February 16, 2018

MEETING NOTES: Dr. Norman Levine, Professor of Geology, College of Charleston
Director of Santee Cooper GIS Laboratory and Low Country Hazards Center
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Lucas Martinez, graduate student, College of Charleston, focus on Kiawah Island

From Kiawah Island: John Leffler, David Pumphery, Bob Cheney, Jim Chitwood, Jim Sullivan, Bruce Spicher + 1 (TOKI), Lyn Schroeder. Guests: Wendy Kulik, Justin Core (Kiawah Island Conservancy)

Levine Capabilities

- Levine has the most accurate elevation maps available and is willing to do additional work of even greater accuracy & precision.

- His current Digital Elevation Model maps (which are also available to us) are accurate to 7 cm height and about 6-7 ft. horizontal points with extrapolation between points.

- His current map can show variation in height across the width of a road as well as along the length of the road.

- He is able to look at rain event flooding as well as storm surge events with any assumptions we wish to use. He can show terrain drainage patterns. He can show where specific vulnerabilities are as sea level increases.

Our Uses of Levine's Capabilities

- Identify likely problems on our roads with various types and levels of water events.

- Identify road issues and how best to solve them (especially if his students do more accurate & precise onsite road mapping and surveying). This can include rain event pooling locations, drainage issues to and from terrain that is near the road, and targeted storm surge protection. He can help map potential solutions (including opportunities for temporary excess water storage) and identify any new water issues that the fix can create.

- He can help home owners examine their local terrain so they can better understand likely sources of their problems (or potential problems) to better help them select among "fix options" that we have identified or that they find.

- Help TOKI evaluate the need for local height requirements for buildings on Kiawah.

- While sediment deposits should increase on the marsh side, this will not be deposited in such a way as to reduce water incursion on the marsh side of the island as sea levels rise (deposits tend to fill the deeper parts of the river).

Some Other Ideas Discussed

- Greenspace Engineering: For example, golf courses might offer ideal, short term storage for excess water. Can be done over time without problems for the course (if designed well). Might help the course owners by keeping more people on the island (short term and long term) to play the courses.

- Trails and paths can help with water movement and hiding drainage pipes.

- It is important to have ways to reduce flood water from storm surge. Some key actions should include automated (or automatic) check valves at all pond system drainage outlets and berms where surge can access the island and provide sudden flooding that is trapped by terrain. With pond drainage outfalls, it is important to have regular maintenance to keep the outfall clear of sand buildup and other obstructions.

- Flood level categories that might be helpful on Kiawah: (a) 0-4" = nuisance but people will still walk through, (b) 6-12" = car passage problems (exhaust pipes gets covered), (c) 24" = no EMS (except large firetrucks and special vehicles).

- Levine says house elevation should be included along with other options for a homeowner's water problems (as is now done in Charleston – even in the historic district).

Summary

Levine's capabilities can be a very valuable help in identifying good solutions to our various water problems. They could be particularly valuable to our long-range plans and strategies. I believe that TOKI should include Levine in their short term and long-range game-plan work for road infrastructure and building height requirements. KICA should include Levine in their planning on ponds and our drainage system (including the work they are currently doing with their consultant). We should probably have some on-island capability to assist those who want to use some aspect of Levine's databases over time.

More detailed description of the meeting follows:

<u>Levine's Maps and Models</u>

Levine's project produced 1-meter digital elevation models (DEMs) for 5 communities. The maps are interactive and can predict the impact of sea level rise, tidal surges, rain fall flooding, or elevation changes (e.g. adding berms or raising roads) on those areas. His maps detail natural terrain and determine natural water flows and drainage. He can model impervious vs pervious surfaces and surface runoff. For example, his model can show what might happen to surrounding yards if a road is raised, or how water flow would change if a berm were added to the landscape. The maps are sufficiently detailed that he can look at individual lots or determine elevations on left and right side of roadways (the "curve" coming into the island ranges from 1.8 to 2.3 meters.)

Levine collected info by LIDAR flights. They got 8 returns per packet from which they collected the lowest point and verified it. He used a 1.5-meter firing range which they sampled to 1 meter. (Most other maps are at best 3-meter DEMs.)

His DEM measures ground elevation, contours, and creates a surface area, filling in points to a 1-meter resolution.

His digital surface model (DSM) measures surface elevation (trees, buildings).

The model was compared to regional benchmarks and is accurate to 7 cm (2.75 inches) elevation. The ground elevation covers 2-3 meters between end points.

Levine's model is a "bathtub" model. It assumes the land is static and water just rises evenly around it.

Levine is working on a new study which will compare actual MHHW water level to the predicted MHHW level over the course of one month.

<u>FEMA and Flood Elevations</u>

FEMA, NOAA, The Army Corp of Engineers and various government agencies use different flood elevation references. FEMA flood maps drive TOKI's building codes based on 100 yr flood events and currently elevations are referenced to NGVD29.

Spicher noted FEMA's new flood maps are lowering base flood elevations 1-5 feet and take some areas out of the flood zone altogether.

FEMA's new maps do not incorporate any SLR.

Levine suggested FEMA's flood maps do not incorporate integrated modeling of the connected floodways. Thus, in some cases, FEMA's map does not connect rivers and streams that are known to connect in "real life." FEMA maps use a standard formula in the model building. This formula often does not work well for coastal areas, particularly barrier islands.

FEMA used inundation mapping to create the flood plain.

New FEMA flood level maps are based on transections (narrow horizontal strips of land from ocean front to back side of the island.) The analysis looks at elevations within the transection and selects one number to represent the entire section. The number of transects, or the size of the transections, makes a difference in the accuracy.

FEMA models use 100-50-25-10 year flooding events resulting from oceans, rainfall or rivers. Whichever feature dominates an area becomes the basis for that area's 100 year event. KI's "event" is a hurricane and FEMA has assumed KI has a low probability of a hurricane.

FEMA's new maps lowered flood elevations in areas where Charleston knows they had repeated flooding.

TOKI can implement their own minimum building elevations. Levine believes the FEMA maps have several significant problems in the way they were derived. He sees no benefit to lowering base flood elevations with the exception of lowering insurance rates. He would not build any lower than the highest historic flood level.

Sea Level Rise Forecast Discussion

1-2 feet of global SLR is the lowest rate we might expect if the thermal temperature coefficients stabilize where they are now. Levine's graph depicting the various scenarios for SLR zeros at 2000, uses actual date up to 2015, and forecasts out to 2100.

Charleston should expect to experience more SLR than the global average because of the ocean floor topography offshore (Charleston Bump). Charleston is considered one of the top 20 most vulnerable cities to SLR globally.

His forecasts do not include the latest data released in 2017. He targets the intermediate high scenario for planning purposes. This scenario currently forecasts 1.44 ft of SLR by 2050 and 1.97 feet by 2060. The intermediate –high scenario is being used by Charleston and Mt. Pleasant. It has support from NOAA scientists Doug Marcy and Russell Johnson from the Office of Coastal Management in Charleston. The newest assessments of sea level rise data (which include the 2017 data) increase the "extreme" scenario of 8-10 feet of SLR instead of the current 8.2 feet of rise.

Levine notes no one wants to under-plan when it comes to flooding. If minimum SLR is projected to be 3ft by 2100, it makes sense to plan for a little higher rise leaving a room for upward revisions in the forecasted scenarios.

The dynamics of land-based glacial Ice melt has created uncertainty.

Which Elevation Reference Datum is Bestt?

MHHW represents an average of daily higher high tides for an area. Floods occur by exceeding this reference by a certain amount. For Charleston, 0.38 m (1.25 feet) above MHHW can be considered the flood elevation. By this measure, during Oct. 2017 Charleston had 23 flood events over 18 days. 5 of those days required barricades on some roads due to deep water. Most of the flooding is minor. Check valves on outlets keep water from flowing in from the marsh. Charleston has about 6 check valves, however, they cannot stop ground water from rising and causing flooding

NOAA uses MHHW as the reference datum on its Digital Coast SLR Viewer.

NOAA uses MLLW as its reference datum when giving water elevations for navigational purposes by boats and vessels so they know depth so they can clear the draft of the boat.

Flood Water Depths

0-4 inches – nuisance, people will walk through up to 4 inches of water to get someplace. This does not address the impact of the accelerated degradation of infrastructure (cement, asphalt, etc.) resulting from regular flood water exposure.

4-6 inches - pedestrians route around the water to get where they want to go.

6-12 inches - car problems, most cars tailpipes are 8 inches off the ground; when water depth is 8 inches, the tail pipes fill, causing cars to stall.

12-16 inches - SUV's, trucks, delivery trucks and EMS vehicles begin to stall.

24 inches - firetrucks may be able to drive through, ambulances must have a "snorkel" on the tailpipe to move around. At 24 inches of flooding EMS may "use their discretion" to move through an area, i.e., they don't HAVE to come through the flooded road to rescue someone.

24+ inches – boats only.

Marshes and Flooding

Barrier islands will usually eventually attach to the mainland. Sand builds on the front and eventually blows over the island to fill in the back side. Marshes also trap sediment and fill in the back side of KI. KI has become a fixed barrier island, it has infrastructure, like cement pads for houses, which impedes the island's natural development.

Marshes promote sedimentation which gradually infills the back side of the island. Increased sedimentation fills in deeper channels of the marsh causing floodwater to spread out over a wider area, so more land might flood. The volume of incoming water is the same, so if “deep” basins fill in, that water has to go somewhere.

As the river side fills in with sediment, you could dredge the river, but it doesn’t raise the land.

<u>Creating Water Management Zones</u>

Water management zones can be created by hardening high sides and swales. Levine identified 17 possible zones, however the plan requires removing 30 houses and raising roadways and causeways to get into the zones.

Once an area is sealed, no water flows out, thus all rainfall, ground water infiltration and water cresting the walls must be pumped out. Sealing an area causes loss of natural wetlands.

Ground water flow is slower than surface water flow, so you can pump *ground water* intrusion out and stay ahead of, or minimize flooding.

For example, in Charleston near the intersection of Huger and King, there is a huge basin subject to ground water infiltration. This area can pump to keep dry assuming that walls keep surface water from flowing in.

Kiawah’s ponds and lakes rise and fall with the tides, not due to inflow alone, but also due to ground water moving up and down with the tides.

<u>Improving Drainage</u>

Enhancing out flow through natural waterways or by adding more drainage will help move water out more quickly. Ground water will continue to infiltrate an area, but pumps can stay ahead of ground water infiltration. However, this practice causes the loss of fines (very small soil particles) and can increases soil liquefaction in the event of an earthquake.

<u>Climate Change Conversations</u>

Was Irma unusual? Levine thinks going forward, probably not, due to the warming oceans. Current forecasting models do not capture the energy in oceans because they do not reflect the warmer water temperatures. He suggested that there is some concern that our current hurricane forecasting models may no longer be statistically valid. He thinks it is likely that all hurricanes, both large and small, will be more intense than models currently predict due to the warmer air and water.

He also suspects that KI' groundwater will become increasingly salty, leading to changes in island vegetation. He expects we will lose some of our maritime forest.
Mangrove trees are moving northward up the coast due to climate change. Manatees are in the Charleston area more often (up to 36 days now) than in the past.

Levine's To Do list suggestions

1. Identify low spots on the roads so they can be addressed.
2. Allow building heights to be adjusted upward.
3. Integrate natural and urban drainage. Identify, maintain or improve outfalls and infalls. Install check valves. It is commonplace for communities to have few, or incomplete, maps of drainage systems as most drainage is installed during construction and the information does not get transferred to the community
4. Keep storm drains clear and well maintained. Consider an "adopt a drain" campaign.
5. Maintain drainage channels, keep water in drainage channels
6. 6. Be prepared: get ahead of the forecasts, plans for 2040 need to be in place by 2030-2035.
7. Turn portions of golf courses into temporary retention ponds during floods. Or add more water features to the courses. Find other open areas that can be used as temporary retention ponds (Houston parks example.)
8. Find areas where tidal water comes in and build berms or walls to block it. The interactive maps can be used to find this type of exposed area.
9. Cart paths and leisure trails could be used to add more drainage pipes.
10. Consider using a 30-year time horizon (30 year mortgages.) Build for a worst-case scenario during a 30-year mortgage.