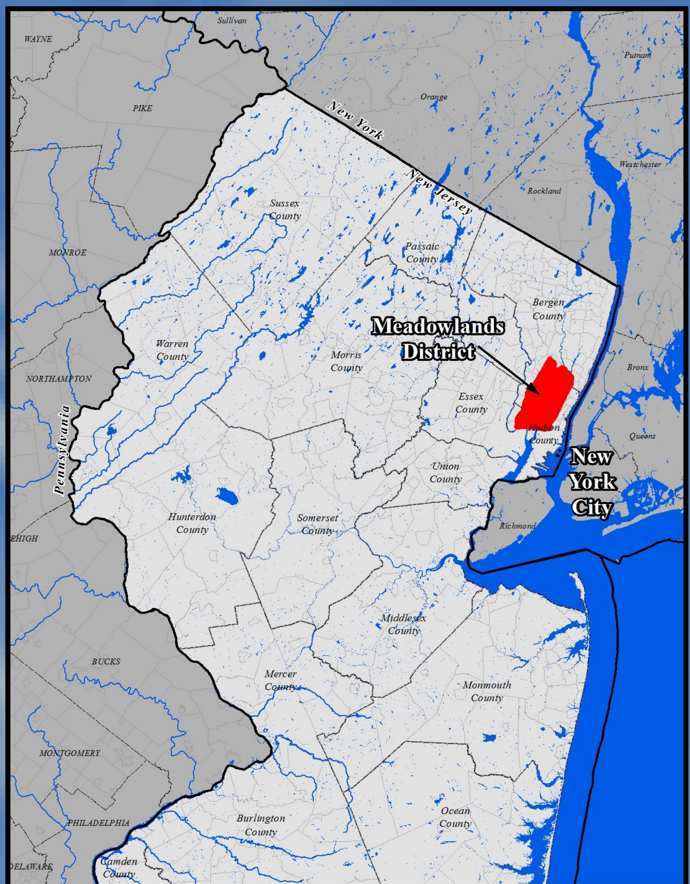
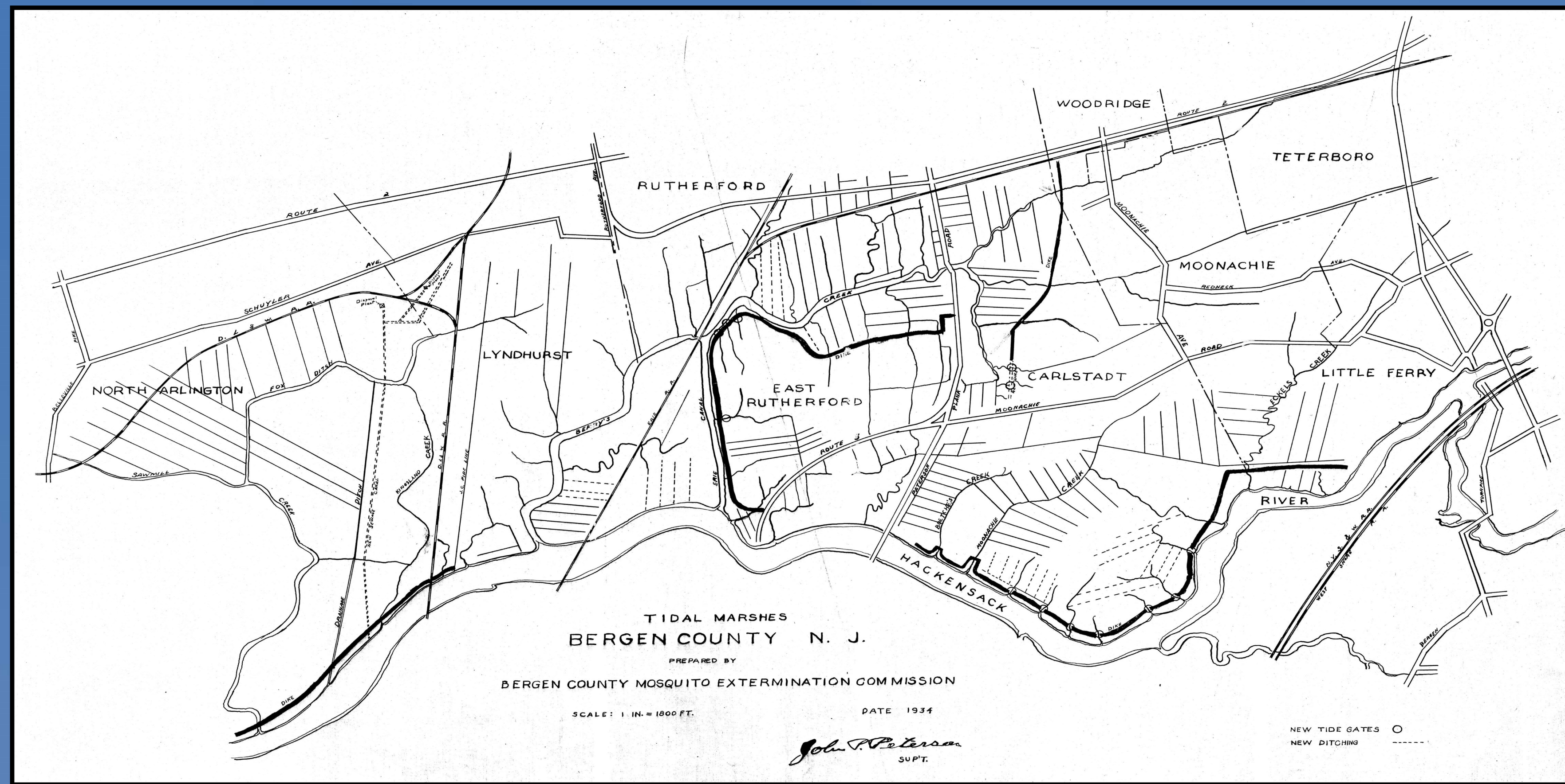
Mapping Earthen Berms in the Meadowlands

Soft Edges Around the Hackensack River Watershed



The Meadowlands region sits less than five miles from the heart of Manhattan. The 30.4 square mile District includes sections of 14 municipalities within Bergen and Hudson county.



Early ditching efforts by the Mosquito Commission resulted in berms around the Meadowlands and are found throughout the Hackensack River Estuary. These earthen man-made berms were not intended to be flood control structures. In events such as a storm surge these structures are susceptible to overtopping.

Superstorm Sandy:

During this unprecedented storm the towns of Moonachie and Little Ferry were hardest hit. The damage, caused by the upwelling storm surge from the Atlantic Ocean up the Hackensack River, struck residential and commercial areas of the towns with inland flood water levels over 3 feet. Meadowlands Environmental Research Institute (MERI) water sensors on the Hackensack River in Carlstadt recorded a depth of 9 feet of water lasting six hours during the night of the storm. Water levels at this height and duration overtopped many earthen berms in the Meadowlands District. These berms are mainly legacy Mosquito Commission dikes not intended as flood control structures. In an effort to assist the towns MERI is studying and identifying these soft edge areas and their effect on the ingress of storm surge water from the Hackensack River.

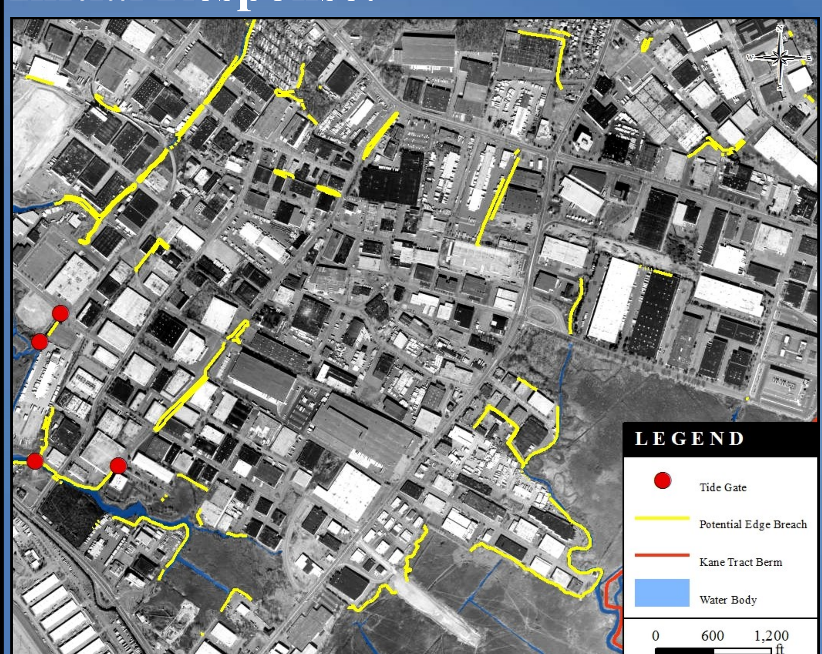
Using elevation rasters, hydrology rasters and vector data MERI is attempting to locate these soft edges. Information on the location of soft edges and studying their impact on the topography will be used for further analysis on flooding in the Meadowlands and the next potential storm surge.

This analysis used a digital elevation model (DEM), a slope raster, a slope aspect raster and a curvature raster. The data from these rasters were combined into a four band raster for use in a classification analysis. Each individual raster being one band in a single composite raster which was then processed for classifications of similar patterns. The idea being that soft edges share similarities:

- Located at low elevations
- High degree of uphill slope on the either side
- Low degree of slope on the top
- Weak points having a concave linear profile
- Breaks in elevation

The results from this ongoing study will be used in combination with our existing flood prediction maps for use in emergency management and preparedness.

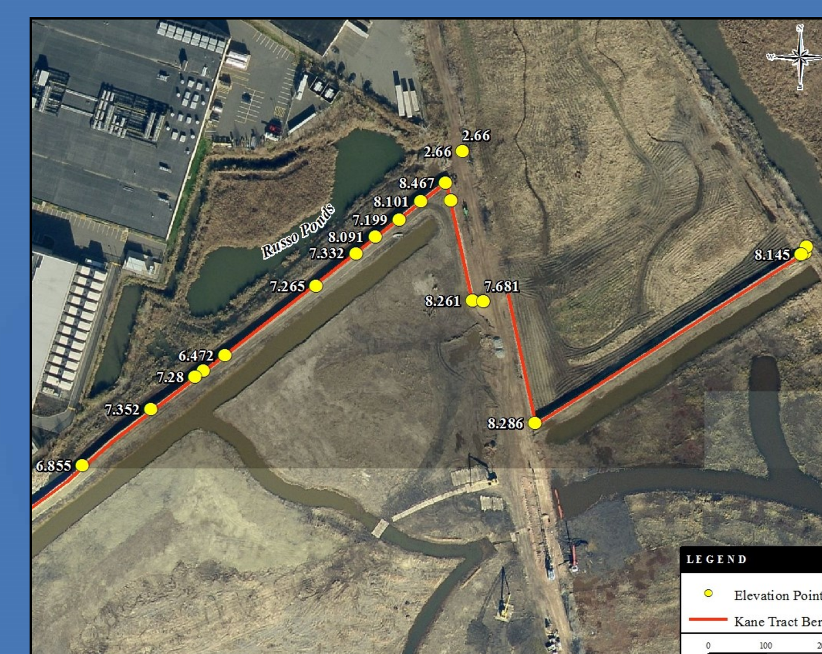
Initial Response:



An initial assessment of berms in the District was done by digitizing known locations and interpreting aerials, topo's and slope rasters.

The lines in yellow represent potential soft edges within the project area. Approximately 15 linear miles of these soft edges were found using this method in Carlstadt, Moonachie and Little Ferry.

Elevations were taken along the known berms. This effort was to understand the heights of these structures that were overtopped by Superstorm Sandy.

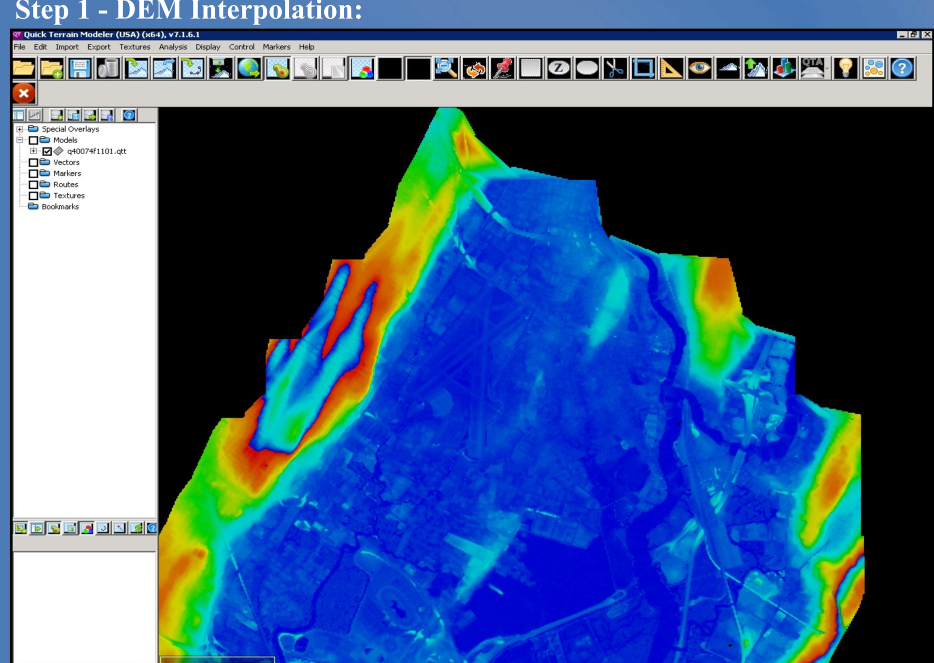


A berm constructed in 2010 within the Richard P. Kane mitigation site was overtopped by the Sandy storm surge. Field work was conducted to collect GPS elevations from the top of the berm and the resulting data complimented MERI water sensor readings.

It should be noted the structure is not intended for flood control.

Edge Detection:

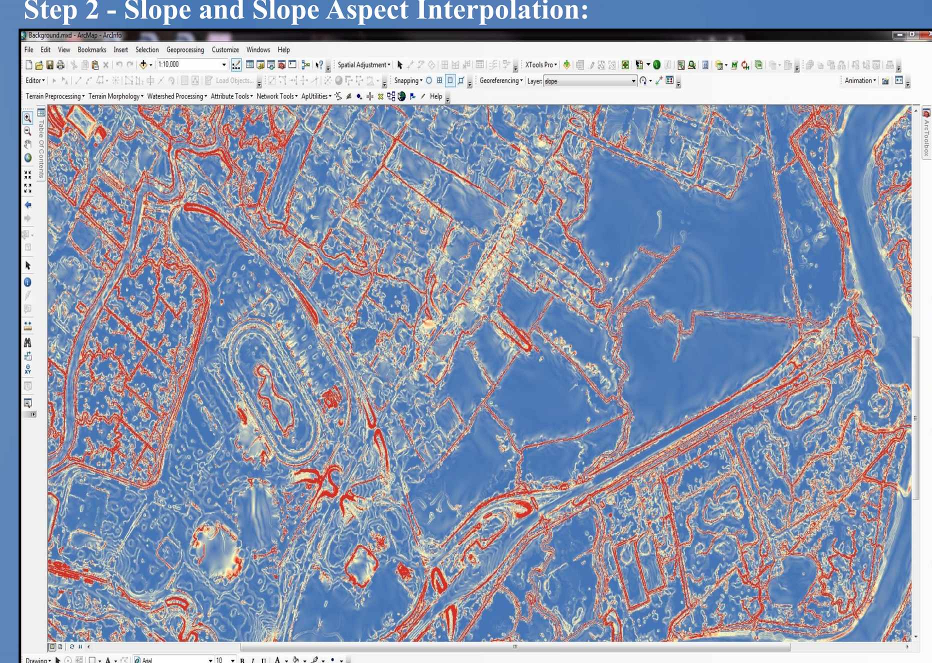
Step 1 - DEM Interpolation:



In order to locate soft edges in cases of flood waters between 1 to 10 feet, a high resolution DEM is needed. The berms which need to be identified are located along wetlands, rivers, streams and other low lying areas.

The DEM used was created using 2009 LiDAR data. The point cloud tiles were imported into QT Modeler and processed as a group to output a bare earth terrain. The resulting data was then exported as a grid file with grid sampling at two feet. This resulted in giving us a DEM compatible with ArcMap and having a 2ftx2ft cell size.

Step 2 - Slope and Slope Aspect Interpolation:

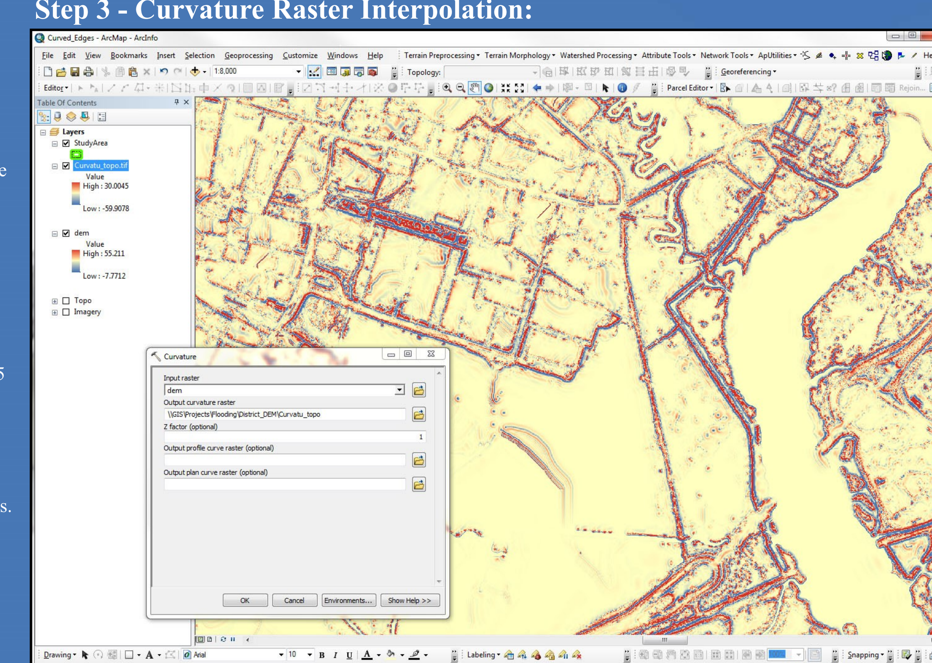


The slope profile of a berm is a high degree on the sides and low degree on the top.

A slope raster was created from the DEM. A slope aspect raster depicting the direction of the downhill slope was created and added another band into the composite raster.

In the analysis slopes of less than 5 degrees were used. This provided the top of the berms and all other flat surfaces. The unneeded areas were erased. These areas being uplands, water bodies and wetlands.

Step 3 - Curvature Raster Interpolation:



A concave curve along the length of a berm can indicate a weak point depending on the bottom elevation of the curve. Including a curve raster as a band provides another degree of classification.

The Curve Raster was created using Curvature (Spatial Analyst) to show the following:
positive = convex (top of berm)
negative = concave (sides of berm)
close to zero = flat (non-berm)

The curve raster also allowed us to differentiate a berm from a ditch.

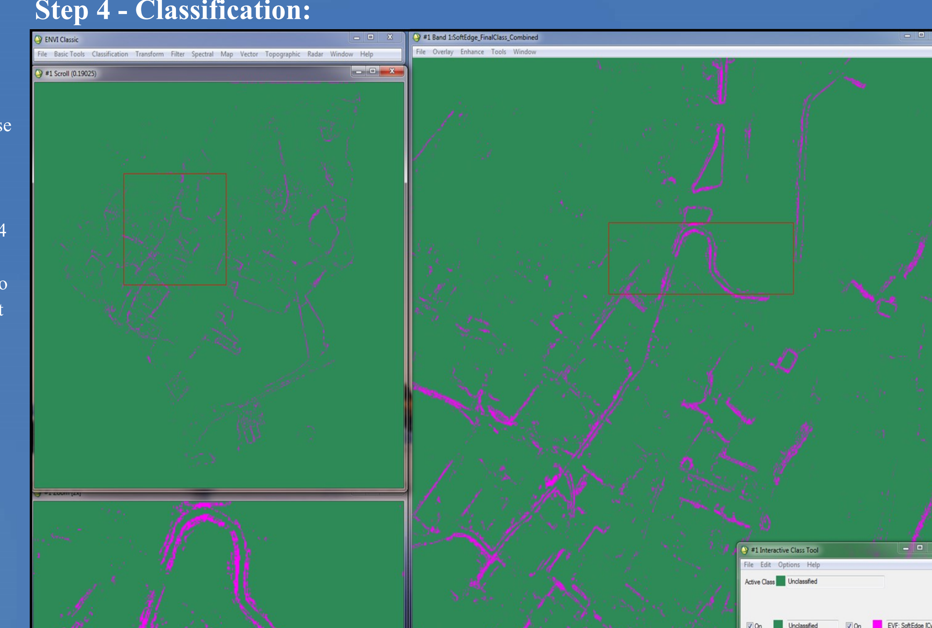
Step 4 - Composite Multi-Band Raster:

Four raster files: DEM, slope, slope aspect and curvature of the study area - created in ArcGIS 10 environment were converted to .dat format and imported to ENVI® (Environment for Visualization, Excelis Inc.). In ENVI a multi-band image was created using ENVI's Layer stacking feature in order to attempt image classification. The result was a four band image where each pixel had a unique combination of elevation, slope, slope aspect and curvature values.

Step 4 - Masking and Erase:

A mask of wetlands, water bodies and buildings was created in ArcGIS. This mask was then applied to the 4 band image to erase low lying, flat wetland areas and pixels that represented buildings from the image. Additionally a band threshold was applied to the 4 band image, where only pixels showing a slope value between 0 to 5 degrees were selected. The result showed only pixels that were not wetlands or buildings and had a relatively flat surface.

Step 4 - Classification:



Training areas were selected prior to image classification, identifying areas with high elevation, that were not berms, areas with low elevation that were not top of the berms, areas that represented creeks or wetlands and areas that were known soft edges. Maximum likelihood classification was applied to the image using these training areas as classes. Maximum likelihood calculates the probability that a given pixel belongs to a specific class. Each pixel is assigned to the class that has the highest probability i.e. the maximum likelihood. The result is a single band image, where each pixel is allocated to the class with the highest probability. All the non-soft edge classes were then combined into one class and named as unclassified. All the various soft edge classes were combined into one class and named as soft edge.

Results:

Pictured above is the result of the classifications; a known soft edge in red was overwhelmed during the Sandy storm surge. The soft edge is along a section of DePeyster Creek in Little Ferry adjacent to a residential area. The residents in this area experienced 3 feet of flooding in this neighborhood. The definition of the classification in red is top of berm with elevations below 5 feet.

New Jersey Meadowlands Commission
Meadowlands Environmental Research Institute
Geographical Information Systems Department
1 DeKorte Park Plaza
Lyndhurst NJ, 07071
Authors: Saleh Kojak, Ildiko Pechmann, Dom Elefante, Adam Osborn

New Jersey Meadowlands Commission

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