

# LOUISIANA CIVIL ENGINEER

Journal of the Louisiana Section

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ACADIANA • BATON ROUGE • NEW ORLEANS • SHREVEPORT



**Metro Polder 10am August 29, 2005**

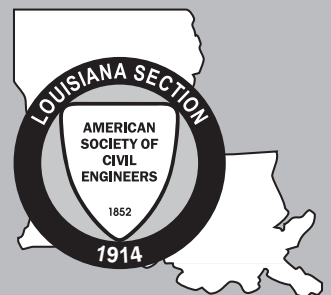
## FEATURE:

Managing Hurricane Surge Risks in the Supercomputing Era, Part II

## NEWS:

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**VOLUME 23 • NO 4**

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The Louisiana Section is located in ASCE Region 5 that consists of the Louisiana, Mississippi, Alabama, Georgia, and Florida Sections.

# President's Message

*By Pamela Gonzales Granger, PE*

Where has the year gone? Not only has summer ended and the new school year started but the ASCE fiscal year end of September 30, 2015 is fast approaching which means my term as President of the Louisiana Section is coming to an end. It has been my pleasure to serve the Section as President. I look back at the challenges that I made to the board and the membership and I am proud to see that we made great strides in the areas of mentoring and working with our student chapters as well as reaching out in elementary and high schools to promote civil engineering. I hope that our members appreciate the value of mentoring younger engineers and working with students to increase awareness of civil engineering. Thanks to everyone who volunteered and participated in events throughout the year focused on the challenges and goals of the year.

In this issue we recognize Hurricane Katrina, the impact, aftermath, lessons learned, civil engineering challenges and 10 years of rebuilding. This catastrophic event in combination with other recent smaller weather related events which greatly affected lives and impacted our infrastructure along with rapid growth in several areas of our state have made me question myself with the following:

- Am I doing everything I can as a civil engineer to make a difference?
- How can I bring awareness to current minimal standards that are outdated and help to "raise the bar" on our design criteria and requirements?
- How can I help political leaders understand development impacts and the need to modify requirements and standards to protect people and our infrastructure?
- Am I involved in my community and within the state enough with decision makers to assist them in understanding our infrastructure issues and how to address them?

These questions and others have motivated me to increase my involvement from a government relations perspective. I have learned that many who make decisions "don't know what they don't know" and without civil engineers helping them to understand, decisions will be made based upon what they know and believe to be correct. For example, how many decision makers on development regulations and criteria know that the rainfall depths and intensity information currently used in most jurisdictions in Louisiana to classify rain events are more than 60 years old and that we have recorded data that actually shows different trends than the assumptions that we are using for design? As civil engineers we need to get more involved in government relations so we can help to turn around our industry from primarily being reactive to catastrophic events or development to proactive and working seamlessly with leaders. On a national level ASCE has identified the increased need for government relations and is

offering training and other tools to assist members and sections that would like to get more involved. Our Section has been one of the most active on a national level in participation and on a state level very active as well. However, on a state level that activity has been from a few very dedicated members. We need

help from YOU, our members, so that we can increase awareness of our infrastructure needs. We need to get our leaders to spend more time with us who know and understand our state and our infrastructure. Many of our leaders have traveled abroad or out of state to see how others are designing. The reality is not that we don't have the engineering knowledge to solve our problems, it's that our criteria, regulations and funding are the differentiators and limiting factors. We can address that with awareness and education for those making the decisions. I would like to challenge each of you to get involved in the government relations committee or simply get involved in your community.

My last challenge is to ask each member to make a continued commitment to "quality". In a time when we know we are facing limited resources in the STEM related fields and in some areas, especially in our state, we are seeing rapid growth and development we need to make sure we continue to focus on quality projects and deliverables. As companies get bigger, many often focus on numbers and growth and look at spreadsheets and reports in much the same way "big box" corporations look at numbers. As engineers, we need to make sure we put quality and our client's needs first as we have made that commitment as an engineer agreeing to do work for the client. We may have to take a step back to manage expectations on schedule to deliver a quality product but with a little explanation and honest feedback it's better than the alternative of meeting the schedule with a lesser quality product. Remember the infrastructure you design or plan will impact you in one way or another in the future so treat your products like it's the last line of defense protecting you and your family and like you are purchasing those products with your money for yourself. ASCE is always striving to "raise the bar" and each one of us can help by individual acts in our daily lives as engineers and in our community.

Thanks again for allowing me to serve our membership as the President for the 2014-15 term. It has been my pleasure. Again, I welcome any ideas or comments regarding the Section and how we can better provide for and represent our membership. I can be reached at [pamela.gonzales-granger@ch2m.com](mailto:pamela.gonzales-granger@ch2m.com).



***Pamela Gonzales Granger, PE***

# Managing Hurricane Surge Risks in the Supercomputing Era, Part II

By Bob Jacobsen, PE

Part I was presented in the May issue and reviewed the pre-Katrina evolution, which is worth knowing in order to truly understand past mistakes which led to the City's devastation and issues which continue to threaten its future.

## Part II: Post-Katrina Progress and Limitations in Surge Hazard Estimation and Implications for Surge Risk Management

### A. HURRICANE KATRINA

On August 29, 2005 Category 3 Hurricane Katrina passed just east of New Orleans. Figure 1 depicts the evolution of Katrina's surge and how Katrina's strong, broad core—with counterclockwise rotating eye-wall winds above 120 mph—created a massive westward-driven setup against major East-Bank topographic features, such as the Mississippi River and the metropolitan New Orleans SPH surge protection system.

The westward pile-up of water was critical at a large regional "Funnel" formed by levees along the Gulf Intracoastal Waterway (GIWW) and the Mississippi River Gulf Outlet (MRGO) east of where the channels converge. The merged interior GIWW channel (west of the junction)—flanked to the north and south by levees—conveyed surge to the Inner Harbor Navigation Canal (IHNC), into the heart of the City and its three polders (areas substantially below sea-level enclosed by levees): the Metro Polder west of the IHNC; the NO East Polder east of the IHNC and north of the GIWW; and the St. Bernard Polder east of the IHNC and south of the GIWW, (which also includes the New Orleans Lower 9th Ward on its western end). Katrina's surge could not exit the IHNC at the northern outlet to Lake Pontchartrain as quickly as it entered via the GIWW, (the Lock connecting to the Mississippi River at the southern end was closed) and levels in the IHNC rose rapidly.

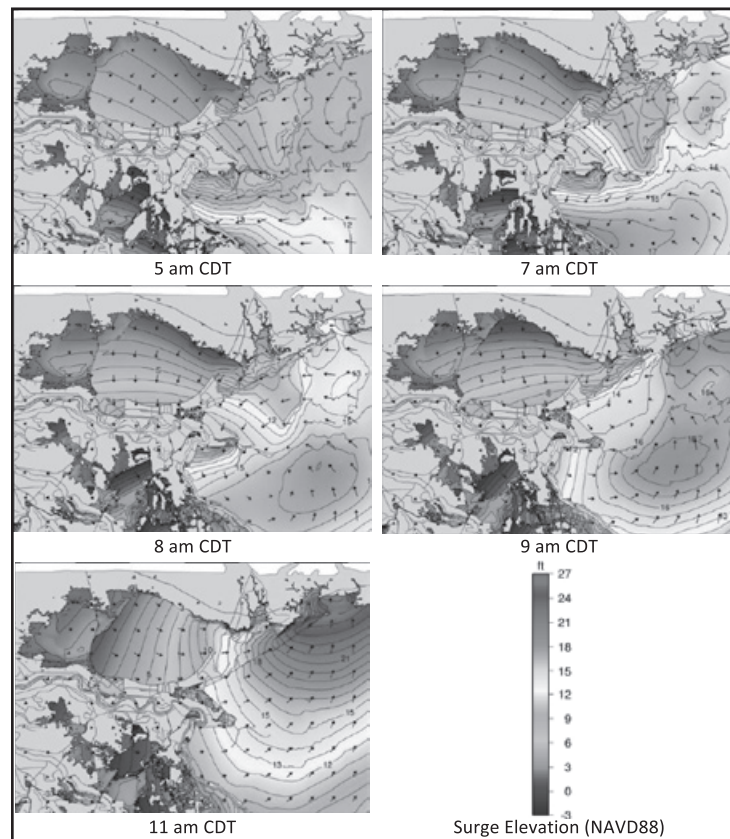
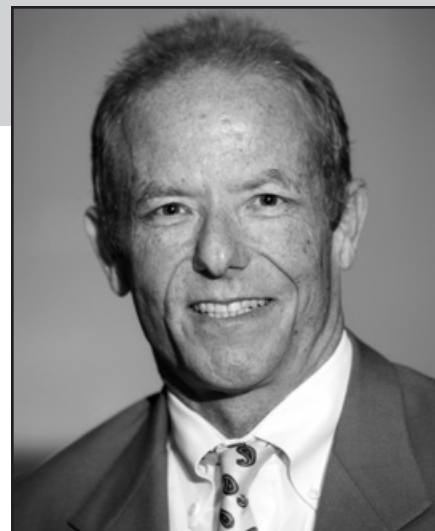


Figure 1. Hurricane Katrina Surge, USACE 2008



Bob Jacobsen, PE

Katrina's surge peak of 19.5 ft NAVD88 (19.2 ft above mean local level) along the MRGO (near Bayou Dupre) exceeded the Standard Project Hurricane (SPH) design surge of 12.1 ft above mean level by over 7 ft! Peak surge reached 18 ft NAVD88 further west in the Funnel (near Bayou Bienvenue), 15 ft NAVD88 in the GIWW (near the Paris Road Bridge just west of the junction), and 14 ft NAVD88 at the south end of the IHNC, all exceeding local protection system crowns. The surge peaks throughout the Funnel area would have been even higher had overtopping and breaches not occurred along the MRGO, GIWW, and IHNC.

Figure 1 also illustrates Katrina's "tilting" of Lake Pontchartrain—driving surge first to the southwest, then shifting to the south, and finally to the east. Southward-driven surge heights along the New Orleans Lakefront reached 11.8 ft NAVD88, raising levels in three outfall canals for the City's main interior drainage pump stations. The New Orleans Lakefront peak was 11.3 ft above Local Mean Level (LML), exceeding the SPH surge by nearly a foot. Later, eastward-driven surge—together with wave heights likely exceeding 10 ft—lifted decks on the Interstate "Twin Span" bridge from their piers.

Hurricane Katrina proved—as the previous decade of extreme surge scenario studies had anticipated—that the 1960s-era SPH surge estimates and surge hazards were woefully outdated. By 2005 surge scientists understood that additional hurricane climatological<sup>1</sup>, hydrodynamic, and landscape factors needed to be incorporated in estimating surge hazards.

#### 1 Hurricane Katrina as a Meteorological Event

On Sunday August 28, 2005 Hurricane Katrina intensified in the Gulf of Mexico to a Category 5 storm as it passed over the Loop Current, becoming the seventh strongest Atlantic hurricane on record—with a central pressure (CP) of 902 millibars (mb) and maximum sustained wind (VMAX) of 175 mph. The radii of maximum winds, hurricane force winds, and tropical storm force winds (RMAX, RH, and RTS) were large—at 21, 105, and 227 miles, respectively (compared to 12, 52, and 202 miles for Category 5 Hurricane Rita later that same year).

At its peak, Katrina's intensity was extreme but not unprecedented, given that ten hurricanes have reached Category 5 in the Gulf of Mexico since 1851 (or an average return period of less than 20 years). Hurricane Katrina's large size at Category 5 intensity made it rarer, but its peak integrated kinetic energy (IKE) at over 120 terajoules was only the second highest of storms analyzed since 1989.

During landfall Katrina's core decayed to top winds of 126 mph (a strong Category 3), while CP remained very low, at 920 mb. The wind-field spread out, with RMAX, RH, and RTS growing to 40, 135, and 282 miles. The storm's forward speed (VF) was a rapid 15 mph.

A landfalling Category 3 or higher hurricane is **not** a rare event for Southeast Louisiana, with a recently suggested return period of less than 20 years (Bob Jacobsen 2012). A *strong* Category 3 landfall has a much longer return period, on the order of 50 years. Major hurricanes with larger cores are rarer, so the Southeast Louisiana landfall return period for a "Katrina near-eye wind-field" is longer, but less than 100 years. As a comparison, Hurricane Betsy (1965) made landfall in Southeast Louisiana with peak winds approaching 150 mph and a RMAX of about 80 miles. Thus, as a local wind-field event for Southeast Louisiana—dominated by the storm's near-eye wind-field—Hurricane Katrina does not appear to be that unusual.

A much more extreme landfall return period of nearly 400 years has been suggested by Resio et al (2007), but is based on the return frequency for the landfall CP of 920 mb, indicative of a borderline Category 4/5 storm, instead of the VMAX, together with the 40-mile RMAX. Katrina's full landfall wind-field—with extended RH and RTS causing significant surge impacts as far away as northwest Florida—does justify a longer return period estimate for a Central-Northern Gulf event. However, Southeast Louisiana surge conditions were a result of Katrina's near-eye wind-field. Interestingly, Hurricane Rita produced a greater volume of surge in Lake Pontchartrain than Katrina.



Overtopping and breaching of the unfinished East-Bank SPH surge system caused catastrophic flooding in the three polders. Four major post-Katrina forensic investigations (ILIT 2006, Team Louisiana 2006, IPET 2006, and ASCE 2007) provided extensive documentation, including the role of engineering concessions on floodwall support conditions, levee materials, and elevation control. Altogether, the East-Bank polders experienced 16 major inflows, listed in Table 1 by polder.

Bob Jacobsen PE (2015) developed flow hydrographs and cumulative volume estimates for the 16 locations based on exterior surge, overtopping, and breach descriptions, together with detailed models of all three polders simulating the 16 inflows. (The simulated inflows and cumulative volumes were developed as part of a 2015 report for the Southeast Louisiana Flood Protection Authority-East, SLFPA-E, on interior topographic features and their effect on residual risk.) Table 1 includes the cumulative volume estimates and the percentage each location contributed to the total polder flooding. Figure 2 illustrates the peak inundation for the three polders. (Hourly snapshots from the simulations are presented in an appendix to the 2015 report.) The cumulative volume estimates and simulation results compare well with polder inundation information in the forensic reports.

Ten segments—all in the Funnel-IHNC area—experienced significant overtopping, causing major *erosion breaches* along six of the segments. Two major contributing factors to overtopping induced breaches were: a) actual crown elevations at all ten segments were below design elevations—due to a combination of outdated vertical control and post-construction settlement and subsidence—and; b) the use of hydraulic fill material along the MRGO. Overtopping along the MRGO began well before Katrina's peak surge. Overtopping and erosion breaches caused over 98 percent of the flooding in both the NO East and St. Bernard polders. (Some flood-side levee erosion from waves prior to overtopping may have also occurred along the MRGO levees.)

Portions of I-wall structures in five segments suffered major *collapse breaches*—failures which occurred prior to surge levels reaching wall crowns. In one I-wall failure—IHNC East, South of Florida Ave—the collapse occurred hours before, and several feet below, the peak surge, evidencing a serious geotechnical design flaw. The other four I-wall collapses occurred later, with water levels approaching but generally below the SPH surge. Three collapse breaches were in the Metro Polder Lakefront outfall canals, producing nearly two-thirds of the polder's flood water.

The forensic investigations determined that faulty assumptions and under-design contributed to all five collapse breaches. Technical "know how" was ample at the time of floodwall design and collapses with water levels below SPH surge were clearly preventable. (Three senior geotechnical engineers from Louisiana made significant contributions to the forensic investigations: Gordon P. Boutwell PhD, PE; Louis J. Capozzoli PhD, PE; and Billy R. Prochaska PE.)

In addition to under-design, the breaches can be attributed to the absence of a Factors of Safety (FOS) to address SPH surge uncertainty. The US Army Corps of Engineers (USACE) had authorization to determine design FOSS. The USACE likely lacked authorization to provide resiliency—i.e., strengthening measures enabling resistance to breaching during overtopping.

For the second time in 40 years New Orleans surge risk management proved to be painfully inadequate. Decades of compromise to the implementation and maintenance of the post-Betsy SPH-surge protection—driven in no small part by

Polder/Location	Type	Cumulative Volume Acre-Ft	Percent
<b>Metro Polder (Orleans Parish and Old Metairie — 27,268 acres)</b>			
17th St Outfall Canal I-wall	Collapse Breach	32,399	34.1
Orleans Ave Outfall Canal I-wall	Opening	89	0.1
London Ave Outfall Canal I-wall, North	Collapse Breach	23,555	24.8
London Ave Outfall Canal I-wall, South	Collapse Breach	6,484	6.8
IHNC West, North of Florida Ave	Overtopping & Breaches	25,022	26.3
IHNC West, South of Florida Ave	Overtopping	7,524	7.9
		<b>95,072</b>	<b>100</b>
<b>NO East Polder (Inside Maxent Levee — 14,792 acres)</b>			
IHNC East I-wall	Collapse Breach	757	1.4
IHNC East	Overtopping	12,494	23.3
Citrus Back Levee (IHNC to Paris Rd)	Overtopping	33,289	62.1
Citrus Back Levee (East of Paris Rd)	Overtopping & Breaches	7,037	13.1
		<b>53,578</b>	<b>100</b>
<b>St. Bernard Polder (Inside 40 Arpent Levee — 20,015 acres)</b>			
IHNC East I-wall, South of Florida Ave	Collapse Breach	2,166	1.4
IHNC East I-wall, North of Claiborne Ave	Overtopping & Breach	13,107	8.5
IHNC East Floodwall	Overtopping	3,400	2.2
MRGO and 40 Arpent Levees (IHNC to Paris Rd)	Overtopping & MRGO Levee Breaches	32,260	20.8
MRGO and 40 Arpent Levees (Paris Rd to Violet Canal)		43,276	27.9
MRGO and 40 Arpent Levees (Violet Canal to Reggio)		60,677	39.2
		<b>154,885</b>	<b>100</b>

Table 1. 16 Major Polder Inflows During Hurricane Katrina

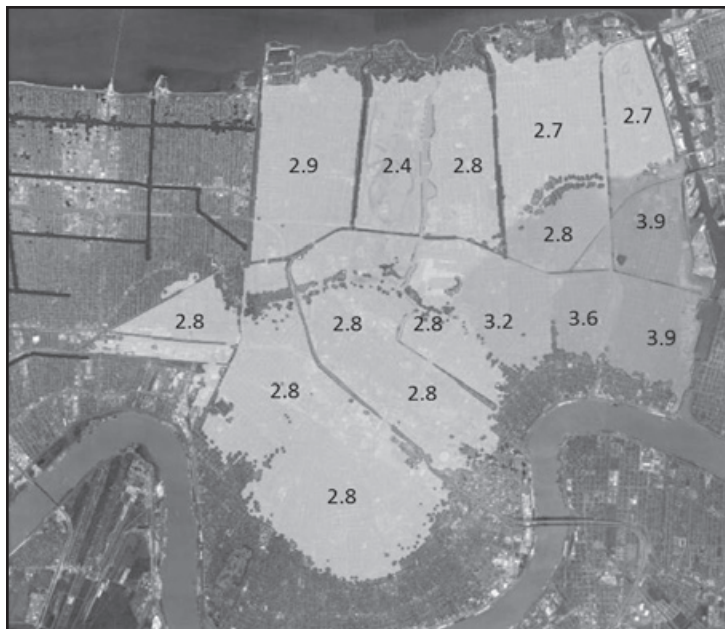
competing priorities—had aggravated polder vulnerability to a tragic extent that only a few appreciated. Disaster response and recovery agencies at all levels were ill prepared for the consequences of allowing for such residual risk<sup>2</sup>. Evacuation was credited with having reduced the loss of life—which would have likely been many times worse had officials not had the improved ContraFlow and other plans in place. However, the post-storm death toll and calamity of thousands stranded in the flooded City showed that evacuation plans were grossly inadequate (Wolshon 2006 and Campanella 2012).

City housing and associated economic recovery was hampered by the limited scope of the National Flood Insurance Program (NFIP, which ironically had stimulated higher project priorities under a separate USACE Southeast Louisiana, SELA, Drainage Program): 1) many owners of homes not under a mortgage—a large portion of the City's housing stock—had chosen not to purchase flood insurance, despite inexpensive NFIP premiums; 2) many home mortgagors not in polder 100-yr hazard zones (reduced by the SELA projects) had also chosen not to purchase flood insurance; and 3) home and commercial property owners who did have flood insurance were often under-insured.

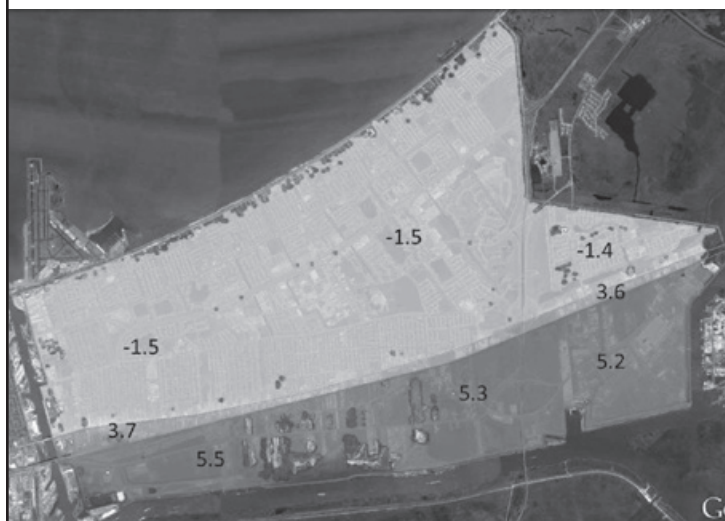
## 2 Hurricane Katrina Consequences

Hurricane Katrina flooding of the East-Bank constituted one of the worst natural catastrophes in the history of the United States. Over 1,400 Southeast Louisiana residents died directly or indirectly as a result of Hurricane Katrina; (see Boyd 2011 and Jonkman et al 2006.) 518 deaths occurred in residences, nursing homes, and other buildings directly as a result of exposure to flood waters or the collapse of the building they were in. As many as another 150 died in local facilities and shelters due to interference with critical healthcare (e.g., inability to obtain insulin, dialysis, etc.). Other impacts in the initial years following Hurricane Katrina (documented by The Greater New Orleans Community Data Center, Insurance Information Institute, U.S. Census Bureau, and FEMA) included:

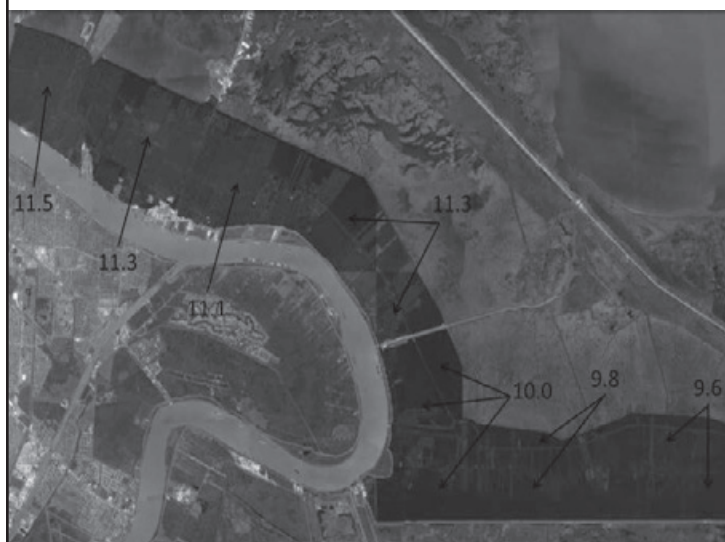
- Orleans Parish population declined from about 455,000 to less than 200,000.
- St. Bernard Parish population declined from about 65,000 to 11,000.
- Severe declines in regional payrolls and consumer spending. Sales tax revenues fell by about 25 percent.
- Damage to over 70 percent of the metropolitan area's housing.
- \$25 billion in Louisiana private insurance claims.
- \$13 billion in Louisiana NFIP payments.
- Nearly \$7 billion in FEMA assistance to agencies and institutions for clean-up, repair, and replacement of New Orleans infrastructure and public facilities, including roads, bridges, water systems, sewer systems, drainage systems, .
- Additional billions of dollars in federal aid to the State of Louisiana for recovery and repair projects, such as the replacement of the I-10 Twin Span Bridge.
- Tens of billions of dollars in self-insured losses by large corporations, including: electrical, gas, communication utility companies; private port facilities; railroads; petroleum and natural gas production and refining industry; and petrochemical industry.
- Total regional cumulative economic losses probably approaching \$100 billion.



Metro Orleans and Jefferson Parishes



NO East



St. Bernard

Figure 2. Hurricane Katrina Peak Polder Inundation from Overtopping and Breach Simulations, Bob Jacobsen PE, 2015

## B. TWENTY-FIVE ADVANCES IN HURRICANE SURGE SCIENCE

Demands for better estimates of surge hazard followed in the wake of Hurricane Katrina (and Hurricane Rita later that same year). Over the next several years concern for extreme surge hazard expanded throughout the Gulf and Atlantic Coasts—spurred on by subsequent storms (e.g., Gustav and Ike in 2008 and Sandy in 2012) and warnings about accelerating climate change, rising ocean temperatures, sea-level rise, and coastal erosion. In addition, coastal residents and their leaders sought better surge forecasts to improve evacuation and other emergency preparations and responses. (The scientists at the LSU Hurricane Center had actually provided remarkable experimental supercomputer-based surge forecasts for Katrina using the Advanced Circulation Model, ADCIRC.) As a result, in the decade since Hurricane Katrina the federal government has invested hundreds of millions of dollars in better spatially and temporally resolved data and depictions of hurricane winds and coastal surge. These depictions rely heavily on High Performance Computing (HPC) processing. The investment has substantially advanced hurricane climatology and surge physics, together with the State of the Practice (SOP) for two-dimensional (2D) surge modeling, surge joint probability analysis (JPA), and “what-if” scenarios.

### i. Hurricane Climatology

Since 2005 meteorologists and climatologists have painted an increasingly more detailed picture of hurricane attributes, atmospheric physics, and trends (Bob Jacobsen PE 2012, 2013). Six key advances have included the following:

1. Improved wind data collection and analysis, and understanding of extended wind-field characteristics. Investigators have examined wind-field energy indicators (such as storm IKE), asymmetries in Holland B, and structures such as secondary eyewalls and banding. Researchers have made closer studies of the effects of the extended wind-field characteristics on surge (e.g., 2008’s massive surge that resulted from very large, Category 2 Hurricane Ike). A critical finding—reinforced by 2012 Hurricane Isaac in Southeast Louisiana—is that large, slow-moving, low intensity hurricanes can create extreme surges along very shallow coastal regions.
2. Further knowledge of hurricane genesis, intensification, and decay. Meteorologists better understand the roles of deep ocean heat energy associated with the Gulf of Mexico’s Loop Current and regional atmospheric conditions.
3. Global climate cycles and trends. Climatologists have shed more light on several cycles (such as the 30-90 day Madden-Julian Oscillation, the inter-annual El Niño-Southern Oscillation, and the Atlantic Multi-decadal Oscillation) affecting hurricane frequency over various time scales and continued their research on potential long-term trends associated with global warming.
4. Historical record refinement. Researchers have continued to upgrade hurricane information dating to the mid-1800s by combing through various sources of pressure, wind, surge, and other data.
5. Paleo-climatology. Geologists have studied indications of very extreme surge return frequency in the coastal Holocene stratigraphy (Wallace et al 2010).
6. Enhancements in quantifying regional probabilities for storm central pressure, maximum wind speed, radius of maximum winds, PC/VMAX, RMAX, VF, track ( $\theta$ ), and Holland B.

These advances have supported development of better:

- Empirical storm sets for wind hazard analysis; (see Vickery et al 2009 and Emanuel et al 2010).
- Hurricane joint probability method (JPM) approaches employed in more than a dozen post-Katrina Flood Insurance Study (FIS) surge hazard analyses extending from Texas to New York.



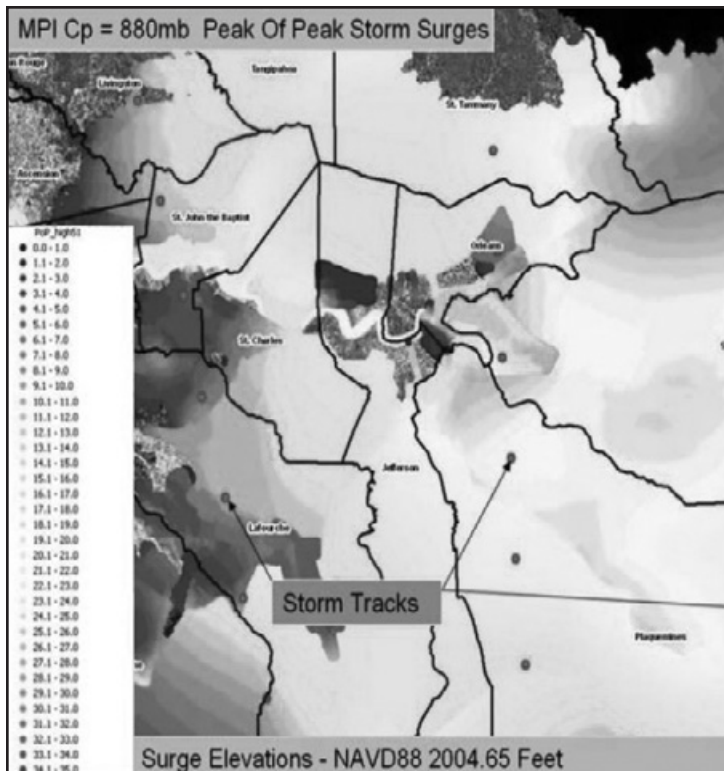


Figure 3. Maximum Probable Intensity MOM for Southeast Louisiana, USACE 2009

- Surge maximum-of-maximums (MOMs) for Category 1 through 5 hurricanes (National Oceanic and Atmospheric Administration).
- Maximum Probable/Possible Hurricanes. The physical extreme of a North-Central Gulf of Mexico hurricane heading for Southeast Louisiana was revised to include a PC of 880 mb (a  $\Delta P$  of over 130 mb) and an RMAX of 25 nautical miles. Figure 3 depicts a surge MOM for this hurricane.

Future work in these topics should improve estimates of extreme hurricane characteristics and return frequency. However, these estimates will retain considerable uncertainty for many decades to come.

## ii. Surge Physics

Since Katrina, surge investigators have improved understanding and representation of surge physics. Fundamental 2D (and even 3D) hydrodynamic equations (referred to as the Shallow Water Equations)—encompassing the full range of physical actions have long been well established (gravity, tides, Coriolis, atmospheric pressure, wind-water drag, canopy and wind sheltering effects, hydrodynamic frictional drag, wave radiation stress, baroclinic stress, and turbulence). Three major advances in surge physics have been:

1. Greater spatial and temporal refinements of the physics. HPC has enabled studying surge physical interaction at more detailed local scales.
2. High resolution nodal attribute data. Topography/bathymetry (topo/bathy), land-cover data, and spatially variable empirical coefficients have allowed evaluation and improvement of formulations for wind-water and hydrodynamic drag, and approaches to canopy and wind-sheltering effects.
3. Nos. 1 and 2 in turn, have enabled scientists to study the details of surge hindcasts, and to develop a quantitative understanding of **Surge Response**—what happens to surge, where, when, why, and how (Resio et al 2009 and Irish et al 2009). Location-specific explicit surge-response functions (Figure 4) are similar in concept to a stage-discharge function for a river. They provide peak surge as a function of hurricane attributes (PC/VMAX, RMAX, VF, track/ $\theta$ , and Holland B) and local coastal features—facilitating a significant

improvement over old “rules of thumb”—such as 2.75 miles of coastal wetland reduces surge by 1 ft.<sup>3</sup>

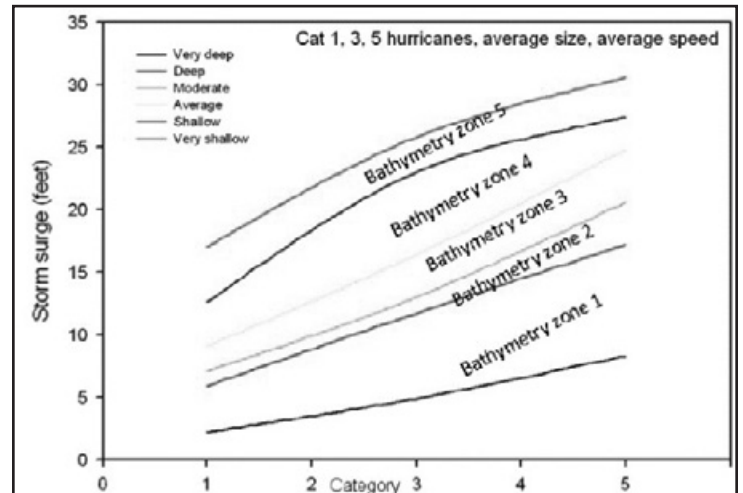


Figure 4. Example of a Surge-Response Function and Idealized Shelf Type, Fitzpatrick et al 2010

In the coming years scientists will continue to investigate Surge-Response topics at even more refined scales, especially the quantification of localized

## 3 Ten Surge-Response Points

1. Extreme surge is foremost a product of wind-water drag—with wind setup proportional to fetch and wind speed squared, and inversely proportional to depth. Researchers have shown that surge is much higher for open coasts facing extended shallow continental shelves (unlike tsunamis).
2. Complex hurricane forerunners can also contribute to surge—such as those driven by long-shore currents along regional shelves, which can create a significant perpendicular setup associated with Coriolis force (Kennedy et al 2011).
3. The passage of the hurricane wind-field over large, shallow interior bays and lakes can produce drastic localized “tilting,” regardless of the “filling” from the prior forerunner or main surge. Slow moving weaker hurricanes are capable of producing extreme tilting of large, shallow, interior water bodies—as the wind set-up has time to “fully develop.” (This occurred in 2012 at Braithwaite Louisiana on the East-Bank just south of St. Bernard Parish during Category 1 Hurricane Isaac, which experienced a worse surge than during Hurricane Katrina.)
4. Setup increases with the presence of topographic blocking features—without which surge will spread out.
5. Counteractions to inland surge created by the landscape—such as from topographic “speed bumps” (e.g., cheniers and road embankments) and hydrodynamic friction (e.g., vegetation) decline dramatically with drowning of features. Features that significantly reduce inundation from small-to-moderate surge can have much less effect on extreme surges.
6. The counteraction of hydrodynamic friction also depends on surge velocity. Thus, setup from slow moving storms may be relatively unaffected by coastal vegetation.
7. Similarly, while coastal (exterior) channels contribute significantly to the conveyance of tides and small-to-moderate surges, their relative impact also declines with regional landscape drowning during extreme surges. The exterior channels do increase interior salinity, causing serious degradation to the wetlands. Wetlands loss results in greater inundation for more frequent small-to-moderate surges, which, in turn further exacerbates wetlands loss.
8. The impact of coastal features during surge events is both storm- and time-specific—resulting in complex impacts on surge hazard. A coastal feature can reduce surge in one area while exacerbating it in another. Closing a coastal channel may aggravate surge for some locations under certain scenarios.
9. Additional setup is contributed by gradients in wave radiation stress associated with wave-breaking in high wave fields. While particularly important along open coasts, the additional wave contribution to setup also needs to be factored in for large interior water bodies such as Lakes Pontchartrain and Borgne.
10. For smooth, uniform open coasts Surge-Response can be a very smooth (almost linear) function of hurricane attributes (see Figure 4). However for complex coasts, with large shallow water bodies and a range of topographic features, local response can be highly sensitive to slight changes in the storm’s local winds, track, and forward speed—making for a more non-linear Surge-Response function.

“tilting” during complex wind-wave conditions and hydrodynamic drag during overland inundation. Teasing out the nuanced influences of terrain, channels, and various forms of vegetation during changing surge depth and velocity are also central to coastal protection and restoration interests.

### iii. HPC/High-Resolution Modeling of Surge-Response

In the years before and after Katrina, continuing rapid microprocessor improvements allowed surge modelers to organize numerical methods<sup>4</sup> to take advantage of increasingly available and affordable HPC clusters. Ongoing HPC gains have facilitated eight notable advances in surge modeling (Bob Jacobsen PE 2013).

1. Tighter spatial discretization. HPC now easily supports models with **millions** of spatial computation locations—represented as nodes in a 2D grid or mesh. Regional surge models can resolve critical features to scales of less than 100 ft, (with local models refining features to less than 30 ft).
2. Nodal attributes. With more highly resolved landscapes, model developers (e.g., ADCIRC, an open source code) can provide detailed spatial specification for topo/bathy, wind sheltering, canopy-induced wind reduction, and land-cover effects on hydrodynamic friction.
3. Boundary and initial conditions. Models can address seasonal variations in regional mean water levels, time varying river inflows, and levee overtopping.
4. Coupling with wave models. The importance of wave radiation stress gradients on surge heights and currents (and of surge depths and currents on wave heights and periods) led model developers to incorporate wave models (e.g., STWAVE and SWAN) directly into the surge hydrodynamic model code for seamless computation of both surge and wave conditions.
5. Wetting and drying. Algorithms to start and stop flow computations at an advancing or retreating inundation front have been improved, along with approaches to issues associated with wetting and drying accuracy and efficiency.
6. Longer pre-storm simulations. Surge investigators can “spin-up” their models with weeks of tide and local wind simulations.
7. Integration with better wind modeling. High-resolution surge modeling is able to employ a variety of hurricane wind-field inputs, both for historic and synthetic storms, which take into account recent advances in hurricane wind-field science.
8. Code developments. In addition to ADCIRC—which has been widely applied for over 10 years—in recent years additional parallelized 2/3D hydrodynamic codes have become available (FVCOM, ADH, MIKE21, and DELFT3D). Researchers have advanced the accuracy and efficiency of numerical methods and the specific application of various HPC architectures. In turn, researchers have also learned how to better optimize spatial resolution in conjunction with these methods to achieve better accuracy and efficiency.

Progress in HPC/High-Resolution surge modeling has led to improved accuracy (bias) and precision—as indicated by average errors and the standard deviation of errors in observed versus predicted high water marks in hindcasts. (See Dietrich et al 2011 which discusses modeling of Hurricanes Katrina, Rita, Gustav, and Ike with an ADCIRC+SWAN model having more than five million nodes). Currently, overall regional hindcast bias can be less than 15 percent. Discounting issues with wind and surge data, regional hindcast precision is also

#### **4 Numerical Methods**

A set of algebraic equations is employed to approximate the complex, partial differential Shallow Water Equations. Computer codes are used to solve this set of algebraic equations, which are written separately for each node in the domain. Subdomains are created and then assigned, one each, to the hundreds of micro-processors in an HPC cluster. Over a simulated time-step—e.g., one second—the equations are solved in parallel for nodes within each subdomain by the HPC processors. Between time-steps output and inputs from each subdomain are transferred and incorporated as needed across subdomain boundaries. This process is then repeated until the entire simulation is completed.

probably better than 15 percent. (Dietrich et al 2011 found precisions better than 25 percent including these other sources of local error.) Worse local errors are present in places with complex wind and wave setup, and at lower surges due to greater influence of local topo/bathy and friction issues. ***Importantly, because understanding of Surge-Response is still developing, the HPC/High-Resolution surge modeling SOP currently does not provide for calibration of models (correction of regional or local bias) for NFIP FISs.***

Supercomputing is now part of the SOP for surge hazard analysis, with the HPC version of ADCIRC being applied in all Gulf and Atlantic coastal FISs—as well as in the preparation of the maximum intensity MOM shown in Figure 3. The accuracy, precision, and increasing economy of HPC/High-Resolution surge modeling has also precipitated its use in surge forecasting. The ADCIRC Development Group is currently teaming with several partners to provide the Coastal Emergency Risk Assessment (<http://coastalemergency.org/>) surge forecasts for use by emergency response agencies.

In the coming decades, further improvements in empirical representations of key surge physics, HPC, and understanding of Surge-Response will support more refined models—ultra-High Resolution regional meshes capturing key features to scales of tens of feet. These should lead to further modest gains in hindcast and forecast accuracy and precision. In addition, future better understanding of Surge-Response will lead to acceptable methods of calibrating HPC/High-Resolution surge models.

### iv. Joint Probability Analysis

Analysts, in turn, have also furthered six enhancements of surge JPM (see Part I):

1. Wider use of tide-gauge analysis using Extreme Value Functions (EVFs, see Part 1). Lengthening tide records and improvements in vertical referencing have allowed better “data-driven” evaluations of surge return period, as shown in Figure 5. These tide-gauge analyses are proving useful to assess JPM results. Researchers are also examining EVF types with broader empirical basis.
2. More sophisticated empirical techniques and climate models, which can improve the representation of track and wind-field variability.
3. JPM-OS (Toro 2008). To keep the number of storms manageable, post-Katrina analysts developed two sophisticated approaches to determining an optimized sample (OS) of storms for the JPM sets. One approach, conducts a preliminary surge hazard analysis with a much coarser (and faster running) surge model using a very large number of synthetic storms. The results of the preliminary surge hazard analysis are evaluated at locations of interest, and a smaller group of storms is then selected to effectively represent surge hazard curves at the various locations. Mathematical techniques are used to optimize storm selection. The smaller, JPM-OS set of storms is then simulated with the HPC/High-Resolution model.
4. Surge-Response OS (Resio et al 2009). A second approach takes advantage of the Surge-Response concept. The OS is used to construct explicit Surge-Response functions for locations throughout the region. Location-specific peak surge are provided for any combination of hurricane attributes (e.g., CP, RMAX, VF,  $\theta$ , and landfall location, X). A separate hurricane joint-probability equation gives the frequency for any combination. Using these two functions, peak surge and joint probability are generated for thousands of synthetic hurricane combinations, and these are then used to compute each location’s surge hazard curve. In the JPM-OS approach there is no focus on explicitly representing Surge-Response. However, both approaches need to ensure that the OS is adequate to capture complex, non-linear Surge-Responses—such as for large sheltered coastal bays and lakes.
5. Epsilon Term (Resio et al 2012). Additional factors affecting surge hazard which are treated for convenience as normally distributed random variables can be lumped into a single variable—termed epsilon—by adding their individual standard deviations ( $\sigma$ ) in quadrature (taking the square

root of the sum of their squares). Example factors can include tide timing, surge model hindcast residual error, Holland B, and wind-field variability. Post-Katrina JPM approaches have incorporated epsilon into the surge hazard curve. Prior to the numerical integration of the surge hazard curve (see Part I), each surge mass probability point is expanded using a range of normally distributed points reflecting the epsilon  $\sigma$ . The numerical integration of this expanded set of points adjusts the surge hazard curve to account for the variables. Including an epsilon term for tide timing, surge model hindcast residual error, Holland B, and wind-field variability, adds one to two feet to the estimated 100-yr surge for some Southeast Louisiana locations.

6. Hurricane Sampling Uncertainty. Besides those random variables addressed with the epsilon term, post-Katrina JPM approaches have recognized the importance of other residual uncertainties, such as hurricane sampling uncertainty. This particular uncertainty refers to the limited length of the hurricane record on which the joint probabilities (and thus the hazard curve and individual hazard levels) are based. If an EVF is fitted to the surge hazard curve the residual error in the fit is inversely proportional to the square root of the record length and EVF residual error can be used as a proxy for hurricane sampling uncertainty. The  $\sigma$  and Confidence Interval (CI) associated with the residual error then provide estimates of the  $\sigma$  and CI for hurricane sampling uncertainty. As with any EVF fit, the estimate of hurricane sampling uncertainty for surge hazard is sensitive to the choice of EVF.

In the coming years JPA will continue to evolve with further improvements in hurricane climatology expanding the array of hurricane attributes and refining estimates of their probabilities, and with more advances in Surge-Response and HPC/High-Resolution modeling. JPA will be enhanced by the ability to expand OSs to hundreds, if not thousands, of storms. There will likely be an increased blending of empirical and JPM approaches to JPA.

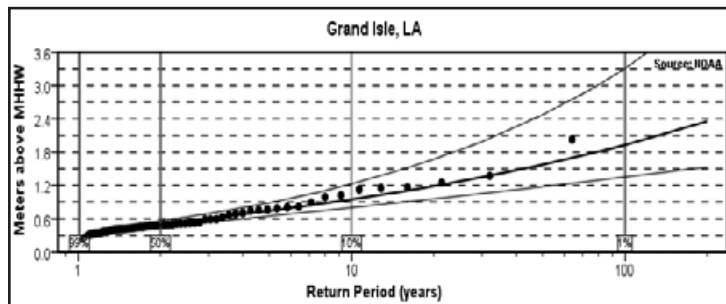


Figure 5. Fit of the EVF to Grand Isle Tide Gauge with 95%CI  
<http://tidesandcurrents.noaa.gov/est/curves.shtml?stnid=8761724>

#### v. What-If Scenarios

HPC/High-Resolution surge modeling has also led to two advances in modeling “what if” surge scenarios.

1. The use of modified High Resolution models—topo/bathy, land-cover, coefficients, etc.—to simulate a future condition—relative sea level rise (RSLR), coastal erosion, restoration—or surge protection project. The models can then be used in conjunction with JPM-OS or Surge-Response OS to evaluate changes in surge hazards. To date most efforts have used limited, smaller OSs than for current conditions, but the approaches allow some indication of impacts on key hazard levels, e.g., 100-yr, 500-yr, and 1,000-yr.
2. Use of codes with constituent transport physics—such as FVCOM, ADH, MIKE21, and DELFT3D—to study surge-related geomorphological and water quality impacts. These models are most useful in evaluating local impacts, such as sediment erosion and deposition around barrier islands and coastal passes and saltwater intrusion—and proposed mitigation measures. They can employ regional High Resolution models for surge event boundary

conditions. Depending on the application, some simulations can run with modest parallelization available in the workstation.

In the future, continued HPC improvements will allow for more detailed spatial refinement of scenario conditions, simulation of complete JPM storm sets, and evaluation of greater ranges of scenarios.

### C. THE POST-KATRINA FIS SURGE HAZARD ESTIMATE

In 2008 the USACE completed new surge hazard estimates for Southeast Louisiana, documented in a NFIP FIS, as part of a multi-action response to Katrina<sup>5</sup>. Table 2 presents 100- and 500- post-Katrina surge hazard estimates at two locations—the New Orleans Lakefront and along the MRGO south of Lake Borgne—along with the pre-Katrina SPH, 100- and 500-yr surge estimates discussed in Part I. The Table 2 post-Katrina surge estimates reflect correction of errors in a FORTRAN code used to compute FIS surge hazards; (see Bob Jacobsen PE 2015; Woods Hole Group 2015 discusses the FORTRAN errors). The corrected estimates are less than one foot higher than the published FIS estimates. The corrected estimates are referred to in this article as FIS estimates since they were derived with the general FIS SOP.

On the basis of surge depth, the New Orleans Lakefront post-Katrina corrected 100-yr estimate is 0.2 lower than the pre-Katrina (1966) estimate. (The uncorrected estimate is 1.1 ft less.) The corrected 500-yr estimate is only 0.8 ft higher. Interestingly, without the additional wave setup contribution to the post-Katrina estimates, the new corrected 100-yr surge would be closer to a foot lower, and the 500-yr estimates would be almost identical.

On the other hand, the post-Katrina analysis increases 100- and 500-yr hazard estimates at the MRGO location substantially—almost 5 and 7 ft, respectively, (without an IHNC Barrier; addition of the IHNC Surge Barrier raises these estimates by another 1 and 2 ft). Table 2 shows a much larger spread between the 100- and Nominal 500-yr hazards in the post-Katrina versus the pre-Katrina (1966) estimates at both locations: 2.6 versus 1.6 ft at the New Orleans Lakefront and 3.2 ft versus 1.2 ft at the MRGO (without the IHNC Barrier).

According to this FIS analysis, Hurricane Katrina’s surge at the New Orleans Lakefront and MRGO was 2.2 and 2.8 ft above the new 100-yr level, respectively, and 0.4 ft below a Nominal 500-yr level, at both locations. This corresponds to roughly a 400-yr event for both locations (using a log-linear interpolation). The FIS analysis thus suggests that Katrina’s surge should be regarded as an extremely unlikely event.

Given the disastrous history of surge hazard underestimation for New Orleans—and associated inadequate risk management—the FIS analysis warrants a closer look.

5	USACE Post-Katrina Surge Related Actions
Since 2005 the USACE has undertaken six parallel efforts:	
1.	Revised surge hazard analysis for NFIP FIS; (USACE 2008).
2.	Support for Katrina forensic investigations by the Interagency Performance Evaluation Task Force, (IPET 2006-09).
3.	Design and construction of a protection system for the 100-yr surge—known as the Hurricane and Storm Damage Risk Reduction System (HSDRRS)—for NFIP accreditation (USACE 2011).
4.	Design of HSDRRS resiliency measures to address 500-yr surge (USACE 2013).
5.	Polder inundation residual risk evaluation; (IPET Volume VIII, 2009).
6.	Comprehensive Louisiana Coastal Protection and Restoration (LaCPR) Study of other regional surge risk reduction projects for up to 1,000-yr surge; (USACE 2009).
In the course of these activities the USACE led and/or funded many surge science advances discussed in Section B, which it then integrated into the FIS surge hazard analysis. The FIS surge hazard analysis—which employed a Katrina validated HPC/High-Resolution ADCIRC model, the Resio Surge-Response JPM approach, and an OS of 152 storms—provides the basis for most of the surge evaluations in all six USACE efforts. The USACE’s approach to the Southeast Louisiana FIS contributed greatly to practices followed and refined in ensuing FISs across the Gulf and Atlantic Coasts. This FIS surge hazard analysis SOP also reflects important methodology limitations (see Sidebar on FNIP programmatic constraints). For a comprehensive discussion of the SOP in surge hazard analysis see Bob Jacobsen PE 2013.	



	NO Lakefront		MRGO (Bayou Dupre)			
	ft MSL (NGVD)	Above LML	Without IHNC Barrier ft MSL (NGVD)	Above LML	With IHNC Barrier	
<b>Pre-Katrina</b>						
Local Mean Level	1.0		0.9			
SPH	11.5	10.5	13	12.1		
100-yr	10.3	9.3	12.5	11.6		
500-yr	11.9	10.9	13.7	12.8		
<b>Post-Katrina</b>	ft NAVD88	Above LML	ft NAVD88	Above LML	ft NAVD88	Above LML
Local Mean Level	0.5		0.3			
Katrina Actual	11.8	11.3	19.5	19.2		
Uncorrected 100-yr	8.7	8.2	16.4	16.1		
Uncorrected 500-yr	11.3	10.8	18.9	18.6	20.2	19.9
Corrected 100-yr	9.6	9.1	16.7	16.4	17.6	17.3
Corrected 500-yr	12.2	11.7	19.9	19.6	21.7	21.4

Table 2. Comparison of Pre- and Post-Katrina Surge Hazards

## D. LIMITATIONS OF THE FIS SURGE HAZARD ESTIMATE

Constraints imposed by the NFIP<sup>6</sup>—together with further improvements in hurricane climatology, surge physics, surge modeling, and JPMs—have clarified many significant issues with the post-Katrina FIS surge hazard analyses.

Table 3 lists ten issues, along with the potential magnitude of surge uncertainty associated with each issue. For convenience each uncertainty is treated as normally distributed and Table 3 gives the current approach to evaluating each  $\sigma$ . The combined  $\sigma$  for all ten can easily exceed 25 percent at sensitive

### 6 NFIP Constraints on Surge Hazard Estimates

FIS surge hazard estimates should be carefully reviewed prior to use for other than NFIP purposes. Important programmatic constraints on these estimates include:

- The emphasis on the 100-yr hazard, which means the other hazard level estimates have a much lower priority. Estimates of more extreme local surge hazard developed in the course of an FIS—such as the 500-yr surge—should be regarded as “Nominal.”
- Tolerance for modest regional error. As noted in Section B.iii HPC/High-Resolution surge models are not currently calibrated. Interestingly, a margin for uncertainty is not used in the delineation of 100-yr flood hazards zones. The NFIP multi-billion dollar national fund has always been heavily subsidized.
- Tolerance for larger localized errors. The FIS SOP focus on regional error, as well as budget and schedule constraints, mean that localized error reduction is often sacrificed. (A common localized source of error is characterization of topo/bathy/drag for key features.) Budget constraints also mean that local surge hazard estimates can become significantly outdated between re-studies.

Local leaders are highly sensitive to the impact of flood zones on community economic stability and growth, and thus monitor FISs closely for overestimation errors. On the other hand, local officials are typically less concerned with underestimation errors. Underestimation tends to be a concern only if there is a focus on local residual risk.

Local surge risk managers planning for potential catastrophic surge impacts—concerns well beyond those of the NFIP—must address extreme risks to a specific community, population, and critical economic and cultural resources. Such objectives demand higher quality estimates of 100-yr, 500-yr, and greater hazards. These objectives also demand a higher quality assessment of uncertainties. Moreover to ensure an adequate FOS in design, local projects for reducing risk beyond the NFIP require *reasonably conservative* estimates of the uncertainties.

locations ( $\sigma$  values are added in quadrature). Importantly, these issues are treated differently under SOPs for NFIP FISs versus local residual risk management—given different priorities.

The first four issues, 1 through 4, are addressed in the JPM epsilon term discussed in Section B.iv. Two of the four—surge model hindcast and tides—are prone to local variations, which are typically ignored in a regional FIS but would be important for local residual risk reduction. Interestingly, the FIS for Southeast Louisiana actually documented a notable hindcast under-prediction error along the New Orleans Lakefront.

Issues 5 through 8 tend to be highly localized, with local values of  $\sigma$  for Nos. 5, 6, and 7 currently requiring professional judgment. The  $\sigma$  values for these issues have not been a subject of the FIS SOP but would be important to local residual risk reduction. Issues 5, 6 and 7 could be important sources of underestimation of Surge-Response for large, shallow, inland lakes and bays.

Uncertainty associated with Issue 9—hurricane sampling—is employed in FIS formal evaluation of surge hazard uncertainty and CI. For the Southeast Louisiana FIS, the hurricane sampling  $\sigma$  was estimated using an EVF fit to JPM surge hazard curves, (see Section B.iv)—yielding a value of about 10 percent (8 percent for the East-Bank). However, a reasonably conservative estimate for local residual risk management would be twice that value based on: a) the hurricane sampling uncertainty associated with the Grand Isle tide gauge record (Figure 5); and b) reconsidering the record length represented by the storms employed in estimating the joint probabilities. (The FIS considered the 65-yr storm record to be equivalent to a nearly 400-yr record since storms defining joint probabilities were drawn from a coastal region 6.1 times bigger than Southeast Louisiana.)

The pre-Isaac Southeast Louisiana FIS hurricane sampling also underplays the contribution of slow-moving less powerful storms to the overall frequency of hurricanes capable of producing a 100-yr surge. This is a potential source of underestimation bias in the FIS analysis.

Finally, Issue 10 considers whether the period of observed hurricanes is representative of the current hurricane climate. The Southeast Louisiana FIS incorporated an adjustment to hurricane joint probabilities based on an initial effort to account for cycles of Gulf of Mexico hurricane activity in the observed 65-yr record. Uncertainties associated with this adjustment are not addressed in FIS surge hazards but would be appropriate for local projects.

Factor	Potential Surge $\sigma$	Evaluation of $\sigma$	FIS SOPs	Localized Variation?	Local Residual Risk Reduction SOP
1. General accuracy and precision of HPC/High-Resolution surge model	>15%	Residual error from hindcast validation.	Region-wide uniform $\sigma$ included in epsilon.	Yes	Evaluate hindcast bias and precision at a sub-regional scale and adjust epsilon or include in CI
2. Timing of tides	<0.3 ft	Tidal analysis.		Yes	Adjust for local tide range.
3. Wind-field shape (Holland B)	>10%	Holland B surge-response analysis indicates direct effect on surge		No	Same as NFIP.
4. Additional wind-field characteristics (e.g., banding)	>5%	Residual error between surge modeling with high resolution wind fields versus the simpler wind-fields.		No	
5. Pre-storm setup and rainfall accumulations in interior lakes and bays	>10%	Requires professional judgment.	Not currently addressed.	Yes	Include a reasonably conservative factor in CI
6. Empirical representations of hydrodynamic and wind-water drags at sensitive locations	>10%	Requires professional judgment.		Yes	
7. OS representativeness of Surge-Response at sensitive locations	>10%	Requires professional judgment.		Yes	
8. Surge-Response function—depends on interpolation method	>5%	Residual error between function and actual OS results.		Yes	
9. Hurricane sampling	>8%	Use regional hurricane history to develop joint probabilities. Fit EVF to the surge hazard curve.	Region-wide uniform $\sigma$ included in surge CI	No	Depending on exposure, include slow-moving low intensity storms in the joint probabilities. Use a reasonably conservative approach to the selection of EVF type and assigned sample length; adjust using analysis of local tide gauge record.
10. Representativeness of historical hurricane record	>10%	Requires professional judgment.	Not currently addressed.	No	Adjust future surge hazard for trends; include a reasonably conservative factor in CI for climate cycle and trend uncertainty.

Table 3. Ten Issues Affecting Current Southeast Louisiana Surge Hazard Analysis

Besides these ten issues for the current surge hazard estimate, there are potential long-term trends—e.g., increasing hurricane frequency and/or intensity, RSLR, coastal land loss, etc.—which could cause future surge hazards to be underestimated. These non-stationary issues are not included in FIS estimates of current surge hazard.

Based on the FIS overall uncertainty  $\sigma$  of 8 percent—which only addresses Issue 9 (and not conservatively)—the corrected FIS 100-yr surge estimate of 9.6 ft NAVD88 for the New Orleans Lakefront has a 90% upper confidence limit (UCL) at 10.9 ft, or 1.3 ft higher. (The 90%UCL for the uncorrected 100-yr surge is 9.9 ft.) However, a more reasonably conservative  $\sigma$  for residual risk management purposes addressing all ten issues would be at least three times that, giving a 90%UCL at 13.5 ft, or 3.9 ft higher—see Figure 6. As noted previously, the post-Katrina spread between FIS 100- and 500-yr surge estimates for the New Orleans Lakefront was 2.6 ft. **Thus, a reasonably conservative 90%UCL for the 100-yr surge is actually much higher than the base estimate for the 500-yr surge—an essential point for local surge residual risk management!**

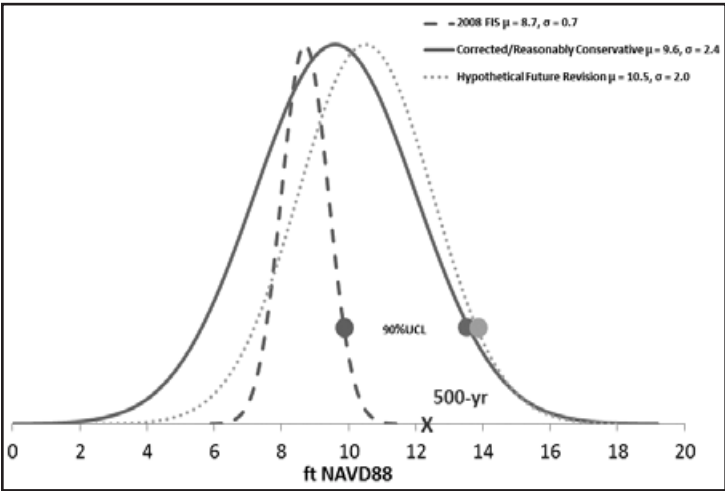


Figure 6. New Orleans Lakefront 100-yr Surge Uncertainty Distribution

A reasonably conservative consideration of all uncertainties indicates that FIS surge hazard values could really be regarded as “Scientific Guesstimates.” The FIS could easily overestimate true return periods by a factor of two. Nominal 500-yr surge estimates are subject to even greater uncertainty than the 100-yr estimates. Thus, Hurricane Katrina’s surge along the MRGO could be regarded as closer to a 200-yr event than the 400-yr event indicated by the FIS analysis.

In addition to uncertainties about local surge magnitude, there is an important issue regarding independent exposures to extreme surges at the polder and regional scale. Locations with independent exposures have separate hazard events. A polder or region with multiple independent surge hazard exposures is subject to a multiple of the surge hazard. Table 4 presents the equivalent polder and regional return periods for a range of local surge hazards—for the case of two and five independent exposures, respectively. Note that in this case the average return period for a 100-yr surge becomes 50 years for a polder and 20 years for a region. In this case, over a longer timeframe of 10 years, a 100-yr event has a 40 percent regional probability of occurrence. Table 4 also includes the equivalent regional return periods if the local surge hazard is increased by a factor of two. Thus, in this case what might be considered to be a local Nominal 500-yr surge event could have a regional return period of 50-yr, which over a 10-yr timeframe has an 18 percent regional probability of occurrence. To date, the actual multiples for polder and regional 100- and 500-yr events in the New Orleans area have not been defined.

**All of the above limitations point toward a crucial and ironic fact: after three centuries and the loss of thousands of lives and multiple devastations, the New Orleans surge hazard is still subject to being significantly underappreciated!**

Those with the responsibility for managing local surge risks beyond the NFIP increasingly recognize that surge hazards must be regularly reanalyzed with appropriate rigor. However, improvement of surge hazard estimates requires major investments in scientific research, data collection, HPC, and administrative functions. In the meantime, for residual risk management purposes, FIS estimates of 100- and 500-yr surge can be corrected for FORTRAN errors and likely local bias issues (see Bob Jacobsen PE 2015). Importantly, as depicted in Figure 6, in the near future revising surge hazard estimates will not appreciably reduce reasonably conservative uncertainty, and may have little effect on the 100-yr 90%UCL<sup>7</sup>.

Local Hazard	Polder Hazard (Example of Two Independent Exposures)	Regional Hazard (Example of Five Independent Exposures)	Future Regional Hazard (Local Hazard X 2)
100	50	20	10
500	250	100	50
1,000	500	200	100

Table 4. Equivalent Return Periods (years)

E. POST-KATRINA SURGE RISK MANAGEMENT

Following the extensive damage caused by Hurricane Katrina, Congress provided 70 percent funding for an accelerated repair and completion of the New Orleans regional surge system. This new authorization directed the USACE to address the NFIP 100-yr hazard—as re-establishing protection to NFIP-level requirements was immediately needed to revitalize City property values and the economy. Furthermore, the NFIP objective would be quicker, easier, and cheaper to finish than protection to a more extreme level. The USACE emphasized this pivot with an explicit re-designation of the project as a “Hurricane and Storm Damage Risk Reduction System” (HSDRRS), eliminating reference to a “Protection System.” **Importantly, the HSDRRS authorization—for the first time ever—provided that surge levees for New Orleans would be designed for a level below the Record Surge!** The post-Katrina design along the New Orleans Lakefront for a 100-yr surge (uncorrected) is for a surge elevation 2.3 ft less than the previous SPH-surge protection objective, and 3.1 ft below Katrina’s surge.

The NFIP requires that levee elevations be at least 2 ft higher than the 100-yr surge, and higher if necessary to prevent wave overtopping and erosion. The NFIP elevation for wave overtopping can be set straightforwardly (above the 0.1 percent wave run-up). The USACE used an alternative approach, setting elevation based on a statistical treatment of 100-yr overtopping uncertainty<sup>8</sup>. The USACE adopted the latter **Elevation FOS** approach and set HSDRRS crown

**7 Future Reduction of Surge Hazard Uncertainties**

Uncertainties can be considered “aleatory” (reflecting inherent and irreducible randomness in the natural phenomena) or “epistemic” (depending on the state of our knowledge and potentially reducible in the future with further improvements to observations, analysis, and modeling). Aleatory uncertainties—such as Issues 2, 3, and 5—are appropriate for inclusion in the epsilon term and incorporation into the base hazard estimate (again No. 5 is currently ignored in the FIS). Uncertainties with the other seven issues (Nos. 1, 4, 6, 7, 8, 9 and 10) are largely epistemic and can be either included in the epsilon term or used to construct CIs (again Nos. 6, 7, and 8 are currently ignored in the FIS). Importantly, upper limits of CIs (UCL) are lower if  $\sigma$  are included in epsilon. Issues 5, 6, 7, and 10 are currently subject to professional judgment. Research over the next ten years and continued improvements in HPC/High-Resolution and JPMs may be able to reduce Nos. 1, 4, 5, 6, 7 and 8. However, many more decades of hurricane observations will be necessary to reduce uncertainties in Issues 9 and 10.

**8 Monte Carlo Analysis of HSDRRS Overtopping Uncertainty**

HSDRRS overtopping was evaluated with empirical equations—such as the standard weir equation for free overflow and the Van der Meer equation for levee wave overtopping. These equations give overtopping rates ( $q$ , cubic feet per second per linear foot, cfs/ft) as a function of freeboard (crown minus the 100-yr surge), wave height and period, embankment geometry, and an empirical loss coefficient. To assess uncertainty in  $q$ , a standard Monte Carlo technique was employed. The equation is solved tens of thousands of times, with each solution using randomly drawn values for key inputs reflecting their own uncertainties. The set of results thus provides an uncertainty distribution for  $q$ . The variation for the 100-yr surge, wave height and period, and the loss coefficient were determined by respective uncertainty distributions. For surge uncertainty, the USACE used the sampling uncertainty discussed above.

elevations so that the estimate of 100-yr overtopping at a 90 percent non-exceedance level (q90, equivalent to an 80%UCL) would not exceed a limit of 0.1 cfs/ft (USACE 2011). (They also set a q50 limit of 0.01 cfs/ft.)

Table 5 includes the previous SPH High-Level and 100-yr HSDRRS hydraulic design elevations for the two locations. The HSDRRS design elevation increased by 0.5 ft for the NO Lakefront and by 9.6 ft for along the MRGO location (with the IHNC Barrier). (Final crown elevation may be slightly higher than hydraulic design depending on geometry, overbuild, and other construction considerations.)

In the engineering and construction of the HSDRRS the USACE implemented several major geotechnical improvements over the previous SPH project, including use of the batter pile-supported “T-” and “L-” designs for floodwalls; more rigorous levee material and construction requirements; and the adoption of more accurate GPS-based vertical control methods. In the East-Bank post-Katrina rebuild, batter-pile supported walls were employed along more than 20 percent of the 111 mile system, including a new 1.8-mile barrier across the Funnel (Silbert 2010). The basic HSDRRS construction was essentially completed in 2013—at a cost approaching \$14 billion—and received NFIP accreditation in February 2014.

To address surge risks beyond the NFIP 100-yr level, the USACE (working for IPET, see Note 5) undertook an initial attempt at quantifying the residual polder inundation hazard. The work employed HPC modeling of an FIS storm subset in an innovative JPM-OS. The polder inundation hazard addressed additional probabilities related to interior flood levels, such as overtopping, breaching, rainfall, interior routing, and drainage pumping. Figure 7 shows the Nominal 500-yr surge inundation hazard.

Pre-Katrina	NO Lakefront		MRGO (Bayou Dupre)			
			Without IHNC Barrier		With IHNC Barrier	
SPH High-Level Design	16.0 ft MSL	4.5 ft above SPH; 15.0 ft above LML	17.5 ft MSL	4.5 ft above SPH; 16.6 ft Above LML		
Post-Katrina						
HSDRRS Design (w/o RSLR)	16.0 ft NAVD88	6.4 ft above 100-yr; 15.5 ft above LML			26.5 ft NAVD88	8.9 ft above 100-yr; 26.2 ft above LML
Corrected 100-yr q90	0.66 cfs/ft				1.05 cfs/ft	
Corrected 500-yr q90	10.69 cfs/ft				31.41 cfs/ft	

Table 5. Comparison of Pre- and Post-Katrina Levee Design

In the same year, 2009, the USACE completed the LaCPR Report (see Note 5) authorized by Congress to evaluate options for further federal action in reducing residual risks beyond the NFIP HSDRRS, including but not limited to higher levees. The LaCPR study employed the results of the FIS hazard analysis, as well as additional HPC/High-Resolution surge modeling for various alternatives. As a result of the LaCPR Study—together with other state and local efforts (including their own HPC/High-Resolution surge modeling)—ten residual risk reduction components have seen post-Katrina developments:

1. Evacuation. Given the clearly acknowledged surge hazard limits for the HSDRRS, federal, state, and local hurricane response agencies have continued to refine plans for mandatory evacuation—adjusting the ContraFlow Plan, modifying evacuee sheltering arrangements, and addressing individuals with



Figure 7. Nominal\* 500-yr Surge Inundation, Times-Picayune 2012 (from IPET 2009)



health, financial, and logistical hardships. Advances in hurricane forecasting—including surge—have improved confidence in mandatory evacuation notices. An August 2008 mandatory evacuation of the City during Hurricane Gustav highlighted ongoing progress in the City's evacuation, as well as the need for more; (see Wolshon 2006 and Campanella et al 2012).

2. Flood insurance. Given the limited pre-Katrina participation in the NFIP and coverages, local Congressional representatives have worked to a) expand the USACE SELA program to further reduce interior 100-yr flood hazard zones, thereby reducing premiums for more polder properties; and b) ensure the NFIP premiums for 100-yr hazard zones remain affordable.
3. HSDRRS floodwall and levee resiliency. In response to the Katrina failures, Congress authorized and funded the USACE to provide HSDRRS resiliency against catastrophic breaching during greater than 100-yr surge events. Overtopping during a 500-yr storm is likely to produce thousands of acre-ft of interior flooding—a significant but not catastrophic volume (less than a 100-yr/24-hr rainfall). On the other hand, breaching can produce many times the volume of overtopping, and over a shorter time (see Bob Jacobsen PE 2015). To provide resiliency against collapse breaching the USACE design called for all features to withstand the Nominal 500-yr surge. For floodwalls, resiliency against overtopping induced erosion breaching is provided by concrete splash pads, as well as overbuilt height for RSLR through 2057. Levee overtopping resiliency is being addressed through armoring protective against 500-yr overflow (USACE 2011). The USACE evaluated 500-yr overtopping uncertainty and employed the 500-yr q90 as an **Armoring FOS**. In addition the USACE has conducted large-scale physical experiments on wave-induced turf erosion and pilot projects to evaluate the installation and maintenance of high performance turf reinforcement mat (HPTRM).
4. HSDRRS upgrade. The USACE's 2009 LaCPR Report investigated options for HSDRRS upgrade to more extreme hazard levels—including a 1,000-yr level. The LaCPR Study suggested that even upgrading the HSDRRS to meet Katrina's record surge was not cost-effective given other options. However, the Louisiana Coastal Protection and Restoration Authority's (CPRA) 2013 Master Plan and the Louisiana Section of the American Society of Civil Engineers (in their 2012 Report Card) have recommended a higher levee system for New Orleans. As of today, no detailed investigation of HSDRRS upgrade has been initiated.
5. The Lake Pontchartrain Barrier Plan. The USACE LaCPR Study and the SLFPA-E (see Ben C. Gerwick 2012) revisited the original Barrier Plan (see Part I). Both investigations showed that a low barrier can reduce Lake "filling" from surge forerunners associated with some storms. However, such a barrier only modestly reduces overall hazard, due to the fact that it does not prevent Lake "tilting." Any Barrier Plan would also have some impact on surrounding surge hazard outside the Lake. The CPRA has initiated further investigation of potential ways to optimize a low barrier.
6. Removal of Mississippi River levees. The LaCPR Study investigated the effect of taking down some levees in Plaquemines Parish. This investigation showed some reduction of East-Bank surge hazard, in addition to potentially facilitating restoration of wetlands in the lower delta. At this time no further investigation of removing downriver levees has been initiated.
7. Coastal protection and restoration projects. The USACE LaCPR Study, the Louisiana CPRA Master Plan, as well as local agencies, have identified numerous basin and sub-basin scale projects to refurbish and enhance barrier islands, ridges and cheniers, and wetlands, as well as close additional man-made canals. Many of these projects have been promoted as a means to reduce surge; (see Smith et al 2010). One cost-effective measure to complement the HSDRRS would likely be the restoration and maintenance of a band of resilient coastal forests fronting the system to reduce wave heights (see Bob Jacobsen PE 2015). However, this measure would require modifying HSDRRS design criteria to allow consideration of vegetation impacts on waves.

8. Polder interior compartmentalization. The Bob Jacobsen PE 2015 report examined numerous options and recommended three for further engineering evaluation: i) improvements to the East Jefferson/St. Charles parish line barrier, ii) upgrade of remaining IHNC Basin I-walls; and iii) use of the Central Wetlands to reduce surge levels in the IHNC Basin. Further engineering evaluation of these projects is required to confirm feasibility, followed by securing funding for final design and construction.
9. Interior drainage. Interior drainage reduces risks associated with overtopping volumes; (see Bob Jacobsen PE 2015). 10,000 cfs of pumping capacity is equivalent to removing 20,000 acre-ft/day of inundation. Following Katrina, the USACE continued to implement drainage improvements under SELA. However, no improvements addressing surge risk reduction have been studied.
10. Flood-proofing. The various post-Katrina studies and plans have recommended further development of "Non-Structural Alternatives" for surge risk reduction. These include more stringent ordinances, building codes, and public investment to implement greater a) elevation of residential, commercial, and public buildings (i.e., even more than required by the NFIP); b) flood-proofing of critical electric, gas, communication, water, and sewage utilities and transportation components; and c) flood-proofing of key community, historic, and cultural assets. (Recall from Part I that flood-proofing is one of the earliest and most basic ways to manage flood risk.)

## F. LIMITATIONS OF POST-KATRINA SURGE RISK MANAGEMENT

Post-Katrina surge risk management for New Orleans has many serious limitations. Foremost, as over its entire history, surge risk management is subject to the potential errors and uncertainties of the surge hazard estimate. *Thus, the issues with the FIS surge hazard estimates discussed in Section D mean that surge risks to life and property are likely to be underestimated.*

Ten additional technical issues for the HSDRRS are:

1. Elevation FOS. The USACE developed the 100-yr q90 estimates to support NFIP accreditation and therefore used an NFIP approach to overtopping uncertainty. A reasonably conservative approach to overtopping uncertainty—with reasonably conservative treatment of surge, wave, and other conditions—would substantially increase estimates of 100-yr q90. Recomputed 100-yr q90s for the New Orleans Lakefront and MRGO levees are 7 and 11 times specified erosion limit of 0.1 cfs/ft. Thus, when considered from a local residual risk management and not simply an NFIP perspective, the HSDRRS 100-yr design has a minimal Elevation FOS. Recomputed q50 and q90 significantly affect levee reaches inland from open lakefronts—such as along the East-Bank levees in St. Charles Parish with 100-yr q90s re-estimated above 5 cfs/ft. Correction of surge hazard uncertainty reveals that these reaches have negative freeboard at the q90. (Recomputed q90s use the levee hydraulic design elevation. They reflect correction of FORTRAN errors noted earlier; modification of inland wave heights; and changes to the Monte Carlo overtopping analysis. These changes also affect computation of the median overtopping, q50, which has a limit of 0.01 cfs/ft; see Bob Jacobsen PE 2015.)
2. Armoring FOS. The 500-yr q90s (and q50s) are affected by the same issues as the 100-yr overtopping estimates. Recomputed 500-yr q90s at New Orleans Lakefront and MRGO are 10.7 and 31.4 cfs (and over 60 cfs in St. Charles Parish). These revised estimates mean that the degree of risk reduction provided by selected armoring measures is likely to be significantly less than anticipated. More rigorous armoring—i.e., stone or paving instead of HPTRM—could be appropriate to provide a greater 500-yr resiliency.
3. Supplemental levee lifts. Supplemental levee lifts will be required along most HSDRRS levee segments over the upcoming years to a) continue meeting the 2007 design elevation, given post-construction consolidation and settlement—especially high for inland levee reaches built across former swamps; and b) compensate for RSLR in accordance with the USACE's 2057

design elevation. These levee lifts are not currently federally funded. Thus, vulnerable reaches could be exposed to even greater 100- and 500-yr overtopping if levee crowns fall below their design elevation.

4. Armoring implementation. Installing armoring soon will result in future expensive removal during future lifting and reinstallation. Deferring armoring exposes the system to breach risks but might be practical if the deferral is only for a short time. The issue becomes more complex as the time horizon is extended to account for more consolidation, settlement, RSLR, and even revised 100-yr surge estimates.
5. Impact of coastal erosion and vegetation changes on future surge. The USACE assessment of RSLR on 2057 design elevations did not include further increases in surge height due to coastal erosion and vegetation change.
6. Vertical control methodologies. Remaining issues with the GEOID model and ellipsoid height measurements can still introduce errors on the order of several tenths of a foot.
7. Subsurface weaknesses. Legacy pipelines, localized voids, transmissive soils, and slip planes could still present opportunities for collapse breaching—especially for a few remaining I-wall segments. More research is needed on techniques for investigation of these geotechnical weaknesses, as well as how to characterize collapse breach probabilities.
8. Structural design weaknesses. There are concerns for future T-Wall pile corrosion and batter pile down-dragging (due to subsurface settlement/subsidence) which could affect long-term performance, as well as for system flood-side armoring (see Turner 2011).
9. Operation of 11 major channel gates and 4 additional perimeter pump stations entail significant complexities and long-term costs.
10. Maintenance. Similarly, there are large long-term challenges and costs associated with maintaining extensive reaches of levees, floodwalls, armoring, breakwaters, gates, pump stations, etc.

Beyond technical issues with the HSDRRS, as well as other risk reduction measures such as coastal projects<sup>9</sup>, effectively meeting future surge risk management challenges—as over the City’s entire history—continues to involve a competition over limited resources and political will. For example:

- Evacuation contingencies for those with health, logistical, or financial problems remain underfunded.
- The voters of St. Bernard Parish have twice declined to pass a tax to increase funding for operations and maintenance (O&M) of their respective portion of the HSDRRS.
- Coastal restoration plans must consider those whose ways of life are tied to the existing coastal landscape and ensure that short- and long-term impacts are reasonable and justifiable given uncertainties about the long-term success of restoration projects.
- Staunch private property interests oppose the establishment of incentives (much less mandates) to expand flood insurance participation and private coverage, as well as the imposition of greater flood-proofing requirements.

#### 9 Technical Challenges for Coastal Projects to Reduce Surge Risk

Surge-Response physics indicate that coastal landscape features have a smaller impact on extreme surge hazards. However, the evaluation of coastal protection and restoration with HPC/High-Resolution modeling to gauge the degree of inland surge reduction (and with JPMs for extreme hazards) is still in its infancy and needs further scientific research. For example, the evaluation of the wave-reduction effects of coastal forests has yet to be fully assessed. Proposals for large-scale refurbishment of wetland platforms and ridges using the transfer of sediment from the Mississippi River to regional sub-basins will require a skillful combination of diversions, dredging, and sediment pipelines to maximize benefits and minimize costs and adverse water quality impacts. It is unlikely these projects can be maximized for both ecosystem productivity and extreme surge reduction.

Challenges over how to best coordinate surge risk management components have been just as daunting, given continuing fragmentation of responsibilities among a plethora of federal, state, and local entities. Fragmentation of responsibility and the absence of “system accountability” were repeatedly acknowledged as major contributors to the Katrina disaster (ILIT 2006, Team Louisiana 2006, IPET 2006, ASCE 2007, Boyd et al 2014). Ironically, the current situation is in some ways worse than before Katrina. Four examples include:

1. Design decisions involving the tradeoff of construction costs/schedule versus long-term O&M costs/headaches. The USACE is responsible for design/construction with a 70 percent cost share; the state CPRA is responsible for a 30 percent match and review; while the local levee authorities (SLFPA-E, as well as the West authority, SLFPA-W, and the Pontchartrain Levee District, PLD) are responsible for 100 percent of O&M. Eliminating this division could have changed key design decisions related to subsurface and structural weaknesses, as well as “right-sizing” of the system (rebuilding instead on 40 Arpent and Maxent Levees, and upgrading IHNC and outfall canal floodwalls instead of installing barriers and perimeter pump stations).
2. Rational risk reduction. The USACE has been reluctant to raise HSDRRS elevation, resiliency, and Elevation and Armoring FOSs beyond narrowly construed Congressional authorizations (as with the SPH design before that). These interpretations do not allow for cost-effective management of residual risk, which is largely the responsibility of the CPRA and local authorities.
3. Formal NFIP HSDRRS re-evaluation and re-accreditation (for 2023). The CPRA and local levee authorities—together with FEMA and the USACE—will have to determine if a re-analysis of the surge hazard is required, as well as if treatment of surge uncertainty needs to be revisited. Some local authorities concerned with residual risk have shown understandable interest in a more rigorous restudy. Complicating a restudy is the fact that the CPRA and the local HSDRRS managers are not the local NFIP agencies, some of which may be opposed to initiating a revision of NFIP FIS.
4. Coastal protection and restoration priorities. In 2013 SLFPA-E sued oil and gas operators responsible for decades-old dredging of coastal canals to obtain compensation and restitution for impacts on East-Bank HSDRRS surge levels. (The impact of these canals on the East-Bank HSDRRS will require a sophisticated analysis of local surge-response.) Opponents of the lawsuit argue (in part) that a) a local authority should not undertake such litigation unilaterally, given the authority/responsibility of CPRA; b) litigation as it is being pursued is not the proper way to facilitate an optimal coastal result; and c) the litigation is discouraging the defendants from engaging in cooperative solutions to coastal restoration and protection.

## G. IMPLICATIONS FOR SUSTAINABLE SURGE RISK MANAGEMENT

The Simple Lesson is that all flood tragedies—and Katrina was not an exception—are due to a) the underestimation of the hazard and b) the failure to prioritize appropriate risk management measures, with the former heavily influencing the latter. The Supercomputing Era has produced—and will continue to produce—remarkable high-resolution surge forecasts, hindcasts, and hazard analysis. However, dramatic risk reductions—for loss of life and economic devastation—are only attainable if we pay very close attention to a) and b)!

### Six Lessons for Surge Hazard Analysis

1. Be familiar with the nature of surge probabilistic estimates. Demand the highest quality estimates of surge hazards when addressing catastrophic risks—i.e., beyond the NFIP. Advances in hurricane climatology, HPC/High-Resolution surge modeling, and JPA are continuing to improve the quantification of the surge hazard curve, including for polder interiors.

2. But appreciate the limitations of surge hazard estimates, especially those developed for NFIP purposes. A new analysis—aimed at being more rigorous than required for the NFIP and taking into account recent advances in surge science—could reduce return periods significantly.

***NFIP levees are to surge what fire departments are to fires—they are complements to effective evacuation preparedness and property insurance.***

3. Understand how uncertainty is treated for the NFIP versus for local residual risk reduction, as well as reasonably conservative treatment of uncertainties. Surge hazards should really be regarded as “Scientific Guesstimates.” In particular, regard 500-yr surge estimates as NOMINAL. A reasonably conservative 90%UCL for the 100-yr surge can exceed the Nominal 500-yr surge and provide a better basis for an Elevation FOS.

4. Furthermore, understand the nature of multiple independent polder and regional exposures.

5. Institutionalize periodic updating of the surge hazard analysis—including for the polder interiors. Moreover, support critical research to improve hurricane climatology, HPC/High-Resolution modeling, JPA, overtopping analysis, breach probability estimation, etc. However, recognize the large uncertainties that are likely to remain for decades to come. Also appreciate different needs within a region: residual risk management should sponsor frequent, high quality re-analyses that closely re-examine extreme hazards, while the NFIP may accept a long lapse before revising the FIS.

6. Study additional extreme hurricane surge scenarios—such as MOMs for maximum probable storms—to fully appreciate the “worst case” hazard.

#### **Ten Lessons for Surge Risk Management**

1. Demand the highest quality quantitative risk assessments to estimate consequences at each hazard level. Educate the whole community on the nature of risk.

2. Understand all flood risks and examine surge risk reduction measures in context with other rainfall and river flood hazards.

3. Set the highest consensus surge risk management priorities in stone. Make them a permanent, marquee community commitment that all future leaders must uphold. Don’t consider a risk management component a consensus priority if there are significant opposing interests that will work to undermine continuing political and financial support.

4. ***Eliminating loss of life is the top priority.*** Ensure readiness of evacuation plans to address the limits of NFIP surge protection systems and their FOSs (see below). Treat uncertainties in protection system performance reasonably conservatively for loss of life risks (unlike in the NFIP). Ensure evacuation plans address those with health, logistical, or financial problems in self-evacuating.

5. Expanding flood insurance participation and coverage is the second priority. Consider incentives and even mandates. For a community as a whole, flood recovery will be quicker, broader, and more effective if more property damage is covered by insurance.

6. Evaluate additional residual risk reduction measures as a “system,” the various components need to function synergistically (see Boyd et al 2013). Beyond evacuation and flood insurance, there are eight potential measures:

- i. Minimal NFIP surge protection system (e.g., 100-yr with minimal FOSs);
- ii. Greater system FOSs to address overtopping and other uncertainties; more reasonably conservative treatment of uncertainties;

iii. System breaching resiliency, per specification for more extreme surge (e.g., 500-yr);

iv. Higher system, per specification for more extreme surge (e.g., 500-yr with appropriate FOSs);

v. Restoration and protection of large-scale coastal features;

vi. Interior compartmentalization (for polders);

vii. Enhanced interior drainage and pumping capacity (for polders); and

viii. Flood-proofing.

Select measures on the basis of cost-effectively reducing residual risks. Don’t oversell the benefits of a surge risk reduction option, especially to the detriment of Priorities 1 and 2.

7. Be mindful of apparent complementary interests, as they can become competing interests—as evidenced in the past by the SELA drainage program and Lakefront revenue generation. Recognize the need for coastal restoration but understand the limited role of coastal features in mitigating extreme surge. Coastal restoration projects are usually optimized for long-term coastal habitat and ecosystem productivity, not for surge reduction. While not mutually exclusive, these objectives are likely to involve major tradeoffs. Use of limited surge risk reduction funds on coastal restoration may not be prudent, and vice versa.

8. Ensure that professionals are allowed independence to choose their methodologies, provide authoritative findings and recommendations, and discuss limitations and uncertainties. Ensure that all professional determinations are well-documented and provide clear authorship by name—for example, on surge protection system FOSs. Let the range of technical differences be defined by recognized experts within the respective professional field.

9. Ensure transparency in surge risk reduction planning and implementation. Monitor progress in new projects and maintenance of existing projects; routinely publish clear, complete, and concise status reports. Surge risk reduction projects have a history of gradually succumbing to competing interests despite the obvious public good and potential high benefit-to-cost ratio. The media and public watch dogs must stay vigilant to ensure that surge risk management priorities are effectively sustained.

10. Recognize that surge risk management is never finished. Leaders must invest in continuous improvement in all areas. They must be prepared to address increases in hazard estimates, to periodically re-evaluate risk reduction measures for gaps and weaknesses, and to fix them.

#### **Ten Lessons for Hurricane Surge Protection Systems**

1. When surge protection systems are built to complement implementation of the NFIP, understand the programmatic goals and limitations of the NFIP, NFIP hazard analysis, NFIP surge uncertainty treatment, NFIP overtopping analysis and limited FOS, and NFIP accreditation. (See Lessons 8 and 9 above.) Ensure that the public understands that NFIP surge protection systems leave considerable residual risk to life and property.

2. Surge protection systems can have significant adverse impacts on areas outside the system—both communities and coastal landscapes.

3. Additional life-saving and economic drivers for urban centers can warrant systems that exceed NFIP requirements: higher hazard level design, higher FOSs to address uncertainties in the 100-yr condition, and/or resiliency against greater storms. Understand what this entails and determine who will pay for and maintain system enhancements. Resiliency can be a better investment than more height—but there are many factors to consider: residual overtopping and breaching risks, authorizations, costs, long-term performance of resiliency measures, O&M, etc.



4. Some communities with excellent evacuation programs and modest uninsured exposure may be satisfied with a minimal NFIP levee system (e.g., minimal FOS). If NFIP credit becomes available for levees below 100-yr hazard, these may be optimal for some communities.
5. Don't allow federal support for design/construction to excuse local buy-in. **Local communities must regard themselves as the ultimate owner of the system and its limitations!** Remember the adage that "no one washes a rental car."
6. Understand the responsibilities as well as the limits of the federal agent—particularly if it is the USACE. Understand the special USACE culture of narrowly construing Congressional authorizations and the impact this will have on any need for flexibility in the face of new information. Also understand the typical timetable and budgeting approaches of the USACE.
7. Establish one local agent to represent the community as the co-sponsor for all NFIP surge protection system design, construction, and O&M decisions. This entity should also be the local NFIP coordinator and in charge of residual property risk reduction measures. This will facilitate clear lines of authority, responsibility, and ultimate accountability.
8. Monitor for inevitable design issues which pit cheaper/faster construction alternatives versus those with lower long-term O&M costs and headaches.
9. Ensure appropriate local funding commitment. Don't pursue alternatives with O&M budgets that the local community cannot afford. Provide perimeter systems that are "right sized" and carefully weigh decisions to encompass low density areas (especially wetlands). Leveeing canals may be preferable to enclosing them behind massive gated structures and pump stations that impose complex and expensive O&M requirements.
10. Make sure that the local community understands all long-term needs and costs associated with keeping NFIP accreditation, such as for levee lifts.

#### **A Final Lesson: The Lake Okeechobee Herbert Hoover Dike**

Lake Okeechobee in south Florida, shown in Figure 8—at over 700 square miles in area—is the second largest freshwater lake lying entirely within the lower 48 states. Lake Okeechobee is extremely shallow, averaging about 9 ft in depth. In 1928 a strong Category 4 hurricane made landfall near West Palm Beach Florida with winds of 145 mph. Residents along the shores of Lake Okeechobee—40 miles plus inland—thought themselves safe from surge.

However, a combination of long fetch, strong winds, and very shallow depth caused a severe "tilting" of the water surface, without any "filling" from the ocean. Southward winds across Lake Okeechobee created a surge depth reportedly reaching 20 ft, overwhelming an existing dike on the south shore. After the eye passed and winds reversed direction, northward winds caused a surge on the north shore. The Lake Okeechobee surge caused over 2,500 deaths, making it the second deadliest hurricane in US history. The dike was subsequently reconstructed to provide greater protection from future wind-driven tilting of Lake Okeechobee. The Herbert Hoover Dike has been raised several times and is currently about 30 ft above the surrounding ground.

Figure 8 compares the size and depth of Lake Okeechobee in Florida with Lake Pontchartrain. The NFIP 100-yr surge depth (above mean level) for the south shore of Lake Okeechobee is about 1 ft greater than for the south shore of Lake Pontchartrain. However, the crest freeboard for the Herbert Hoover Dike above the 100-yr surge is much greater than for the HSDRRS—by almost 10 ft. The catastrophic 1928 Lake Okeechobee Hurricane produced a surge reportedly 10 ft greater than the current NFIP 100-yr surge. On the other hand, Hurricane Katrina produced a surge about 3 ft above the 100-yr surge (uncorrected) at the New Orleans Lakefront. It is apparent that the Herbert Hoover Dike was not designed simply for NFIP accreditation.

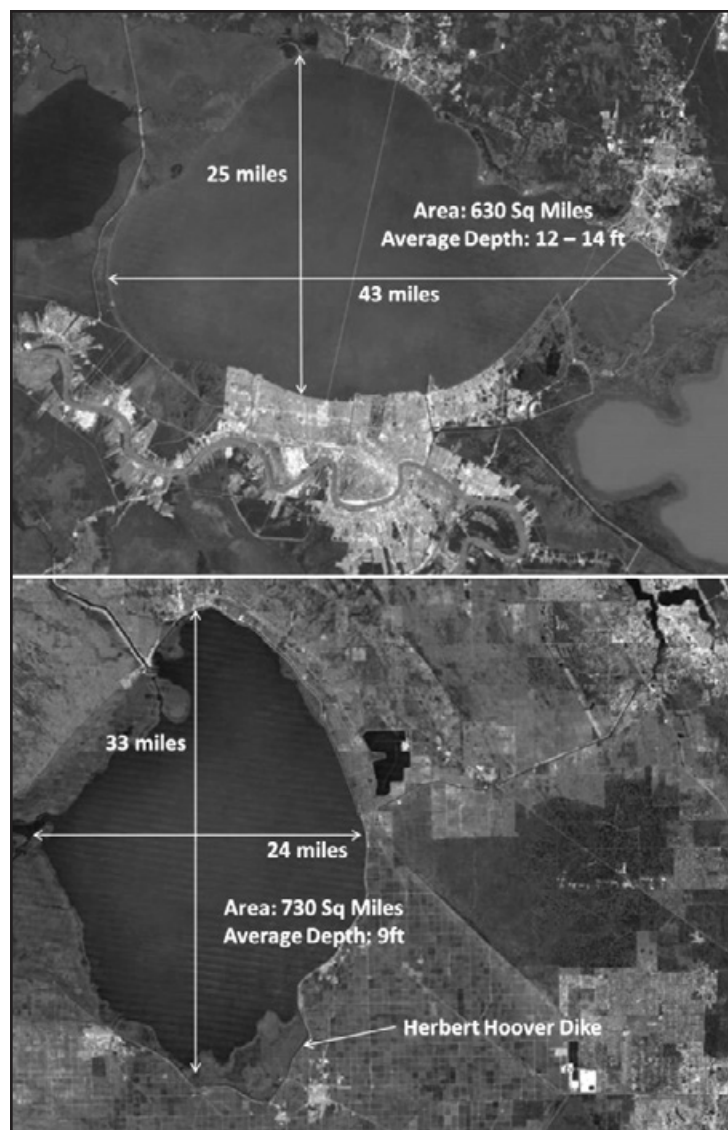


Figure 8. Comparison of Lakes Pontchartrain and Okeechobee (Florida), Google Earth Imagery (same scale)

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**This article is dedicated to the 1,400 Louisianans who lost their lives during Hurricane Katrina ten years ago.**

*Some of the information presented in this article resulted from recent work sponsored by the Southeast Louisiana Flood Protection Authority-East and the Louisiana Coastal Protection and Restoration Authority. However, this article does not represent the opinion of either agency, or of the Louisiana Section of the American Society of Civil Engineers.*

**Bob Jacobsen, PE** grew up in Metairie and earned undergraduate and graduate degrees at LSU, including an MS in Civil (Environmental) Engineering. His 35-year career has focused on state-of-the-art environmental and water resource planning studies and conceptual designs for South Louisiana. Since 2001 he has been at the forefront of applying HPC/high-resolution hydrodynamic modeling for coastal restoration and hurricane storm surge protection. Bob served as the 2013-14 President of the American Society of Civil Engineers Louisiana Section.

# ASCE Members Elect Norma Jean Mattei, PhD, PE, F.SEI, M.COPRI, M.ASCE, as the next President-Elect

Norma Jean Mattei, PhD, PE, F.SEI, M.COPRI, M.ASCE, of New Orleans, Louisiana will be ASCE's 2016 president-elect, to succeed to Society president in 2017, as decided by ASCE members in the Society's June-concluded officers election. Mattei is the third woman elected president in the Society's 163 years. A civil and environmental engineering professor at the University of New Orleans, Mattei has served ASCE for more than 20 years in local, regional, and national leadership positions.



*Norma Jean Mattei, PhD, PE,  
F.SEI, M.COPRI, M.ASCE*

## ASCE Region 5 Director's Letter

*By Melissa Wheeler, M. ASCE*

Dear Region 5 Members,

Your Board of Governors is excited about the future of our Region. We are having a Strategic Conversation to set the direction of the Region for the now and future. As part of this process, we have a new purpose statement.

The Purpose of Region 5 is Advancing the Profession by:

- Inspiring Members
- Creating Excitement
- Promoting Excellence in Civil Engineering

I'm encouraged by the support and participation of your Governors in this process. There is an air of excitement about the future of Region 5. One of our initiatives is to help groups that are struggling. If your Section/Branch/YMG/Institute/Student Chapter would be interested in meeting with the R5BoG, please let me know. We can discuss general concerns or focus our meeting on one topic like student transition. I like to think of these meetings as personalized information beyond the MRLC.

At the Society level, we are also participating in Strategic Planning. At the upcoming Board of Direction meeting on July 17-19, your officers will be analyzing our Strategic Initiatives and discussing how these align with The Vision for Civil Engineering in 2025. I look forward to sharing discussion and updates to this vision of the Society with you.

Are there exciting programs and events going on in your local Section, Branch, Student Chapter, YM Group, or Institute Chapter? I would like for everyone to know how much success and fun we have in Region 5! Please consider submitting an item for the

Region 5 News. This is the place for photos from tours, shout outs to award winners, news of successful programs and events, and all the great things happening around Region 5. It's easy to submit news items with this link:

<https://asceforms.wufoo.com/forms/x1ygbyn217de85a/>.



*Melissa Wheeler, M. ASCE*

Your Region 5 Board of Governors is always open to hearing about what's important to you. If you have something you want to share, please feel free to contact me at any time. I will be happy to address any issues or concerns at monthly BOG calls. Your Director and Governors are here to help you and make your group successful. Please let us know how we can help!

\*Remember, the R5BoG is made up of seven Governors who are willing and able to help:

Quincy Alexander (MS): Quincy.G.Alexander@erdc.dren.mil  
Eric Czerniejewski (FL): eczerniejewski@gmail.com  
Brett Goodman (FL): bgoodman@jonesedmunds.com  
Peter Moore (FL): pmoore@chenmoore.com  
Stu Moring (GA): smoring@aol.com  
Ali Mustapha (LS): alimm@bellsouth.net  
Tony Palmer (AL): tpmailbx@aol.com



## ASCE Region 5 Governor's Message

By Ali M. Mustapha, PE, F. ASCE

Congratulations to David T. (Tom) Iseley, PhD, PE, and George Z. Voyiadjis, PhD, D.Eng.Sc., F.EMI on their election Distinguished Members by the ASCE Board of Direction in May 2015. Dr. Iseley is a Professor of Civil engineering and Construction Engineering Technology, and the Director of the Trenchless Technology Center at Louisiana Tech University in Ruston. Dr. Voyiadjis is the Boyd Professor in the Department of Civil and Environmental Engineering at Louisiana State University in Baton Rouge, the highest professorial rank awarded by LSU. The contributions of both Professors to Civil Engineering and their outstanding leadership in the Engineering Profession qualified them for this honor. Dr. Iseley, Dr. Voyiadjis and Eleven (11) members of the Society will be inducted in the class of 2015 Distinguished members at the ASCE Annual Convention in New York City in October.

Distinguished Members are those ASCE members who have attained eminence in some branch of engineering or in the arts and sciences related thereto. As of 2015, only 661 Distinguished Members have been elected to this level of membership in the Society.



**Ali M. Mustapha, PE, F. ASCE**

Congratulations to both Professors for a well-deserved honor and thank you for your outstanding service and contributions to the Civil Engineering Profession.

Two (2) Governors were elected to the Region 5 Board in June, William L. Pratt from the Alabama Section and Steven Goldstein from the Florida Section. Also Barbara R. Lehman from the Alabama Section was selected by the Region 5 Board to the Governor at large position. The Board has finalized the development of a survey questionnaire and plans to email it to the Sections and Branches in the fall. The intent of the survey is to determine how the R5 Board can best serve and assist the Sections, Branches and Student Chapters leadership in the Region in promoting ASCE programs, developing priorities and implementing successful programs that will grow the membership.

Region 5 Director, Melissa Wheeler, has initiated monthly conference call meetings for the Region's Board to discuss how the Board can get more involved in assisting struggling Branches, Student Chapters and Younger Member Groups. If your Group needs any assistance and would like for the Director or me to visit and meet or conduct a forum, please don't hesitate to contact me. The Region's Board is here to assist and provide you the tools to succeed.

My mentor, Dr. Bobby Price's favorite phrase was "working together works". Let's join forces and work together to strengthen our profession, promote it and protect it. I am always available and committed to provide any needed assistance to insure our organization continues to grow and provide excellent and unique service to our membership.



**Louisiana**  
**CIVIL ENGINEERING**  
Conference & Show

### ***Call for Potential Speakers and Exhibitors!***

***We are proud to announce the dates for the 25th Annual Louisiana Civil Engineering Conference and Show. This event, a joint effort from the New Orleans Branches of ASCE and ACI, is the premiere gathering for the Civil Engineering community in the Greater New Orleans Area. We are in the process of soliciting sponsors and exhibitors and establishing the technical program for the fall conference which will be held on September 23-24, 2015, at the Pontchartrain Center in Kenner, Louisiana.***

**For additional information on the conference, please visit our web site at [www.LCECS.org](http://www.LCECS.org)**

## **SAVE THE DATE!**

### ***ASCE-LA Section Board Installation Luncheon***

**September 11, 2015 at 11:30 am  
Chateau Country Club in Kenner, LA**

# Voyiadjis Elected to the Grade of Distinguished Member

By Catherine Ort-Mabry

George Z. Voyiadjis, D.Eng.Sc., F.EMI, Dist.M.ASCE, F.SES, F.AAM, a pioneering researcher in multi-scale modeling of materials to address problems in instabilities and the high-energy impact and damage of structures, has been honored by ASCE for his contributions as an outstanding leader in the engineering profession by being named a Class of 2015 Distinguished Member.

Voyiadjis is the Boyd Professor in the Department of Civil and Environmental Engineering at Louisiana State University, the highest professorial rank awarded by the university. Voyiadjis' seminal contribution in damage mechanics has impacted many disciplines including aerospace, civil, and mechanical engineering.

His book, *Advances in Damage Mechanics: Metals and Metal Matrix Composites with an Introduction to Fabric Tensors*, is used by researchers and students worldwide. It includes Voyiadjis' achievement in the characterization of the damage and the microstructure for metal matrix composites, and his research endeavors provide a consistent framework for all future work in this area. He also is the chief editor of the *Handbook of Damage Mechanics: Nano and Macro Scale for Materials and Structures*.

He led a joint research effort on the analysis of the fuel tank rupture in the January 1986 Space Shuttle Challenger disaster. His

contribution in developing numerical models and simulations of structures considering damage evolution helped other researchers and industries achieve a better understanding of structures' behavior under severe static and dynamic loading.



**George Z. Voyiadjis, D.Eng.Sc., F.EMI,  
Dist.M.ASCE, F.SES, F.AAM**

Voyiadjis is a foreign member of the Polish Academy of Sciences and the recipient of the Kahn International Medal for outstanding life-long contributions to the field of plasticity. He was also awarded ASCE's Nathan M. Newmark Medal. In 2015, he was awarded the medal for distinguished work in the area of damage mechanics by ICDM-IJDM, International Journal of Damage Mechanics. Voyiadjis earned his bachelor's degree in civil engineering from Ain Shams University, Egypt, a master's in civil engineering from the California Institute of Technology, and doctor of engineering degree from Columbia University.

## In Memory of Robert L. "Robby" Cangelosi, Jr.

Robert L. "Robby" Cangelosi, Jr., PE, M.ASCE, 52, of Baton Rouge, died Friday, May 1, 2015, due to pancreatic cancer. He was born to Robert Lawrence Cangelosi and Frances Pecora Cangelosi, October 15, 1962, in Baton Rouge. Robby was reared and schooled in Baton Rouge, attending St. Aloysius School, Catholic High School (1980 graduate), and LSU (1985 graduate, Bachelor's degree in Civil Engineering; 1987 graduate, Master's degree in Engineering Management). Upon earning his Master's Degree in 1987, Robby moved to Maryland to work as an engineer. He returned home to Baton Rouge in 1997 with advanced engineering experience and flourished in the engineering industry. He was married to his surviving widow, Toni Latuso Cangelosi. He is survived by four sons, Michael Anthony "Mac" Cangelosi, Chase Robert Cangelosi, Nicholas Quinn Latuso, and Brandon Lane Schrimsher. He was the Principal in Charge and Office Manager of the Baton Rouge office of T. Baker Smith professional services firm. Robby was a member of the ASCE Baton Rouge Branch; he became a student member in

1983 and a full member in 1991. He was a deeply religious man, a parishioner of Our Lady of Mercy Catholic Church. He was a very active member of our community. Robby was an eternal optimist, always smiling and joking, having a positive effect on others. He loved his family, was insuppressibly loyal to all of his friends, and thrived on helping others. His faith was the bedrock of his optimism, which never wavered during his cancer treatment.



**Robert L. "Robby" Cangelosi, Jr.**

# Making Raise the Bar a Priority Issue in Louisiana

Raise the Bar, one of ASCE's three strategic initiatives, seeks to advance the public welfare by actively supporting the national movement to raise the educational requirements for licensure of future professional engineers. Many of us have engaged in supporting infrastructure through the Report Card for America's Infrastructure, or sustainability by earning an ENV SP credential attesting to our ability to apply the Envision infrastructure sustainability assessment tool, but we may wonder how we can support the Raise the Bar initiative.

The national ASCE Public Policy Committee and the ASCE Board of Direction have identified the following state legislative priorities for 2015.

- Continuing Education
- **Licensing**
- Qualifications Based Selection for Engineering Services
- Science, Technology, Engineering & Math (STEM) Education
- Sustainability
- Transportation Infrastructure Financing

Coinciding with the state priority issue on licensing is one of ASCE's primary initiatives—"Raise the Bar" on engineering educational requirements for licensure. This initiative was launched because a bachelor of science degree in civil engineering currently requires, on average, significantly fewer college credits than in the past, even

though our profession is facing more technical challenges than ever before.

## Engineering Leaders Agree That the Time Is Now

Most other professions have raised their educational standards in response to an increased body of knowledge and require a higher educational commitment (see graphic below). ASCE evaluated the knowledge requirements for professional civil engineers and published the findings in the *Civil Engineering Body of Knowledge for the 21st Century, Second Edition*, which describes the expected outcomes from a civil engineering education and documents the need for additional education. (This publication can be downloaded from the ASCE web site.

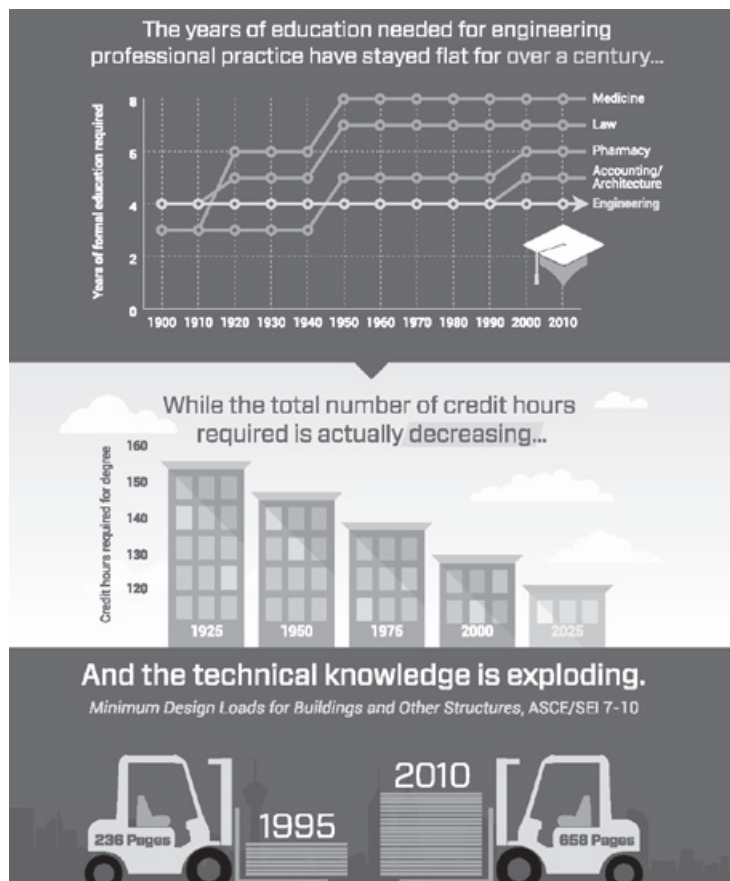
ASCE developed the Raise the Bar framework in the late 1990s through its Policy Statement No. 465, which calls for future licensed civil engineers to complete a baccalaureate degree and a master's degree in engineering or 30 equivalent credits, plus the requisite experience, before gaining licensure as a Professional Engineer. These proposed educational requirements exceed the current requirements in the State of Louisiana. It is ASCE's position that the Raise the Bar initiative is necessary to enhance the public's future health, safety, and welfare, thereby effectively and efficiently serving public needs, fulfilling our obligations as Professional Engineers, and continuing our legacy of success in building infrastructure and communities.

The Raise the Bar initiative has not been the topic of everyday tête-à-tête in Louisiana; therefore, the Section encourages **you** to start the dialogue. This Initiative will not impact currently licensed civil engineers and would only be implemented for future graduates (likely students now in middle school). ASCE is currently working to pursue legislative approval in one or more states to implement the Raise the Bar concepts as a first step in gaining national acceptance of these new standards. We urge you to review this issue through the Raise the Bar and ASCE websites and to support the concepts embodied in the Raise the Bar initiative. The proposed Raise the Bar requirements, which include additional education before we start our professional career, is wholly consistent with our lifelong duties to serve the public good.

The Louisiana Section is currently building public awareness of Raise the Bar through stakeholder outreach, the web ([www.RaiseTheBarForEngineering.org](http://www.RaiseTheBarForEngineering.org), which includes both a 3- and 8-minute video), and member education, such as distribution of infographics.

## Raise the Bar Is an Investment in the Future

Questions? For information on joining the Louisiana Section Committee on Raise the Bar, please contact Nedra Davis at [nedrasuedavis@gmail.com](mailto:nedrasuedavis@gmail.com). For information on Raise the Bar in general, contact [Info@RaiseTheBarForEngineering.org](mailto:Info@RaiseTheBarForEngineering.org).





# ASCE-COPRI Louisiana Chapter News

By Erin Rooney, PE, Director - Communications



COAST, OCEANS,  
PORTS AND RIVERS  
INSTITUTE

Louisiana Chapter

The Louisiana Chapter of the American Society of Civil Engineers (ASCE) Coasts, Oceans, Ports, and Rivers Institute (L.COPRI) is continuing to promote membership and visibility throughout the State of Louisiana by conducting joint seminars with local Branches and State Sections of ASCE.

The chapter is now accepting applications for its first annual student scholarship. The scholarship award of \$1,000 will be to a candidate based on academic achievements and submitted application responses. The minimum criteria to be eligible are listed below. The scholarship form can be found at <http://www.laseagrant.org/wp-content/uploads/L-COPRI-Scholarship-Application-Form.xls> and can be submitted by emailing the completed form to [LCOPRI@yahoo.com](mailto:LCOPRI@yahoo.com).

Applicant must:

- Be a graduate or undergraduate student studying Civil, Coastal or Environmental Engineering in Louisiana
- Be in good academic standing with the College of Engineering (must be able to verify if shortlisted)
- Have a minimum 2.5 Overall GPA (must be able to verify if shortlisted)
- Be a member of a student professional organization (preference for ASCE and/or COPRI members)

The chapter is planning a seminar related to Ports and Liquefied Natural Gas (LNG) facilities in the Lake Charles or Acadiana area in August. More information will be distributed to the L.COPRI email list as details are finalized.

The Ports & Harbors Waterfront Facility Inspection Task Committee of National COPRI recently published a new Manual of Practice, 130: Waterfront Facilities Inspection and Assessment. This MOP supplies engineers with guidelines and tools for inspecting and evaluating the condition of waterfront structures located in seawater and freshwater environments. The MOP is available on the ASCE publications website.

The PORTS '16 Conference will be held in New Orleans June 12-15, 2016 at the New Orleans Marriott. The theme of the conference will be "PORTS: Gateways to a World of Opportunities". Sponsorship and Exhibitor opportunities are currently available; please contact Sean Scully ([sscully@asce.org](mailto:sscully@asce.org)) with any questions about available

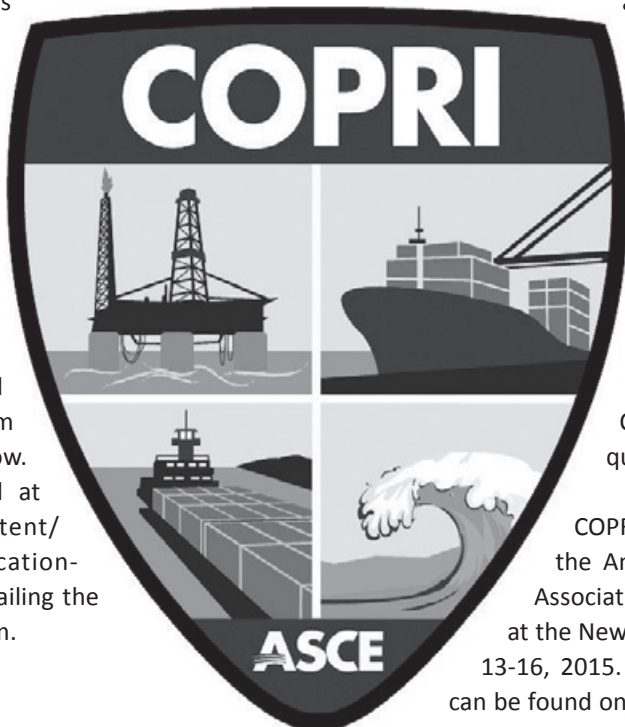
options. The PORTS Conference series is internationally recognized as an outstanding opportunity to network with hundreds of practitioners, researchers, and specialists at the leading edge of the port engineering profession. For the most up-to-date information, please visit <http://www.portsconference.org/>. A student paper competition will be held and is open to all undergraduate and masters students. Submissions are due April 8, 2016. Contact the PORTS '16 Student and Younger Member Committee at [copri@asce.org](mailto:copri@asce.org) with any questions.

COPRI is also a cooperating organization for the American Shore and Beach Preservation Association (ASBPA) National Coastal Conference at the New Orleans Intercontinental Hotel October 13-16, 2015. More information on this conference can be found on the ASBPA website at [www.asbpa.org](http://www.asbpa.org).

For more information on all COPRI conferences, please visit <http://www.asce.org/coasts-oceans-ports-and-rivers-engineering/coastal-engineering-conferences-and-events/>.

A P3 For Waterways Infrastructure Subcommittee of the Waterways national committee has been established to evaluate Public Private Partnership authorization under the Water Resources Reform and Development Act of 2014 (WRRDA). The subcommittee is working with the American Association of Port Authorities (AAPA) to assess the USACE's implementation of Section 5014 and evaluate whether ASCE should make changes to its existing policy on public-private partnerships, Policy Statement 526, among other subcommittee activities. A workshop to be held at that USACE New Orleans District is currently being planned to discuss potential uses of the P3 funding model on projects in the state. For more information on the subcommittee or its upcoming workshop, please contact Dennis Lambert ([delm@cowi.com](mailto:delm@cowi.com)).

The activities of L.COPRI will include seminars, workshops and other activities to benefit all ASCE and COPRI members. One does not have to be an Engineer to join COPRI. These Institutes are formed for the benefit of ASCE and non-ASCE members to participate and interact with other professionals interested in coastal, oceans, ports, and riverine efforts in Louisiana. If you have any questions or to add your name to our mailing list, please contact Erin Rooney, at [LCOPRI@yahoo.com](mailto:LCOPRI@yahoo.com).



## State Advocacy Captains Visit Washington for Program Kickoff

By Aaron Castelo (ASCE Staff) and Maria Matthews (ASCE Staff)

State Advocacy Captains: Members from around the country visited ASCE's Washington, D.C. office this week as part of the official launch of the State Advocacy Captains program. A total of 13 members from 11 states attended a day-long training session to learn in-depth information about the government relations program at ASCE and the efforts on ASCE's strategic priorities at the state level. Region 9 State Government Relations Committee member Ken Rosenfield (California) and Region 5 State Government

Relations Committee Corresponding Member Nedra Davis (Louisiana) assisted in the training program. State Advocacy Captains are meant to build a bridge between action at the state capitals and ASCE's State Government Relations Staff as well as promote Section and Branch advocacy activities at the state level. The next class will be held sometime in the Fall. Please see website for more: [http://www.asce.org/issues\\_and\\_advocacy/](http://www.asce.org/issues_and_advocacy/)



Pictured left to right: Shane Binder (WA), Ken Rosenfield (CA), Andrew Feranda (NJ), Mojgan Hashemi (CA), Tonya Mellen (FL), Ernesto Longoria (KS), Maria Matthews (ASCE Staff), Patrick Lach (IL), Gabby Briffa (PA), Ravi Shah (CA), Caleb Hing (TX), Seth Spsychala (MN), Kat Gurd (GA), Nedra Davis (LA), and Aaron Castelo (ASCE Staff)

## Multi-year, Robust Surface Transportation Bill Clears Senate – Now to the House

By Russell J. "Joey" Coco, Jr. PE, MBA

The ASCE LA Section GRC is following the progress in Washington DC regarding a long-term surface transportation bill. The U.S. Senate finished work at the end of July on a multi-year surface transportation bill, approving the legislation with a strong vote in favor by a wide margin of 65-34. The bill provides \$350 billion and a six-year surface transportation package that contains increased funding for highways and transit and keeps the highway trust fund solvent for three years. It is now up to the House to support the legislation by the end of October in order to avoid another short-term program extension. **The GRC is urging ASCE members to become vocal about long-term programs with increased funding and asks that you now reach out to your House representatives to encourage their support of the Senate bill.**

In a statement from ASCE President Thomas W. Smith, III, on July 29th 2015, he stated "the country needs and deserves a multi-year bill supported by reliable, sustainable, long-term funding, not more short-term extensions supported by complex pay-fors. ASCE urges consideration of all viable funding options, including raising the federal gas tax. The user-based fee is simple, fair and already in place... In the next three months, ASCE urges the House and Senate to work through their policy differences and continue the legacy of the Highway Trust Fund. This short-term extension needs to be the last and we believe it can be, so long as Congress moves the nation forward by working together in a bipartisan way to finish their work on improving America's surface transportation infrastructure."

## New Member Announcement

The T&DI Executive Committee would like to welcome a new member, Jay X. Wang, PhD, PE. Dr. Wang is the Chair of the Program of Civil Engineering at Louisiana Tech University, as well as a Bobby E. Price Endowed Associate Professor. His areas of specialization are Geotechnical Engineering and numerical modelling and material behavior. Prior to joining the faculty of Louisiana Tech University in 2002, Dr. Wang worked as a Research and Development Engineer with ADINA R&D (a software development company located in Watertown, Massachusetts) for four years. Dr. Wang obtained his BS and MS from Hohai University in Nanjing, China in 1983 and 1986, respectively. He obtained his PhD in Geotechnical Engineering from the University of Alberta in Edmonton, Canada in 1998. We are excited to have Dr. Wang join the Executive Committee.

## Blueprint for Louisiana Growth Management and Transportation Seminar

The Chapter held a seminar on May 5th at the UNO Engineering Auditorium to highlight the work the Merritt C. Becker, Jr. UNO Transportation Institute (UNOTI) recently completed related to the establishment of a growth management policy for the state of Louisiana. The speakers for this seminar were Eric Kalivoda, PhD, PE and John Renne, PhD, AICP. Dr. Kalivoda presently serves as the Deputy Secretary for LADOTD and Dr. Renne is an Associate Professor of Planning and Urban Studies at UNO and he also serves as the Director of the Merritt C. Becker, Jr. UNO Transportation Institute. This seminar was coordinated by T&DI Executive Committee member Jennifer Stenhouse, AICP, who is the Director of Development at Center for Planning Excellence (CPEX).



Growth Management Seminar – from left to right; John Renne, PhD, AICP; Tara Tolford, AICP; Jennifer Stenhouse, AICP; and Eric Kalivoda, PhD, PE

## Upcoming Repeat LADOTD BDEM and Revised Concrete Specification Seminar

Due to considerable interest in the seminar that was held in Baton Rouge on the recently published LADOTD Bridge Design and

Evaluation Manual (BDEM) and the soon to be updated Concrete Materials Specification, it was decided to offer a repeat seminar in the New Orleans area. The repeat seminar will be held Thursday, October 22nd at the UNO campus. The speakers will be Zhengzheng “Jenny” Fu, PE, who acts as the Assistant Bridge Design Administrator for LADOTD and Tyson Rupnow, PhD, PE, who has worked for the Louisiana Transportation Research Center (LTRC) for the past six years, as well as serving as the LADOTD concrete materials expert. Be on the lookout for an announcement for this seminar.

## Upcoming ITS Seminar in Baton Rouge

Information and Communication Technologies (ITS) and Traffic Management Procedures are continually evolving as new technologies are developed. Our ability to monitor traffic in real time and relay traffic conditions to drivers via variable message signs, the internet, mobile apps, advisory radio, and the 511 service has improved drastically over the past several years. This seminar will have two parts: Part I will present a brief overview of the existing ITS infrastructure in Baton Rouge, as well as some planned projects that will strengthen the ITS architecture of Baton Rouge; Part II will focus on research on connected vehicles, using the driving simulator at the Civil and Environmental Engineering Department at LSU. The speaker will be Sherif Ishak, PhD, PE, Professor and Interim Associate Dean for Academic Affairs in the College of Engineering at LSU. The seminar is planned to be held at the LTRC facility at the LSU campus sometime in November. Be sure to check your email for the announcement for this seminar.

## Looking Ahead

The intent of T&DI is to promote transportation and development as a career path, and to provide training and networking opportunities for all professionals involved in transportation projects. If you are interested in co-sponsoring a seminar at your branch, the T&DI Louisiana Chapter has prepared a Seminar Coordinator’s Check List to assist in your preparation. Contact Michael Paul, PE, at [MPAUL@trcsolutions.com](mailto:MPAUL@trcsolutions.com) for a copy of the checklist. Seminars are two hours in length and are typically presented from 5:30-7:30 pm in either the New Orleans or Baton Rouge areas. We have also presented out-reach seminars with the ASCE Acadiana Branch and Shreveport Branch. We are open to co-hosting seminars in additional Louisiana cities if requested. The Louisiana Chapter is planning the following future seminars:

- I-49 South Corridor
- Toll Road Feasibility for I-10/LA 1 connector in Baton Rouge
- Pavement Engineering (Part 3 of 3) Application of Earthwork and Embankment Materials
- New Pavement Design / Empirical Methods
- Mitigation Banking



## Branch News

### ACADIANA BRANCH

*By Beau J. Tate, PE, Branch President*

The Acadiana Branch had a successful May luncheon on May 12. The meeting/luncheon was held in Lake Charles to provide more member services across the Branch area and increase the involvement of the McNeese University Student Chapter and Professionals from the Lake Charles area. Sonny Launey, PE, provided an ethics presentation along with a geotechnical presentation by Travis Richard, PE of Eustis entitled Engineering on advances in instrumentation/testing. Eustis Engineering incorporation with Geo Products, LLC also volunteered to sponsor the event, which made the luncheon free to members.

Following the May luncheon the Acadiana branch has had no additional meetings while everyone is enjoying vacations and family time. The board has met once to discuss the upcoming year and has one additional meeting planned to finalize the upcoming events. We have also recruited new board members who will be inducted at our October meeting, and we also plan on presenting scholarship awards to both UL and McNeese Universities at that meeting.

The Acadiana Branch is also continually coordinating with McNeese University and other local professionals to discuss plans for the 2016 Deep South Conference, which is being hosted by McNeese for the first time. There will be a need for judges for each competition, sponsors, and volunteers to help organize the event. Please contact the Acadiana Branch if you are interested in serving at: <http://asceacadiana.net/>



### BATON ROUGE BRANCH

*By Kirk Lowery, PE, Branch President*

The Baton Rouge Branch co-hosted with the Baton Rouge chapter of LES a luncheon at Juban's on May 28th. This year's speaker Baton Rouge Mayor Kip Holden spoke about the state of East Baton Rouge City Parish. On June 18th Bob Jacobsen presented Managing Hurricane Surge Risks in the Supercomputing Era. These events were well attended and the topics were quite interesting.

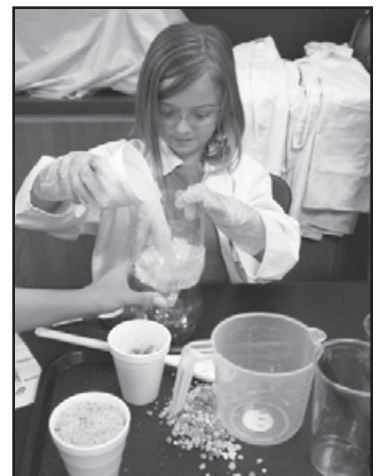
The Young Members hosted a social event at the end of July at the Rum House in Baton Rouge. The invite for this event asked everyone to come stop by for "island time" and there was plenty of Red Stripe and "Pain Killers" to go around during the happy hour (see photo).



On August 20th, the Baton Rouge Branch in conjunction with the LES chapter hosted LADOTD's Secretary Sheri Lebas. In addition, nominations for officers for the 2016 fiscal year were taken. In September the Baton Rouge Branch will be presenting our award winners at the monthly luncheon.

The Baton Rouge Branch has teamed up with the Louisiana Art and Science Museum (LASM) to bring the program, Engineer It: Water Works!, to life. LASM and ASCE recognize the need to educate children on the importance of science, technology, engineering, and mathematics and how it impacts their daily lives and their future. In order to provide an opportunity to cultivate an interest and develop an understanding of these important subjects, leaders in the Baton Rouge civil engineering community have created a program to teach children about the concepts of civil engineering and the engineering process. The primary goal of Engineer It! is to help audiences gain appreciation for engineering and design and to inspire deeper learning and application of basic engineering and design principles, including problem solving skills used in the design process.

The 60-minute workshop includes an exciting, hands-on activity where children make dirty, Mississippi River water clean by pouring it through a filter that they built with simple materials supplied at the workshop. The first workshop was held in April at LASM downtown Baton Rouge and it will continue through September on the third Saturday of each month.



## NEW ORLEANS BRANCH

*By Lee M. Alexander, PE, F.ASCE, Branch President*

Congratulations to all in Louisiana and especially the New Orleans Branch for having in our midst Norma Jean Mattei elected as the ASCE National President-Elect!! We could not be any prouder of her!!

Please fasten your seatbelts as we prepare for lift off. After months long process of intense meetings and planning, including proposing, protesting and proposing again, the New Orleans Aviation Board has awarded Gibbs Construction as part of a joint venture, the Construction Manager at Risk contract for the initial phase of a new terminal at the Louis Armstrong International Airport. The 300th birthday of New Orleans will be celebrated with this new airport! Our keynote speaker for April was Melissa Gibbs, of Gibbs Construction, where she directs the business development and also manages small and disadvantage subcontractor outreach. Gibbs has recently been awarded the City Business Women of the Year Award.



*New Board Members of New Orleans Branch; (left to right) Wes Eustis, Karishma Desai, Tonja Koob, Steve Johns, Lee Alexander, Steve Nelson, Robert Delaune, and Myriam Bou-Mekhayel*



*Lee Alexander with guest speaker Melissa Gibbs*



*Wes Eustis and guest speaker Nicholas Altiero, PhD*



*Guest speaker Senator David Vitter with Lee Alexander*

In May, we were very fortunate to have Nicholas Altiero, PhD, Dean of Engineering at Tulane University, to be our guest speaker. He outlined the state of Engineering at Tulane, the future and Master Plan for Tulane Engineering. May also had a fun and endearing "Hogs for Cause" get together with the Young Engineers for Charity and fellowship.

May was our elections for the next incoming Branch officers. They will be as follows:

President-Wesley Eustis, PE  
President-Elect-Tonja Koob, PE  
Vice President-Steve Nelson, PE  
Treasurer - Karishma Desai, PE  
Secretary-Robert Delaune, PE  
Director-Dean Nicoladis, PE  
Director-Myriam Bou-Mekhayel

Our last luncheon guest speaker before the Awards Banquet was U.S. Senator David Vitter. He is the current Chairman of the Senate Small Business and Entrepreneurship Committee and oversees U.S. Army Corps of Engineers work and contracts. His presentation covered U.S. Army Corps works, State of Louisiana Infrastructure and the outlook of Louisiana Education. It was well attended and we had lively discussions in the Q&A session.

The last big event was the July Awards Banquet in which 3 scholarships were awarded to Dallas Rolnick, Stephen Borengasser and Ben Barcelona, all attending UNO. We were pleased to have 6 Life Members in our group. They are Kevin Fry, Pete Olivier, Robert Grubb (in photo) and Ashton Avegno, Dale Hunn, John Leary (not in attendance).

The 2015 Award Winners were:  
Outstanding Young Civil Engineer: Karishma Desai  
Outstanding Civil Engineer: J.T. Cooper  
Lifetime Achievement: Brad Rogers  
Educator of the Year: Enrique La Motta, PhD, UNO  
Outreach: Anthony Schoencker-EWB Coordinator  
President's Metal: Kyle Galloway



*Life Members; Robert Grubb, Kevin Fry, and Pete Olivier*



*Branch Award Winners; Karishma Desai, L.T. Cooper, Brad Rogers, Dr. Enrique La Motta, Anthony Schoencker, and Kyle Galloway*



*Scholarship Winners Dallas Rolnick, Stephen Borengasser, and Ben Barcelona*



## SHREVEPORT BRANCH

By David Smith, PE, Branch President

Hello ASCE Members and Associates,

We hope everyone has been enjoying their summer, whether it's getting to work on the design and construction of much needed infrastructure projects, or taking a break for yourself or to spend with family and friends. ASCE-Shreveport functions have slowed to a crawl, with little in the way of events or meetings for the summer months. Although, our officers have been meeting intermittently to gear up for the next year of events, especially the ASCE Spring Conference for 2016, which will be held in Shreveport. We hope to live up the high standards that the Baton Rouge Branch set this past Spring. If you are interested in taking part in this year's Spring Conference as a speaker or exhibitor, please contact me or one of the branch officers.

New design projects and construction seem to be keeping most local engineers busy. With the oil and gas industry in a depressive state, the effects have been positive for project costs (and vacation travelling costs). The City of Shreveport has continued releasing engineering and construction projects to rebuild its aging infrastructure, particularly the sewerage system. Gravity main inspection, repairs, and surveying can be seen taking place in nearly all communities. We intend to bring some key personnel in for monthly meetings to discuss the extent, procedures, and findings of this massive undertaking.

The Shreveport area, as well as others, saw a tremendous amount of rain in the late spring, bringing the Red River to a peak crest of 37.14 feet on June 9th, with a flood stage elevation of 30 feet. The National Guard and local volunteers were called upon to build make-shift levees and plug cross drains on Clyde-Fant Highway in hopes of minimizing flood damage. Several communities impacted despite engineering and volunteer efforts, but it certainly could have been worse without the thoughtful planning and action of all involved. Our thoughts go out to those affected, and those in South Louisiana that are still being affected along the Mississippi.

Our first meeting for this academic year, will be on Thursday, September 17th, 2015. We plan to bring our members opportunities to gather knowledge, create relationships, and give back to the community through the rest of 2015. With the organizational year coming to a close in September, this will be my last journal article as Branch President. Serving ASCE over the past year has been a true honor and pleasure. Chris Myers, PE, will be taking over for me as Branch President, and I'm more than confident that he will continue to grow our chapter and provide benefit to our members and community.

To everyone working outside, please stay hydrated and mindful of pushing yourself too hard in the dreadful heat of Louisiana in summertime. To those stuck at desks, get up and move before you get old.



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- Global transportation hub – NYC is easily accessible from anywhere in the world and has reliable, and inexpensive options to get around
- Lots to do – 24,000 restaurants, 83 museums, and one of the most progressive arts and cultural scenes in the world



# ASCE-SEI New Orleans Chapter News

By Om Dixit, PE, FASCE, F-SEI & L.T. Cooper, PE, FASCE, F-SEI



The ASCE SEI New Orleans Chapter has continued hosting and planning seminars and workshops in April and May. Two more seminars were held at University of New Orleans.

24th Annual David Hunter Lecture for 2015 was "The Building of a Building Code (ACI 318-14)" and was presented by Randall W. Poston, PhD, PE, SE, (former Chairman of ACI 318 Committee) on April 28. Dr. Poston explained that the framework of the current ACI Building Code has remained essentially unchanged since 1963. The Code served to inform, educate and provide guidance for the introduction of strength design methods. Knowledge expands with time through practice and research. In the case of structural engineering, knowledge is also gained through lessons learned from behavior of structures in catastrophic events such as earthquakes. The Code captures change through this insight into behavior, addition of new materials and construction techniques, and advancement of technology. ACI Committee 318 stepped back and examined the organization of the Code for the 2014 edition. The David Hunter Lecture examined the reasons why Committee 318 took the giant leap to completely reorganize the Code as it had existed for more than four decades. The history behind the reorganization effort and how decisions were made in "building" the new organizational structure of the 2014 Code, which is based on the design of members, was covered in this lecture. This lecture was attended by 54 members.

On May 12 ASE SEI NO Chapter cosponsored "New API Structural Standards Workshop (API 2A, 2SIM, 2MET, 2EQ, and 2GEO)" with the American Petroleum Institute (API). This 6 hour workshop was presented by various API Subcommittee 2 members. The workshop presented the history of the API 2A Recommended Practices for Design and Construction of Offshore Structures. It also covered the new changes in recently published documents. It was attended by about 95 members.

Besides planning the 2 hour seminars, SEI New Orleans Chapter also helped the 2015 Louisiana Civil Engineering Conference and Show (2015 LCEC&S) host committee finding some good topics and speakers for the conference. Every year SEI NO arranges the Annual Herbert J. Roussel, Jr. Lecture at this conference. This lecture is to honor the late Herbert J. Roussel, Jr. who was one of the founding members of ASCE Structural Committee of New Orleans Branch and served on its Executive Committee 1991-2005. Since 2006 each year a distinguished presenter is selected by the Structural Engineering Institute Chapter of New Orleans (SEI NO) to deliver this Lecture.

This year the Annual Herbert J. Roussel, Jr. Lecture will be presented by Vitaly Feygin, PE, Marine and Industrial Consultants, Petersburg,



Florida. The title of the lecture will be Performance Based Design of Flexible and Semi-Flexible Dolphins and Piers. This Lecture will cover several aspects associated with the design of semi-flexible and flexible dolphin systems insufficiently covered by Permanent International Association of Navigation Congresses (PIANC) and national marine codes. The list of covered subjects includes Geotechnical Conditions (Why Flexible Dolphins?), Fender selection conflicts, Review of US and Australian Codes, Flexible and Semi-Flexible Dolphins, Review of Guidelines for the Design of Fender Systems (PIANC WG-33) requirements, concept of capacity protected elements, and design of Flexible Dolphins. The Lecture will also address Application of overload factors, Review of CALTRAN requirements, Effective Moment of Inertia of Partially Plasticized Pipe Section, and Dolphin Ductility. Detailing mistakes in the pile to pile cap connections will also be shown during the presentation.

Other topics for the future seminars include Masonry Design Seminar, Simplified Seismic Design for Louisiana, Embedded Anchor Design, Steel Design-Connections/joints and many more.

The committee is looking for good topics and speakers for future presentations. Members with expertise in the field of structural engineering would be welcome to join the Executive Committee. For any suggestion and information on joining the Executive Committee, contact Chairman L.T. Cooper, PE, at LTCOOPER@edg.net.

All seminars are held at the University of New Orleans. Seminar dates and pertinent information on registration or addition of your name to the emailing list can be requested by e-mailing to Om P. Dixit, PE at omdixit@cox.net.



Seminar Coordinator Om P. Dixit, PE (on right) with Speaker Dr. Randall Poston (left) at SEI New Orleans Chapter hosted Annual David Hunter Lecture on April 28, 2015

# Student Chapter News

## LOUISIANA STATE UNIVERSITY

*By Kelsey Schmaltz, Student Chapter Secretary*

Student involvement in the LSU and Baton Rouge community continues to be an important goal for the Student Chapter of ASCE at LSU. This past spring semester, ASCE members participated in three community service events. On March 28th, the LSU ASCE Student Chapter volunteered at Geaux BIG Baton Rouge in order to help out our community in the Baton Rouge area. LSU ASCE



*Geaux BIG Baton Rouge Service Event, March 28, 2015 (left to right): Destiny Parker, Amy Olson, Alicia Fortier, Peter Graffeo, Enrico Targa, and Danny Gutierrez*

## UNIVERSITY OF LOUISIANA AT LAFAYETTE

*By Sarah Pippen, Student Chapter President*

Since May the University of Louisiana at Lafayette ASCE Student Chapter has been preparing for the 2015-2016 year. Before taking the torch, however, we had to send off our graduating seniors. This Spring we had fifteen seniors showcase their hard work in their Senior Design class before going on to graduate. As our seniors leave, new ones take their place, this includes the election of new officers.

### 2015-2016 UL Student Chapter Officers:

Sarah Pippen – President  
Rachel Ducote – Vice President  
Jeanne Zeringue – Secretary  
Jonathan Trahan – Treasurer  
Austin Kittok – LES Liaison  
Tommy Philayvanh – Events Coordinator  
Jacob Medus – Conference Chair



members helped strip and repaint the eaves around a woman's home and helped clean out debris and overgrowth in her backyard. LSU ASCE members also worked to beautify LSU's campus and learned about sustainability at the service event for Spring Greening Day on April 24th. The latest service event was the LSU Lake Cleanup on May 23rd, in which members assisted in cleaning the areas around LSU's campus lakes. This was LSU ASCE's third year to participate in Geaux BIG and Spring Greening Day, and we plan to continue our involvement within our community.

LSU ASCE wrapped up the Spring semester with general student chapter meetings on April 13th and April 20th. Our guest speakers were Steven Estopinal, PE, PLS., and Meghan Montgomery from SJB Group, LLC who discussed land surveying and storm water drainage projects, and Lynne Roussel, PE, from Terracon, who spoke about geotechnical and environmental engineering. If you are interested in speaking at one of our meetings in the fall semester about ethics, professional development, licensure, current civil/environmental projects, etc. please contact us at [asce@lsu.edu](mailto:asce@lsu.edu).

To learn more about our LSU ASCE Student Chapter, please visit [asce.lsu.edu](http://asce.lsu.edu)

The previous officers worked hard to finish the year successfully. Working with the Chi Epsilon student chapter they put on our Annual Departmental Banquet on May 1st. This year as our keynote speaker for our banquet, we were fortunate enough to have our current National ASCE President-Elect, Norma Jean Mattei, PhD, PE F.SEI, M.COPRI, M.ASCE.

Over the summer the officers met to discuss upcoming events for the Fall Semester. The first thing we look forward to every year is our annual Fall barbeque. At this barbeque we have many students, faculty, local professionals, and alumni come and socialize. This year the barbeque will be held at 5 pm on Tuesday, September 15, 2015 in the big pavilion at Girard Park.

This semester we will be participating in many sporting events hosted by the Louisiana Engineering Society (LES). The first sport will be volleyball, we will participate in a team against the other engineering disciplines. This brings the school of engineering here at UL closer together, along with the ASCE chapter itself. The plans for this year are never ending, and our new group of officers hope to make this year as great as the last.



# — CALENDAR OF EVENTS —

## SEPTEMBER 2015

- September 2-4, 2015**     **Structural Design for Bomb Blast Loads and Accidental Chemical Explosions (Buildings and Industrial Facilities)**  
Atlanta, GA
- September 10-11, 2015**     **Seismic Design of Highway Bridges**  
Tampa, FL
- September 11, 2015**     **ASCE-LA Section Board installation luncheon**  
Chateau Country Club, Kenner LA, 11:30 am
- September 17-18, 2015**     **Wind Loads for Buildings and Other Structures**  
New Orleans, LA

## OCTOBER 2015

- October 11-14, 2015**     **ASCE National Convention**  
New York, NY

For more events visit the ASCE Events Calendar: <http://www.asce.org/#about>

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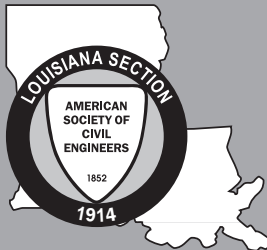
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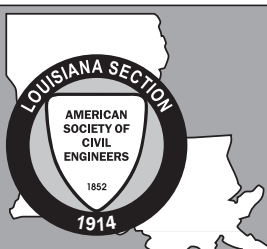
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