FRM

Flood Risk Management Newsletter

NATIONAL FLOOD RISK MANAGEMENT PROGRAM
Driving Down Risk

Silver Jackets Activities in Alaska 2017

StormSim-CHRP: Rapid Prediction of Coastal Storm Hazards

Next-Generation I-Wall Analysis Software: Corps_I-Wall

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Flood Risk Management Newsletter

US Army Corps of Engineers

Jan 2018 • vol 11 no 1

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October 2017

FRM Newsletter
Office of Homeland Security
441 G Street, NW
Washington, D.C. 20134-1000

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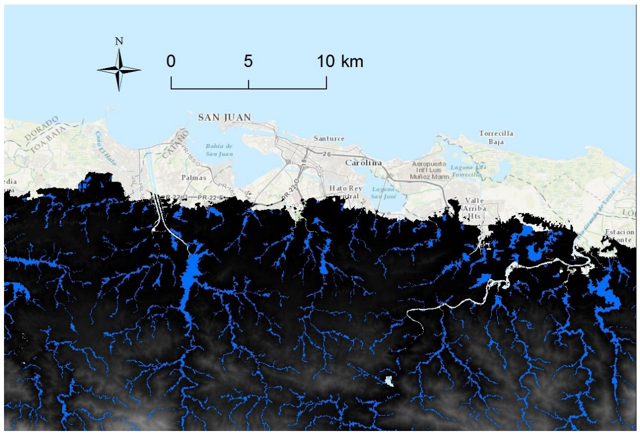

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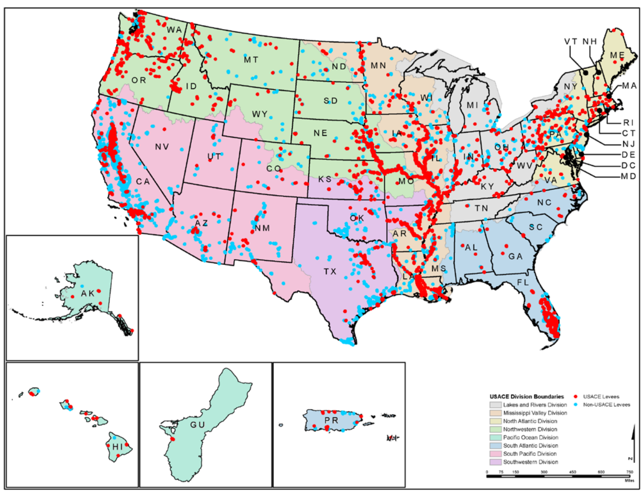

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“Change” in the Office of Homeland Security

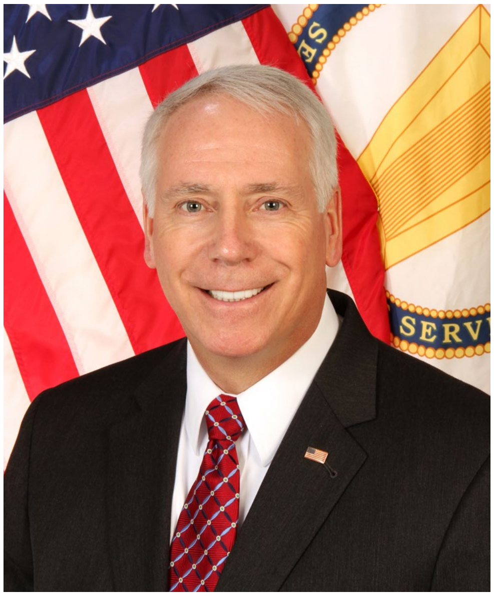
By Mark Roupas, Deputy Chief, Office of Homeland Security

“It is my honor and pleasure to (re)introduce Mr. Charles “Ray” Alexander as the new Director of Contingency Operations and Homeland Security.”

Happy New Year! I’ve written in past editions of this Newsletter about change and transition, and I find myself continuing that theme as we move into the New Year. 2018 marks a new year of change in leadership with Homeland Security. It is my honor and pleasure to (re)introduce Mr. Charles “Ray” Alexander as the new Director of Contingency Operations and Homeland Security. Most recently, Mr. Alexander filled the position as the Chief of Interagency and International Services at HQUSACE, a role which he moved to after being appointed to the Senior Executive Service in November 2014. Prior to promotion to the Senior Executive Service, Mr. Alexander served as Deputy Chief, Office of Homeland Security.

Mr. Alexander also previously served as the USACE Deputy Chief of Operations (G3) responsible for the command’s programs involving Engineer force structure, current and future operations, plans and concept development, and training and exercises. He spent 5 years in the private sector with experience in program management, business development, and contingency operations before returning to Federal service in March 2011. Mr. Alexander completed over 26 years of military service, retiring at the rank of Colonel and commanded at every level from platoon to brigade. His diverse experience includes service as a District Commander in the U.S Army Corps of Engineers; as a faculty member at the U.S. Army War College; a division chief at the U.S. Army Maneuver Support Center where he oversaw the $18 billion Army Engineer program; a combat engineer battalion commander in a mechanized Infantry Division, a program manager with experience in the Department of Defense’s Planning, Programming, Budgeting and Execution System (PPBES) at both Army and Joint Combatant Command staff level; staff experience at the Headquarters of both Department of the Army and U.S. Army Europe; command and staff experience in combat engineer troop units with service world-wide. Mr. Alexander is a graduate of the U.S. Army War College, the University of Virginia, and the University of Richmond. This background and expertise means that he comes to us well versed in flood risk management and emergency management and I anticipate that he will be a strong champion for these programs!

Now, onto the other areas of evolution and transition that I mentioned. As you know, we are still heavily engaged



Ray Alexander, Director of Contingency Operations, Homeland Security

in recovery actions from Hurricanes Harvey, Irma, and Maria, as well as other significant events of 2017. As we continue the recovery efforts, and look for opportunities to incorporate mitigation actions, we are also evaluating lessons learned from the response operations, as well as lessons learned as we move through the recovery process.

USACE recently deployed a assessment team led by Ms. Susan Turek and COL Eric McFadden to obtain an initial snapshot of the concerns, issues and best practices for the 2017 hurricane disaster operations. Over the course of several weeks, the team met with FEMA leadership, USACE Commanders, ESF#3 Management Teams, and our state, local and tribal partners in Florida, Texas, Virgin Islands and Puerto Rico. It is evident from the interviews that FEMA and our partners appreciate USACE’s support and our relationships are strong, but we also learned that there are opportunities for improvements. While a complete assessment of findings is still being compiled, a number of clear themes emerged from the team’s

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interviews regarding mission execution, non-standard missions, integrating the military-civilian cultures and resourcing for success. Our plan is to address these issues in a deliberate manner under our Remedial Action Program and identify a subset for action. High level policy matters will be elevated to the 2018 USACE/FEMA Senior Leaders' Seminar to be hosted by the Chief of Engineers and the FEMA Administrator in May 2018 prior to next hurricane season. We will develop solutions that will improve our processes and training so that USACE is better able and postured to support FEMA and disaster survivors in the future.

Additional observations from the experience so far include the need to review and where possible within resource limitations, improve and enhance multiple facets of training. We need to make sure our team members have the experience and knowledge, both tactical and operational, to adequately and efficiently provide the advice and guidance that is needed to enhance execution of the mission during disaster situations. We also need to ensure all team members (military and civilian) are well versed in the Stafford Act and understand the various authorities available in these situations. And finally, as was suggested above, we need to work to improve our knowledge in how to better manage and execute non-standard missions. These, and other lessons learned coming out of our after action review processes, will be some of the things we look to improve as we move into the next disaster season.

Silver Jackets Activities in Alaska 2017

By Wendy Shaw, USACE Alaska District

The Alaska Silver Jackets Team is an interagency team "developing comprehensive and sustainable solutions to Alaska's hazard issues." In 2017, the team successfully participated in U.S. Geological Survey (USGS) gage datum conversion, high water mark sign placement, funding for fiscal 2017 and 2018 interagency non-structural proposals, and coordinated survey efforts to support FEMA and NWS mapping efforts.

USGS Gage Datum Conversion

There are only 102 real-time USGS river gages for the State of Alaska; many of which are referenced to a local gage datum. In 2016, the team began a program to tie 27 of these gages into North American Vertical Datum (NAVD88 datum). The gages were identified as priority locations by the USGS and the National Weather Service (NWS)-Alaska River Forecast Center. USACE was able to deploy in-house survey resources and augment the work using an existing open agreement with a survey contractor. All work was completed the summer of 2017, and survey data was shared with all partners. These surveys are not only important for real-time data but especially when modeling river systems, as the gage heights can be directly converted to relative datum elevations.

High Water Mark Signs

Interpretive Display and High Water Mark Sign near Chena River commemorating 50th anniversary of flood.

High water mark collection, verification, and signage are important to any flood risk mitigation and communication effort. In 1967, floodwaters from the Chena River inundated the town of Fairbanks. To commemorate this event and to acknowledge the mitigation efforts that have been put in place within the last 50 years, the Alaska Pacific River Forecast Center (APRFC) received a grant through the Preserve America Initiative to create and install interpretive displays and high water mark signs for this historic flood. The grant paid for a set of two interpretive panels, while USACE coordinated a third set of high water mark signs to be placed at the Moose Creek Dam project office. The partners for this project included USGS, City of Fairbanks, Fairbanks Northstar Borough, Festival Fairbanks, National Weather Service Alaska Region, State of Alaska, and USACE. These high water mark signs and panels provide the public with quick access to the historic flood and additional information through a scan-enabled QR code located on the panels (https://www.weather.gov/aprfc/Fairbanks1967).

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Fiscal 2017 Non-Structural Project

USACE funded a Silver Jackets proposal to support a nonstructural project that provides inundation mapping for high water scenarios of Willow Creek in the Matanuska-Susitna Borough. This project gave USACE and the Silver Jackets team a unique opportunity to work with a new partner, the Alaska Railroad Corporation (ARRC). The ARRC approached Silver Jackets through the State Department of Homeland Security and Emergency Management after a large rainfall event nearly overtopped its bridge crossing at Willow Creek. The Matanuska-Susitna Borough supported this project because there is an increase in population growth in the Borough and it supports the ability to identify potential at-risk areas before development. The Alaska River Forecast Center will use the inundation maps to estimate impacts during forecasted high water events. The project also expanded the forecasting capabilities by linking the USGS gage on Willow Creek to the NAVD88 datum. Through the development of the high water modeling and scenario mapping, USACE also plans to include discussions on potential flood risk reduction measures. High water mark signs from the 2012 event will also be placed throughout the study area to assist the Borough in telling the flood risk story. This project is due to be completed in December 2017.

High water threatens Railroad Bridge in 2012 rainfall event.

Kenai River Cross-Section Survey

Kenai River at Soldotna Creek Park.

The team also completed another significant survey effort that exemplified the solutions-based approach of the Alaska Silver Jackets. The team is constantly striving to find creative ways to use existing resources to work together to collect the data and provide the technical assistance that the communities so desperately need. At the request of FEMA Region X and the State RiskMAP Coordinator, the Silver Jackets Team was also able to complete the collection of 112 river cross sections along approximately 40 miles of the Kenai River. FEMA identified this river system as a priority location for remapping; however, resources were not immediately available to develop an updated survey. The Kenai Peninsula Borough had collected LiDAR in 2012, enabling the survey to be mostly limited to the in-water cross section data collection. The NWS Alaska River Forecast Center supplied technical assistance in determining the appropriate locations of the river cross sections in order to develop a Kenai River hydraulic model for inundation scenarios and impact analyses. The USGS gages in the region were already converted to the NAVD88 datum from a previous USACE survey. The effort was partially funded through an existing interagency agreement between the Alaska District and FEMA for technical assistance and through USACE Floodplain Management Services. USACE was again able to use an existing open contract with a survey contractor, while providing quality control. It was also especially helpful to have local surveyors that were familiar with the area and its population.

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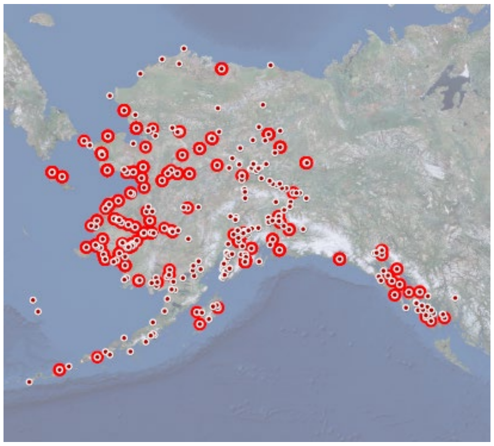
State-Wide Historical Flood Database

The Silver Jackets Team was also integral in the initial development of a statewide historical flood hazard database. USACE Floodplain Management Services and NWS Alaska River Forecast Center began with the most recent flood events throughout the state and cataloged them as minor, moderate, or major events. Research was conducted to include all flood accounts identified in community hazard mitigation plans and FEMA or State disaster declarations. The data is stored in a georeferenced relative database that allows users to query a community, region, or river system. This initial effort was further funded through a project with the Denali Commission to add erosion and permafrost data to the database. Future efforts will continue cataloging floods throughout the State of Alaska. In FY18, USACE and the team plan to reach out to as many communities as possible to collect oral histories of events and to verify the information already added to the database. This effort is the first of its kind in Alaska and includes the core Silver Jackets Team of USACE, State, NOAA/NWS, USGS, and FEMA, while partnering with the Denali Commission, Alaska Native Tribal Health Consortium, Western Alaska LCC, and various community leaders and elders.



Snapshot of identified historical flooding locations (large red dots)

ERDC R&D Products Applied in Support of 2017 Hurricane Emergency Management

Compiled by Julie Rosati and Mary Cialone; by Aaron Byrd, Mike Follum, Chris Massey, Nawa Pradhan, Alan Snow, and Mark Wahl,
Engineer Research & Development Center, Coastal & Hydraulics Laboratory (ERDC-CHL)

Overview

The 2017 Hurricane season including Hurricanes Harvey, Irma, and Maria directly impacted U.S. urban populations affecting life and safety, emergency operations, navigation, national economics and security, and environmental health. In late August, Hurricane Harvey dropped nearly 52-inches of rain in Houston, Texas over a 5-day period, causing 82 deaths and $180 billion in damages. Hurricane Irma, the most powerful Atlantic Hurricane in recorded history, followed in early September causing 61 deaths and $150-200 billion in damages as it traversed Puerto Rico, the U.S. Virgin Islands and through Florida. Hurricane Maria compounded the devastation in Puerto Rico with a direct hit in late September with 30-inches of precipitation in one day. Damages from Hurricane Maria have been estimated between $5-95 billion with at least 55 deaths reported to date.

In support of USACE response, technologies developed through ERDC R&D were applied to estimate storm surge and inundation, support flood control operations, and estimate impacts to navigation. This article highlights three of several R&D applications that supported the 2017 hurricane response. A companion article in this newsletter (Nadal-Caraballo, Lewis, and Diop) provides more detail about application of another R&D product, the StormSim Coastal Hazards Rapid Prediction (StormSim-CHRP) software.

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Hurricane Harvey – ADCIRC (Chris Massey, ERDC-CHL)

Harvey intensified from a Tropical Storm to a Category 3 Hurricane on August 24, 2017. Numerical simulations with the ADvanced CIRCulation (ADCIRC) storm surge model for Hurricane Harvey began on Friday August 25, 2017 with Advisory 16 from the National Hurricane Center (NHC). Model results were provided to the USACE Galveston District (SWG) in the form of time series of water elevations at 19 key locations selected by SWG along with contour plots of maximum water surface elevations along the entire Texas and Louisiana coast. Leading up to the first landfall of Harvey on Aug 25, modeling updates were provided for each NHC advisory (18 through 22). The ADCIRC simulations were forced with winds, atmospheric pressures and tides. The input meteorology products were derived using the NHC forecast (Advisory) data. As Harvey continued to impact the Texas and Louisiana coast, ADCIRC modeling was conducted for all advisories through August 29th (Advisory 37). ADCIRC calculations provided temporal and spatial estimates of winds, tides, and storm surge magnitudes so that USACE emergency response operations could better prepare for the timing and location for response and mitigation measures. Other R&D products were applied in advance of Hurricane Harvey, including the GSSHA inundation model. A description of another GSSHA application for Hurricane Irma is described in the next section.

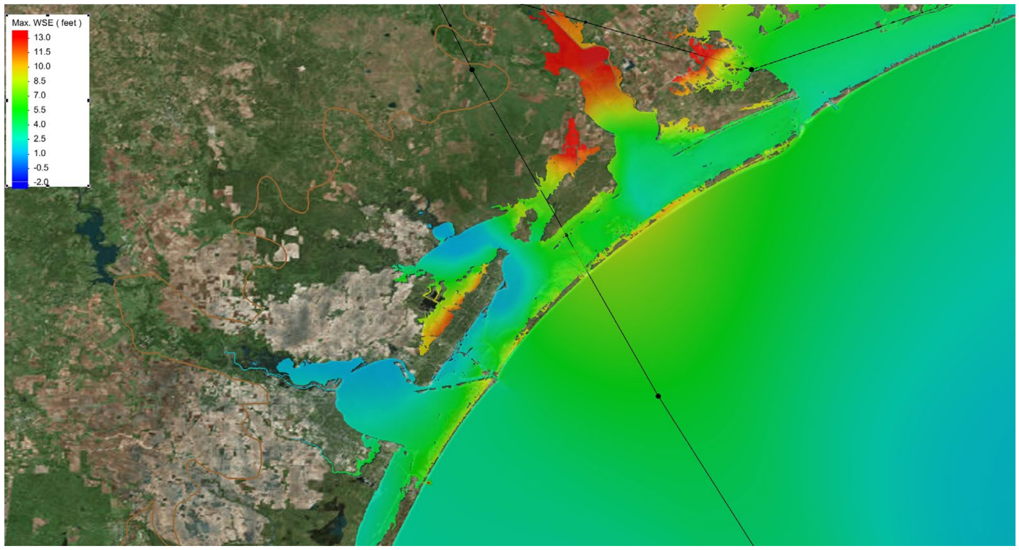
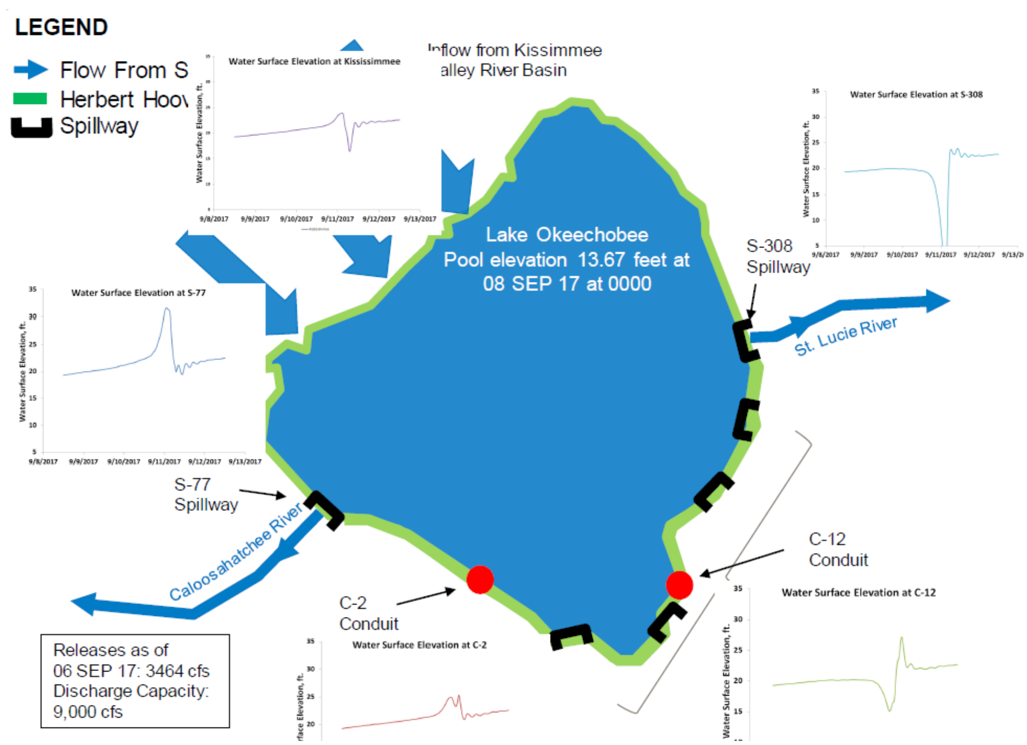


Figure 1. Maximum surface water elevation from Hurricane Harvey Advisory 18 from Corpus Christi (south) to Matagorda Bay (north), Texas as calculated by ADCIRC

Hurricane Irma – GSSHA and AdH (Aaron Byrd, Mark Wahl, Nawa Pradhan, Chris Massey, and Guarav Savant (contractor), ERDC-CHL)

Numerical models for inland flood inundation developed in the Flood and Coastal R&D Program were applied to estimate potential impacts to Lake Okeechobee, FL in preparation for and during the response to Hurricane Irma. Two CHL simulation tools were used. The AdH (Adaptive Hydraulics) model was used to model set up on Lake Okeechobee in response to hurricane-force winds. Of concern were several locations along the Herbert Hoover Dike that are still under construction and protect nearby population centers. The GSSHA (Gridded Surface Subsurface Hydrologic Analysis) model was used to estimate flooding extents from both rainfall and storm surge along the eastern coast of Florida, from Miami to West Palm Beach. It was also used to look at flood extents from rainfall and potential failure modes of the Herbert Hoover Dike.



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The results of the modeling efforts showed that communities to the south and east of Lake Okeechobee were likely not in immediate danger, whereas the communities to the west were likely in danger of flooding from this event. Based on CHL analyses, the communities to the west were warned of the flooding potential and evacuation orders were issued to protect the local communities. Other models applied during Hurricane Irma included the Coastal Storm Modeling System, CSTORM, which coupled ADCIRC with the STWAVE wave model to estimate water level and wave impacts on Lake Okeechobee.

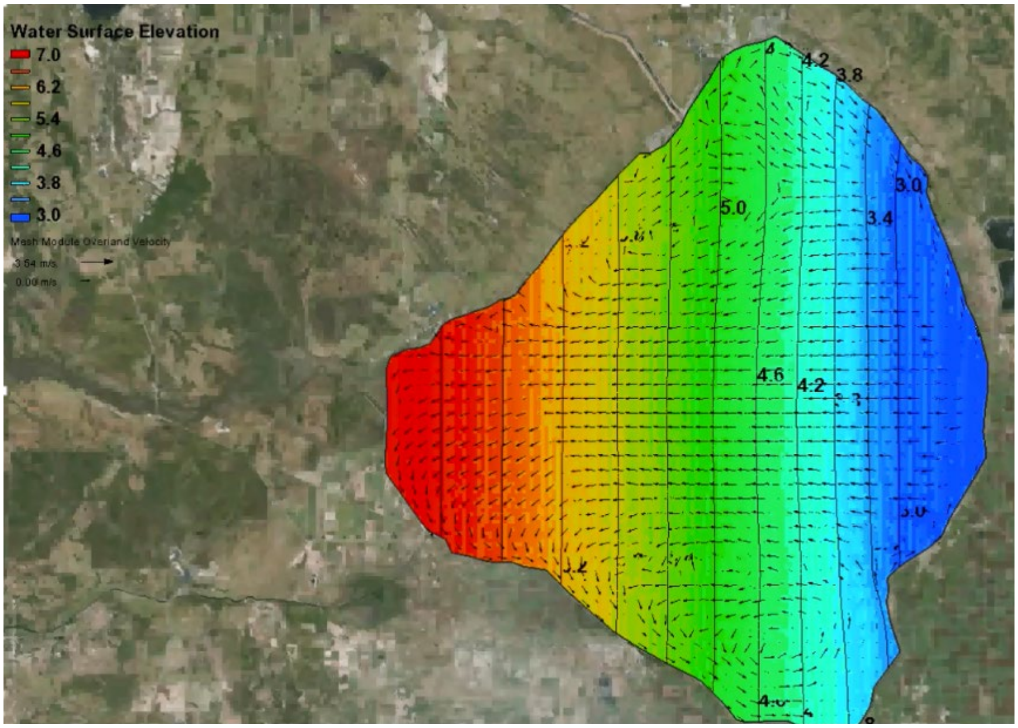

Figure 2. GSSHA and AdH calculated time-dependent pool elevations and outflow from various spillways and conduits (upper) and water levels (lower; red=7 m, green 5 m, blue 3 m) for Lake Okeechobee, Florida, in advance of Hurricane Irma

Hurricane Maria – AutoRoute (Mike Follum, Mark Wahl, ERDC-CHL)

Prior to Hurricane Maria making landfall in Puerto Rico, storm surge and inland flooding information was requested by U.S. Army South. To magnify the complexity of the problem, an expedient timeframe (1-day turn-around) was required to meet emergency management needs. Web links to previously calculated storm surge results using the ADCIRC model were immediately sent to U.S. Army South. Inland flood data for the entire island were generated using the ERDC AutoRoute model (Follum et al., 2017). Elevation datasets (10-m) were collected and processed, resulting in a high-resolution stream network for the entire island. AutoRoute was then used with the USGS flow regression equation for Puerto Rico (Ramos-Ginés, 1999) to create a high-resolution 100-year flood inundation map for the entire island. These data layers were sent to U.S. Army South, where they were used in planning and operational support prior to Hurricane Maria making landfall in Puerto Rico.

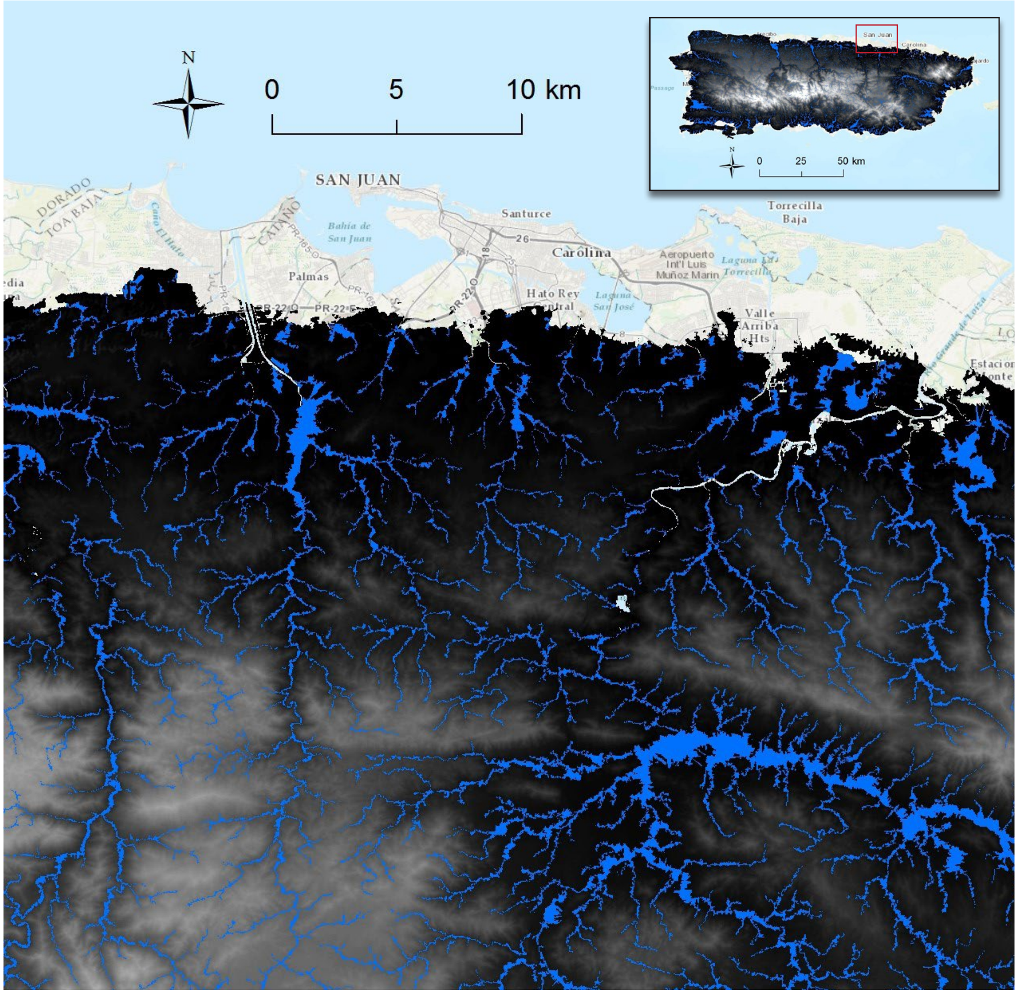

Figure 3. Calculations of inland flood inundation (blue; grayscale indicates elevation) for Hurricane Maria in Puerto Rico for mainland (upper) and San Juan area (lower).

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In summary, hurricane preparations, response, and recovery were informed through application of products developed through several ERDC R&D programs. The availability of previously-developed numerical grids and databases enabled assessments in hours to days, facilitating planning reservoir operations, mobilizing resources to address likely storm surge and flooding impacts, and evacuating communities in advance of the storms. R&D products applied ranged from those that can provide quick response (order of 1 day turn-around), using online data sources, to high-fidelity advanced models that were readily adapted using existing topographic and bathymetric data, infrastructure operations, numerical grids and databases. Research has been proposed to streamline future emergency operations for vulnerable urban cities, including pre-calculation of hazard data that can be rapidly queried in advance of storms, and development of numerical grids for major urban cities in support of future Flood Risk Management operations.

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Joint Airborne Lidar Bathymetry Technical Center of Expertise Support of Coastal Mapping and Analysis: Post-Storm Missions

By Jennifer Wozencraft and Lauren Dunkin,
Engineer Research and Development Center, Coastal Hydraulics Laboratory

The Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTCX) deployed to support regional-scale post-storm damage assessments following Irma (2017) for the Federal Emergency Management Agency and previously in 2005 (Dennis). In addition, the JALBTCX has deployed for the U.S. Army Corps of Engineers (USACE) after several major extreme storm events in 2004 (Charley, Frances, Ivan, Jeanne), 2005 (Katrina, Rita, Wilma), 2008 (Ike), 2012 (Sandy), and 2016 (Matthew). The regional datasets extend beyond project boundaries providing critical data needed to quantify impacts associated with storm events to directly support missions within the USACE, other federal agencies, academia, and the broader coastal community. The data has been used to support the USACE South Atlantic Division districts following Hurricane Matthew to develop their Project Information Reports, the United States Geologic Survey uses post-storm data to support research objectives, and NOAA (National Oceanic and Atmospheric Administration) relies on the technology and data to support the objectives of the Interagency Working Group on Ocean and Coastal Mapping (IWG-OCM) as the congressionally mandated effort to develop a coastal mapping plan. The JALBTCX provides a unique coastal mapping capability that collects and processes concurrent topographic and bathymetric lidar, aerial photography, and hyperspectral imagery from a single platform system to provide regional datasets for a comprehensive picture of the coastal zone (Figure 1).

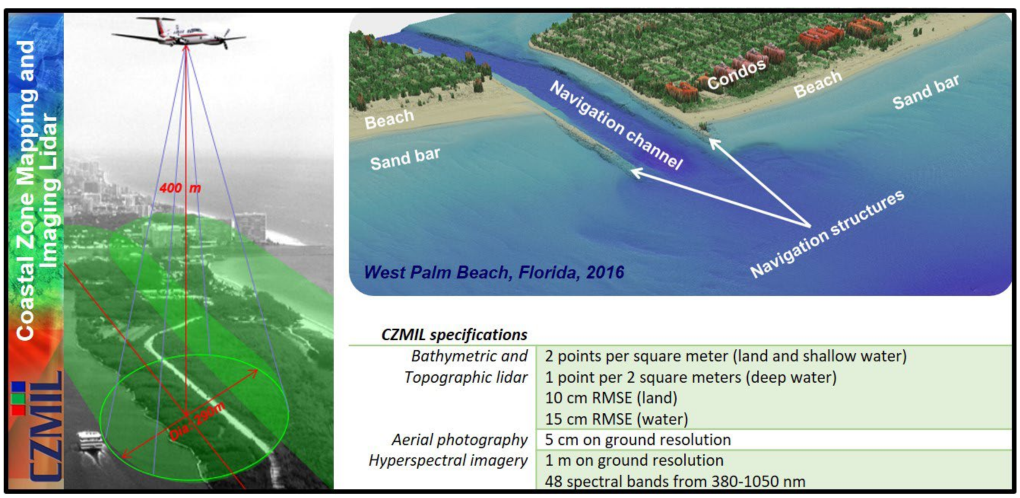

Figure 1. The Coastal Zone Mapping and Imaging Lidar (CZMIL) provides a single platform to collect topographic and bathymetric lidar, aerial photography, and hyperspectral imagery that are used to capture the coastal zone that includes navigation channels, infrastructure, and the beach and nearshore.

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To date, the JALBTCX has collected over 10,000 miles of shoreline for post-storm emergency response efforts. More specifically, following Hurricane Matthew's impact in October 2016, the JALBTCX surveyed over 1000 miles of shoreline in one month by utilizing two airplanes (Figure 2A) and recently over 500 miles were surveyed in 5 weeks following Hurricane Irma (Figure 2B). Depending on the mission requirement, the two airplanes can support between a 4 and 8 hour window of surveying time that typically covers an average of 30 square miles per flight. In addition, the JALBTCX aircraft operate from outside the immediate storm impact area, reducing risk to personnel and use of limited resources (lodging, food, gas, cars) after a major storm event.

To further support the post-storm assessment, the JALBTCX has developed quick response data products from the lidar and imagery data including Digital Elevation Models (bare earth models), Digital Surface Models (with vegetation and man-made structures), aerial photo and hyperspectral image mosaics, laser reflectance images, volume and shoreline change, and coastal structure metrics. The lidar data products are delivered within 24 hours after survey with volume and shoreline change products available within 5 days of survey, and incrementally as data are collected.

In addition to post-storm survey response, the USACE's National Coastal Mapping Program (NCMP) collects recurring surveys around the sandy shorelines of the United State that provide regional datasets that can be used as the base data necessary for quantifying post-storm volume and shoreline change. These high resolution, regional datasets are essential for understanding and quantifying the coastal impacts of extreme storm events in addition to monitoring changes through time. For example, the impacts of Hurricane Matthew on the coastal zone and navigation channels can be clearly observed from the elevation change comparison and volume and shoreline change can be quantified providing essential data to support the emergency response effort and recovery process (Figure 2C).

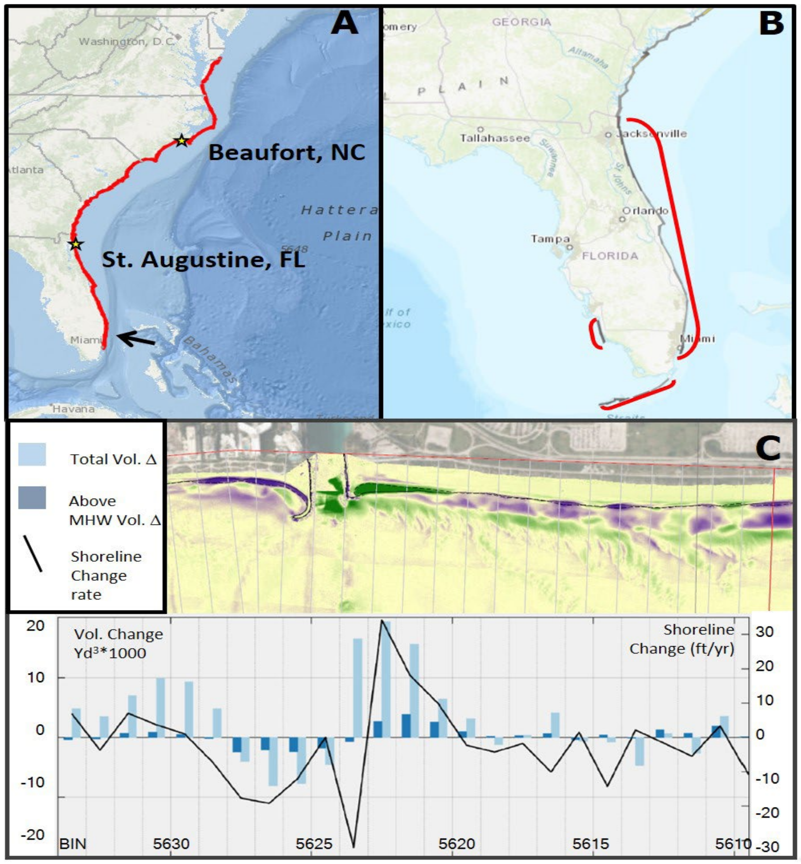

Figure 2. (A) Post-Matthew survey response in 2016 from Key Biscayne, FL to the Virginia/ Maryland border. (B) Post-Irma survey response in 2017 for Florida east coast, Keys, and small portion of the west coast of Florida. (C) Elevation change for an example site in Florida following Hurricane Matthew. Volume and shoreline change for individual bins are shown on the graph. Black arrow in A shows location. Dark purple indicates 3 ft of erosion and dark green indicates 3 ft of deposition while yellow indicates no change.

Data dissemination is another area that has been addressed to better meet the emergency response needs of the districts and other federal agencies. Secure ftp and web maps provide efficient transfer of these large datasets for the rapid response effort while also making the data available for download through NOAA's Digital Coast data center (https://coast.noaa.gov/dataviewer/) and through the Engineer Research and Development Center Cold Regions Research and Engineering Laboratory at (https://griduc.rsgis.erdc.dren.mil/griduc/corpsmap/). Since 2004, over 36,000 downloads from NOAA's Digital Coast have provided data to support users at the USACE, other federal agencies, academia, and coastal industry.

The post-storm data collected by the JALBTCX supports many emergency response efforts that may include: quantifying regional impacts of volume and shoreline change, quantifying project impacts for beaches, navigation channels/ structures, upland placement areas, and ecosystem restoration, assessing damages to infrastructure, and quantifying volumes of debris. Further, these datasets are uniquely available to assist with the recovery effort by establishing the baseline and providing the next pre-event dataset. The JALBTCX surveys and data products are invaluable tools that support the USACE through the flood risk management and navigation missions in addition to other federal agencies, academia, and more broadly the coastal community.

StormSim-CHRP: Rapid Prediction of Coastal Storm Hazards

By Norberto C. Nadal-Caraballo, PhD; **Amanda B. Lewis**; and **Fatima Diop**
Engineer Research & Development Center, Coastal & Hydraulics Laboratory, Coastal Hazards Group

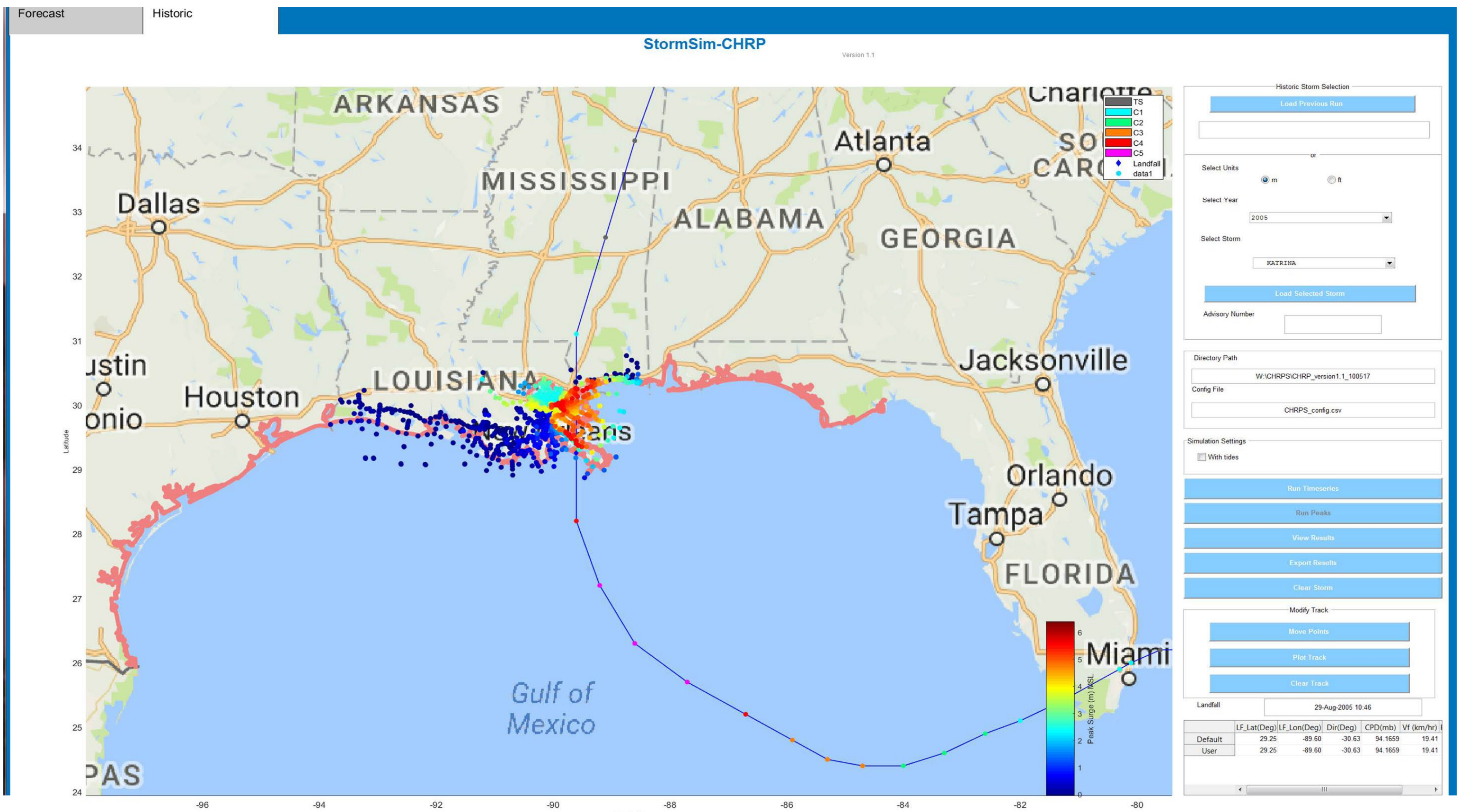

Figure 1. StormSim-CHRP GUI with surge predictions for Hurricane Katrina (2005) displayed on the map.

Hurricane storm surge forecasting in the United States has improved significantly during the last couple of decades. However, the technologies that are currently employed for these purposes result in either rapid predictions with high uncertainty (low-accuracy meteorological and hydrodynamic modeling) or slow predictions with lower uncertainty (high-accuracy hydrodynamic modeling with meteorological forcing forecasted every 6 hours).

Public storm surge forecasts are typically too late and only include peak surge responses that that are too high due to the deliberate inclusion of conservative uncertainty. Predicted values can often be 2 to 3 times higher than observed values. Moreover, these forecasts provide no knowledge of the surge time history that is required for federal planning, operation, and emergency management.

StormSim-CHRP Improvements

The StormSim Coastal Hazards Rapid Prediction (StormSim-CHRP) software is part of the StormSim suite of statistical and probabilistic modeling tools currently under development at the Engineering Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL). StormSim-CHRP performs rapid prediction of coastal storm hazards, including hurricane-induced flooding for forecasting and risk assessment. A probabilistic framework is currently in development with the goal of providing Federal agencies and partners a complete description of expected storm surge responses and associated uncertainties.

StormSim-CHRP exploits high-fidelity coastal storm modeling results readily available within the Coastal Hazards System (CHS). The CHS, developed as part of the Flood & Coastal Storm Damage Reduction (FCSDR) R&D program, is a coastal storm hazards data storage and mining system that stores comprehensive, high-fidelity, numerical modeling storm-responses such as storm climatology, storm surge, water level, wave height, wave period, wave direction and current magnitude as computed by state-of-the-art numerical and probabilistic coastal storm models. CHS data can be accessed, mined, plotted, and downloaded through a web tool found at http://chs.erdc.dren.mil.

For USACE district level emergency management, local decision-makers, and the public, StormSim-CHRP is the first software tool of its kind to offer time series predictions of hurricane responses (e.g., storm surge, wind, wave climate) in

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a matter of seconds. This new capability was developed using a machine learning technique called Gaussian Process Metamodeling (GPM) and it is based on state-of-the-art coupled surge-wave simulations that were completed and stored in CHS as a part of ongoing coastal hazards assessment work at ERDC-CHL. GPMs are trained with regional databases of synthetic storms that represent the full practical range of hurricanes, producing high-accuracy and computationally efficient tools that can inform emergency management and planning in real time. The current StormSim-CHRP graphical user interface (GUI) is shown in Figure 1.

Figure 1. StormSim-CHRP GUI with surge predictions for Hurricane Katrina (2005) displayed on the map.

The hurricane forcing inputs to StormSim-CHRP are storm landfall or reference location, central pressure (intensity), radius of maximum winds (size), translational speed, and heading direction. Storm responses, such as storm surge, storm tide (still water level), and wave height, are the outputs. Currently it can predict surge and/or surge + tide time series for over 10,000 locations in Texas, Louisiana, Mississippi, and the Florida panhandle in a matter of seconds using a simple interface. An example interaction with the interface to view Hurricane Harvey surge results can be seen in Figure 2. More locations and responses will be added in future versions of the tool. One of the most useful features of StormSim-CHRP is the ability to run scenario-based analysis. For example, the tool has the capability to run historical and active storms with altered tracks and parameters or run storms that have not yet occurred. Additional capabilities that are planned are the option to show the probability of each event separately, and the ability to investigate varied sea level rise scenarios. The technology can also be used for risk assessment studies by running thousands of storms in probabilistic simulations.

Evaluation during the 2017 Hurricane Season

During the 2017 hurricane season, the Coastal Hazards Group (CHG) at ERDC- CHL utilized the StormSim-CHRP tool to provide water level predictions for the Texas coast in the days leading up to the landfall of Hurricane Harvey. The CHG worked with the USACE Galveston District (SWG) to identify approximately 20 locations along the Texas coastline for which there was a need for water level information to support decision making. Using StormSim-CHRP, hurricane parameters were read directly from the National Hurricane Center's (NHC) 6-hourly storm track updates and used to predict time series of water levels. Additionally, adjustments to the storm's track and intensity were run as requested. For example, the track was moved north towards Port Arthur, TX to investigate the surge potential in the event of a significant track shift. Within minutes of each NHC track update, the results were provided to SWG team members, as well as the Galveston District Emergency Management office.

Many lessons were learned during this event that will help the team to improve its operational capacity and the ultimate goal is to be able to provide access to the StormSim-CHRP to coastal USACE districts for use during upcoming hurricane seasons. For further information regarding StormSim-CHRP, contact Dr. Norberto C. Nadal-Caraballo (Norberto.C.Nadal-Caraballo@usace.army.mil) at (634) 601-2008.

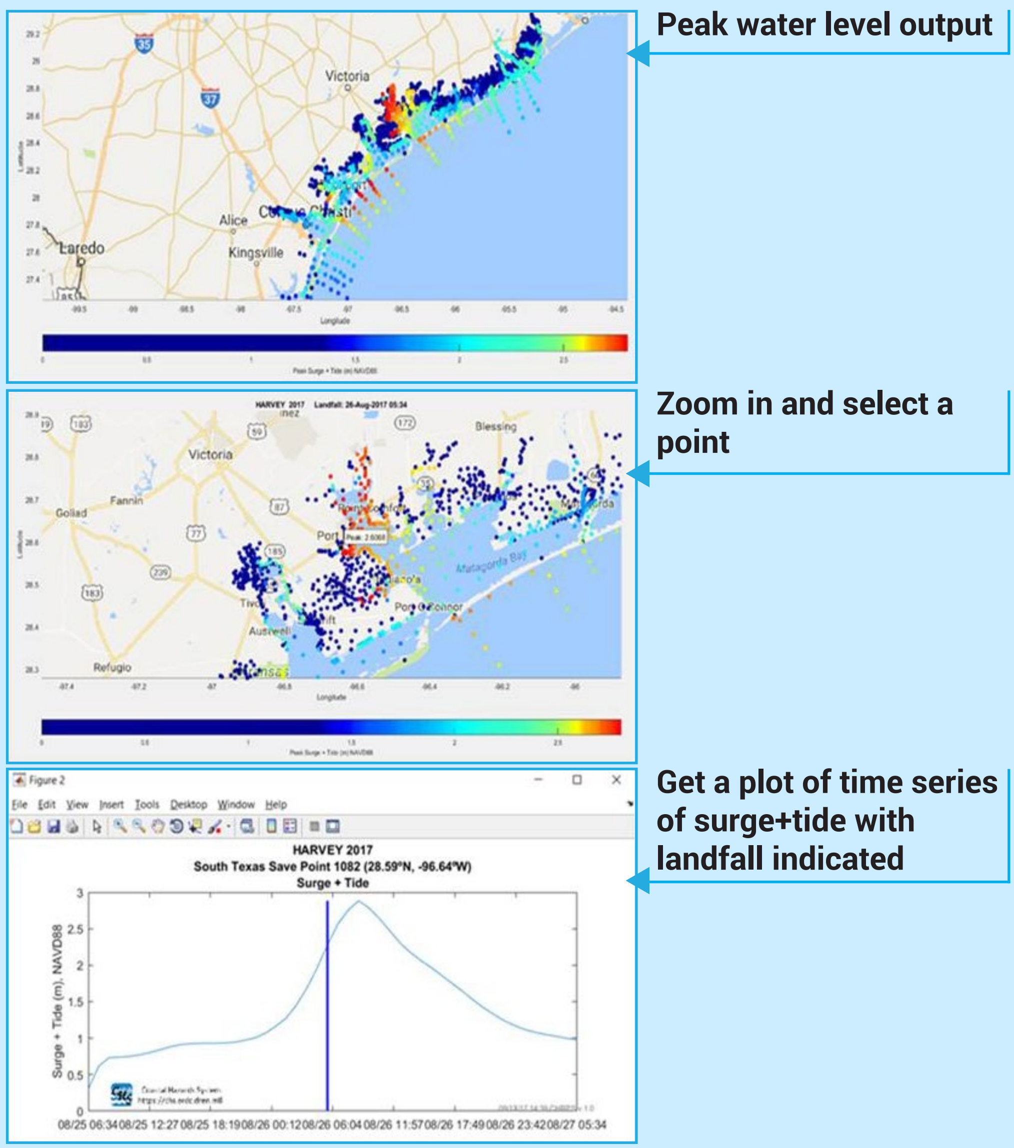

Figure 2. StormSim-CHRP example application for Hurricane Harvey (2017).

Next-Generation I-Wall Analysis Software: Corps_I-Wall

By Robert Ebeling, Ph D, PE, Research Civil Engineer, and **Barry White,** Computer Engineer, Engineer Research and Development Center – Information Technology Laboratory

In August of 2005, there were three notable failures of I-Wall flood protection in New Orleans as a result of Hurricane Katrina. One was along the 17th Street Canal and two were along the London Avenue Canal. An engineering stability evaluation conducted as a part of a post-Katrina forensic investigation into the failure of these I-Wall sections showed the impact of gap initiation and propagation between the soil below the flood waters in the canal and the embedded sheet pile foundation (Figure 1) of the I-Wall. This investigation was performed as a part of IPET (IPETF, 2007). Additionally, in the post-Katrina era, the Corps has embraced probabilistic engineering evaluation procedures to incorporate levels of uncertainty in their engineering evaluations. The software Corps_I-Wall was developed to answer these and other needs for next-generation design/evaluation I-Wall software with funding provided by the Flood & Coastal Systems R&D Program at the Engineer Research and Development Center.

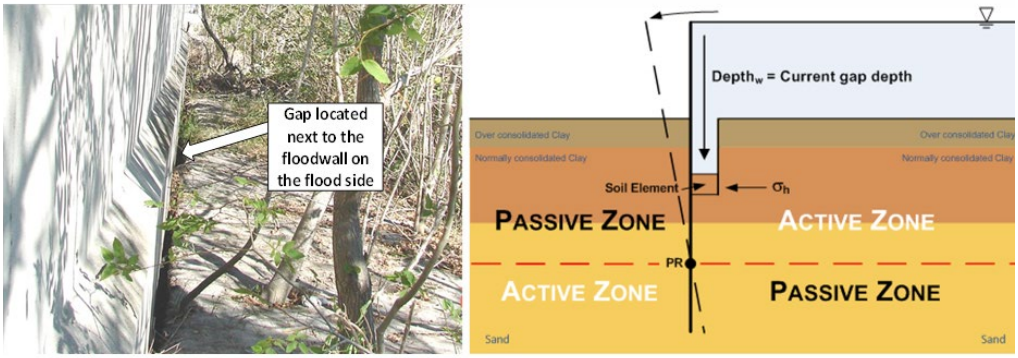

Figure 1. Gap Initiation and Propagation

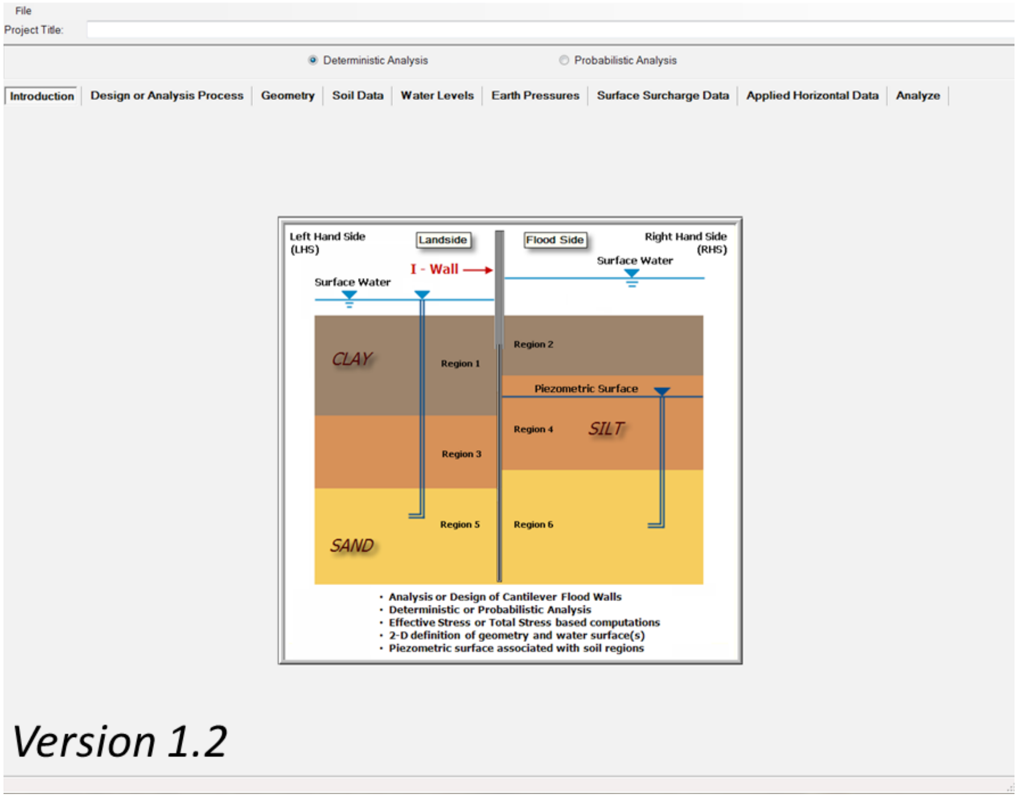

Figure 2. Corps_I-Wall Version 1.2 Software Introduction Tab

Corps_I-Wall is PC-based software developed for the design of new I-Walls and for the analysis of existing I-Walls founded in floodplains and coastal environments with level soil deposition and near level ground surfaces (Version 1.2). Corps_I-Wall allows for deterministic and probabilistic design or analysis for I-Walls, giving the engineer a rich set of design and analysis methods to numerically model I-Walls with soil structure interaction. In 2018, an extension of Corps_I-Wall software will be achieved (Version 2.0) that will allow for the stability analysis of I-Walls founded in levees and along riverbanks that possess variable (nonlevel) ground surfaces.

Corps I-Wall Version 1.2 (Figure 2) is currently available for downloading from the Computer-Aided Structural Engineering (CASE) library of software located within the Knowledge Hub (https://knowledge.usace.army.mil). This version is restricted to design or analysis of I-Walls founded at sites with level ground surfaces. It uses the earth pressure coefficient method of analysis to compute the distribution of earth pressures acting along both sides of the sheet pile foundation in its stability calculation to flood loads.

The probabilistic design and analysis modes give the engineer the ability to account for uncertainty in the material properties of the soils and the interface friction along the wall. In design mode, simulations will give a probabilistic range of sheet pile depths that will be required, leading to an understanding of the impact of dispersion in strength parameter(s). In analysis mode, the probability

Continued on page 13.

of failure can be calculated, given a specified (existing) wall tip depth, for a set of different load cases from minimal expected to extreme flood elevations generating a System Response Curve (SRC) required for the Corps' engineering evaluation process (Figure 3).

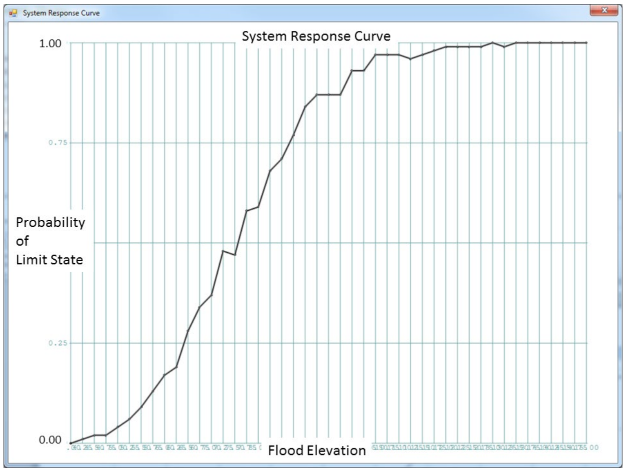

Figure 3. The System Response Curve (SRC) in Analysis Mode

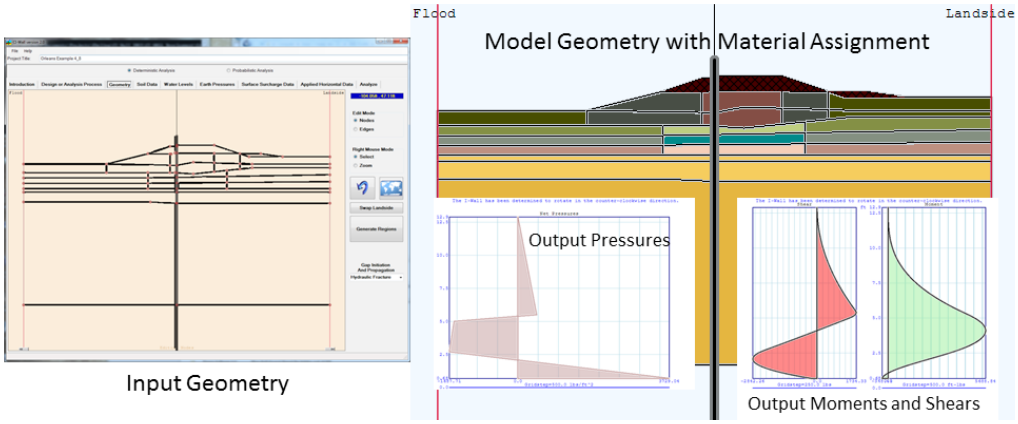

Figure 4. Corps_I-Wall Version 2.0 Deterministic Analysis

Version 2.0 of the Corps_I-Wall software package will work with nonlevel ground using the wedge solution to address more comprehensive geography like that shown in Figure 4. Observe in this figure the large number of soil material regions (in various colors). It is anticipated that the user's guide will be published and the Version 2.0 software can be posted in the CASE software library late in 2018. When completed, the Corps_I-Wall software version 2.0 package will be a versatile design and analysis tool for I-Walls. Summarizing its capabilities:

- Performs deterministic or probabilistic analysis.
- Design or analysis of I-Walls in floodplains, riverbanks and coastal environments with changing slope ground surface elevations and changing slope soil layer interface elevations.
- Floodwall can rotate clockwise or counter clockwise.
- Can include layered soil regions.
- Can use Rankine, Coulomb or Logarithmic spiral-based earth pressure coefficients (via the coefficient method).
- Uses the wedge solution to compute earth loadings acting on the wall and converts these forces into earth pressure distributions (Version 2.0) (via the wedge solution technique).
- Uses total stress- or effective stress-based earth pressure calculations. Soil regions can be classified as either total or effective stress; these regions can be used in intermixed layers.
- Hydrostatic pore water pressures are computed from surface water(s) and/or piezometric surface(s) within each of the layered soil regions.
- Pore water pressures can also be computed from Line of Seepage in soil regions with different hydraulic conductivities (for level ground sites and using the coefficient method only).
- Gap initiation and propagation are included using Hydraulic Fracturing criterion.
- Computes Boundary pressures (e.g., for wave loading of coastal structures) and/or surface surcharge).

Corps I-Wall is cited as the go-to engineering software for I-Walls in Corps guidance (e.g., EM 1110-2-2502, 2018 revision). Version 1.2 is being used by numerous Districts to perform deterministic or probabilistic I-Wall stability analyses. When completed, Version 2.0 will provide for a comprehensive I-Wall stability software package for design and analysis of I-Walls founded in levees and along riverbanks that possess variable (nonlevel) ground surfaces. Corps_I-Wall is an expedient software engineering package that puts design and analysis procedures in the hands of District engineers. I-walls designed using the Corps_I-Wall software will be efficient and meet standards for reliability that consider problem areas identified during Katrina.

References:

IPETF. 2007. The Performance- Levees and Floodwall. Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System, Final Report of the Interagency Performance Evaluation Task Force. Vol V. Washington, DC: Interagency Performance Evaluation Task Force. https://biotech.law.lsu.edu/katrina/ipet/ipet.html

Headquarters, U.S. Army Corps of Engineers. 2018, in revision. *Retaining and flood walls*. EM 1110-2-2502. Washington, DC: Headquarters, U.S. Army Corps of Engineers.

System-Wide Improvement Framework (SWIF) – More Than Just a Plan

By Ryan Buckley, SWIF Program Manager, Omaha District

In November of 2011, the "Policy for Development and Implementation of System-Wide Improvement Frameworks (SWIFs)" was issued providing our non-federal levee sponsors in the Public Law (P.L.) 84-99 Rehabilitation Program a process to remain conditionally eligible for P.L. 84-99 rehabilitation assistance "while they correct unacceptable operation and maintenance deficiencies as part of a broader, system-wide improvement to their levee system." The SWIF is more than just a plan that allows our non-federal levee sponsors to bring their levee systems back into USACE O&M compliance. The SWIF is indirectly encouraging our non-federal levee sponsors to incorporate risk communication and risk management into their growing duties as a non-federal levee sponsor.

The first step of the SWIF process is for the non-federal levee sponsor to submit a Letter of Intent (LOI), which is endorsed at the district and division levels and approved at HQUSACE. After the LOI is approved, the non-federal levee sponsor has up to two years to develop a SWIF plan; and just like the LOI, the SWIF plan is endorsed at the district and division level and approved at HQUSACE. The SWIF plan is a living document. Each SWIF plan is unique to the levee system and the associated deficiencies, but generally, all SWIF plans include system identification information, a list of deficiencies, a plan for rectifying the deficiencies based on risk, a funding plan, interagency collaboration details, Interim Risk Reduction Measures (IRRMs), and a schedule with project milestones. At the Omaha District, we request annual updates to the SWIF along with an annual progress report. Every two years, the SWIF plan is resubmitted for HQUSACE approval which grants up to another two years of "Active" status in the P.L. 84-99 Rehabilitation Program

Ryan Buckley (back right) with the Omaha District Emergency Management office, discusses innovative flood fight products with a P.L. 84-99 non-federal levee sponsor and state/local emergency management officials.

Continued on page 15.

Personnel from the Omaha District Emergency Management office, present on USACE P.L. 84-99 response authorities, the process to request USACE assistance, flood fighting techniques, and flood fight products during a local flood fight training in Grand Island, Nebraska in May 2017.

during implementation of the SWIF plan. This re-approval process continues until the plan is fully implemented.

Omaha District non-federal levee sponsors began to utilize the SWIF in early 2012, where we had three communities in Montana submit and subsequently get their LOIs approved. The Omaha District Readiness Branch manages the SWIF Program in coordination with the District's Levee Safety Program and has the overall responsibility of: monitoring the development of the LOIs, monitoring the development of the SWIFs, monitoring the non-federal levee sponsors' milestones during SWIF implementation, conducting reviews for eligibility extensions following initial reinstatement, notifying the local FEMA regional office on the acceptance of a SWIF, and providing approval recommendations to the MSC and HQUSACE. The Omaha District takes a proactive approach to SWIF implementation and management, which in some cases surpasses what is directed by policy. Throughout the entire LOI and SWIF development stages, we work with our non-federal levee sponsors by providing them technical assistance through policy/guidance education, discussing specific levee risks pertaining to their deficiencies, discussing various risk management activities (i.e. risk communication, flood fight training, construct or improve seepage control measures), and providing LOI and SWIF reviews throughout the entire process. The Omaha District has participated in numerous Emergency Preparedness Planning (EPP) workshops and flood fight training exercises hosted by non-federal sponsors, all of which can be attributed to the non-federal levee sponsors' participation in the SWIF. The "SWIF provides committed sponsors the opportunity to transition their levees over time to USACE standards. By using a SWIF, sponsors can prioritize deficiencies to address the highest risk first to achieve system-wide risk reduction." The Omaha District takes every opportunity to promote, encourage, and educate our non-federal levee sponsors on the benefits of the SWIF and how the SWIF provides an "insurance blanket" for those non-federal levee sponsors who are committed to the SWIF process, therefore, receiving the conditional eligibility (federal funding assistance) in the P.L. 84-99 Rehabilitation Program. As of early November 2017, the Omaha District's SWIF Program includes:

- 7 approved SWIFs covering 18 systems and 21 segments;
- 8 SWIFs under development covering 14 systems and 19 segments;
- 3 LOIs under development covering 3 systems and 6 segments;
- 1 SWIF cancelled due to levee systems being reinstated into the P.L. 84-99 Rehabilitation Program during SWIF development after the sponsor completed necessary repairs. This SWIF covered 2 systems and 2 segments.

Not all of our non-federal levee sponsors have jumped on the SWIF train. This is primarily due to the wide range of non-federal levee sponsors the Omaha District has within its portfolio. With over 90 non-federal levee sponsors covering 155 total levee systems, which includes 149 federally constructed levee segments and 29 non-federally constructed levee segments, our sponsor backgrounds range from large municipalities to small communities, from drainage districts to levee districts, from Natural Resource Districts to farmers. Our levee sponsors face the challenges of satisfying the multiple requirements that apply to their levee system(s) and struggle to meet these challenges due to funding and resource constraints. Depending on the complexity of the deficiencies requiring inclusion in a SWIF plan, the development of a SWIF plan can become a significant financial and resource challenge that some of our sponsors cannot take on. These sponsors often choose not to develop a SWIF plan and will prioritize what funding they do have on rectifying their deficiencies.

The SWIF has become more than just a plan to develop solutions to satisfy the multiple requirements of operating and maintaining a levee to USACE O&M Standards. Within the Omaha District, the SWIF has become a tool for educating our non-federal levee sponsors, impacted communities, and elected officials about USACE programs and risk communication, risk management, and emergency preparedness activities.

The SWIF program has given the Omaha District another avenue to educate stakeholders on the USACE Levee

Continued on page 16.

Safety Program and also our P.L. 84-99 Rehabilitation Program. It has also allowed us to educate on the differences of the mentioned USACE programs and FEMA's National Flood Insurance Program (NFIP). Specifically, how do our inspection results for our routine or periodic inspections in the USACE Levee Safety Program and eligibility status in the P.L. 84-99 Rehabilitation Program, impact a community's standing with FEMA.

The SWIF has become an avenue for the Omaha District to promote and communicate flood risk with our non-federal levee sponsors and also for our non-federal levee sponsors to communicate flood risk with those living and working within the leveed area. One of the pieces that is required to be in a SWIF plan is Interim Risk Reduction Measures. Specifically, a plan for how the non-federal levee sponsor will communicate risk with those within the leveed area. The risk communication plan is scalable in size and largely deals with the activities associated with the project prior to, during, and after a flood event. Public awareness activities may include such things as providing information on risk, current levee deficiencies and what the non-federal levee sponsor is doing to reduce risk due to these deficiencies, steps the public can take to prepare for a flood event and steps to take after an event. Conducting risk awareness prior to any event provides for a well-informed public and can be part of an overall preparedness activity that includes an outreach and awareness program that would address floodplain management activities. The Omaha District non-federal levee sponsors have completed outreach via public meetings (with USACE and FEMA representatives), radio interviews, mailings, and some have created websites. Three examples of the websites created by non-federal levee sponsors as part of their SWIF:

- http://saltcreeklevee.jeo.com/ - Salt Creek and Tributaries Flood Risk Reduction Project – Lincoln, Nebraska
- http://acldlevee.com/ - Missouri River Levee Units L-561-550-536 – Atchison County, Missouri
- http://cblevees.com/ - Missouri River Levee Unit L-627-624-611-614 – Council Bluffs, Iowa

> "Our non-federal levee sponsors have communicated and coordinated with multiple federal, state, county, and local agencies to determine the roles and responsibilities during a flood event to include specific communication protocols based on levee conditions or river levels, evacuation procedures, flood response actions, material locations, and post flood response."

Overall risk communication is a local responsibility either by the non-federal project sponsor or in a shared process with jurisdictional/community leadership to inform the public at risk. That doesn't mean that USACE has no involvement. The Omaha District has begun to integrate the findings from the levee risk screening assessments into our communication with our non-federal levee sponsors. These findings can be utilized in risk prioritization during SWIF plan development and also in the non-federal levee sponsors outreach and awareness programs. By doing this, the Omaha District is improving our sponsor engagement, improving our non-federal levee sponsors' understanding of the benefits and risks of the levee systems, promoting active risk management, and it helps to build and improve our relationships with our non-federal levee sponsors. The non-federal levee sponsor utilizes this information to improve public awareness of the flood risk reduction project and preparedness planning, to help improve the public's understanding of the risk to the levee and risk of living behind a levee, and helps to communicate to the public what the non-federal levee sponsor is doing to reduce the levee safety concerns.

Another IRRM that has been extremely beneficial to the non-federal levee sponsor is the development of some form of an emergency preparedness plan. As noted earlier, not all of our sponsors are a municipality, therefore, do not hold the responsibility of an incident commander or have the authority to issue evacuation notices. Also, many of the Omaha District's Local Emergency Operation Plans (LEOPs) we have encountered do not incorporate the USACE P.L. 84-99 flood risk management projects. Our non-federal levee sponsors have communicated and coordinated with multiple federal, state, county, and local agencies to determine the roles and responsibilities during a flood event to include specific communication protocols based on levee conditions or river levels, evacuation procedures, flood response actions, material locations, and post flood response.

The release of the SWIF policy in November 2011, not only provided a process for our non-federal levee sponsors to get their projects back to the USACE O&M standards, but it has made our sponsors better equipped and willing to discuss the condition of the levees, the risks associated with the levees, and what is being done or can be done to reduce that risk. Not only that, it has built better relationships, created communication lines, defined roles and responsibilities for emergency preparedness, response, and recovery, and is building a foundation where risk communication and risk management is a shared responsibility.

Review of Our Nation's Levees is Underway

By Noah Vroman, Vicksburg District, and **Jamie McVicker**, St. Louis District

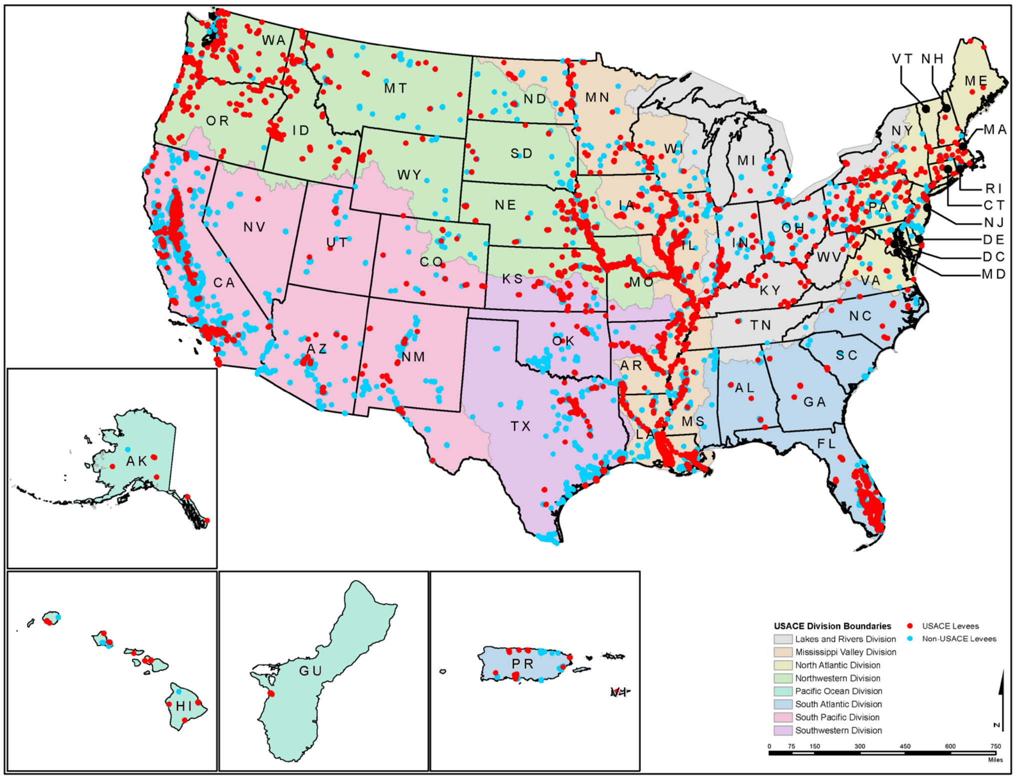

Figure 1. Levees Currently in the National Levee Database

In 2006, the U.S. Army Corps of Engineers (USACE) began the task of developing a comprehensive inventory of the nation's levees and performing inspections and risk assessments on the portfolio of levee systems within the USACE Levee Safety Program. USACE is in the process of sharing risk assessment information with our non-federal sponsors and communities. This portfolio includes levees that were federally constructed and either operated and maintained by USACE or levee sponsors in addition to non-federally constructed levees in the USACE Rehabilitation Program. Building on the success of that accomplishment, Congress authorized USACE, through the Water Resources Reform and Development Act of 2014, to continue the inventory and conduct a one-time inspection and risk assessment of all the nation's levees. Key objectives of the effort include: building an inventory of the nation's levees by collecting information on levee location, condition, benefits, and risks, sharing this information with states, communities, and people who live and/or work behind levees, and building capacity in states, tribes, and levee owners/operators who may perform similar activities in the future. More information on this topic can be found in the July 2017 Flood Risk Management Newsletter article "Inventory and Review of Our Nation's Levees".

We know there are levees in each state and on tribal lands, however the precise location, condition, and the nature of population and property behind them remain largely unknown. Preliminary estimates indicate there may be more than 100,000 miles of levees across the nation with tens of millions of people living and/or working behind them. Despite the fact that inspection and risk assessment has been accomplished for most of the USACE portfolio of levees, there are tens of thousands of levee miles across the United States already identified in the NLD and their condition and risk is unknown. On a national scale, we currently do not know how many more levees there are, where they are located, their condition, or the consequences of poor performance.

A better understanding of this information will help identify: previously unknown risks, repair and rehabilitation needs, partners for flood risk management, investment priorities, flood fighting and emergency management activities, and the ability to describe what is at stake to residents and businesses. Gathering baseline information will allow the nation to more efficiently and cost-effectively identify the most critical levee safety issues, quantify the nation's risk exposure and true cost of maintaining levees, focus priorities for future funding, and have fully informed communities.

USACE is leading the effort by partnering with state agencies, tribal nations and their levee operators/owners, on a volunteer basis. The level of partner involvement may range from USACE conducting the inventory and review to sharing best practices on levee safety that enables levee owners/operators to manage their own levees. USACE activities currently underway that will extend into future years include the following:

- Identifying the location of levees and their owners/operators
- Conducting a one-time field inspection and risk assessment on levees at no cost to levee owners and operators
- Providing results of inspections and risk assessments to assist with flood hazard mitigation planning and budget prioritization
- Offering training and technical assistance on best practices in levee safety for interested parties
- Gathering lessons learned, challenges, and best practices to inform future levee activities.

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Figure 2. USACE Training Session

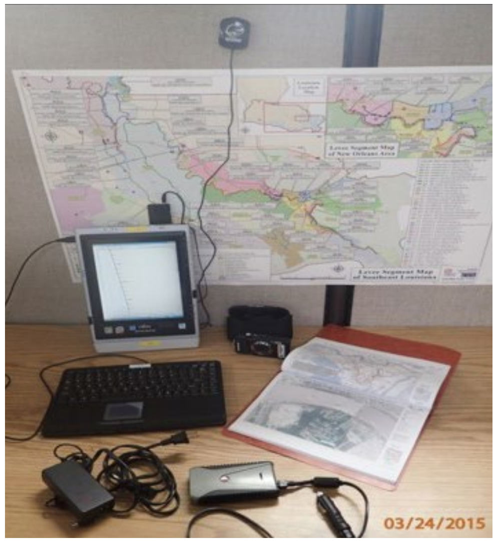

Figure 3. GPS-enabled field data collection device

Figure 4. Field inspection in Commonwealth of Pennsylvania

In preparation for this effort, the USACE Levee Safety Production Center, located in Mississippi Valley Division, collaborated with USACE subject matter experts on methods and tools to conduct the work.

Teams of USACE professionals from each region of the country have been identified to perform outreach to prospective volunteer partners. Resources and tools have been developed for these outreach teams in their pursuit of building partnerships with volunteer states and tribes. These materials include: program fact sheets and maps showing the location of known levee infrastructure within the prospective partner's jurisdiction along with an estimate of population and property value that rely on levees for flood risk reduction.

Teams of technical professionals with experience and expertise in levee safety including levee inspections, risk assessments and risk communication have also been identified. These teams will use similar procedures, processes and tools for inspections and risk assessments as performed on the USACE levee portfolio. Workshops have been held with these USACE technical teams to promote national consistency in the effort and share information on the correlation with the USACE Levee Safety Program, procedures related to engagement with levee owners/operators, and methods for accomplishing inspections and risk assessments. Technical teams will conduct inspections and risk assessment activities in a hands-on or interactive approach that allows levee owners/operators as well as interested states or tribal partners to gain experience in the inspection and risk assessment processes and tools.

Regarding tools, USACE will use a GPS-enabled levee inspection system which is a hand-held tablet to capture field data and a web-based levee screening tool that will house risk assessment information gathered by the team focused on the likelihood of flood loading, the anticipated performance of the levee and the consequences if the levee does not perform as intended. Levee information collected through this effort will be stored in the National Levee Database which serves as the nation's repository for levee-related data.

Letters explaining the National Levee Inventory and Review effort were recently sent from USACE HQ to the governors of each state and executives of all Federally-recognized tribes. As a follow-up to the letter notification, USACE outreach teams are in the process of contacting individuals from state agencies and tribes to gain a better understanding of levee infrastructure within their jurisdiction and gauge their interest in participating in this effort. USACE will work with states and tribes to schedule an introductory meeting to provide an overview of the effort, discuss current levee data within their jurisdiction and determine their desired level of involvement with the inventory and review effort. To date, sixteen states have indicated their interest in participating. Once voluntary state and/or tribal partners are identified, levee systems will be prioritized for inspection and risk assessment activities.

At this time, there are ten multi-disciplinary USACE technical teams from across the nation currently available to lead the inspection and risk assessment activities. Three USACE technical teams are already underway with the review of levees in Texas, Pennsylvania, Montana, Nebraska, Illinois and Iowa.

For more information on inventorying, inspecting and conducting risk assessments on non-USACE levees, please contact us at DLL-CEERD-NLD-General-Support@usace.army.mil or **1-877-LEVEEUS** (1-877-538-3387). A local USACE team member will be available for assistance in these efforts.

For more information about the National Levee Database, please visit: http://nld.usace.army.mil

Folsom Dam Auxiliary Spillway Completion, Sacramento, CA: An American River Watershed Flood Risk Management Story

By Sara Schultz, Regional Technical Specialist, Sacramento District, and
Miki Fujitsubo, National Technical Specialist, FRM-PCXo

Poster from the Dedication Ceremony of the Joint Federal Project

This past October, the U.S. Army Corps of Engineers Sacramento District and U.S. Bureau of Reclamation, along with State and local sponsors, hosted a ceremony to celebrate the completion of nearly a decade of planning and construction on a $900 million auxiliary spillway for Folsom Dam, located about 20 miles upstream on the American River from downtown Sacramento, California. "We have four major goals that our nation needs us to consistently achieve," said LTG Todd Semonite, commanding general of the Corps of Engineers stated at the ceremony. "These goals are to support national security, deliver integrated water resource solutions, reduce disaster risk, and prepare for tomorrow. Right here in Folsom, the auxiliary spillway proudly stands as a tangible example of our commitment to advance all of these goals."

The auxiliary spillway, also known as the Joint Federal Project or "JFP," is a dual purpose project for both flood risk management and dam safety. It serves a critical component of the overall strategy and effort in reducing the flood risk from the American River to the Sacramento area, home to California's capitol and a population of more than two million people. The auxiliary spillway will allow more water to be released from Folsom Reservoir sooner during a major storm event, thereby reducing the peak flow released into the American River and increasing the ability of downstream levees to better handle potential flood events.

The JFP is the latest installment in risk reduction to California's capital city. The breadth and complexity of the American

Continued on page 20.

River watershed necessitated multiple long-term studies looking at flood risk management issues in a systemwide context. For the JFP, this includes not just the existing Folsom Dam and dam operational changes but also the levee systems downstream.

The flood risk story of Sacramento began when the city was first established at the confluence of two major rivers during the height of the California Gold Rush in 1850. The American and Sacramento rivers were the major transportation corridors in this western frontier in a landscape that consisted of majestic riparian forests, abundant wetlands and massive floodplains that were frequently inundated. The region was known as the "Inland Sea", a product of its location at the downstream end of large watersheds fed by surrounding mountains. Flooding is part of a natural cycle of the region but as the population of Sacramento grew, the consequences of that flooding grew as well.

Early residents constructed levees along the rivers but these levees frequently failed, causing catastrophic flooding within the fledgling community. These events galvanized the community to work even harder to keep the flooding at bay by working with the State of California and the Corps of Engineers. Together, the State of California and the Corps of Engineers constructed a massive flood management system consisting of levees along the rivers and a network of bypasses in the low lying floodplain that would carry high flows away from the populated areas. In the early to mid-1900s, numerous upstream reservoirs, including Folsom Dam on the American River, were constructed to further reduce the risk to downstream areas.

The Sacramento population continues to grow and record flood events have occurred since Folsom Dam was completed in 1956. Our understanding of levee performance over time and during flood events has allowed the Corps of Engineers to better understand flood risk and recommend improvements to the levees surrounding urban areas. The Corps has worked closely with the California Department of Water Resources and the Sacramento Area Flood Control Agency on these recommendations, which recently culminated in several authorized studies for levee improvements in Natomas, West Sacramento and the American River Common Features Project for the City of Sacramento.

Sacramento will always be at risk of flooding, but continued, successful federal, state and local partnerships will help incrementally reduce the regional flood risk and associated consequences.

Other Important Information

Events

This listing is for information only and is not a complete list of FRM-related meetings. These meetings are not endorsed by the Corps of Engineers unless specifically stated. If we have failed to list a conference/meeting/symposium that would be of interest to the Flood Risk Management community, please forward the conference details to us.

7-11 January 2018 – **98th American Meteorological Society Annual Meeting** – Austin, TX – https://annual.ametsoc.org/2018/

19-23 February 2018 – **Public Law 84-99 Advanced PROSPECT Course** – Mobile, AL

26-29 March 2018 – **National Hurricane Conference** – Orlando, FL – http://hurricanemeeting.com/

26-30 March 2018 – **Public Law 84-99 Basic PROSPECT Course** – Wilmington, NC

22-25 April 2018 – **American Water Resources Association Spring Specialty Conference: GIS and Water Resources X** – Orlando, FL http://awra.org/meetings/Orlando2018/index.html

14-18 May 2018 – **Public Law 84-99 Basic PROSPECT Course** – Kansas City, MO

17-22 June 2018 – **Association of State Floodplain Managers 42nd Annual Conference** – Phoenix, AZ – http://floods.org/index.asp?menuID=223&firstlevelmenuID=181&siteID=1

8-13 December 2016 – **9th National Summit on Coastal and Estuarine Restoration and Management** – Long Beach, CA – https://www.estuaries.org/2018-summit-general-info

Be sure to check out floods.org for the dates of state conferences and training opportunities: http://www.floods.org/n-calendar/calendar.asp?date=3/12/2016

FRM Statements of Need: Submitting "Statement of Need" is the first step in the process of a concept becoming a requirement for research and development. If USACE District personnel have problems or situations they feel should be addressed by research, the Flood Risk Management Gateway, http://operations.usace.army.mil/flood.cfm, is the place to submit these research Statements of Need (SoNs).

Past issues of this newsletter, various links, news items, and presentations, are all available on the Flood Risk Management Gateway, https://operations.erdc.dren.mil Check it out!

This newsletter is a product for and by the Flood Risk Management Community. The views and opinions expressed in this unofficial publication are not necessarily those of the U.S. Army Corps of Engineers or the Department of the Army.

If you would like to submit an article or an idea for an article for the next edition of the newsletter, or if you have any comments or questions about articles in this edition, please email ***Stephanie.N.Bray@usace.army.mil.***

FRM Flood Risk Management Newsletter

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