HSE professionals on the LSU campus and in the community to ensure that DSM courses prepare graduates to meet HSE needs.

9. Education Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Implement Geography and Anthropology approved DSM Concentration in BS/BA.	8/1/2016	100%	
Implement approved Certification Program.	8/1/2016	100%	
Implement one (1) or more course curricula for Baton Rouge Community College (BRCC).	9/1/2016	100%	Curricula were implemented, but course enrollment was insufficient
Education Milestone			
Offer at least three (3) DSM courses during the Fall2016 and Spring 2017 semesters.	5/31/2017	100%	
Promote and enroll two (2) students into the DSM Certificate Program.	6/30/2017	100%	
Deliver one (1) or more course curricula for Baton Rouge Community College (BRCC) during the Fall 2016 semester and Spring 2017 semester.	5/31/2017	100%	Curricula were implemented, but course enrollment was insufficient

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Develop DSM social media page (Facebook) to further capture DSM Student Post- Graduation activities.	7/29/2016	100%	
Continue with the American Red Cross Baton Rouge Chapter to offer service learning project for DSM 2010 course and identify additional volunteer activities for DSMA student association.	7/29/2016	100%	
Contact each HSE end user listed on the working document to capture end user input on internship program via one-on-one phone calls and email.	9/1/2016	100%	
Transition Milestone			

Continue DSM Student Post-Graduation tracking method and document post-graduation activities in Homeland Security enterprises or continued grad school of 50-60% of Fall 2016 and Spring 2017 students.	5/31/2017	100%	
Through the partnership with the ARC, 75-80% students enrolled in DSM 2010: Fundamentals of Emergency Management in Fall 2016 completed the service learning portion of that class.	5/31/2017	100%	
DSMA student organization participated in community service projects.	5/31/2017	100%	
Partner with three (3) end users in the HSE to secure internships for DSM students.	1/31/2017	100%	

11. Interactions with research projects:

Stephen Kreller, MS student at LSU, is currently participating in an internship through the CRC SUMREX program. He is hosted by Dr. Brian Blanton at RENCI at UNC-Chapel Hill.

Dr. Don Resio presented a lecture on March 17, 2017 at LSU.

12. Publications:

Gilliland, J. M., and B.D. Keim. Submitted. Spatiotemporal analysis of upper-level wind speed trends of Brazil during 1980-2014. *Journal of Climate*.

Gilliland, J. M., and B.D. Keim. Submitted. Surface Wind Speed: Trend and Climatology of Brazil from 1980–2014. *International Journal of Climatology*.

Black, A.W., and G. Villarini. Submitted. Effects of Methodological Decisions on Rainfall-Related Crash Risk Estimates. *Accident Analysis and Prevention*.

Xue, G.Z., K. Sampson, W. Yu, B.D. Keim, Z. Zang, A. Dugger, D. Sathiaraj, D. Gochis, Q. Ge. Submitted. Assessing Hydroclimatic Change in Southwest Louisiana Rivers using WRF-Hydro. *Journal of Hydrology: Regional Studies*.

Black, A.W., G. Villarini, and T.L. Mote. 2017. Effects of Rainfall on Vehicle Crashes in Six U.S. States. *Weather, Climate, and Society* **9**: 53–70.

Shao, W., S. Xian, B. Keim, K. Goidel, N. Lin. 2017. Understanding Perceptions of Changing Hurricane Strength Along the U.S. Gulf Coast. *International Journal of Climatology* **37(4)**:1716-1727. DOI:10.1002/joc.4805.

Allard, J.M., J.V. Clarke, and B.D. Keim. 2016. Spatial and Temporal Patterns of In Situ Sea Surface Temperatures within the Gulf of Mexico from 1901–2010. *American Journal of Climate Change* **5**:314-343. DOI:10.4236/ajcc.2016.53025.

Shao, W., J.C. Garand, B.D. Keim, and L.C. Hamilton. 2016. Science, Scientists, and Local Weather: Understanding Mass Perceptions of Global Warming. *Social Science Quarterly* **97(5)**:1023-1057. DOI:10.1111/ssqu.12317.

Hamilton, L.C, J. Hartter, B.D. Keim, A.E. Boag, M.W. Palace, F.R. Stevens, M.J. Ducey. 2016. Wildfire, Climate and Perceptions in Northeast Oregon. *Regional Environmental* Change **16**:1819-1832. DOI:10.1007/s10113-015-0914-y.

13. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by Louisiana State University under Project Disaster Science and Management Program at LSU						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
DSM/ GEOG 2000	**Hazards, Disasters, and the Environment**	T	R/T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		150	164			
DSM / GEOG 2010	**Fundamentals of Emergency Management**	T	R/T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		54	135			
DSM 3910	**Hazards Seminar**	T				
Offering: Elective (E), Concentration (C), Minor (M)		C				
Enrollment		10				
DSM 4000.	**Practicum in Disaster Science and Management**	T				
Offering: Elective (E), Concentration (C), Minor (M)		C				
Enrollment		5				
GEOG 4200	**Hazard Risk Reduction**		D			
Offering: Elective (E), Concentration (C), Minor (M)			C			
Enrollment						
DSM 4600	**Crisis Management**	T				
Offering: Elective (E), Concentration (C), Minor (M)		C				
Enrollment		8				

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Southern Climate Impacts Planning Program (SCIPP)	Keim	$358,000	NOAA
Leveraged Support			
Description			Estimated Annual Value
NA			

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	5	1
Undergraduates provided tuition/fee support (number)	0	0
Undergraduate students provided stipends (number)	0	0
Graduate students provided tuition/fee support (number)	2	2
Graduate students provided stipends (number)	2	2
Undergraduates who received HS-related degrees (number)	4	5
Graduate students who received HS-related degrees (number)	0	0
Certificates awarded (number)	0	0
Graduates who obtained HS-related employment (number)	2	3
Lectures/presentations/seminars at Center partners (number)	1	0
DHS MSI Summer Research Teams hosted (number)	0	0
Journal articles submitted (number)	1	3
Journal articles published (number)	5	1
Conference presentations made (number)	2	17
Other presentations, interviews, etc. (number)	4	132
Trademarks/copyrights filed (number)	0	0
Requests for assistance/advice from DHS agencies (number)	2	1
Requests for assistance/advice from other agencies or governments (number)	5	8
Total milestones for reporting period (number)	6	6
Accomplished fully (number)	6	6
Accomplished partially (number)	0	0
Not accomplished (number)	0	0

SMITH, UNC

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Expanding Coastal Resilience Education at UNC

2. **Principal Investigator / Institution:**
   Gavin Smith, Research Professor, Department of City and Regional Planning, Senior Recovery Advisor-North Carolina Division of Emergency Management; Rick Luettich, Professor, Department of Marine Sciences, University of North Carolina at Chapel Hill.

3. **Other Education Participants/Partners:**

   UNC partners include: Departments of Marine Sciences, City and Regional Planning, Geological Sciences, Law School, Curriculum for the Environment and Ecology, Center for Public Service. North Carolina State University partners include the departments of landscape architecture and architecture in the College of Design. State partners include the North Carolina Division of Emergency Management and North Carolina Governor's Office. Federal partners include FEMA's Community Planning and Capacity Building team. Additional local partners include: local officials and residents in the towns of Princeville, Windsor, Kinston, Seven Springs, Lumberton and Fair Bluff, North Carolina (communities represent many of the most hard-hit locations following Hurricane Matthew that possess limited capacity to recover). Local governments are tied to the Hurricane Matthew Disaster Recovery and Resilience Initiative described below.

4. **Short Project Description ("elevator speech"):**

   UNC has expanded its capabilities in Coastal Resilience by developing a graduate certificate program in Natural Hazards Resilience and by hiring a tenure track faculty member (trained in physical science and/or engineering) in the area of Coastal Natural Hazards and Climate Science. A new addition includes the Hurricane Matthew Recovery and Resilience Initiative (HMDRRI), which involves a team of faculty, students and practitioners focused on assisting the state of North Carolina and 6 hard-hit communities recover following Hurricane Matthew. This effort is expected to last until July 2018.

5. **Abstract:**

   The 10-hour credit Natural Hazards Resilience certificate program focuses on the nexus between the threats and impacts of natural hazards and disasters on human settlements, including those exacerbated by climate change, and how individuals, organizations, communities, and larger systems of governance prepare for, respond to, mitigate against, recover from, and adapt to these events. Emphasis is placed on the concept of disaster resilience, or "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (National Research Council 2012). The curriculum provides students with an academic and practice-based exposure to the science underlying our

understanding of natural hazards phenomena and a critical analysis of the policies, programs, and plans in place that are intended to help societies manage the effects of natural hazards and disasters, to include a discussion of those actions that effect disaster resilience. The certificate program is designed to serve enrolled graduate students and is not available to practicing professionals located outside the university.

6. End users:

Key "end users" of the program are our students. The certificate program is open to master's and Ph.D. students from all departments at UNC-CH that have identified an advisor in their home department that is willing to work with the head of the certificate program or an advisor that is actively participating in the certificate program.

A Program Director (Gavin Smith) and Certificate Coordinating Committee - comprised of one representative from the Department of City and Regional Planning (Nikhil Kaza), the CRC (Rick Luettich); the Law School (Don Hornstein); The Department of Public Policy (Pan Jagger), the Department of Marine Sciences (to be determined), the Department of Geological Sciences (Laura Moore); Carolina Center for Public Service (Lynn Blanchard); a student representative currently enrolled in the program (to be determined on a bi-annual basis). The Program Director and Certificate Coordinating Committee are also responsible for assessing other certificate compliance issues, such as course credits, the transfer of courses from other universities (if applicable), the appropriateness of fieldwork or student internships, the possible creation of on-line courses, or other issues that may arise. Anna Schwab, CRC Program Manager and UNC Department of City and Regional Planning Student Services Coordinator, Sandra Lazo de la Vega provide key administrative support to include tracking of student progress and provision of certificates upon completion of required coursework.

DHS constituent agency representatives (e.g., FEMA, US Coast Guard) other federal agencies (e.g., NOAA, US Army Corps of Engineers, US Geological Survey), professional associations (e.g., American Planning Association, Association of State Floodplain Manager's) and CRC Advisory Board members play an important role in the certificate program in a number of ways, including: 1) serving as invited guest speakers in courses, 2) hosting student interns as identified, 3) providing feedback on course content, and 4) notifying the Program Director of available job postings. Given the certificate's focus on disaster recovery and hazard mitigation, Matt Campbell (FEMA Disaster Recovery - Community Planning and Capacity Building) and Kathleen Smith (FEMA Hazard Mitigation – Planning Lead) serve as federal agency end-user contacts. They advise the Program Director on course content, conduct class lectures, and assist in the identification of internship and job opportunities). Both have served in this capacity for the last two years prior to the official start of the certificate program in the Fall of 2015.

HMDRRI-related end users described above include the North Carolina Division of Emergency Management, North Carolina Governor's Office, FEMA's Community Planning and Capacity Building team and the 6 communities we assisting following Hurricane Matthew. Newer end-users include those tied to the International Learning Lab in Australia and Vietnam. In Australia this includes the Bushfire and Natural Hazards Resilience Centre, WHM Global (private sector firm), and emerging community partners. In Vietnam, partners include several academic planning departments and the National Planning Agency.

7. Unanticipated Problems:

No unanticipated problems.

8. Project Impact:

The study of natural hazards resilience, including those hazards exacerbated by a changing climate, and translation of these findings to practice is becoming increasingly important. Disaster losses continue to rise at an exponential rate in the United States and across the world. One of the most troubling manifestations of climate change is an increase in the extent, duration, and intensity of natural hazards and disasters. Examples include more frequent flooding, droughts, extreme heat, wildfire, and hurricane-induced damages. In addition, climate change is resulting in rising sea levels, increased flooding of low lying lands, and subsidence in arctic environments. The effects of a changing climate are particularly devastating to coastal communities, which comprise a disproportionate amount of the world's population. In the United States, for instance, more than 50% of the nation's population lives within 50 miles of the coast.

The Department of Homeland Security's Science and Technology Directorate, Office of University Programs, the National Science Foundation, and the National Academy of Sciences have all expressed their concerns about this growing trend. A common refrain among all groups is the need to educate the next generation of natural hazards scholars and practitioners as the field is greying and is less diverse than the population as a whole. The activities also align with Quadrennial Homeland Security Report Goal 1.3 (manage risks to critical infrastructure), Mission 5 (ensuring resilience to disasters) and all of its associated goals (mitigate hazards, enhance preparedness, ensure effective emergency response, and rapid recovery). The certificate program is building important capacity by attracting and training the next generation of natural hazards scholars and practitioners. In addition, the faculty position described in the project is fully funded by UNC after the CRC's 5-year lifetime to provide a long-term programmatic contribution to the HS enterprise.

The North Carolina Division of Emergency Management and the Governor's Office has asked Dr. Gavin Smith, Director of the Coastal Resilience Center of Excellence, to serve as a Senior Recovery Advisor and Chief of the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI). This role involves advising the North Carolina Division of Emergency Management, the Governor, and members of his cabinet on a range of disaster recovery policy issues. Key issues include helping the state develop a disaster recovery housing strategy, advising the state on the allocation and coordination of funding, the identification of unmet local needs, and developing strategies focused on assisting local governments and disaster survivors recover from one of the worst disasters in the state's history.

These issues are being addressed in partnership with a team of faculty, students, and practitioners over the life of the project, which is estimated to be in place for 1 to 2 years. The idea for the HMDRRI was proposed by the Director of North Carolina Division of Emergency Management, Mike Sprayberry, and has been strongly supported by Governor Roy Cooper. In addition, it was suggested that this effort should be codified as part of a formal ongoing partnership between the North Carolina Division of Emergency Management and UNC's CRC in subsequent disasters. We are in the process of discussing how this could be formalized and linked to the certificate and the Coastal Resilience Center.

Three primary objectives of the HMDRRI include:

1) Serving as point of contact for UNC System faculty, students and staff, drawing on these resources to help the state address a range of policy and technical issues as identified.

2) Engaging with communities to assist them identify local needs and help them develop post-disaster recovery plans.

3) Coordinating activities with FEMA's Community Planning and Capacity Building team which strives to assist communities collect data, assess needs and facilitate recovery planning.

The State of North Carolina General Assembly (including money drawn from a UNC – based research Collaboratory as well as money drawn from a Hurricane Matthew relief fund) has provided the funding needed to support Dr. Smith and a team of recovery planning and design experts drawn from UNC and North Carolina State University (faculty and students) as well as top practitioners to assist communities develop disaster recovery plans, provide policy and design-based guidance, and advise the state and local governments on several aspects of disaster recovery (see Figure 1). The team is working most closely with heavily impacted communities, many of which have less capacity to recover due to limited staff. The teams include a mix of recovery planning experts, faculty, and students.

The Department of Homeland Security (DHS) Science and Technology Directorate has also provided funding that is closely aligned with the objectives of the HMDRRI. In 2014, at the request of the Federal Emergency Management Agency (FEMA) administrator, DHS created the Flood Apex Program. This program brings together new and emerging technologies designed to increase communities' resilience to flood disasters and provide flood predictive analytic tools. The Flood Apex program has provided funding to the CRC to assess the degree to which hazard mitigation and disaster recovery actions taken following Hurricane Floyd (the state's worst disaster to date, which struck in 1999), influenced the impacts and consequences of Hurricane Matthew in 2016. This study will assess both state and local actions in order to better understand the important, but currently understudied interplay between these two levels of government in the context of disaster resilience. This will enable the HMDRRI team to improve our understanding of state and local level hazard mitigation and disaster recovery decisions, activities, and investments intended to enhance community resiliency and reduce flood fatalities and losses.

The HMDRRI serves as the first part of a larger International Learning Lab. The other partner nations include Vietnam and Australia. In Vietnam, the foreign collaborators are the dean and department head of the School of Architecture of planning at National University of Civil Engineering (NUCE) in Hanoi, Vietnam. Since 1966, NUCE has trained more than 60,000 technical experts, including engineers, architects, and urban planners in Vietnam. This work is supported by the Vietnamese national government through the Ministry of Construction. This support from both the university and national government is critically important for conducting research in a socialist government because it will provide access to secondary data sources, connections to key stakeholders, and will offer local knowledge that would otherwise be impossible to acquire. In Australia, the foreign collaborators work at Bushfire & Natural Hazards Cooperative Research Center (BNHCRC), a public not-for-profit and WHM Global Consulting, a private consulting firm. The BNHCRC draws together all of Australia and New Zealand's fire and emergency service authorities, land management agencies, non-government organizations, and leading experts across a range of scientific fields to explore the causes, consequences, and mitigation of natural disasters. The BNHCRC is funded by the Australian Government as well as partnering agencies, government organizations, and research institutions in Australia and New Zealand. Dr. Smith has agreed to serve on the BNHCRC research board, providing a close inter-institutional bond between the Australian center and the US-based Coastal Resilience Center

of Excellence. Our collaboration with WHM Global Consulting provides us with a prospective from the private sector, which is important because they often serve as the planners and risk assessors in the field who can provide a street-level view of what works and what does not. Furthermore, governments often contract with private sector firms to assess risk, develop plans, and implement plans. Therefore, having the varied sectors and stakeholders involved in this collaboration will enhance the learning opportunities tremendously. WHM Global is based in Australia and the US, and as a result, can provide a comparative perspective.

This collaborative research will enable the ability to conduct comparative analyses between the U.S., Australia, and Vietnam on the topic of sustainable and resilient coastal development and planning. The lack of evidenced-based international lesson drawing represents a significant gap spanning both research and practice in the U.S. and this relationship aims to help fill this gap. This collaboration allows the P.I.'s to leverage additional research and teaching funding through a variety of sources, including the Vietnamese national government, funders in Australia through connections with Bushfire and Natural Hazards CRC, and WHM Global Consulting.

9. Education Activity and Milestone Progress:

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Teach certificate program courses	May 2017	100%	
Provide students with the knowledge and experience to actively contribute to the study and/or practice of natural hazards and disasters	June 2017	100%	
Recruit students into certificate program	June 2017	100%	
Attract and engage additional UNC faculty to coastal resilience to include developing new coursework (in addition to core courses already created and taught) that is closely aligned with the certificate and CRC's mission	June 2017	100%	
Education Milestone			
Deliver 3 core courses per year that support the certificate program	May 2017	100%	
Track student performance (including graduates).	June 2017	100%	
Two students admitted to certificate program	June 2017	100%	
Develop one new elective course to be taught by UNC faculty (beyond the three core courses already developed)	June 2017	100%	

10. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 7/1/16 – 6/30/17			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Promote internship opportunities for students/recruit end users to host students	January 2017	100%	
Promote certificate program graduates to potential employers	June 2017	100%	
Transition Milestone			
Establish a list of potential employers and secure commitments from them to support internships	June 2017	100%	

11. Interactions with research projects:

Researchers from across CRC have been invited to speak in each of the three core courses in the graduate certificate program. This has provided an opportunity for PI's to discuss their CRC-funded research and its connectivity to classroom materials. PI's have also served on guest panels that serve to review student presentations and group projects. It is estimated that at least one CRC-affiliated PI or student will speak in each of the three certificate program classes in a given year. The Lecture Series course has will also provide an opportunity for invited speakers to deliver lectures to students enrolled in the class, as well as the larger UNC-CH community.

Some presentations have involved serving on a panel with other PI's, members of our Advisory Board, and DHS component agency officials. This is intended to expose students to the issues and connections that span research and practice (a key theme of the certificate program).
Student internships are encouraged and serve as an elective in the certificate program. The CRC Director has actively solicited internship opportunities with research partners and practicing professionals working closely with the student to ascertain their interests. In addition, the Director regularly assesses the needs of potential employers.

12. Publications:

Smith, Gavin. "The Role of States in Disaster Recovery: An Analysis of Engagement, Collaboration, Leadership, and Capacity Building." 2017. In *Building Community Resilience to Disasters: The Handbook of Planning for Disaster Resilience*, Routledge Press. (published)

Smith, Gavin. "Pre- and Post-Disaster Conditions, their Implications, and the Role of Planning

for Housing Recovery." 2017. In *Coming Home After Disaster: Multiple Dimensions of Housing Recovery*, Eds. Ann-Margaret Esnard and Alka Sapat. Boca Raton, Florida" CRC Press. (published)

Smith, Gavin, Amanda Martin and Dennis Wenger. "Disaster Recovery in an Era of Climate Change: The Unrealized Promise of Institutional Resilience." 2017. In *Handbook of Disaster Research*, Second Edition, Eds. Havidan Rodriguez, Joseph Trainor and William Donner. New York: Springer. (accepted/submitted)

Smith, Gavin. 2016. Remembrances of the Past, Concerns for the Future, and the Potential Resilience of a Small Coastal Town, Southern Cultures. Summer: 64-87. (published)

13. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by University of North Carolina under Project Expanding Coastal Resilience Education at UNC						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
PLAN 755	Planning for Natural Hazards and Climate Change Adaptation	T	T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		8	21			
PLAN 754	Speaker Series	T	T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		14	33			
PLAN 756	SURVEY of Natural Hazards and Disasters	T	T			
Offering: Elective (E), Concentration (C), Minor (M)		C	C			
Enrollment		9	15			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
Hurricane Matthew Disaster Recovery and Resilience Initiative	Smith	$340,602	University of North Carolina at Chapel Hill
Hurricane Matthew Disaster Recovery and Resilience Initiative	Smith	$274,364	North Carolina Division of Emergency Management
Leveraged Support			
Description			Estimated Annual Value
Free office space in Hurricane Matthew Joint Field Office (4 offices x 1 year)			$10,000

14. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)	2	14
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		1
Graduate students provided tuition/fee support (number)	2	2
Graduate students provided stipends (number)		13
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		3
Certificates awarded (number)	1	3
Graduates who obtained HS-related employment (number)	1	3
Lectures/presentations/seminars at Center partners (number)		3
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)	1	1
Journal articles published (number)		2
Conference presentations made (number)	6	12
Other presentations, **interviews**, etc. (number)		11
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)		1
Requests for assistance/advice from other agencies or governments (number)		
Total milestones for reporting period (number)	10	11
Accomplished fully (number)	9	11
Accomplished partially (number)	1	
Not accomplished (number)		

KNIGHT, UMD

DHS Coastal Resilience Center

Education Project:

Annual Project Performance Report

Covers reporting period July 1, 2016 – June 30, 2017

1. **Project Title:**

   Development and Testing of a Project Management Curriculum for Emergency Managers

2. **Principal Investigator:**
   Sandra K. Knight, PhD, PE, D.WRE, D.NE, Senior Research Engineer, Department of Civil and Environmental Engineering, University of Maryland, College Park. Lead investigator for research and key advisor for emergency management training and curricula content.

   Co-Principal Investigator: John Hart Cable, Director, Project Management Program, A. James Clark School of Engineering, University of Maryland. Lead advisor for Project Management curricula and certification.

3. **Other Education Participants/Partners:**

   - Allison Reilly, PhD, Assistant Professor, Department of Civil and Environmental Engineering, University of Maryland
   - Gerald E. Galloway, PhD, PE, NAE, Glenn L. Martin Institute Professor of Engineering, Department of Civil and Environmental Engineering, University of Maryland
   - Gregory Baecher, PhD, PE, Glenn L. Martin Institute Professor of Engineering, Department of Civil and Environmental Engineering, University of Maryland

4. **Short Project Description ("elevator speech)*:***

   The goal of this educational work plan is to develop and test an educational and training curriculum that prepares professionals to manage and deliver disaster-related project(s), by merging the unique challenges of emergency management with the capabilities and technologies introduced by applying project management processes. By incorporating modern project management organizational processes, technologies, and skills, emergency managers will be able to manage and execute disaster-related projects and meet resilience goals more effectively and efficiently. By building disaster resilient concepts and emergency protocols and goals into project management processes, project managers will be equipped to contribute to a more sustainable and disaster-resilience future.

5. **Abstract:**

Emergency managers are often assigned to lead many of the emergency activities and oversee the execution of large programs in the wake of disaster that are funded through federal and state programs. Furthermore, agencies and organizations (federal, state and local governments, utilities, non-profits, private industry, etc.) have a strong reliance on contract support and expertise that is often responsible for the response and recovery for sector-specific projects or program execution (marine transportation, healthcare, supply chain, utilities, etc.). Therefore, it is imperative, in this demanding environment, that project and

emergency managers have the right training and educational skills to effectively deliver projects on-time and on-budget while being considerate of the needs of the community and planning for a resilient future.

This research aims to fill a gap in training by merging emergency management and project management curriculum for the purposes of advanced learning or certification for practitioners. This research will aim to support existing certifications, and both degree and non-degree programs. Practitioners in emergency management and project managers who carry out emergency management activities will have the opportunity to hone their knowledge and skills through a set of courses that will be offered through the existing UMD Project Management Program. Additionally, through collaboration and coordination with existing accreditation programs, specific emergency training institutes (like the Emergency Management Institute), other academic institutes of higher learning and DHS supported programs, targeted training materials and short-courses will be developed and opportunities identified for providing the broadest access possible for practitioners.

The proposed research comprises three distinct phases: 1) understanding the requirements and needs of practitioners and developing a disaster-focused curriculum to be offered within the UMD Project Management program or Civil Engineering graduate program, 2) developing training and short course plans of instruction that align with existing certification programs, and 3) executing initial course offerings and/or training programs for delivering the developed approaches and technologies to practitioners.

6. End users:

The following partners, collaborators and potential end-users have or will be contacted to participate in a needs interview, provide guidance and direction on existing certification requirements, collaborate on and/or review course curriculum development and either enroll or offer courses and training developed from this education research.

Initial contact and discussions have been carried out with many of the people/institutes identified below. At each phase of the project, organizations and individuals will be asked to provide feedback and confirmation on products. A product roll-out strategy has been developed that will seek to include more on the list.

Certification activities

- Project Management Institute (PMI), John Hart Cable, Director PMP, UMD is coordinating this effort through the existing collaboration UMD has with PMI.
    - Role: PMI provides three certifications in project management. Working with both PMI and IAEM, this project will attempt to establish training and curricula that satisfies certifications and could potentially be accredited by both. Additionally, because of the close relationship UMD has with PMI, opportunities will be sought to collaborate and leverage resources to make the effort a success.
- International Association of Emergency Management (IAEM), IAEM Certification Coordinator, Daryl Spiewak.
    - Role of IAEM: IAEM provides two certifications in emergency management. Working with both PMI and IAEM this project will attempt to establish a connection between these two programs and identify curriculum that could be accredited by both.
    -

Needs and outreach

- FEMA Federal Coordinating Officers, Director, TBD

    - Role: Identify requirements for federal and state coordinating officers in executing disaster programs and create training and curriculum that would support those needs. Use office as an opportunity to transition PM training into the FCO training and identify professionals interested in program.
    - Two current or former FCO's participated in a needs survey: Libby Turner, Tony Russell
- Industry Partners, various
    - Role: Provided invaluable feedback during the needs assessment survey and at the FEMA HMA Workshop
- Hazard Mitigation Assistance Workshop
    - Role: Provided forum with over 50 attendees from federal, state, local and tribal organizations to assess importance and training needs for both emergency manager practitioners and graduate studentsl

Potential Delivery Partners

- DHS Center for Domestic Preparedness, Anniston, AL, TBD
    - Role: Will contact as potential partner leverage opportunities and resources to offer PM training based on Plans of Instruction that have been developed.
- Emergency Management Institute, Emmitsburg, MD. Supervisor, Tony Russell, and Lillian Virgil, Chief Mitigation Branch
    - Role: establishing training and curriculum needs, leveraging opportunities and resources and establishing opportunity to transition training products to their organization.
- DHS FEMA Recovery Directorate, Matt Campbell, Branch Chief, National Coordinator Community Planning and Capacity Building and Gerilee Bennett, FEMA Recvoery
    - Role: Review curriculum and training Plans of Instruction and help identify delivery partners for recovery program training. Opportunities to support the National Disaster Recovery Framework and leverage resources will be sought with this organization.
- FEMA Emergency Management Higher Education Program, Wendy Walsh, Program Manager
    - Role: Established opportunity with her to learn how UMD can interface with this program and continue contribute and benefit from the Higher Education Program
- FEMA Director, National Training and Education Division, Gerald White
    - Role: Along with EMI the development of the education program and course offerings will be closely coordinated with the EMHEP and NTES at FEMA. Opportunities to obtain financial or in kind support will be sought through their programs to leverage grant resources funded under this plan.
- National Disaster Preparedness Training Center (NDPTC) at University of Hawaii, Tim Manning, Deputy Administrator for Preparedness, FEMA and Karl Kim, Director NDPTC
    - Role: Consider as potential training deliverer and partner to develop a course or courses to be offered through their program.

Potential Practitioners who would take the training

- National Emergency Managers Association, Paul Hogue
    - Role: NEMA could provide an opportunity to advertise the course offerings to its members which cover all the state emergency management agencies and FEMA and provide critical input to program development

- District of Columbia Homeland Security Emergency Management Agency, State Hazard Mitigation Officer, Donte Lucas
    - Role: Provided input on needs.
- Maryland Emergency Management Agency, TBD
    - Role: NEMA and connections to State emergency management agencies will be used to identify practitioners to help develop and test the course curriculum

Academic Partners and collaborators

- Jackson State University, DHS Coastal Resilience Center of Excellence, Tom Richardson
    - Role: As education partner lead for the CRC, UMD will coordinate and seek advice for improving and enhancing the work plan
- Louisiana State University, Barry Kiem, Disaster Management Program
    - Role: Used collaborative opportunities to gather lessons learned while establishing their program at LSU
- National Center for Security and Preparedness, Director Rick Mathews
    - Role: Can provide lessons learned and identify potential partners form their experiences as a COE
- State University of New York, David Rousseau, Dean College of Emergency Preparedness, Homeland Security and Cyber Security
    - Role: Can provide lessons learned in establishing their new college in emergency management
- National Consortium for the Study of Terrorism and Responses to Terrorism (START), UMD, Holly Roberts and Michael Egnoto
    - Role: potential on campus partner to mutually support, promote and leverage programs as well as provide critical input into needs and curriculum development
- University of Maryland University College, Emergency Management curriculum faculty adjunct, Cliff Oliver
    - Role: Advisor on curriculum and point of contact with UMUC and potential guest lecturer at UMD
- University of the District of Columbia, Chair Civil Engineering, Pradeep Behera
    - Role: Partnerships and collaboration with other academic institutes including but not limited to these will be used to 1) improve curriculum development, 2) collaborate on projects, symposia and training, 3) identify students that could participate with the PIs and interface with practitioners to validate content and usefulness of curriculum.

7. Explanation of Changes:

The YR2 Workplan updates provided to the CRC on April 22, 2016 reflected and explained all modifications in YR1 and beyond from the original work plan submitted August 2015 prior to DHS S&T approval and funding in January 2016. Since award, there were some minor shifts in funding. One modification resulted from an unnecessary requirement to support an intern in the SUMREX program. In discussions with Dr. Whalin at the March 2016 PI meeting, this project does not lend itself to supporting an intern. Therefore, budgets were modified to reflect that change. RETALK can be considered in YR2 or YR3 to replace the SUMREX activity. Further, by the time funding arrived in January 2016, it was too late to identify and hire a graduate student. These funds were shifted to contract support. Delays

in contracting and some shifts in travel funding required a carryover of funds which was requested by the PI to CRC on June 2, 2016.

There were only shifts to two milestones and one related transition milestone (all documented in the YR2 work plan updates under review). These shifts were in part due to receipt of final approval and funding by UMD, but also due to 1) administrative delays at UMD of putting a sole-source contract in place to conduct a needs assessment and 2) adding attendance of an EMI higher education summer symposium in June. Both of these efforts will contribute to a better product. This should not impact overall effort. Other activities can be completed as scheduled.

8. Unanticipated Problems:

There were no real problems of concern. The biggest challenge was just getting things in place in January to get started and dealing with the unexpected challenge by the PI of putting sub-contracts in place at UMD. This has been resolved and processes should be better understood moving forward.

9. Project Outcomes:

Natural Disasters between 2003 and 2012 resulted in estimated global average annual economic losses of $156.7 billion and average annual deaths of 106,654[3]. Following the tremendous losses that come with these disasters, come billions of dollars for emergency management activities that must be managed by federal, state and local agencies and/or organizations. For instance, the federal disaster appropriations following Hurricane Sandy were approximately $58 billion[4] and were dispersed via many programs and agencies with specific regulatory or policy requirements for execution. Disaster relief funds such as these are spent to get communities back on their feet by replacing or rebuilding critical infrastructure, key facilities, businesses and homes. Further, the organized response to a disaster shares all the characteristics and has all the organizational needs of a built project. It is also well understood that building resilience into our built, social and environmental systems prior to an event has recurring benefits to disaster losses. Therefore, resources are often allocated for mitigation following a disaster as well as on "sunny days."

Project outcomes:

- Help professionals, whether emergency managers or project managers, more effectively and efficiently deliver projects and programs to provide for a disaster resilient future.
    - Broaden and/or improve the skills and capabilities of emergency management workforce professionals
    - Educate program and project delivery professionals on the complexities and unique requirements that arise in the face of disaster
- Identify and link the best practices and lexicons of emergency management and project management
- Develop test courses/training/curriculum that can be easily adapted and used by other institutes of learning

[3] Guha-Sapir D, Hyois Ph., Below R. *Annual Disaster Statistical Review 2013: The Numbers and Trends.* Brussels: Center for Research on the Epidemiology of Disaster (CRED): 2014

[4] https://www.congress.gov/113/plaws/publ2/PLAW-113publ2.pdf

10. Education Activity and Milestone Progress:

Education Activities and Milestones: Progress to Date

Reporting Period 7/1/2016 – 6/30/2017			
Education Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Education Milestone			
Needs assessment: to include review of literature and existing academic and accreditation programs, interviews with subject matter experts, case history review. (Needs assessment report)	07/31/16	100%	
Top Priority Course Curriculum Offerings Descriptions: completion of 3 introductory course prospectus and targeted scheduling for initial delivery in year 2 and/or year 3 (depending upon university capacity): Course Prospectus and University Approval	05/31/2017	90%	Three courses have been identified and one offered. The other two will be delivered next year (not yet on UMD course schedule) but two newly hired Resilience Faculty Members. Additionally, other concepts for courses have been identified and prospectus begun. However, the expected completion is now September 30, 2017.
Develop requirements for a short course(s) suitable for CEU, in-person and/or online training for transition to existing emergency management institutes such as CDP or EMI (Prepare Course Prospectus for inclusion in agency training catalogue or similar source of training offerings)	05/30/2017	100%	Three complete Plans of Instruction following EMI guidelines were developed in lieu of the Course Prospectus. These are required by FEMA in advance of actually delivering a short course. To deliver a short course, we will need a delivery partner to help pay for the final expenses of developing lecture materials and providing the instruction.
Identify feasibility and process needed to get courses accredited through PMI and IAEM or identify and alternative for certification if not feasible.	12/31/2017	50%	Contacts were made and requirements identified. However, it was important to have the Plans of Instruction and the course offering complete to document the process and set up an implementation strategy to share with potential certification organizations.
Offer 1 Introductory Couse at UMD Spring of 2017.	5/30/2017	100%	The course was approved by the university and offered. 11 students completed the course

11. Transition Activity and Milestone Progress:

Transition Activities and Milestones: Progress to Date

Reporting Period 1/1/2016 – 6/30/2016			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity / milestone was not reached, and when completion is expected
Develop a Roll-out strategy for Plans of Instruction to identify delivery partners	5/25/2017	100	The needs report was completed and confirmed the gaps identified in PM for emergency managers. Its results were shared at the annual PI meeting at UNC, February 2017 and at HMA conference of practitioners in June 2017. However, it was deemed more important to share the actual Plans of Instruction and the Course development ideas with the contacts and potential partners.
Site visits and other correspondence to FEMA Headquarters, EMI, CDP and/or others in development of needs. (This will continue throughout project)	01/31/2018	100	Contacts were made and interviews conducted with FEMA, EMI staff and others by the original deadline. Additionally, PI presented the Plans of Instruction and Course offerings to over 50 attendees June 2, 2017 at the HMA workshop. However, the PI will like to schedule further meetings and visit facilities to identify training delivery partners and refine the offerings..
Obtain University Approval for introductory Course at UMD	9/30/2016	100	
Post introductory course prospectus for students to enroll	11/30/2016	100	

12. Interactions with research projects:

We had two RETALK opportunities this year. Sandra Knight visited LSU and discussed with Barry Kiem the process, successes and setbacks of establishing a research program at LSU. This was further shared with UMD faculty from across the colleges with Robert Twilley came a presented how he established the Coastal Sustainability Studio.

13. Publications:

None to date

14. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by University of Maryland under Project Development and Testing of a Project Management Curriculum for Emergency Managers						
Course		Developed (D), Revised (R), and/or Taught (T), by Project Year				
Number	Title	1	2	3	4	5
ENCE688B	Principles of Disaster Management	D	T	N/A	N/A	N/A
Offering: Elective (E), Concentration (C), Minor (M)		-	E	N/A	N/A	N/A
Enrollment		-	11			

Table 2: Documenting External Funding and Leveraged Support

External Funding			
Title	PI	Total Amount	Source
NA			
Leveraged Support			
Description			Estimated Annual Value
NA			

15. Metrics:

Metric	**Year 1** (1/1/16 – 6/30/16)	**Year 2** (7/1/16 – 6/30/17)
HS-related internships (number)		
Undergraduates provided tuition/fee support (number)		
Undergraduate students provided stipends (number)		
Graduate students provided tuition/fee support (number)		1
Graduate students provided stipends (number)		
Undergraduates who received HS-related degrees (number)		
Graduate students who received HS-related degrees (number)		
Certificates awarded (number)		
Graduates who obtained HS-related employment (number)		
Lectures/presentations/seminars at Center partners (number)		
DHS MSI Summer Research Teams hosted (number)		
Journal articles submitted (number)		
Journal articles published (number)		
Conference presentations made (number)		
Other presentations, interviews, etc. (number)	25	1
Trademarks/copyrights filed (number)		
Requests for assistance/advice from DHS agencies (number)	2	
Requests for assistance/advice from other agencies or governments (number)	3	
Total milestones for reporting period (number)	3	9
Accomplished fully (number)	3	8
Accomplished partially (number)		1
Not accomplished (number)		0

COASTAL RESILIENCE CENTER
A U.S. Department of Homeland Security Center of Excellence

Appendix: Coastal Resilience Center Career/Workforce Development Grant Reports

This appendix contains reports submitted by Career Development and Workforce Development Grant recipients.

Ashton Rohmer
UNC – Chapel Hill
Department of City and Regional Planning
Masters of City and Regional Planning (awarded May 2017)

Relevant courses:
Planning for Natural Hazard Mitigation and Climate Change Adaptation, Survey of Natural Hazards, Advanced GIS, Development Dispute Resolution, Facilitation, Mediation, Land Use Planning, Land Use Policy, Development and Environmental Management, Development Impact Assessment

PI/Mentor:
Gavin Smith

Research projects:

1. Disaster Recovery: A Comparative Analysis of Gubernatorial Leadership, Collaboration, and Capacity Building
2. Resilient Design Education Study (co-PI: Mai Nguyen)

Research project abstracts:

1. This paper explores the roles of states and governors in the disaster recovery process following two historic events: Hurricane Floyd in North Carolina in 1999 (under Governor Hunt) and Hurricane Katrina in Mississippi in 2005 (under Governor Barbour). In both cases, these disasters were the worst events either state had ever experienced, and highlight the varying roles that governors can play following a disaster (e.g., creating commissions, lobbying for funds, coordinating state agency recovery efforts, etc.). They provide rich case studies from which to analyze recovery efforts at the state level through the lens of three overarching themes: understanding local needs, timing of assistance, and vertical and horizontal integration. From the interviews, we develop a set of policy recommendations based on lessons learned and provide areas for future study.

2. The focus of this study involves the review of existing college and university educational programs that teach resilient design approaches in the face of natural hazards, disasters, and climate change adaptation. Resilient design is defined as architecture, planning, engineering and building sciences that advances “the ability to prepare and plan for,

absorb, recover from, and more successfully adapt to adverse events" (National Research Council).

The review will emphasize planning, architecture, building sciences, and engineering programs that address the built, natural, and social environment, including how these elements are intertwined and help produce design solutions that are mutually reinforcing. An important sub-part of this effort involves the identification of multidisciplinary programs that bridge planning, architecture, building sciences, and engineering.

The impacts of climate change and extreme weather impose increasing risks to communities across the nation and world. These risks include sea level rise as well as increasing frequency of severe drought, storms, and floods. A key aspect of addressing these risks is planning and designing in ways that incorporate adaptability and uncertainty over time and rely on the utilization of the latest models that address the non-stationarity problem. That is, what is the latest thinking on how the design, planning, and development community should account for deep uncertainty and adapt to what amounts to a new normal?

Relevance to Homeland Security:

1. The disaster recovery process presents a unique opportunity to integrate hazard mitigation and climate change adaptation policies and actions – in particular, states are in a unique position following a disaster to take advantage of increased funding (both from donations - from individuals, foundations, etc. – and the federal government), resources (staff, expertise, etc.), and heightened attention (from Washington to private foundations and organizations) to get things done. Without sufficiently understanding the full extent of the tremendous opportunity that is available to governors and states in such situations, these opportunities to make our communities more resilient may be squandered. For example, by highlighting the proactive efforts by state-level officials to help get funding applications prepared before Hurricane Floyd hit, North Carolina was able to take advantage of available buyout funds to move houses out of the floodplain. Moreover, following Hurricane Katrina, Governor Barbour was able to appeal to political

leadership and secure more funding for housing initiatives in Mississippi using data available about the needs at the local level.

Because climate change will likely increase either the frequency or intensity of coastal storms and will contribute to a rapidly rising sea level, and because coastal areas are attracting more and more residents, a larger proportion of communities will be in harm's way. By examining how states and governors can participate in thoughtful pre-disaster recovery planning and effective post-disaster recovery efforts, we will be able to improve our nation's resilience to coastal hazards.

2. This project was requested by the White House under the former Obama administration as a way to learn about the state of the U.S. resilient design education. Given the scale and breadth of resilience challenges that our nation faces, this is an important undertaking to determine what training our higher education system provides to students interested in tackling these issues professionally, as well as what gaps exist. Talking with professors and administrators about what their respective programs provide students – both in terms of course content and applied experiences – can help stakeholders understand if our students are prepared to tackle critical homeland security issues and provide exemplary case studies to improve that preparation.

<u>Summary of research accomplishments and contributions for each project worked on:</u>

1. I helped Gavin draft an overview of Mississippi's response at the state level, and providing editing assistance for the rest of the article he wrote. I also reviewed the literature for peer-reviewed articles and government reports related to disaster recovery. The article has been submitted to one journal, and Gavin is in the process of submitting it to a second journal.
2. For the Resilient Design Education Study, we started by researching programs and schools across the country that offered courses related to resilience and design across several different disciplines: engineering (my primary focus area), architecture, landscape architecture, planning, building sciences, and related programs (including any that took a more interdisciplinary approach to the topic). Our goal was both to create a comprehensive list of relevant programs that actually taught about resilient design (rather than institutions that were strictly research centers), and to potentially identify

cutting-edge programs or those that had piloted particularly innovative initiatives related to resilient design.

Our second task was to create an interview tool, guided by the research we had completed as described above, so that we could survey professors and administrators that were knowledgeable about their fields to ensure we had captured all the relevant information and that we had not missed any key programs in our search.

I interviewed (either on my own or with another colleague on the project) half a dozen academics to discuss the current state of disaster design education, what innovative ideas have been implemented at colleges and universities across the country, and what challenges or gaps may exist that could be addressed by higher education institutions. These interviews were transcribed so that they can be used by the other researchers (Gavin, the co-PI Mai Nguyen, and two other grant recipients) affiliated with the project to glean lessons learned, trends, etc. for inclusion in the report.

<u>What new skills and/or knowledge I have acquired over the course of the last two years:</u>

Working on the Resilient Design Education Study was the first time I was involved with designing a survey tool and methodology, so it was a really helpful skill to build, especially since we had to both work within a fairly broad scope and cater research questions to experts in specific fields. Additionally, it was helpful experience to be exposed to the article drafting process through the "Disaster Recovery: A Comparative Analysis of Gubernatorial Leadership, Collaboration, and Capacity Building" project, as that was the first time a project I had been involved with had been submitted to an academic journal.

I've also learned a lot from my classes, particularly those focused on dispute resolution, negotiation, mediation, and facilitation. These are skills that could be very helpful in future jobs in the hazards and resilience space, particularly given how contentious issues related to hazard mitigation, disaster recovery, and climate change adaptation can be. Additionally, my development impact assessment class provided useful experience crafting impact assessments and analyzing data related to environmental reviews. Lastly, I've had the opportunity to build my GIS skillset through various class projects and a class ("Advanced GIS") that I took. For

example, for one course project a classmate and I determined the most suitable sites to place temporary housing in two eastern North Carolina towns following Hurricane Matthew using several criteria that could be used to maximize energy efficiency.

Lastly, the experience of planning a symposium was really worthwhile, as I had to not only craft a cohesive agenda and coordinate with student presenters and expert panelists, but also had to take on event planning responsibilities and delegate tasks to students who helped with coordinating the event.

Relevant conferences, seminars, and/or lectures attended:

I attended three conferences over the past two years: the 2016 National Land Conservation Conference, the 2016 Carolinas Climate Resilience Conference, and the 2017 Association of State Floodplain Managers Conference. The National Land Conservation Conference had several sessions dedicated to discussing issues of climate change and resilience (and was helpful for my master's project, which focused on the open space created by floodplain buyouts). I also plan to attend the 2017 Natural Hazards Workshop in Broomfield, CO, which will provide a great opportunity to network with professionals in the field and identify potential job opportunities.

Additionally, I led efforts to create a hazards and resilience research symposium for students around the Triangle (at UNC, Duke, and NC State) to present their social and physical science research projects and for experts across the Triangle (including representatives from FEMA) to share their thoughts on issues related to equity, coordinating across siloes, and tackling climate change issues given our challenging political atmosphere. This was the first annual event that brought together 25 participants, and hopefully it will continue in future years with increased institutional collaboration and university financial support.

Throughout the course of my program, I've also attended dozens of lectures related to hazards and resilience. Many of them have been through courses that Gavin has offered, and all of them provided interesting insights into work being done in the field and challenges that exist on the ground. The three presenters that were most impactful for me were David Perkes, Kristin Baja, and Daniel Aldrich.

Publications, presentations, poster sessions, etc.:

In addition to the report I wrote for the National Park Service (referenced below), I also had the opportunity to present my master's project research at two conferences. The first was at the 2016 Carolinas Climate Resilience Conference where I focused on preliminary research results. The second was presenting my final research findings at the 2017 Association of State Floodplain Managers Conference, where I was selected as a runner up for the student paper competition award.

Internship placement and experiences:

During the summer of 2016, I interned with the National Park Service as a Climate Change Adaptation Planning Intern through the George Melendez Wright Young Leaders in Climate Change Program. In this role, I spent 12 weeks in the Park Planning and Special Studies office of the NPS, located in Washington, D.C.

With the guidance and support of my supervisors Thomas Sheffer and Rebecca Beavers, I got to visit parks and interview superintendents, regional park planners, park facilities managers, and the Hurricane Sandy recovery project manager to learn more about what coastal parks are doing to adapt to a changing climate.

Through trips to Assateague Island National Seashore and Statue of Liberty National Monument, I saw first-hand what parks are doing to ensure facilities are more resilient to sea level rise and strong storms. As a result of these visits and the many informative conversations I had this summer, I produced a report, *Building Resilience at our National Parks: Fact Sheets for Adapting Facilities to Reduce Risk* (NPS #133754A), which highlights site-specific adaptation actions that have been implemented using fact sheets (developed in InDesign) to share this information with other parks hoping to take an innovative approach to adaptation.

I also participated in a climate change adaptation planning workshop focused on climate change impacts to cultural resources at Saint Croix Island International Historic Site, a particularly interesting case given its status as the only international site in the Park System as well as its various stakeholders at the local, regional, and global level.

Lastly, I produced a summary document for park planning leadership that summarized lessons learned and best management practices I had gathered through my discussions with park superintendents, and presented my research to park planning leadership. Given the difficulties of planning for a changing climate, particularly considering the wide array of issues they must tackle on a daily basis, this is no easy feat. Therefore, by compiling these challenges and opportunities, hopefully park planners can more fully understand how best to assist park leadership with resilience efforts.

During the summer of 2017, I am interning as a Planning Assistant with the Hurricane Matthew Disaster Recovery and Resilience Initiative (the Initiative), directed by Gavin Smith. The Initiative is based at the Joint Field Office in Durham, NC, co-located with North Carolina Emergency Management and Federal Emergency Management Agency staff active in Hurricane Matthew recovery efforts. Specifically, we are tasked with helping six low-capacity communities in eastern North Carolina plan for their recovery. Thus far, I have helped develop an intake survey for displaced residents, have brainstormed community engagement strategies, and have completed research in the areas of floodplain buyouts and relocation. For a related workshop class, I also worked on a report on Kinston, NC, which analyzed disaster impacts across the town, researched vulnerable populations, and provided recovery recommendations related to community engagement and mitigation measures, among others.

Personal reflection

The past two years have provided incredible experiences through my classes, research, and internships. I've appreciated how much I've learned about hazard mitigation, climate change adaptation, and disaster recovery and how many people I've met throughout my time as a CDG recipient. Most recently, my time with HMDRRI has been particularly illuminating, as I've been exposed to the complexities and challenges of disaster recovery and planning in a post-disaster context. I think HMDRRI's unique position has also provided an interesting perspective: in terms of how it works with the state, FEMA, university partners, and private consultants. These relationships and added layers of collaboration have added complexity to our work, though they have also resulted in increased collaboration.

I think the most impactful lesson I will take away from my experience this summer is the tremendous difficulty of "doing" community engagement, particularly as an outside, state-sponsored organization. Given that we are mainly white students and practitioners and have little to no experience with these communities – many of which have large black populations that have faced centuries of segregation, discrimination, and racial tensions with elected officials – I felt unprepared (and unsupported) to wrestle with questions of community engagement. Moreover, after participating in a community engagement training with FEMA, I was left with a lot of questions around how we talk about and address issues related to race and equity. While these two experiences – in my opinion – show serious deficiencies and challenges in how we engage with members of the public, it also highlights tremendous areas for opportunity, improvement, and innovation.

Overall, I've learned that the field is unimaginably diverse, and am excited about the breadth of professional opportunities that exist. There are so many ways to make our communities more resilient – from initiatives that increase the social capital of a neighborhood, to community engagement efforts that ensure historically underrepresented populations have a say in how to build communities with lower hazard risk, to communications and outreach activities that inform residents about climate change adaptation options, to empowering communities to plan for their own disaster recovery. I ultimately hope to find a role that works at the local level to support these types of efforts that make our communities stronger and more connected, adaptable, and resilient.

Post-graduation employment:

In September, 2017, Ashton Rohmer accepted a position with ASI Government as a consultant based out of FEMA headquarters, supporting the National Flood Insurance Program.

Colleen Durfee
UNC – Chapel Hill
Department of City and Regional Planning
Masters of City and Regional Planning (expected graduation May 2018)

1) Colleen Durfee, Department of City and Regional Planning, UNC Chapel Hill

2) Master's in City and Regional Planning, 2018

3) Fall 2016 – Land Use and Environmental Policy
   Fall 2016 – Natural Hazards and Climate Change Planning
   Spring 2017 – Planning Workshop (Hurricane Matthew related work)
   Spring 2017 – Natural Hazards and Resilience Speaker Series
   Fall 2017 – Survey of Natural Hazards and Disasters

4) Gavin Smith, Research Professor, Department of City and Regional Planning, UNC Chapel Hill

5) Resilient Design Education Study

6) The impacts of climate change and extreme weather impose increasing risks to communities across the nation and world. These risks include sea level rise as well as increasing frequency of severe drought, storms, and floods. A key aspect of addressing these risks is planning and designing in ways that incorporate adaptability and uncertainty over time and rely on the utilization of the latest models that address the non-stationarity problem. That is, what is the latest thinking on how the design, planning, and development community should account for deep uncertainty and adapt to what amounts to a new normal? The focus of this study involves the review of existing college and university educational programs that teach resilient design approaches in the face of natural hazards, disasters, and climate change adaptation. Resilient design is defined as architecture, planning, engineering and building sciences that advances "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (National Research Council). The review will emphasize planning, architecture, building sciences, and engineering programs that address the built, natural, and social environment, including how these elements are intertwined and help produce design solutions that are mutually reinforcing. An important sub-part of this effort involves the identification of multidisciplinary programs that bridge planning, architecture, building sciences, and engineering.

7) This research project is relevant to the mission of the Department of Homeland Security because it will identify the best ways for the U.S. to improve and expand upon the programs educational degrees related to resilience. The research question comes from the growing awareness that threats to our national security are diverse and ever present. Specifically, resilient is used frequently when describing what the US needs to be to remain a leader in global economic and political affairs. When we cannot respond to shocks to our system,

whether from terrorist attacks, natural disasters, or financial crises, we are not able to remain safe and secure. For this research, we are honing in on the role that design plays in producing and maintaining resilience in our country when it comes to natural disasters.

The need to address resilience to natural disasters is made evident from recent events in the 21st century, hurricanes Katrina, Rite, Sandy, and Matthew, droughts in California, and flooding in Baton Rouge just to name a few. It is important to know how to be proactive when it comes to addressing resilience and this is integrally tied to education. How are we teaching resilient design to the future workforce of America? Is it good enough? How can it improve?

For this reason, our research centers around how resilient design is taught in higher education. Ultimately, our results will identify the components of a resilient design oriented education in landscape architecture, architecture, engineering, planning and building sciences that make high quality. We will identify best practices through interviews with academics in these fields and case studies of specific programs on the cutting edge of resilient design education. Ultimately, our results will be published and schools around the country will be able to recognize what works best in teaching resilient design, what makes it difficult to teach this topic, and other schools they could partner with, model their programs off of, and improve the education of resilient design in the US. Our research will hopefully improve the quality and prominence of resilient design in these disciplines which will serve to make America more resilient as students learning about resilient design will be better prepared to address the threats to America's security.

8) I helped develop qualitative research methods including structured interview questions and case studies. I then conducted and transcribed interviews and identified common themes. Below is a sample of the general research questions we used when interviewing academics and practitioners in these fields.

9) Through my participation in this research project, I learned how to create and conduct a structured interview, transcribe that interview, and pull out key themes of the interviews. This last year, my work on this project has taught me a lot about project management. I understand the value of project management and working with professors and peers to solve problems, discuss findings, and develop research methods. It has been invaluable learning from peers and professors in this setting.

10) Conferences Attended:
    September 2016 - NC APA Conference in Asheville, NC
    December 2016 – Solutions for Affordable Housing, panel on flooding and housing, Washington DC
    Spring 2017 – Triangle Resilience Spring Student Symposium, Chapel Hill, NC
    July 2017 – Natural Hazards Research and Applications Workshop, Broomfield, CO

11) This past year I co-wrote a blog article for Carolina Angles on Charlotte-Mecklenburg's greenway system and their use of the buyout program to add amenities to their city. I also presented on the topic of women in disaster recovery for the Triangle Resilience Spring Student Symposium.

12) Internship placement and experience

Location: Joint Field Office in the Research Triangle Park, NC
Dates: May 1 – August 3, 2017

For this summer, my primary duties included supporting the Hazard Mitigation Recovery and Resilience Initiative (HMDRRI) team by investigating how best to rebuild the economic foundations of six highly vulnerable and impacted communities post-Hurricane Matthew. In my studies, I focus on economic development so the opportunity to better understand the role of economic recovery in the larger disaster recovery process was fascinating and invaluable. I developed a funding opportunities resource as well as a memo that describes how to floodproof/retrofit the downtown areas of these communities. I had to become familiar with historic preservation as well as different methods to floodproof buildings. I am also helping develop and follow through with community engagement strategies of these communities which will inform the relocation and rebuilding process. Ultimately, the work I do this summer will feed into the development of recovery plans for these communities.

I have learned how complicated the recovery planning process can be through this internship. I gained experience in community engagement processes, which includes how to be sensitive to those going through traumatic experiences and giving them the platform to be heard and have agency in their recovery. I also learned a lot about which public officials are most involved in disaster recovery in small towns. Because these are small and low-income areas, there are less stakeholders but still a strong sense of identity tied to the community. Remaining in their town is an upmost priority despite the risks which is something we had to work with. We want to allow them to recover on their own terms but it has to reduce their risk and be cost effective. I also now have a better idea of what work environment I want to be in and how important working with peers I admire and respect is for my enjoyment of my work.

13) Personal Reflection:

My internship and research through the workforce development fellowship has exposed me to doing research with professors and peers in a graduate school setting. I am learning a lot about the importance of project management and scheduling deadlines in advance. I learned about the challenges of the disaster recovery process and what it is like to be in a consultant role working with federal agencies which will serve me well when considering future employment opportunities. During the internship, I grappled with questions without answers with my co-workers. I think I expected the research and internship to be more organized and goal oriented but while working in this space I realized that this is difficult to do because of the chaotic nature of disaster recovery. I expected to be brought into already planned existing projects rather than deciding with experts what to move forward on. Working on those decisions with the consultants and experts was a valuable experience because I learned about what questions to ask and how to go about moving forward.

2016-2017 Workforce Development Student Annual Performance Report

Prepared by Darien Alexander Williams
Prepared for The Department of Homeland Security
Coastal Resilience Center of Excellence

Darien Alexander Williams, Department of City & Regional Planning, University of North Carolina at Chapel Hill, Master of City and Regional Planning, Expected Graduation Spring 2018

Fall 2016 Coursework

Fall 2016 semester, my first at the program at UNC, featured three especially relevant courses. The first, Urban Neighborhood Revitalization, provided a cursory introduction to historic and contemporary community engagement strategies. While this class did not feature hazard-specific contexts, it furnished a mental toolkit for later work I would be doing through the fellowship regarding community engagement techniques that are commonly explored following a disaster event. Primary takeaways from this course include perspective on community groups, an understanding of neighborhood-scale planning history, and my first experiences thinking of marginalized populations in city-planning contexts.

The second relevant course taken during Fall of 2016 was Planning for Natural Hazard Resilience, led by Professor Gavin Smith. This class was my first foray into academic understanding of not only disaster events but recovery processes and mitigation techniques. Smith drew upon his years of experience in both academic and professional settings, across a multitude of geographies in the American South. This class most neatly aligned with my initial interests, as it covered not only hazard events, but events and recovery processes taking place in my interest geography. Smith went so far as to use numerous examples from the state of North Carolina, where I would later be doing work. A macabre benefit to the facilitation of this class was Hurricane Matthew, which took place mid-semester and brought with it numerous challenges discussed in class playing out in real-time. This course primed me for navigating the tangled, acronym-laden verbiage of hazard mitigation and disaster recovery work.

Lastly, Introduction to Law for Planners proved to be an important foundational course for understanding not only planning but the intersection of the field and disaster events. Led by David Brower, a professor specializing in hazards and environmental challenges, the class drew upon hazard contexts to explain legal challenges. Class guests, including the professor's daughter, spoke from an international perspective, detailing planning and institutional challenges following major earthquakes in Christchurch, New Zealand. The greatest benefit from this class was the connection it made between hazards and standard, mainstream planning processes and terminology. Rather than treating hazard mitigation and recovery as an area of specialization, it was presented as an assumed foundational context.

Spring 2017 Coursework

Spring of 2017 featured courses with foundations based less in theory and more in practice. Natural Hazards Resilience Speaker Series, led by Gavin Smith, brought numerous professionals either linked to hazard planning by title or by fate – from mayors forced to lead their community through disaster recovery, data science experts, to internationally-oriented researchers. The semester also featured a Housing Workshop course, led by Mai Thi Nguyen and Andrew Whittemore, working in tandem with Gavin Smith, which propelled me into much of the work I'm engaged in this summer. My team focused on Princeville, the oldest town found by freed African American former slaves. The research I engaged in alongside my team aided opportunities that would later present themselves, described further in this report.

Research

Principal Investigator:
Dr. Gavin Smith, Research Professor, University of North Carolina at Chapel Hill. Director, Department of Homeland Security Coastal Resilience Center of Excellence

Title:
Resilient Design Education Study.

Abstract:
The focus of this study involves the review of existing college and university educational programs that teach resilient design approaches in the face of natural hazards, disasters, and climate change adaptation. Resilient design is defined as architecture, planning, engineering and building sciences that advances "the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events" (National Research Council).

The review will emphasize planning, architecture, building sciences, and engineering programs that address the built, natural, and social environment, including how these elements are intertwined and help produce design solutions that are mutually reinforcing. An important sub-part of this effort involves the identification of multidisciplinary programs that bridge planning, architecture, building sciences, and engineering.

The impacts of climate change and extreme weather impose increasing risks to communities across the nation and world. These risks include sea level rise as well as increasing frequency of severe drought, storms, and floods. A key aspect of addressing these risks is planning and designing in ways that incorporate adaptability and uncertainty over time and rely on the utilization of the latest models that address the non-stationarity problem. That is, what is the latest thinking on how the design, planning, and development community should account for deep uncertainty and adapt to what amounts to a new normal?

Approach

The scope of work noted above will be addressed in two phases. In Phase 1, we will conduct a review of the existing academic and professional literature surrounding resilient design curricula and training. In Phase 2, we will analyze graduate, undergraduate, and professional programs addressing resilient design that builds on the work done in Phase 1.

Research Takeaways

This project will serve as a gauge for the next generation of design professionals who will engage in the work of climate change adaptation, resilient recovery, and hazard mitigation. This project outcome is important to homeland security because natural hazards and disasters affect the livelihoods of residents across all 50 states and territories of the United States – better understanding the gaps that exist within the programs that educate hazard professionals will enable educators to fill them, ideally leading to better disaster recovery and overall mitigated risk. Through assessing the educational landscape in the United States with regard to the fields of architecture, city and regional planning, engineering, building sciences, and landscape architecture, department chairs and program heads will be able to create or modify

programs that maximize the potential for interdisciplinary education rooted in resilience.

The professional and intellectual markets are increasingly demanding the skillset and background that these programs produce. We can observe this by recognizing the increased number of resilience-oriented degree programs, certificates, and specializations emerging from universities across the United States with each passing year. This demand isn't simply market-generated, but is becoming more so a cultural and institutional necessity. More specifically, resilience-oriented skillsets seem novel until a region is hit by a major disaster, often relating to flooding. Because the country is seeing greater number of flood-related disaster instances occurring, these skills are increasingly becoming a requirement.

The project remains in its nascent stage – concepts have been solidified, an interview guide has been produced, and interviews with professionals across the listed disciplines have taken place. At the time of this report's drafting, 13 interviews have been conducted, with two more scheduled before the end of June 2017.

Knowledge gleaned from the interviews include an understanding of the institutional barriers to effective resilience-oriented education, ideas for interdisciplinary collaboration, and the opportunities that exist across the United States. These have the impact of helping me understand what opportunities exist in my field in other geographies. The study has larger impacts for pedagogy in these fields and even institutional organization at universities across the country.

Aside from amount of perspective I'm gaining from participation in this project, I have been able to hone my interview skills. Coming from the field of sociology, interviews are often an important way we collect data that cannot easily be measured. Having the opportunity to sharpen these skills, especially with interviewing high-achieving professionals, has aided in my understanding of techniques for the collection of qualitative information.

Conferences

In December of 2016 I attended the National Affordable Housing Conference in Washington DC. This was my first conference experience with planning professionals. I gathered that the climate was unusual, as the conference took place shortly after Ben Carson was appointed as the Secretary of Housing and Urban Development. One hazards-focused breakout session during the conference connected me to projects taking place outside of the southeast - a region that's often easy to limit my focus to. Noteworthy was my learning of Project Rapido, a new modular temporary-permanent post-disaster housing project that seems to be accomplishing a great deal in the western United States.

June of 2017 brought the pleasure of both planning and attending the Southeast Disaster Recovery Partnership Annual Meeting (SDRP). The Partnership, funded by a grant from NOAA, enabled me to spend the day in a room with professionals from FEMA, state emergency management departments, state natural resource departments, business professionals, and others. Up until that point, much of my nonacademic work and exposure had been with emergency management professionals – the scope and target audience for the Annual Meeting was much broader, focusing on the role of private businesses in short and long-term economic recovery following a disaster event.

Moving forward, I will be joining the other recipients of this fellowship to the Annual Natural Hazards Workshop in Colorado. There, I plan to connect with researchers and practitioners I have read and cited in my coursework – hopefully getting a deeper understanding of their work and potentially laying the foundation for future collaboration.

Publications

Publications have been steady, with a growing draft list waiting for editing and submission. Fall 2016 saw the joint-effort of "The Future of Floods: Lessons from Charlotte-Mecklenburg County," co-written by Ashton Rohmer and Colleen Durfee for Carolina Angles. This piece is a reflection on a site visit with Charlotte-Mecklenburg County storm water management professionals. Through innovative budgeting, being in an environment to kick off projects with new ideas, and with political will, the storm water management office was able to mitigate flood risk for communities alongside city streams. Through collaboration with nature conservancy agencies, this mitigation project was also able to restore wetland acreage, flora and fauna habitats, and provide a useful park asset to adjacent neighborhoods. Reflecting on this site visit was good, but collaborating with other students – specifically other recipients of this grant – was better. Writing this piece allowed us to walk away from the site visit with a long, combined list of takeaways.

In Spring 2017, I published a review of the book Precarious Claims by Shannon Gleeson was in the Carolina Planning Journal. This text featured numerous examples of the constraints vulnerable populations face when navigating workplace and workforce issues. More specifically, Gleeson's work illustrated gaps between labor legislation and enforcement agencies and the exploitation marginalized workers face in low-wage positions across the American Southwest (primarily California). Though this book does not directly deal with national security and hazards, it furnished my understanding of workforce needs – a perspective I later carried into work with SDRP as well as the Hurricane Matthew Disaster Recovery and Resilience Initiative.

Internship

My first summer internship is taking place between April and August 2017 at the Hurricane Matthew Disaster Recovery and Resilience Initiative (HMDRRI). This organization came into formation under Gavin Smith, with the support of both UNC – Chapel Hill and the State of North Carolina. HMDRRI selected six modest-capacity/high-need North Carolinian communities to do work with: Princeville, Windsor, Lumberton, Seven Springs, Fair Bluff, and Kinston.

My role within the initiative emerged over time. The aforementioned Housing Workshop course placed me in a group working primarily with Princeville. This enabled me to smoothly transition to doing Princeville work within HMDRRI – starting with thinking through organizational structure and relocation strategies. The research background the course provided a foundation for further research with HMDRRI.

Thus far, my primary occupation has been with developing a survey and interview instrument as a means to collect community input and characteristics for relocation. Historically, not much information is collected from FEMA buyout participants in North Carolina. Surveying them for basic information, alongside details about their post-disaster plans, may give future emergency managers and planners insight into how to better execute post-event mitigation programs. This

survey connects with potential future research avenues, and I have been responsible for helping the project navigate the institutional review board (IRB) process.

Final project outcomes remain to be seen – however the survey instrument is near completion – and will be able to serve research efforts for future hazard events. The opportunity to see through an IRB process has been beyond valuable, as I intend to pursue a PhD in related research. Our team is also forging connections with officials and community leaders in all six communities, posturing them for participation in later planning efforts.

Moving forward, we will be launching a meaningful community engagement strategy – guiding the communities through the visioning process towards the completion of disaster recovery plans. This will be accomplished by July 2017. Visioning and goal-setting is first, before deeper, more substantive planning tasks, eventually leading to a final draft document for each of the chosen communities.

Personally, the research, classroom, internship, and mentoring experiences have opened my eyes to the wide array of careers within the field of disaster recovery. My focus is narrowing. With a diversity of experience under my belt, after one year I am better able to steer myself away from opportunities that appeal less to my interests and background towards a path that would likely lead to satisfaction.

In some ways, my expectations have been exceeded, in other ways there is still work to be done. The classes, particularly the speaker series led by Gavin Smith, has been the most beneficial for my understanding of the aforementioned diversity of careers within the field. Speaking to actors at all levels of government and academia has inspired me more than anything else.