The NHWC Transmission

April 2017

CONTENTS

Click on hyperlinks located throughout this newsletter for more information.

Key Challenges to Communicating Risk of Flooding from Hurricane Matthew

Debra Fleischer and Colleen Donovan, Abt Associates
Stacy Langsdale and Jason Needham, USACE

The response to Hurricane Matthew demonstrated the many challenges to communicating flood risk by local, state, and federal officials. However, it has also been an opportunity to reflect and review recommendations for how officials can most effectively communicate risk so that lives are saved in future disasters.

Background

Hurricane Matthew in October 2016 made landfall as a Category 1 hurricane with 75 mph winds. Heavy rains continued for about 36 hours and caused record flood conditions. The flooding was exasperated by above average rainfall in September.

Hurricane Matthew caused at least 48 deaths and $4 to $6 billion in insured property loss from wind and storm surge damages – not including flooding, business interruption, or other losses.

Local, state, and federal officials call for evacuation

Throughout the southeast Atlantic (including Florida, Georgia, South Carolina, and North Carolina), state, local, and federal officials called for more than 2.5 million people to evacuate. North Carolina issued further evacuation orders for tens of thousands of people in low-lying areas, as rivers continued to swell after the hurricane. Some people living on the coast heeded the initial evacuation orders but found themselves caught in the flash flooding further inland, even as far as 125 miles from the coast.

Ahead of Hurricane Matthew, President Obama declared a state of emergency in all four states and urged people to follow guidance of emergency response officials, as did the Federal Emergency Management Agency and other federal agencies. Florida Governor Rick Scott issued a strong statement to his 1.5 million coastal residents.

In some areas, however, the evacuation and other communication messages from local and state officials were unclear and sometimes contradictory. For example, in Georgia local elected leaders and the governor have the authority to issue evacuation orders, though historically, local elected leaders have always exercised this authority. For the first time, however, Georgia Governor Nathan Deal issued a mandatory evacuation order for all Georgia counties east of 1-95, which superseded the Chatham Emergency Management Agency's evacuation order for certain parts of Chatham County.

Challenges with communicating risk of flooding

Hurricane Matthew highlighted some of the key challenges to effectively communicating flooding risk and managing disaster evacuations. First, per the National Hurricane Center, local, state, and federal leaders rely heavily on potential storm surge – the most life-threatening hazard – to make evacuation decisions. Storm surge has accounted for nearly half of the tropical cyclone-related deaths in the United States during the past 50 years, with rainfall-induced flooding contributing to more than a quarter of the deaths. Thus, decision makers may not fully consider flooding potential in inland areas when making evacuation decisions. Additionally, there is inherent uncertainty in predicting when a hurricane will hit, how strong it will be, how long it will last, and what the associated effects might be. This uncertainty poses challenges to evacuation decisions and messaging, particularly when evacuation orders need substantial clearance times in the southeast region of the United States, as was the case for Hurricane Matthew.

Second, hurricane classification is based solely on maximum sustained wind; it does not address the potential for other related impacts, such as storm surge, rainfall-induced floods, and tornadoes. Thus, because Hurricane Matthew made landfall as a Category 1 storm, residents in affected areas may have underestimated risks from hazards other than wind.

Finally, even if the media and decision makers clearly communicate the risk of flooding, some populations are unable or unwilling to evacuate, for example, people without access to transportation, people who do not speak English well, older people, those with disabilities, and even tourists who do not know anyone locally. For Hurricane Matthew, only 35 to 50 percent of those affected by mandatory evacuation orders actually complied. Other factors that could influence whether someone evacuates include previous disaster experience, gender, how long someone has lived in their home, feelings of responsibility ➡

for friends or family members who decide not to evacuate, expectations and perceptions of risk, and ability to afford alternative housing. Additionally, some people may become complacent due to infrequent landfall of hurricanes. For example, the last hurricane to make landfall on the Atlantic coast of Florida was Hurricane Wilma in 2005. The last hurricane to cause an evacuation in South Carolina was Hurricane Floyd in 1999.

Improving the communication of hurricane-related flood risk

A USACE *Guide to Public Alerts and Warnings for Dam and Levee Emergencies* provides recommendations, in order of priority, for emergency managers and others on creating an effective alert/ warning system for public emergency situations. They state that the single most important thing an emergency manager can do to improve public protective action is to provide the best messages possible, which requires appropriate content, style, and length. Appropriate content includes listing the source of the message; description of the threat; description of the location of the people that need to take action; guidance on where, how, and when to take protective action; and when the message expires. Additionally, the guide recommends: (1) establishing an emergency warning process with different levels of threats mapped to different warning messaging strategies; (2) writing plans, practicing those plans, avoiding communication breakdowns, and anticipating the unexpected to facilitate timely issuance of flood watch or warning; (3) using a mix of channels to deliver emergency information to achieve rapid dissemination of public messages; and (4) tailoring messages to the unique character of a community and reflect where people are, what they are doing, and the nature of the threat.

…the single most important thing an emergency manager can do to improve public protective action is to provide the best messages possible, which requires appropriate content, style, and length.

Additionally, the National Academy of Sciences recommends ways to build community resilience through effective communication of disaster-related risks. These strategies include constructing narratives that promote resilience (e.g., maintaining collective memory of disasters), using evidence-based strategies for communication and public education, leveraging social aspects of communication to strengthen ties and involve the community, and strengthening communication networks to ensure access to information.

Disaster Risk Assessment of Extreme Rainfall Flood and Sea Level Rise Impacts on the City of Los Angeles, California and Surrounding Areas

Tucker Stafford, M.S., Quang Nguyen, Ph.D., Waheed Uddin, Professor of Civil Engineering
University of Mississippi

Flood disasters generally occur due to heavy rainfall and river overflow. To determine floodplain areas in a river watershed, the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) hydraulic model is commonly used[1]. HEC-RAS is hydraulic analysis program capable of simulating a full network of open channels. Land in port cities can be submerged by sea level rise (SLR). As reported by the National Oceanic and Atmospheric Administration (NOAA)[2], a global mean sea level rise of up to 2 meters is expected by the year 2100 due to climate impacts. The SLR simulation methodology, developed by the researchers at the Center for Advanced Infrastructure Technology (CAIT), at the University of Mississippi, is used to evaluate the impact of gradually-rising sea levels up to 2 m SLR. Results of both rainfall flood and 2 m SLR simulations are described and discussed in this article.

For floodplain simulations, the hydrograph is the most important input, which is derived from rainfall-runoff measurements typically in a stream or river. The hydrograph data for the Los Angeles (LA) region was acquired from the United States Geological Survey (USGS)[3]. The hydrograph data came from the most extreme rainfall flood in LA which occurred during January, 2005. Discharge data for this hydrograph were measured every 24 hours from January 5, 2005 to January 23, 2005. The peak discharge of 838.2 m^3/s was measured on January 11, 2005.

The second key input is the digital elevation model (DEM) data[4]. The DEM used in this study has a reported absolute vertical accuracy of 2.44 m, and relative vertical accuracy of 1.64 m[4]. The elevation contour map was created from the DEM data. Figure 1 shows the hydrograph and topographic map with elevation contours at 5 m interval. Most areas along the western coast are located on hills with elevation from 40 m to 240 m. The areas in the north and east include the foothills of the Santa Monica Mountains and the San Gabriel Mountains. The center and the south portions of the study area relatively flat.

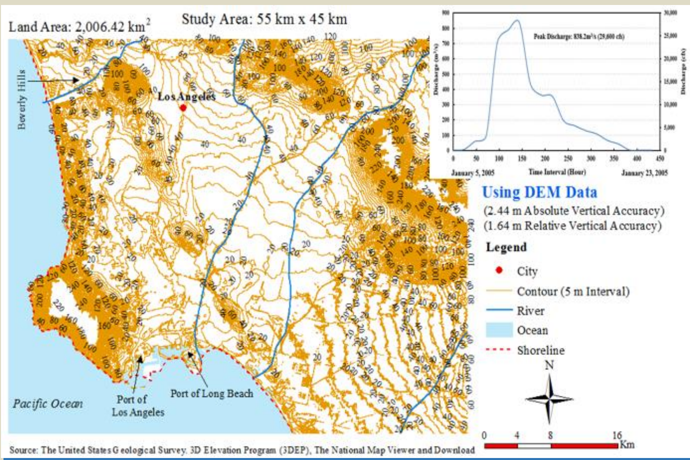


Figure 1. Hydrograph (top right) and contour map at 5 m elevation interval in Los Angeles, California and surrounding areas

Rainfall flood simulations were conducted as described in detail by Nguyen and Uddin[1]. The LA metropolitan boundary area map[5] was imported into ArcGIS. The final output of the extreme rainfall 1-D flood simulation[6, 7] is shown on the spatial map in Figure 2. The inundated area with blue color covers the land area near the ports and expands into the heart of downtown LA. A total 747.06 km^2, or 37.23% of land area is inundated by floodwater. Both the Port of Los Angeles and the Port of Long Beach are inundated with floodwater, while key infrastructure such as the LA International Airport, remain unscathed. Many of the roads and other important infrastructures of the port city are also inundated by floodwater. Approximately 4.8 million people are at risk from extreme rainfall flooding in the study area; with a density of population at risk at 2,381 per km^2.

The following steps of the CAIT SLR methodology for 2 m SLR simulation were implemented using 3-D analyst tools of ArcGIS software (http://www.esri.com/software/arcgis/extensions/3danalyst):

- Create a spatial map of DEM elevation ranges (Figure 3).
- Create a shapefile of 2 m SLR.
- Classify areas below 2 m elevation as submerged land.

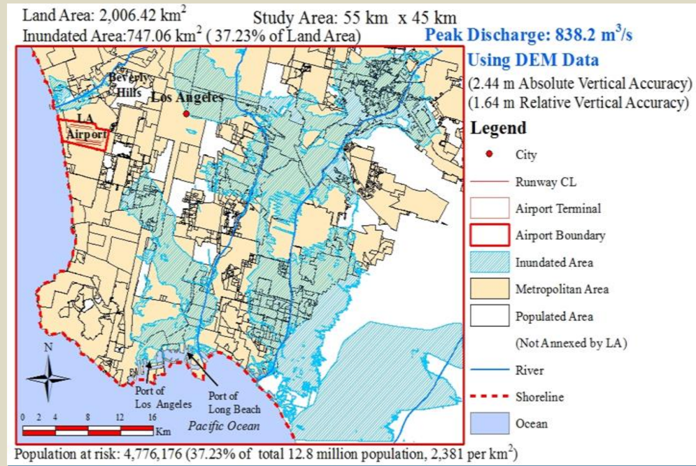


Figure 2. Spatial map of floodplain overlay on metropolitan boundary area map, Los Angeles, California and surrounding areas

Figure 4 shows a spatial map of the 2m SLR submerged land overlay on the map of LA metropolitan boundary area and surrounding areas. The results from 2m SLR simulation indicate that 33.76 km^2, or 1.68% of the land area, is submerged by seawater intrusion[6, 7]. Most of the land area in LA is not affected by 2m SLR because of high ground elevation topography. Some submerged land areas occur in the south and west coastal areas where ground elevation is less than 2m. Both the Port of Los Angeles and the Port of Long Beach are at risk by 2m SLR. There is no risk to the LA International Airport site.

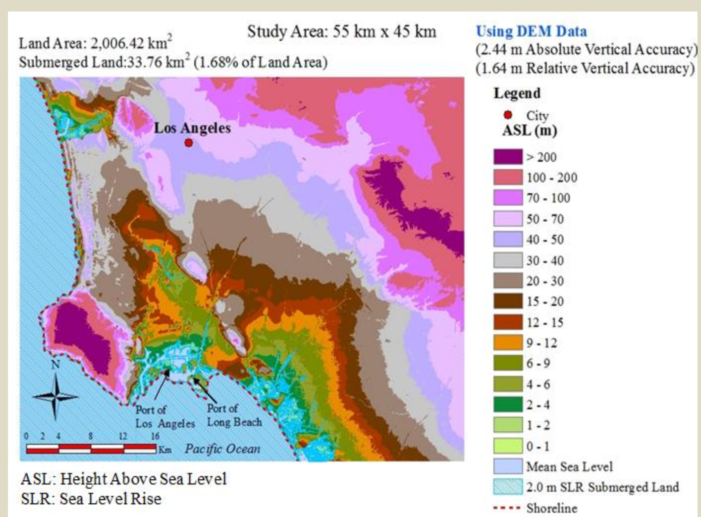


Figure 3. Spatial map of 2 m SLR simulation overlay on DEM elevation map, Los Angeles, California and surrounding areas

The population at risk in the study area is 215,857; and the density of population at risk is 108 per km^2. The 2m tsunami simulation results[6, 7] using the CAIT methodology, based on 2011 Fukushima mega tsunami data, are similar. The tsunami simulation shows just 0.4% less submerged land area than that by 2m SLR. However, a tsunami can occur any time if there is a strong earthquake in the Pacific Ocean along the west coast.

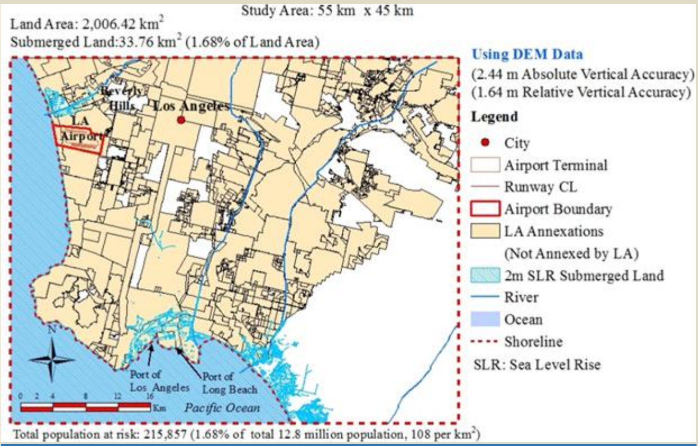


Figure 4. Spatial map of 2 m SLR simulation overlay on metropolitan boundary area map, City of Los Angeles, California and surrounding areas

The land area under water due to a rainfall flood is 22 times compared to that under 2m SLR simulation. Recall that 2m SLR is predicted beyond the year 2100[2] and should be gradual.

In comparison to 2m SLR impacts, the rainfall flood will inundate larger areas in any year as seen during the extreme snow and rainfall events on the U.S. west coast in early 2017 winter months. Therefore, a resilience management plan should be made to protect the critical infrastructure assets and people from rainfall flood inundation. Examples are: floodwalls to protect health centers and levees on both sides of the rivers. Additionally, a long-term field assessment plan should be established to identify potential areas and port infrastructures at risk. Structural alternatives such as seawalls should be considered to combat intrusion of future rising sea levels due to tsunami wave surges and long term 2m SLR expectations.

Acknowledgment and References:

The authors thank ERDC Hydraulic Engineer Vince Moody in the Hydrologic Engineering Center of the U.S. Army Corps of Engineers for support in using 1-D HEC-RAS software. Acknowledgement is also due to the USGS for providing hydrograph data used for this research.

[1]Nguyen, Q. and W. Uddin. Applications of Shuttle Radar DEM Data and Landsat-8 Satellite Imagery for HEC-RAS Floodplain Modeling. The NHWC Transmission, January 2016.

[2]The National Oceanic and Atmospheric Administration. Global Sea Level Rise Scenarios for the United States National Climate Assessment, December 6, 2012. http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf/2012/NOAA_SLR_r3.pdf accessed May 2, 2016.

[3]The United States Geological Survey. National Water Information System: Web Interface. USGS 11087020 San Gabriel r AB Whittier Narrows Dam CA.https://waterdata.usgs.gov/nwis/dv?cb00060=on&format=html&site_no=11087020&referred_module=sw&period=&begin_date=2005-01-01&end_date=2005-01-25 accessed January 29, 2017

[4]The United States Geological Survey. National Elevation Dataset (NED). Accessed February 01, 2017. https://lta.cr.usgs.gov/NED

[5]Los Angeles County GIS Data Portal. GIS Data for LA County. City Boundaries and Annexations/ Detachments.http://egis3.lacounty.cov/dataportal/2013/06/11/city-annexations/ accessed February 10, 2017.

[6]Stafford, W.T. Geospatial Assessment of Port Infrastructure and Computational Modeling of Coastal Disasters. *M.S. Thesis*, University of Mississippi, 2017.

[7]Nguyen, Q. Extreme Weather Disaster Resilient Port and Waterway Infrastructure for Sustainable Global Supply Chain. *PhD Dissertation*, University of Mississippi, 2017

Interactive, On-Line Flood Hazard Mapping – A Prototype

Brett F. Sanders[1,2], **Adam Luke[1], Jochen Schubert[1] and Richard Matthew[2]**
[1]Department of Civil and Environmental Engineering
[2]Department of Planning, Policy and Design
University of California, Irvine

In February 2017 over 180,000 people were evacuated below Oroville Dam due to concern about an imminent failure of the emergency spillway. During the crisis, emergency management officials relied on a flood map prepared by the California Department of Water Resources showing the geographical extent of flood inundation from a complete dam failure, and the time to flood wave arrival (Albert, 2017). Dam safety programs across the U.S. rely on similarly-prepared maps based on existing federal guidelines (FEMA 2013). However, computer models today are capable of producing flood hazard information far beyond geographic extent that poses tremendous opportunities to inform emergency decision-making by both public officials responsible for community safety, and individuals vulnerable to localized impacts. Furthermore, online mapping systems allow users to access powerful visualizations of flood hazards with local context and clarity. Amidst a technological revolution where mapping tools routinely inform daily decision-making at many levels, what is the next step in using online information systems to support emergency management?

At UC Irvine, a group of researchers is improving flood maps to benefit all phases of the disaster management cycle: mitigation, preparedness, early warning, emergency response and recovery, and to reach a broad constituency of end-users. Our approach begins with state-of-the-art surveying techniques and computer models that predict flooding at the scale of roads and buildings, and we collaborate with end-users including natural resource managers, city planners, public works engineers, emergency responders and citizens to produce flood maps that are responsive to their needs. The culmination of our work is an on-line system that presents flood risk information in simple ways that meet end-user needs. Here we use Lake Oroville to showcase the types of flood hazard maps that could and should be readily available for watersheds throughout the U.S.

The information system includes maps that communicate different aspects of flooding, such as its depth, its force, its potential to scour the ground, and its arrival time. From an emergency management perspective, what's especially helpful is that these maps estimate the level of danger in different parts of the flood zone. The fact is that in some areas, it is safer to "shelter in place" than to evacuate. Evacuation of thousands of people often results in traffic gridlock, which can be terrifying and endangering. Indeed, the goal of emergency management is moving people to safety, which could simply be across the street in a reinforced concrete building. Information about the flooding danger also assists emergency response personnel in navigating more safely through a flood zone and designating mobilization centers.

Flood maps are also being developed for planning and mitigation. The computer visualizations promote a shared understanding of the hazard that helps to bring forward ideas and initiatives with the potential to reduce vulnerability. With a trustworthy tool in hand, the community can measure the benefits and drawbacks of proposed interventions, and move to find a mix of hard and soft interventions that work best based on the factors that the community values the most. By providing broad access to flood risk information, there can be greater synergy among watershed activities such as wetland restoration, green urban infrastructure, and fire management.

A reality facing the U.S. is that the practice of flood mapping lags far behind the state of technology, and behind the state of practice in other parts of the world such as Europe and Australia (Moel et al. 2009; AIDR 2013). Flood maps in the U.S. are often produced with simplistic models and outdated information. Moreover, flood maps are difficult to access compared to other types of geographical information such as traffic and weather provided by on-line tools such as Google Maps.

While FEMA Flood Insurance Rate Maps are essential for administering the National Flood Insurance Program, they bare little meaning to non-expert users and do not support other aspects of flood risk management effectively (Burby 2001). Fortunately, the technology exists to radically improve flood hazard mapping in the U.S. The cost is pennies on the dollar of disaster losses avoided.

Citations:

Albert, Marc. "Oroville dam failure would drown vast area," North State Public Radio report, March 6, 2017. http://mynspr.org/post/oroville-dam-failure-would-drown-vast-area

Federal Emergency Management Agency, Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures" FEMA P-946, July 2013.

Burby, Raymond J. "Flood insurance and floodplain management: the US experience." *Global Environmental Change Part B: Environmental Hazards* 3.3 (2001): 111-122.

Moel, H. de, J. van Alphen, and J. C. J. H. Aerts. "Flood maps in Europe–methods, availability and use." *Natural Hazards and Earth System Sciences* 9.2 (2009): 289-301.

Australian Institute for Disaster Resilience (AIDR), "Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia*" Australian Disaster Resilience Handbook 7* (2013): 130-144.

12th National Hydrologic Warning Council Training Conference and Exposition

June 6-8, 2017 at Olympic Valley, California

Latest News

- The full conference program is available now, go to **www.hydrologicwarning.org**
- Registration fees are available at a reduced rate until April 30 (members and speaker $575, non-members $700). Registration fees include an evening social event at High Camp, 8,200 feet above Squaw Valley and the awards banquet on the last night. Start your registration planning now!
- A limited number of exhibit booths and unique sponsorship options are still available, so make your selection now to avoid being shut out.
- Special hotel rates of $189 per night are available at Squaw Creek. Hotel reservations can be made online from the NHWC webpage or by calling (530) 583-6300 and referencing "National Hydrologic Warning Council" to secure the group rate. The hotel will honor this special rate until May 15, 2017.
- Reduced government rates of $119 + taxes are available for government employees. To request the special government passkey, please contact **april@aprilkrieg.com** and **govrooms@hydrologicwarning.org** and provide your government agency information.
- For all the latest information visit

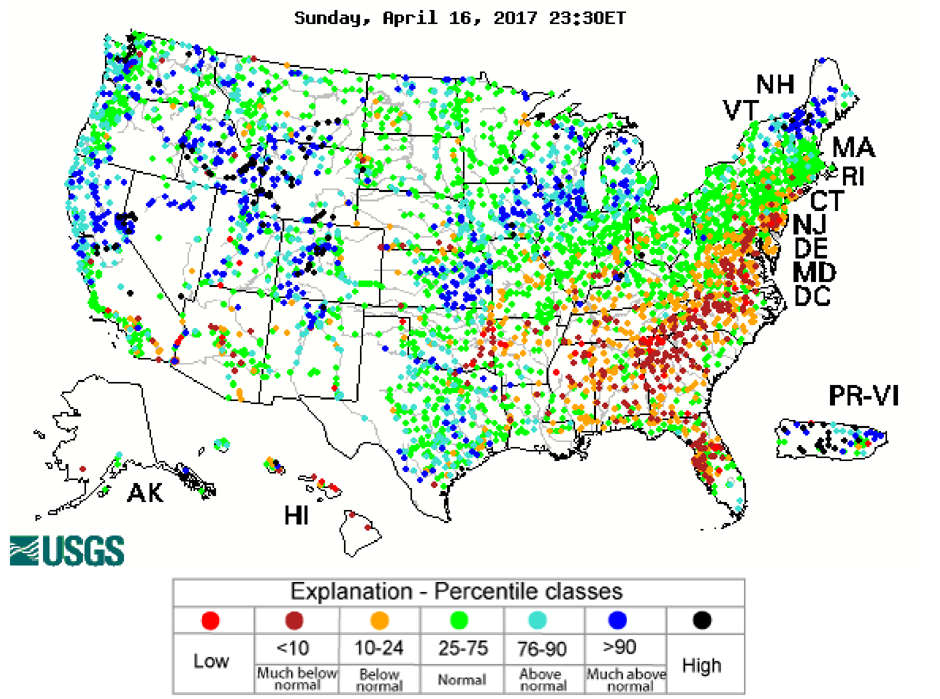
www.hydrologicwarning.org

For any registration questions contact

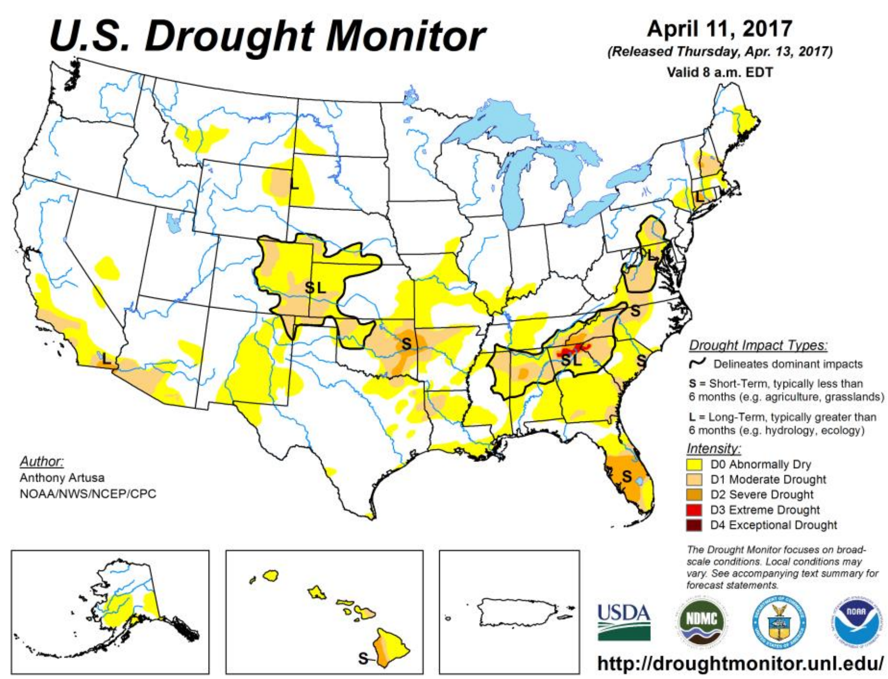
april@aprilkrieg.com

Hydrologic Conditions in the United States

Through April 11, 2017



Latest stream flow conditions in the United States. (courtesy USGS)



Latest drought conditions in the United States. (courtesy National Drought Mitigation Center)

May Newsletter Articles Focus:

Modeling & Analysis

The NHWC is requesting articles that focus on practices, technologies and tools used to model, predict and analyze hydro-meteorological events and to support decision making for emergency response and floodplain management.

Submit your article to:

editor@hydrologicwarning.org

May 8th is the deadline for inclusion in the May issue.

Future Newsletter Articles Focus

To give you more time to prepare articles, below is the article focus schedule for the next four months:

May - Modeling/Analysis
Jun - Data Collection
Jul - Hydrology
Aug - Hazard Communication & Public Awareness

NHWC Calendar

June 5-8, 2017 - NHWC 2017 Training Conference & Exposition, Squaw Valley, California

General Interest Calendar

April 30 – May 5, 2017 - ASFPM 41st Annual National Conference, Kansas City, Missouri

May 21-25, 2017 - American Society of Civil Engineers, EWRI World Environmental & Water Resource Congress 2017, Sacramento, California

November 5-9, 2017 - AWRA Annual Conference, Portland Oregon

(See the event calendar on the NHWC website for more information.)

Parting Shot

What does one do when birds insist on roosting on top of your solar panel?

You give them a better place to roost.

San Joaquin County, California technicians have installed an extended side mount for the McIntire Road ALERT station solar panel (Station ID 203). Providing a more comfortable place for birds to rest has helped to keep the solar panel clean.

Real-time data generated by this station can be viewed here.

Photo courtesy Matthew Ward, Flood Management Division, Public Works for San Joaquin County.

National Hydrologic Warning Council

Providing Timely, Quality Hydrologic Information to Protect Lives, Property, and the Environment

http://www.hydrologicwarning.org