

**PAGAN/LÓPEZ - UPRM
DHS COASTAL RESILIENCE CENTER
EDUCATION PROJECT
YEAR 3 REPORT TEMPLATE**

Project Title: Education for Improving Resilience of Coastal Infrastructure

Principal Investigator Name/Institution: Ismael Pagán-Trinidad (PI), Ricardo R. López (Co-PI); Department of Civil Engineering, University of Puerto Rico at Mayagüez, Mayagüez, Puerto Rico

Other Partners/Institutions: ERDC-US Army Corp 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, Transportation Technology Transfer Center, Civil Infrastructure Research Center); NOAA (National Weather Service), INESI (“Instituto Nacional de Energía y Sostenibilidad Islaña” = National Institute on Energy and Island Sustainability), CRB (Community Resilient Building).

Project Start and End Dates: January 1, 2016 to June 30, 2018

Short Project Description (“elevator speech”):

This project helped educate the community by transferring state of practice knowledge to stakeholders (students, faculty, professionals, first responders, and workforce) through formal (curriculum, internships, student projects, undergraduate research) and informal (workshops, seminars, lectures, short courses, webinars) learning experiences. It served 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 helped the community understand better various stages in coastal infrastructure hazard prevention, preparedness, response, recovery, and mitigation. The focus was to understand the natural phenomenology, the engineering methodologies to address the level of risk the infrastructure is exposed to, the engineering methodologies and technology to analyze and predict the level of resistance and vulnerability the infrastructure and community is exposed to, the sustainable and resilient alternative available at the state of practice or state of art to cope with risks and vulnerabilities. The project helped motivated students and professionals into CRI careers and practice.

PROJECT NARRATIVE:

1. Introduction and project overview:

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 the Resiliency of Coastal Infrastructure (RCI) of the built and natural environment. 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 is focused on pre-incidents, incidents and post-incidents. New courses and revisions of existing course were evaluated in Civil Engineering and related disciplines dealing with estimates of causes and effects of coastal flooding, storm surge, ocean waves, tsunami loads, earthquake effects, and strong winds. Instruction was alternatively offered in the form of conferences, workshops, and lectures. Lecturers and experts from CRC, ERDC, FEMA, and other partners were invited to participate. State of practice technology is a priority, e.g., FEMA P646 publication for tsunami load estimates. The National Infrastructure Protection Plan and state infrastructure protection programs and plans are 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 are 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. Most recent Hurricane Irma and María experiences on the devastation over Puerto Rico will continue to be evaluated and the lessons learned will be incorporated in presentations, curriculum contents, and guidelines. The principal investigators will continue participating in various working teams, forums and meetings addressing building a resilient community in Puerto Rico for the future. At present time the PI's are involved with various initiatives, for example, Resilient Puerto Rico, ReImagine Puerto Rico, and others. All communities in Puerto Rico have been left overexposed to major damages and recovery challenges which require strong capacity building from the engineering perspective. The Island continues to present more catastrophic settings from overdeveloped and exposed urban and rural communities, more vulnerable zones (flood prone, weak soils and landslides, 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 and research perspective.

Puerto Rico will be in a continuous development process focusing on providing a more resilient community, infrastructure, families, and individual. The project collects, disseminates and exposes new knowledge and lessons learned from our past and expected natural events causing damages to the community.

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 $\frac{1}{3}$ 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 benefits from the opportunity to collaborate with DHS and the community it serves.

2. History:

The project began by kicking off various activities to meet, engage and commit partners and constituents who can collaborate within and outside the university. Strategic alliances with partners were focused on collaborative educational efforts. Students and faculty were targeted to participate in formal and informal courses in order to develop leadership and start a pipeline toward terminal degrees and labor force in the homeland security enterprise. Priority topics were defined from the civil infrastructure perspective as geotechnical, transportation, water, power, communication, and other built infrastructure exposed to coastal wind, earthquake and water forces on built infrastructure.

Faculty was engaged by developing formal and informal courses, undergraduate research and graduate theses. Students were allocated in summer educational internships experiences like SUMREX at CRC partner institutions and the ERDC-UPRM ERIP at the US Army Corp of Engineers national laboratories.

A series of workshops, conferences, lectures, trainings, short courses and other activities on relevant coastal topics were developed and offered with the participation of students, faculty, professionals, government officials and the community. Over a thousand mentors, faculty, lecturers, students, invited speakers, professionals and general public participated.

The third year was particularly special for the occurrence and devastation of Hurricanes Irma and María, two Category 5 hurricanes that not only surpassed any projection we had learned and experienced in the past, but also devastated the island's coastal and upland built and natural infrastructure. Despite the major institutional operational and administrative disruptor and interruptions, the PI's were able to provide real time adaptation to pursue the project goals and objectives. They engaged in preparedness, response, damage assessment, recovery, and adaptation educational and advisory activities to support the reconstruction of Puerto Rico. All of a sudden the resilience of all the built and natural infrastructure in Puerto Rico shifted to one of the first priorities be federal, state, and municipal governments, industry, non-for profit organizations and the general public in Puerto Rico and abroad. In addition the project continued offering formal and informal educational activities, through workshops, lectures, undergraduate research, graduate theses, formal course offering, and meetings. A new generation of "Conversations" were offered where experts, partners, government officials, the university and general communities, and the press gathered to openly discuss the impacts

of and lessons learned from the hurricanes on the built and natural infrastructure, the economic development, the environment quality, and the integrity and the social wellbeing of the community in Puerto Rico. The PI's actively participated in various forums, field reconnaissance, presentations, community and press advise, meetings, and many other initiatives not only to help recover community from the University perspective but also to help educate the community and capture the lessons learned after the hurricanes.

The following main outcomes can be identified from the project up to date:

1. UPRM administrations has identified as a primary university strategic challenge the needs to become a leader to provide the appropriate educational and research elements necessary to warranty the resilience and sustainability of the built and natural environment in Puerto Rico.
2. The PI's and the associated faculty were invited to participate with leadership roles in various initiatives to identify and develop ideas, opportunities, and priorities for the reconstruction project through capacity building, analyses and design of reconstruction projects, and new educational ideas and projects for Puerto Rico.
3. New funding sources were identified to lever and sustain resilience initiatives.

3. Results:

Courses:

a. Special Courses: Ten different existing formal courses were offered to undergraduate and graduate students. Nine of those courses were offered in civil engineering and marine science with the assignment of special engineering problems and research topics. Since the strategy in the project was to engage students and faculty, it was found that a "learn by doing" approach was followed by identifying interesting and priority themes and assigning formal independent study course in a wide variety of modes depending on which mode applied better. Topics were assigned in a variety themes including wind, water, and earthquake forces on structures, coastal erosion, floodplain and ocean modeling, prediction of hurricane tracks, coastal transportation infrastructure, coastal geotechnical hazards, and many others.

Approximately 120 students were formally registered in one of various special or regular courses at UPRM during the past 2 ½ years:

The following shows a list of special courses:

Course	No.	Title
INCI 4998	3	Undergraduate Research
INCI 5995	4	Special Topics (undergraduate in civil engineering)
INCI 5996	1	Special Problems (undergraduate in civil engineering)
INCI 6995	4	Special Problems (graduate in civil engineering)
INCI 6065	1	Engineering Project (Master of Engineering Project)
INCI 6066	4	Research Thesis (Master of Science)
INCI 8999	3	Doctoral Research and Thesis
CIMA 8999	1	Doctoral research and Dissertation (Marine Science)
CIMA 6999	1	MS Research and Thesis (Marine Science)
Total	22	

b. New courses: Two new course were developed, one was offered through the Special Topics mode and the second one was developed and is being videotaped with the intention of being distributed to a broader audience:

INCI 6997	7	Special Topics (Graduate in civil engineering): “Rehabilitation of Coastal Structures”
INCI 6XXX	N/A	“Resilience and Reliability of Coastal Infrastructure”
INCI 5XXX/6XXX	N/A	Others are under development

c. Capstone course: Seven Coastal Comprehensive Urban Development hypothetical projects with real constraints were assigned to senior civil engineering students to develop (analyzed and designed) multidisciplinary solutions during three consecutive semesters with the participation of a total of 88 undergraduate students, five faculties, five graduate students, and the participation of various guest speakers and lecturers on coastal engineering, resilient design and sustainability topics. The proposed sites are exposed to multi-hazards, namely: earthquakes; tsunamis; riverine and urban floods; coastal floods caused by storm surge, waves, tides, and winter ocean swells; soil liquefaction; corrosive environment; extreme hurricane winds; and localized sporadic twisters. Projects required to satisfy multiple objectives in function of economic development, environmental quality and compliance, social wellbeing and social satisfaction, construction sustainability, and resilient design against coastal hazards. Students formed companies, were trained by faculty and external professionals, worked in teams, and developed the whole design process, namely: Feasibility analyses, conceptual design, preliminary design, final design, project management, permit requirements, and oral and verbal presentations. This experience exposed our graduating students to mature the concept of coastal resilient systems, motivated some to go to graduate school, and directed others to participate in reconstruction activities in PR after Hurricanes Irma and María.

Faculty:

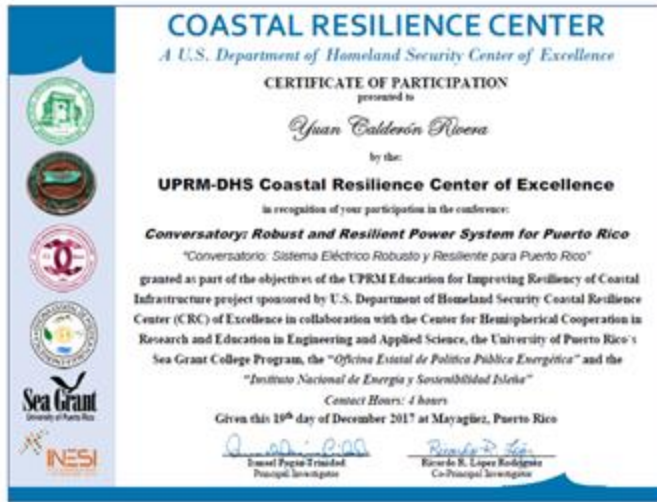
The project directly sponsored part of the time and effort of only the two co-pi's. However, a significant leverage was achieved with the engagement of many professors who were assigned to supervise courses through which students were exposed to civil engineering and coastal engineering topics and experiences. Others participated either as lecturers, collaborators, and participants in field reconnaissances after the hurricane.

An estimated 26 faculties participated in various modes of teaching, learning and research activities. Faculty were assigned a total of 12 different courses which were repeated during four different semesters. Some like theses and dissertations were continuous until graduation, but others like Undergraduate research and Special Problem courses were repeatedly taught every semester. Engaged faculty supervised approximately 118 student-semester for four semesters and three summers, for an average of about 40 students/year.

Four "Conversatories" were coordinated with two faculties who direct COHEMIS office in Campus. One faculty from Geology, three from Electrical and Computer Engineering, one from Industrial Engineering, and two from Marine Science Departments participated in the conversatories". These served either to engage new faculty or to share and collaborate with the work they have been doing in community resilience after the hurricane.

Certificates:

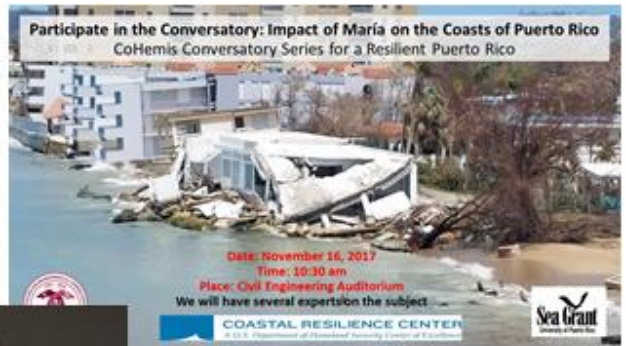
Over 800 participants and trainers were exposed to activities sponsored by the project including lectures, short courses, workshops, regular and special courses, conferences and the capstone course. An estimated 3137 person-hour of contact time of training are estimated for the audience. Formal and special curriculum courses are not included here. Each 3 credit-hour regular course requires 45 hour-semester of contact time, while a 3 credit-hour special course requires 135 hour-semester of research or working time.



Example of Certificate

Impact on the Coast

- Participants and Announcement



Example of Conversatory.

4. Students:

In addition to the number of students who participated as audiences in various lectures, conferences, “conversatories,” and other activities, a total of approximately 118 student-

semester for four semesters and three summers, for an average of about 40 students/year were registered in formal and special courses.

Six students finished their BSCE or MSCE degrees. Out of these, two finished their MS, and one of the two (Félix Santiago) entered the PhD Program in Coastal Engineering at LSU under Dr. Scott Hagen. The other four finished their BSCE. Three of them were admitted to Master Programs as a transition to eventually pursuing a PhD. One (Diego Delgado) will be studying in Spain, another (Peter Rivera) at UPRM. Both will follow coastal engineering related studies. The third student (Gabriela Buono) finished with outstanding qualifications her BSCE.

Various students who participated in the project received various recognitions:

1. **Gabriela Buono:** Graduated from the CE program in June 2018 and shared with another student the **Department Honor Medal as the best CE department student**. She also won the Dwight D. Eisenhower Fellowship awarded by the Federal Highway Administration during her senior year and worked a project entitled “*Scouring Impacts in Bridges at River Mouth: Puerto Rico Case Study of Victor Rojas Avenue Bridge*”) which derived from her participation in our CRC project. She was hired by Dewberry and Davis Company and she is working with site development applying all the principles she learned in her Capstone Course.
2. **Felix Santiago:** Graduated from the CE Program in the option of Environmental Engineering in June 2017. He is currently studying a PhD in Civil and Environmental Engineering at LSU at Baton Rouge (Coastal Engineering) and won the prestigious **NSF Graduate Fellowship**.
3. **Juan Gonzalez-Lopez:** PhD, worked as a university post doc and **was sponsored through a one year project under the PI’s BAA grant by ERDC through one of our projects** to complete the study entitled “*Updating and Improving a High Resolution Finite Element Mesh for Storm Surge and Hurricane Wave Modeling in Puerto Rico*”. Currently working as Physical Oceanographer/Modeler with Wood plc, based on Dartmouth, Nova Scotia, Canada since August 2017.
4. **Giovanni Seijo:** Participated as undergraduate student with Dr. González’s project, graduated from Physics at UPRM in June 2017, and **currently pursuing doctoral studies** at City University New York (CUNY, Earth & Environmental Sciences).
5. **Peter Rivera:** Graduated from the CE program in June 2018 and was **admitted to the ME department at UPRM** to study materials related to coastal engineering. He is aiming at pursuing a PhD in coastal engineering after he will finish his MS degree.

6. **Diego Delgado:** Graduated from the CE program in June 2018 and was **admitted to pursue a MS degree in a Coastal Engineering Program** in Coasts and Ports at the Cantabria University, Santander, and City, Spain.
7. **Efrain Ramos:** Ongoing MS student in Environmental Engineering at UPRM who participated with the ERDC-UPRM Internship Program at the Coastal and Hydraulic Laboratory (CHL). Responding to our leverage initiatives of the project with our partners he was one of five students sponsored by ERDC to participate in the Summer Internship at CHL under the supervision of Norberto Nadal to study the prediction of hurricane tracks in the Atlantic Ocean. Consequently, **he adopted his internship Scope of Work as his MS Thesis topic, his sponsor was appointed ever since through the project as Adjunct Professor at UPRM, his thesis project was sponsored by ERDC to work at UPRM, and he was hired by the CHL to work as a full time employee in September 2016** while he continues working in his thesis.
8. **Daniel Martínez:** A graduate student in Mechanical Engineering with option in Coastal Engineering, participated in an internship with our partner at the ERDC. He was hired by the ITL laboratory at ERDC in Nov. 2017.
9. **Alexander Molano:** MS Graduate Student in CE program in the option of Transportation Engineering, began as an undergraduate student in the program, participated in undergraduate research in the project with topic “Resilient Coastal Transportation Infrastructure”, **coauthored various local and international presentations with the PI’s and collaborators. Molano received the Dwight D Eisenhower during Spring 2018.**
10. **Angel Alicea:** PhD student planning to graduate by December 2018. He already has an offer to teach Structures in the new Civil Engineering Program for the Interamerican University of Puerto Rico. **He won the Dwight D. Eisenhower fellowship sponsored by the Federal Highway Administration for year 2016-2017.** Alicea worked in a project entitled *“Implementation of Innovating Structural Health Monitoring Techniques to a Highway Bridge” as part of his PhD thesis* which is of high priority in coastal seismic regions. His PhD thesis is entitled *“Dynamic Identification and Non-Linear Modeling for the Structural Health assessment of Aged Coastal Infrastructure”*.
11. **Héctor Colón:** An undergraduate student who participated in the SUMREX at OSU under Dr. Dan Cox in Summer 2017. **His summer internship research work entitled “Numerical Modelling of Tsunami Inundation Considering the presence of Offshore Islands and Barrier Reefs” was approved to be presented in 36th International Conference on Coastal Engineering to be celebrated in Baltimore, MD from July 30th to August 3, 2018.**

5. Institutionalization:

- a. What will be the sources of ongoing support?

Department and Deanship: Commitment to Resilient Infrastructure as an emerging strategic area at the department, deanship and Campus levels

UPRM created the Mitigation Committee: Faculty called to engage and and participate in after Hurricane María mitigation and recovery projects

Research/Education: Various proposals on research and curriculum development on the topic of resilient infrastructure are under consideration which will leverage and support the mission and vision of the project.

- Proposal with Dr. Zachary Grasley, Director of the Center for Infrastructure Renewal at Texas A&M University: **NSF Planning Grant: Engineering Research Center for Hurricane Resistant Coastal-Community Neighborhoods (HuReCaNe) through Reimagined House Construction**, June 2018.
- **Proposal with:** Dr. Dan Cox, Professor, Civil and Constr. Engineering, Oregon State University: Director Cascadia Lifelines Program, and Assoc. Director Center for Risk-Based Community Resilience Planning, **NSF Planning Grant: Engineering Research Center for Adaptive and Resilient Coastal Infrastructure (CARCI)**, June 2018.
- **Proposal to: RAND Corporation PR - “Proposal HSOAC FFRDC Task Order - Expert Analysis of FEMA Cost Estimate Development process and validation for FEMA-4339-DR-PR and FEMA-4340-DR-VI (Hurricane Maria) Remediation / Reconstruction”**, July 2018.
- Proposal to NSF: A partnership with various institutions led by the civil Engineering Department faculty including the Co-PI’s - **“Building Capacity: Collaborative Research: Resilient Infrastructure and Sustainability Education: Undergraduate Program (RISE-UP)”**, **March 6, 2018.**

Continue partnering with other institutions: Various initiatives are under development (see previous section) with partner institutions like: Cornell University, UPR-Rio Piedras, UPR- Ponce, Catholic University of Puerto Rico, Government agencies, Communities, Professionals related to building capacity and launching new educational strategies and activities. New collaboration is under negotiation with the US Army Corp of Engineers Research and Development Office on engineering and scientific coastal resilience advances and lessons learned after Hurricanes Irma and María.

Increase participation: Increase in faculty and students participation in coastal projects/theses/undergraduate research

Stakeholders: Continue strengthen collaboration and engagement with stakeholders on homeland enterprises.

- b. Where in your institution will your project be maintained?
At the Civil Infrastructure Research Center under the Department of Civil and Surveying Engineering
- c. Who will be involved in sustaining your project?
The PI and the Co-PI will be the main responsible persons. Other faculty will be assigned leadership roles in future activities.

6. Interactions with research projects:

a. **SUMREX** participation has been successful for 2016, 2017, and 2018. In 2017 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). In 2016 SUMREX students were Kevin Cueto and Diego Delgado at OSU and Felix Santiago at UCF/LSU. Felix has now started 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 in 2017 were Peter Rivera and Hector Colón to attend OSU and Diego Delgado will attend UCF/LSU. In 2018 two opportunities were communicated by Oregon State University (Dr. Dan Cox and Dr. John van de Lindt. The students selected for this Summer following the same procedure as in 2017, were Brian Acevedo and Jorge Santiago. Both are currently in the middle of the internship. In summary, UPRM students participated in 8 SUMREX internships for the 3 years.

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, PR 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.

d. **After Hurricane María** Profs I. Pagán and R. López of UPRM gave a talk on Dr. Gavin Smith's course at University of North Carolina describing the observed damage in Puerto Rico after Hurricane María. Dr. Smith visited Puerto Rico on 2 occasions for meetings at FEMA, at UPR School of Planning, and with Profs Pagán and López, to discuss several possibilities of helping FEMA with improving resilience in PR. Dr Smith and Prof. Pagán gave presentations at the Conference organized by the UPR Graduate School of Planning.

e. **A Series of Conferences (“Conversatories”) on the Impacts of Hurricane María in Puerto Rico** was organized in partnership with CoHemis (Center for Hemispheric Cooperation in Science and Engineering at UPRM), Sea Grant and other collaborators and were held in the Auditorium of the Civil Engineering Building of UPRM. The topics covered were: (1) Impact of María on the Coasts of PR, (2) Impact on the Power System, (3) Impact on Telecommunications, and (4) Impact on the Infrastructure. A total of 16 presenters representing academia (8), the community (3), Professionals (3) and Government (2) discussed the impact from their points of view, made recommendations, and answered questions from the audience. These conversatories were attended by 618 persons.

7. Publications:

a. Robert W. Whalin, Ismael Pagán-Trinidad, Evelyn Villanueva and David Pittman, "A Quarter Century of Resounding Success for a University/Federal Laboratory Partnership", Proceedings, 123rd ASEE Annual Conference and Exposition, Vol 1, presented June 27 2016 in New Orleans, LA. ISBN: 978-1-5108-3480-4

b. Ismael Pagán-Trinidad and Ricardo R. López, editors, Digital proceedings of Conference **“Lessons Learned and Best Practices: Resilience of Coastal Infrastructure”**, organized by the project, 2017, can be found in the link http://engineering.uprm.edu/inci/?page_id=3522

c. Morales-Velez, A. C., and Hughes, K.S., “Comprehensive Hurricane María Mass Wasting Inventory and Improved Frequency Ratio Landslide Hazard Mapping”, Revista Dimension Year 32, Vol 1, 2018

d. Aponte Bermúdez, Luis D., “Huracán María,: Sinopsis y Análisis Preliminar del Impacto en la Infraestructura de Puerto Rico”, Revista Dimensión Year 32, Vol 1, 2018

e. Martínez-Cruzado, José A. Huerta-López, Carlos I. Martínez-Pagán, Jaffet, Santana Torres, Erick X, and Hernández-Ramírez, Francisco J., “Destrozos, Recuperación, y Planes en la Red Sísmica de Movimiento Fuerte a Raíz de los Huracanes Irma y María”, *Revista Dimensión*, Year 32, Vol 1, 2018

f. Acosta, Felipe J, Esquilín-Mangual, Omar, Wood, Stephanie G., Long, Wendy R. and Valdés, Didier, *Lessons Learned from the Evaluation of Concrete Pole Failures Following Hurricane María*, *Revista Dimension* Year 32, Vol 1, 2018

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-wecdr-2016/>

g. 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.

h. 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.

Presentations on Impact of Hurricane Maria on Infrastructure

i. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, “Overview of the Impact of Hurricane María in Puerto Rico”, Presented at UNC-Chapel Hill, Graduate Resilience Certificate, by invitation from Dr. Gavin Smith, Feb 28, 2018

j. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, “Education for Improvement of Coastal Infrastructure in PR”, CRC First Annual Meeting, UNC Chapel Hill, March 2-3, 2016.

k. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, “Education for Improvement of Coastal Infrastructure in PR”, CRC Second Annual Meeting, UNC Chapel Hill, Feb 1-3, 2017.

l. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, “Education for Improvement of Coastal Infrastructure in PR”, CRC Third Annual Meeting, UNC Chapel Hill, Feb 28 - March 1, 2018.

m. Ismael Pagán-Trinidad, Ricardo López-Rodríguez, “Education, Resilience and the Built Environment: Impacts and Some Lessons Learned on Infrastructure for Improvement of Coastal Infrastructure in PR”, Symposium: Planning and Resilient Recovery in Puerto Rico, Graduate School of Planning - University of Puerto Rico – Río

Piedras, May 18-19, 2018

n. Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Ismael Pagán Trinidad and Didier. M Valdés Díaz. Impact of Extreme Climate in Coastal Transportation Civil Infrastructure in the Caribbean, World Engineering Forums November 26 to December 2, 2017, Rome, Italy

o. Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impact of Hurricane Maria on Puerto Rico's Transportation Infrastructure: Lessons Learned, 97th Transportation Research Board Annual Meeting, AHB55 Committee, *Work Zone Traffic Control Committee Meeting*, January 9, 2018.

p. Benjamín Colucci Ríos (Presenter) and Alexander Molano Santiago, Impacto del Huracán María en la infraestructura de transportación de Puerto Rico (Impact of Hurricane María in Puerto Rico's Transportation Infrastructure), 4th Conversatorio para un Puerto Rico Resiliente. February 20, 2018

q. Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago and Joel F. Alvarado López, El impacto del Huracán María en la infraestructura de transporte de Puerto Rico: Lecciones aprendidas (The Impact of Hurricane Maria in Puerto Rico's Transportation Infrastructure: Lessons Learned), Mega Viernes Civil 2018: Resiliencia Aplicada, College of Engineers and Surveyors of Puerto Rico, San Juan, April 6, 2018

r. Benjamín Colucci Ríos (Presenter), Alexander Molano Santiago, Luis Sevillano García, Launelly M. Rosado Rosa and Joel F. Alvarado López, Transportation Engineering Innovation Spearheading the Economic Development of Puerto Rico after an Extreme Natural Disaster, XXX Congress of Engineering and Surveying, COINAR 2018, San Juan, April 17, 2018.

8. Lessons Learned:

- It requires vision, courage and passion to make significant contributions to society. But vision is what really drives the others. A main lesson we learned is that opportunities come after leaders. One highlight we can identify is that this project was given an opportunity and it succeed thanks to the intervention of Dr. Robert Whalin, who invited us to participate. Thanks to him, the UNC PI's, and the DHS; hundreds of people (ranging from professionals, faculties, students, government officials, and the community citizens) have benefitted from the contributions made through the project. Lesson learned: It has been worth it!

- We understand the project has been very successful in integrating several partners to deliver quality courses, seminars and conferences. In essence, would do substantially the same. There are more opportunities available to partner with other groups than our possibilities as a small education project.
- Because of the interaction with several groups after Hurricanes Irma and María, we now know several key players that can be brought early into the project. Also because of the hurricanes, we were able to focus on particular problems observed that had huge consequences in the recuperation. Some of those problems were the lack of resilient electrical power system, the damage caused by storm surge on the coast, the lack of potable water, problems with sanitary plants, lack of reliable communication system (both public and private), and several structural failures that could have been avoided with better compliance with modern building codes.
- We have learned that capacity building must be audience type oriented. Being our expertise engineering, it must be our priority to engage, commit, and disseminate information with the engineering background. However, building resilience in the community from the infrastructure perspective requires a diverse multisector and multidisciplinary approach. For that reason, we have engaged and plan to continue engaging experts from diverse backgrounds and expertise.

9. Tables:

Table 1: Documenting CRC Education Project Courses and Enrollments

Courses Developed and Taught by <u>University of Puerto Rico Mayaguez</u> under Project Education for Improving Resiliency of Coastal Infrastructure					
<u>Course</u>		<u>Developed (D), Revised (R), and/or Taught (T), by Project Year</u>			
<u>Number</u>	<u>Title</u>	<u>1</u>	<u>2</u>	<u>3</u>	
<u>INCI6997</u>	<i>“Rehabilitation of Coastal Structures (under development)” - Guevara</i> Dual codes for graduate and undergraduate		D	T	
<u>INCI5995</u>					
Offering: Elective (E), Concentration (C), Minor (M)		-	E	E	
Enrollment		-	-	7	
<u>INCI6XXX</u>	<i>“Resilience and Reliability of Coastal Infrastructures (under development)” - Saffar</i>		D	R	
<u>INCI5XXX</u>					
Offering: Elective (E), Concentration (C), Minor (M)		-	E	E	
Enrollment		-	-	-	

INCI6995	<p align="center">CE Special Problems (Graduate):</p> <ul style="list-style-type: none"> ● “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 ● “Assessment of Existing Tropical Cyclone Vortex Models for the Development of Wind and Pressure Profiles and Fields” 	T T	T T T		T
Offering: Elective (E), Concentration (C), Minor (M)		E/C	E/C	C	
Enrollment		3	5	1	
INCI5996	<p>CE Special Problems (Project)</p> <ul style="list-style-type: none"> ● “Impact of Projected Sea Water Rise on Coastal Infrastructures” - IPT ● “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	<p>MS-Thesis</p> <ul style="list-style-type: none"> ● “Structural Effects of Tsunami Loads on Coastal Infrastructure,” by Kevin Cueto (Ricardo Lopez) ● “Computation of Gradually Varied Flow in Channel Networks with Hydraulic Structures” by Felix Santiago (Walter Silva) ● “Cost analysis of the alternatives to mitigate damage to the infrastructure in Rincon” by Francisco Villafañe (Luis Aponte) ● “Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty Associated with Storm Recurrence and Intensity” by Efrain Ramos (Norberto Nadal) 	D D	D D	T T	T T

Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment		1	4	4	
INCI6065	<i>Master of Engineering Project</i> <i>Structural Analysis of Common Coastal Structures found on the West Coast of Puerto Rico using FEMA P-646 by Jorge Romeu</i>		D	T	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	
INCI8999	<i>PhD Dissertation</i> <ul style="list-style-type: none"> • <i>“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</i> • <i>“Variation of the nonlinear dynamic response of three-dimensional buildings of reinforced concrete considering the directionality of seismic accelerations” by Juan Rodríguez</i> • <i>“Dynamic Identification and Nonlinear Modeling for the Structural Health Assessment of Aged Coastal Infrastructure in Puerto Rico” by Angel Alicea</i> 	D	D T	T T	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			3	3	
INCI4950	<i>Civil Engineering Integrated Design Project - Capstone Course</i>		T	T	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			45	43	
CIMA8999	<i>Marine Science PhD Dissertation</i>		D	D	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	

CIMA6999	<i>Marine Science Master Thesis</i>		D	D	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	
INCI4998	<i>Civil Engineering Undergraduate Research</i>		T	T	
Offering: Elective (E), Concentration (C), Minor (M)			C	C	
Enrollment			1	1	

Table 2: Documenting External Funding and Leveraged Support

2A: External Funding			
<u>Title</u>	<u>PI</u>	<u>Total Amount</u>	<u>Source</u>
Stochastic Simulation of Tropical Cyclones for Quantification of Uncertainty Associated with Storm Recurrence and Intensity (Efrain Ramos)	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 (Felix Santiago, Giovanni Seijo)	Juan Gonzalez (as Co-PI of a broader BAA with the ERDC)	\$36K Fall 2016 - Spring 2017	CHL-ERDC-US ARMY Corps of Engineers
“Houston Ship Channel Ship Simulation Study”- Gabriela Buono	Ismael Pagan Trinidad	\$7267, Allen Hammack Summer-Fall 2017	CHL-ERDC-US ARMY Corps of Engineers
“Feasibility of using the Weather Research and Forecasting Model (WRF) as forcing for the Advanced Circulation Model (ADCIRC)”, Nelson Cordero “Evaluating simulation runs techniques using the Weather Research and Forecasting Model (WRF) capabilities”, Nelson Cordero “Assessment of Existing Tropical Cyclone Vortex Models for the	Ismael Pagan Trinidad	\$36903 Summer-Fall 2017	CHL-ERDC-US ARMY Corps of Engineers (three different task orders)

Development of Wind and Pressure Profiles and Fields”; Nelson Cordero			
“Physical Model Testing of Improved Ribbon Bridge”,Kevin Cueto Alvarado	Ismael Pagan Trinidad	\$8364, Dr. Matt Malej, Summer-Fall 2017	GSL--ERDC-US ARMY Corps of Engineers
2B: Leveraged Support			
<u>Description</u>			<u>Estimated Annual Value</u> <u>(Mostly In-Kind)</u>
UPRM Release Load - 2 CE Researchers worked on CRC project (Pagán 6 crs. ; López 6 crs)			\$55,000 years 2 and 3
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” Other speakers at the Conference @\$500/participants)			\$45,000 \$6000
Sea Grant Program Collaboration - Promotional materials, arts, announcements			\$2,000
COHEMIS-Collaboration, Coordination of conversatories, promotional material, personnel time)			\$5000
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			\$2,000
PR Climate Change Change Speaker - 6 hours			\$2000
Conversatories - Speakers 16 @\$500			\$8000

Table 3: Performance Metrics

Pagan Education Project Metrics

<u>Metric</u>	<u>Year 1</u> (1/1/16 – 6/30/16)	<u>Year 2</u> (7/1/16 – 6/30/17)	<u>Year 3</u> (7/1/17 – 6/30/18)
HS-related internships (number)	10	16	9
Undergraduates provided tuition/fee support (number)		1	
Undergraduate students provided stipends (number)		2	1
Graduate students provided tuition/fee support (number)	5	9	5
Graduate students provided stipends (number)	6	9	4
Undergraduates who received HS-related degrees (number)		N/A	2
Graduate students who received HS-related degrees (number)		N/A	2
Certificates awarded (number)		245	800
Graduates who obtained HS-related employment (number)		2	1
Lectures/presentations/seminars at Center partners (number)		1	2
DHS MSI Summer Research Teams hosted (number)		N/A	N/A
Journal articles submitted (number)	1	0	4
Journal articles published (number)	1	0	4
Conference presentations made (number)	2	31	23
Other presentations, interviews, etc. (number)	2	8	5
Trademarks/copyrights filed (number)		0	0
Requests for assistance/advice from DHS agencies (number)			
Requests for assistance/advice from other Federal agencies or state/local governments (number)	5		4
Total milestones for reporting period (number)		2	7
Accomplished fully (number)	2	2	7
Accomplished partially (number)		N/A	
Not accomplished (number)		N/A	

10. Year 3 Education Activity and Milestone Achievement:

Education Activities and Milestones: Final Status as of 2018

Reporting Period 7/1/17 – 6/30/18
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Education Activities	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not reached
1. Assessment and Rehabilitation of Coastal Infrastructure course for students and professionals	Dec 2017	100	100 (Guevara)
2. Outreach high school students and faculty	May 2018	50	Schools schedule and availability within their schedule highly limited because of school closures, class delays, and priority to schools agenda.
3. Expand scope of offerings (workshops, seminars, lectures)	Dec 2017	100	100
4. Offer first train the trainer workshop	June 2018	100	
5. Launch project web page-engine to access repository and web navigation on educational RCI issues	Dec 2017	80	Web page ready. Needs to be uploaded. Documentation copy-rights screening.
Education Milestones			
1. Expand the Educational Community in RCI (Metric: List participants and sectors)	June 2018	100	100
2. Create a Community of Minority Educational Leaders in RCI (Metric: Number of women and Latin-Americans engage as leaders)	June 2018	100	100
3. Provide second round of certificates (Metric: Number of certificates)	June 2018	100	100

11. Year 3 Transition Activity and Milestone Achievement:

Transition Activities and Milestones: Final Status as of 2018

Reporting Period 7/1/2017 – 6/30/2018			
Transition Activity	Proposed Completion Date	% Complete	Explanation of why activity/milestone was not reached
1. Provide second round of certificates	June 2018	100	
2. Engage second formal course on Assessment and rehabilitation on Coastal Infrastructure	Dec 2017	100	
3. Increase /expand seminars/lectures	June 2018	100	
4. Offer second annual local workshop/conference	June 2018	100	
5. Offer first Train the Trainer workshop	June 2018	100	Workshop de Flood Mapping
6. Provide access to RCI literature, guidelines, and websites	Dec 2017	80	Web page ready. Needs to be uploaded. Documentation copy-rights screening.
Transition Milestone			
1. Offer second new formal course (Metric: Contents learned)	June 2018	100	
2. Provide second round of certificates(Metric: No. and distribution of certificates given)	June 2018	100	

3. Create pipeline for precollege students to engineering programs engaged in CRI activities (Metric: No. of students pursuing engineering careers with HLS aspirations)	June 2018	100	
4. Develop RCI leaders (Metric: Distribution of certificates of trainees granted)	June 2018	100	