Planning for Sea Level Rise in the Matanzas Basin

Appendix A:

Sea Level Rise Scenarios and Digital Elevation Model for the Matanzas Basin

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The following sections describe the development of sea level change scenarios, evaluation of the characteristics of digital elevation models (DEMs), the process of creating inundation layers and the results of this process for the Matanzas study area.

Sea Level Change Scenarios

Climate and sea level change are current topics that continue to grow in prominence, amongst both the scientific and general populations. Knowledge of what sea level change is, how it is measured, and what causes it is often assumed, but not always explained. Therefore, a few simple explanations are presented, followed by a description of the process employed to develop sea level change projections or scenarios.

Sea level change is a term that refers to the change in the average ocean water surface elevation, or height, expressed globally, regionally or locally. Sea levels are measured using tide gauges that are referenced to adjacent land surface benchmarks. A benchmark is a point of known location and elevation, based on land survey data, which is often derived from Global Positioning Satellite (GPS) information. The Intergovernmental panel on Climate Change (IPCC) attributes sea level rise to an increase in the global volume of the world's oceans, commonly associated with changes in the shape of ocean basins (measured by bathymetry), changes in the mass, or amount of water, as well as, changes in the temperature and salinity of the world's oceans (IPCC, 2007). The factor cited most often for changes in mass and water temperature is the increase in global air temperatures.

While the IPCC is often cited as a source for global sea level change projections, there are numerous methods and projections available in the literature. A recent study by Florida Atlantic University (2012) cited sixteen methods and models used developed to project sea level change. Consequently estimates of sea level change and associated time periods vary, sometimes widely. Projections are derived using historic global mean sea level trend data and different combinations of variables to account for specific climate or physical environmental conditions. In addition, methods can either focus on the time frame of change, or the rate of change. For this project, sea level rise scenarios used in GIS-based analyses were based on the curves produced by the IPCC 2007 Climate Change Report (IPCC AR4 WG1 2007), most importantly for Sea Level Affecting Marshes Model (SLAMM) analyses. However US Army Corps of Engineers (USACE) sea level rise curves and guidance documents were also referenced and used for public communication and outreach purposes (USACE 2009, 2011).

Simulations for the SLAMM modeling used sea level values of 0.2, 0.5, 1.0, 1.5, 2.0, and 2.5 m sea level rise by 2100, while those for the inundation and storm surge used the rates of 0.5 and 1-meter. Future land use change scenarios were based on a 1 meter scenario, while conservation analyses were based on 1 and 2.5 meter scenarios. The rationale for the use of these various scenarios is described in the respective appendix for each analysis, but in general a 1 meter scenario was used across all analyses as a median estimate for Florida by 2100.

Evaluation of Digital Elevation Data

Digital elevation data was a requisite component of all project modeling efforts. For the purposes of this project, it was necessary that the elevation data be compiled into a digital elevation model (DEM). The DEM is a grid-based format, represented by cells of equal height and width, and referenced by row and column. Elevation data is assigned to the center point of the cell and assumed to be equal across the entire cell.

When evaluating DEMs for a given application, there are three primary considerations: completeness, and resolution, both horizontal and vertical. Completeness is important in terms of spatial extents and data gaps. Horizontal resolution refers to the cell size of the DEM, which has an effect on the size and arrangement of the topographic/elevation features that can be measured. Finally, vertical resolution also determines the features that can be measured, as well as the level of detail that can be represented. For example, put in probability terms, a DEM with a vertical resolution of +/-3-meters (i.e. any given cell could have an elevation of its listed value +/-3-meters) would be able to accurately represent the location and elevation of a 1-meter sea level rise 65% of the time. A detailed discussion of the effects of vertical resolution and the uncertainty in mapping inundation is presented in Gesch (2009).

A decision was made by the project team to conduct all analyses at ten meter cell resolution. That is, each cell is 10-meters on a side, representing an area of 100 square meters. There are currently three readily available digital elevation data sources for the GTMNERR:

- National Elevation Dataset (NED)
- Lidar-derived DEM (L_DEM)
- Florida Fish & Wildlife Conservation Commission (FWC)

The NED is a seamless contiguous United States DEM generated by the USGS. It is derived from a variety of traditional and current sources of elevation data, including topographic contours produced over time by the USGS, radar (IFSAR), and Lidar. It is available in 30, 10 and 3-meter horizontal resolution, which varies by geographic area. Florida reportedly has areas that are covered by all three resolutions, although this could not be confirmed. This product offers seamless coverage of the Matanzas Basin study area, at both the 30 and 10-meter resolutions, derived from data ranging from the 1950s to the 1990s. Additional information with regard to the creation and content of this data can be found at: http://ned.usgs.gov/.

One major limitation of the use of NED for this project is its relatively gross vertical resolution. *The accuracy of the National Elevation Dataset (NED) varies spatially because of the variable quality of the source digital elevation models (DEMs). As such, the NED inherits the accuracy of the source DEMs. The most recently published figure of overall absolute vertical accuracy expressed as the root mean square error (RMSE) is 2.44 meters*. Details of this analysis are explained in the Vertical Accuracy of the National Elevation Dataset paper, and are published in the *Digital Elevation Model Technologies and Applications: The DEM Users Manual 2nd Edition* (from: http://ned.usgs.gov/Ned/faq.asp#VERTICAL).

One caveat to note about the accuracy assessment presented by the USGS is that even though the reference control point data set is large, the number of quadrangle-based USGS DEMs on which the points are located is relatively small. Approximately 11 percent of the source DEMs have at least one point located within. Thus, *if users have a need for very specific accuracy information for the NED for a local area, a separate assessment should be done with suitable reference data just for that area* (from: Vertical Accuracy of the National Elevation Dataset).

The L-Dem was sourced from the NOAA Coastal Services Center (CSC) and was created using several sources of Lidar Data. The majority of the original Lidar data was sourced from a statewide coastal collection, supervised by the Florida Division of Emergency Management (FDEM), over the course of 2008. Additional Lidar data were compiled by the CSC to fill in certain coastal gap areas, although specific locations of these gaps were not noted. L-DEM data were delivered by the CSC in a series of files that corresponded to National Weather Service districts. Overall vertical accuracy for this data is approximately 9-inches, based on the accuracy reports submitted by the original contractors supervised by FDEM.

These files were mosaicked together to create a statewide, coastal DEM. The inland extent of this DEM was limited, and gaps still existed in certain areas, including a portion of Flagler County.

The FWC DEM is a 5-meter resolution product that provides coverage for the "inland" portions of the State and is intended to "*map and catalog aquatic habitat*.". The following description is taken from the metadata associated with the DEM.

"*The Florida Statewide 5-meter digital elevation model (DEM) was generated primarily from gridded Tagged Vector Contours (TVCs) produced by Florida Department of Environmental Protection. This data, representing over 1,000 USGS topographic maps from the1950's to 1980's, spans a variety of contour intervals including 1- and 2-meter and 5- and 10-foot. In addition to gridded TVCs, the FWC production process includes the introduction of over 90,000 surface control points to ensure vertical accuracy of the* *resulting 5-meter elevation model. The measured accuracy of the FWC-produced 5-meter digital elevation model, using almost 10,000 independent test points, yields results that are within National Map Accuracy Standards for vertical accuracy. The contour intervals vary across the state therefore the value for the accuracy also varies. The Florida Department of Emergency Management is currently collecting LiDAR data for the state's coastal areas. In order to avoid duplication of work effort, the coastal areas which have or are scheduled to have LiDAR data available are not included in this statewide DEM work effort. In order to make the data more manageable, and since the topography of the state varies considerably from north to south, the state was divided into three blocks for data processing."* (from: http://research.myfwc.com/). The vertical resolution of this DEM varies from 1 to 10-feet, dependent on the geographic area of coverage.

Ultimately, two DEMS were created for use in the project due to delays in the availability of data. An initial 10-meter mosaic of coastal Lidar and NED data was created for use in the SLAMM modeling, which was on an early timeline. Subsequently, a mosaic of coastal Lidar and inland FWC data was created for use in the sea level rise inundation and storm surge modeling. For both products the mosaic was necessary to eliminate data gaps in the study area.

Inundation Layers

Inundation layers were created using the simple "bathtub" methodology, using projected sea level rises of 0.5-meters and 1-meter and the Lidar/FWC composite DEM as inputs. These projections were chosen as most likely low and moderate levels to occur within the relative time frame addressed by the project. The bathtub approach identifies all land areas with elevations below the chosen sea level value and classifies them as inundated. These inundated areas are then converted into polygons for further classification and summary of total area. There are numerous descriptions of the characteristics of this method in the literature, several of which are cited in the Bibliography.

While it is simple and straightforward, the bathtub method often has the effect of overestimating the total area of inundation. This occurs because both hydrologically connected (i.e. land areas in direct proximity to the "sea") and non-hydrologically connected areas are summarized as inundated. These non-hydrologically connected areas are typically low lying interior areas such as wetlands or isolated water bodies. One method to reduce the overestimation is to selectively filter polygons by size or location to remove isolated areas.

References

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