Hydrodynamics of the Condado Lagoon

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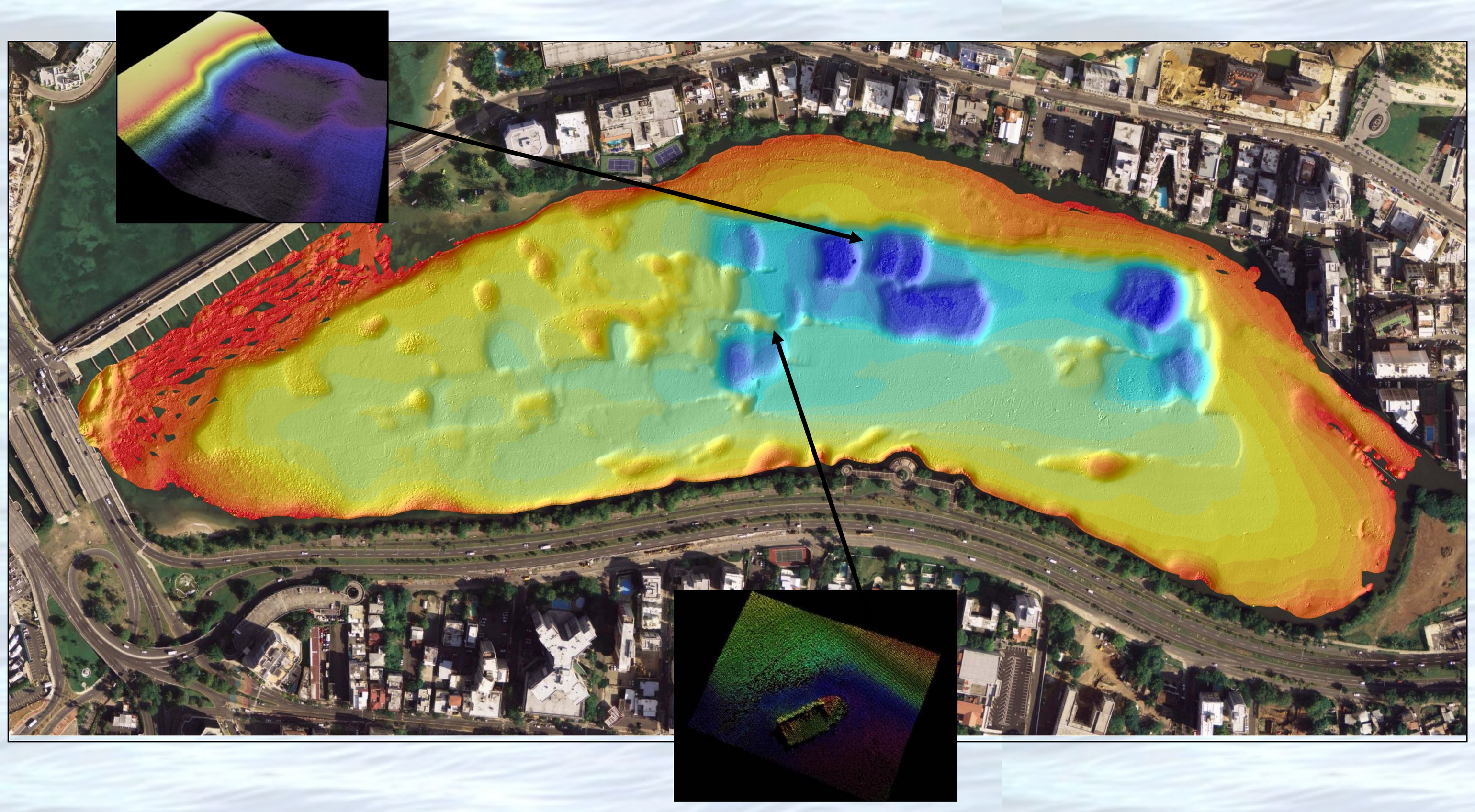
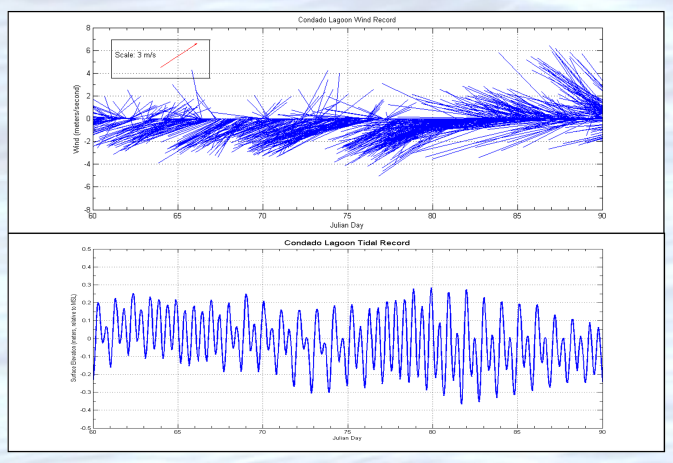
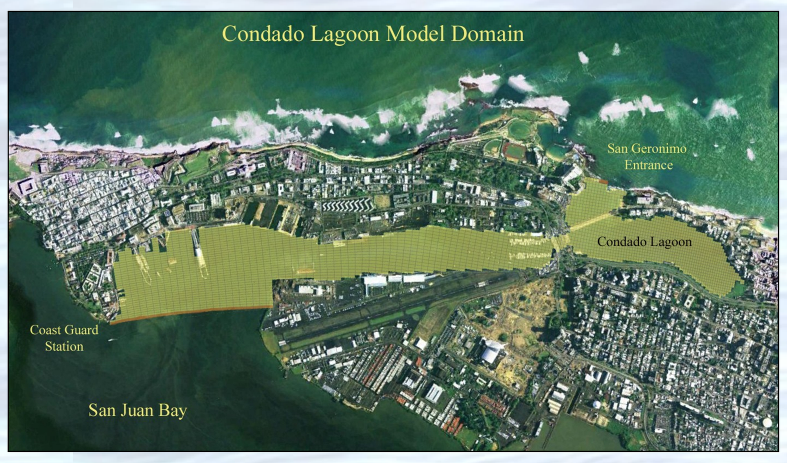
The Condado Lagoon was dredged in the late 1950's in order to obtain fill material for the foundation of the Baldorioty de Castro Avenue, which borders the lagoon to the south. Biological surveys indicate that the lagoon's flora and fauna were severely affected by the dredging activities, with essentially zero life surviving within the dredging footprint . In an effort to restore the lagoon to its original pristine condition, Caribbean Oceanography Group was engaged to determine the grain size requirements necessary to ensure the stability of any fill material to be placed within the dredging footprint. The Environmental Fluid Dynamics Code (EFDC) Hydrodynamic model was implemented in order to determine the required characteristics of the fill material. The results are shown below.

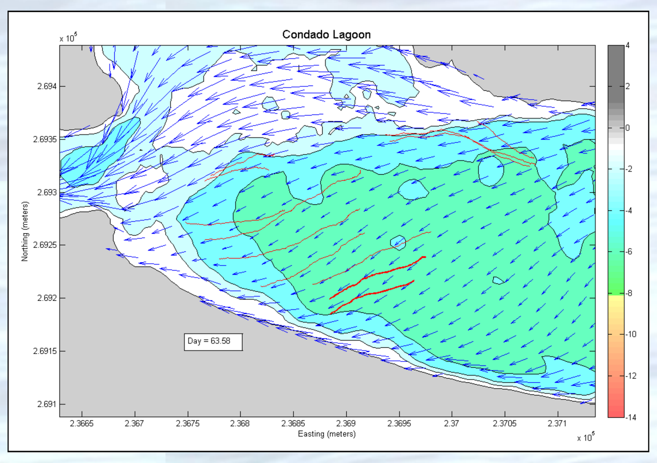
Condado Lagoon at Present. Note Baldorioty de Castro Avenue along southern border. Material for the foundation of the avenue was obtained by dredging the lagoon (See image of Multi-beam Sonar bathymetric data at right, courtesy Kyle Enright, TetraTech).

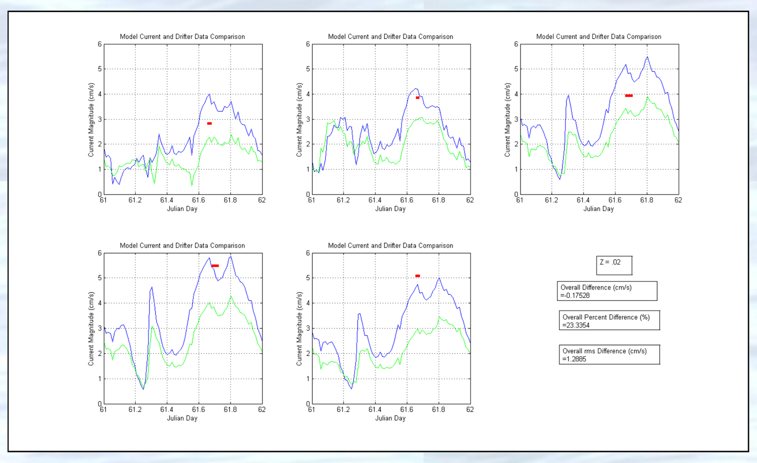


Condado Lagoon circa 1951. Note absence of Baldorioty de Castro Avenue.









The hydrodynamic model Environmental Fluid Dynamics Code (EFDC) was set up to model the circulation within the Condado Lagoon. EFDC was driven with the local winds and tides, obtained from the Coast Guard Station located at the western end of the model domain (left). A curvilinear grid was set up to properly capture tidal dynamics at western end of the lagoon (left center). The model was calibrated with the use of "holey sock" type, gps-tracked Lagrangian drifters (See drifter tracks overlaid on the model surface currents, center right). The model was found to satisfactorily correspond to observations (See calibration data, right).

The outputs of the EFDC runs are shown at right. The top row corresponds to an incoming spring tide, the bottom row to an outgoing spring tide. The left column represents the surface currents, the center column shows the bottom currents, and the right column depicts the mean circulation.

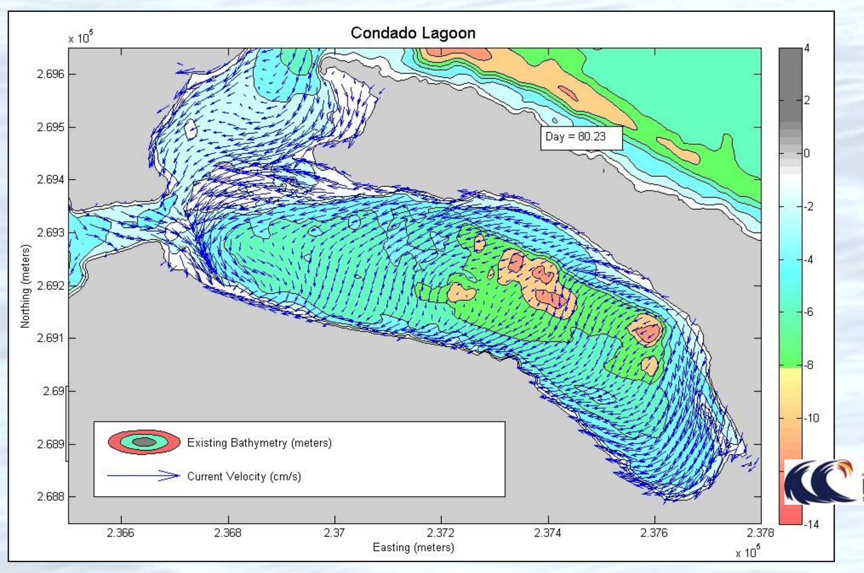
Note that the mean and bottom currents at the dredged location flow towards the northeast, against the wind. This fact, as well as the high correlation between the wind stress and the shear stress indicate a largely wind driven circulation, with tidal influence important only near the western end of the lagoon.

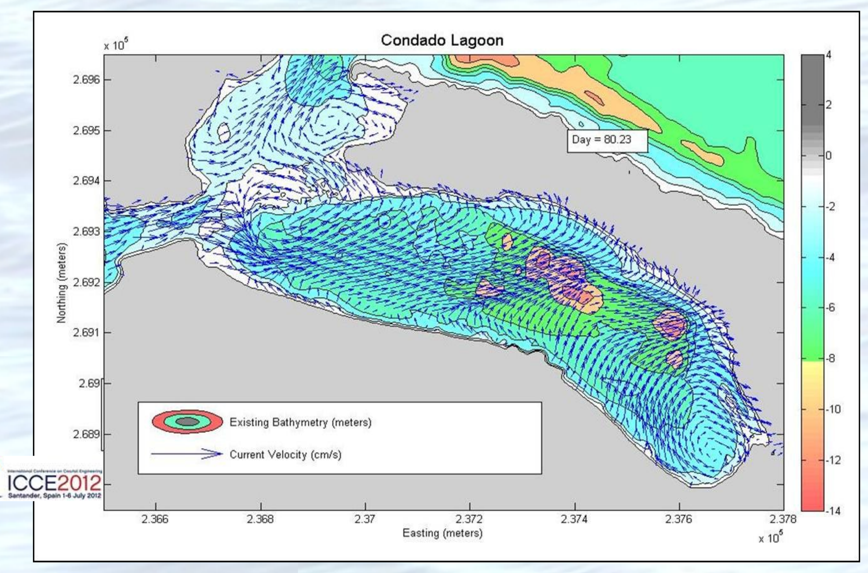
Note also that the currents at the northwestern shore of the lagoon are always towards the west, regardless of the tidal phase. Consequently, this shore is under constant erosional stress, the cause of the ongoing (and failing) efforts to maintain a beach in this location (See photo, below left).

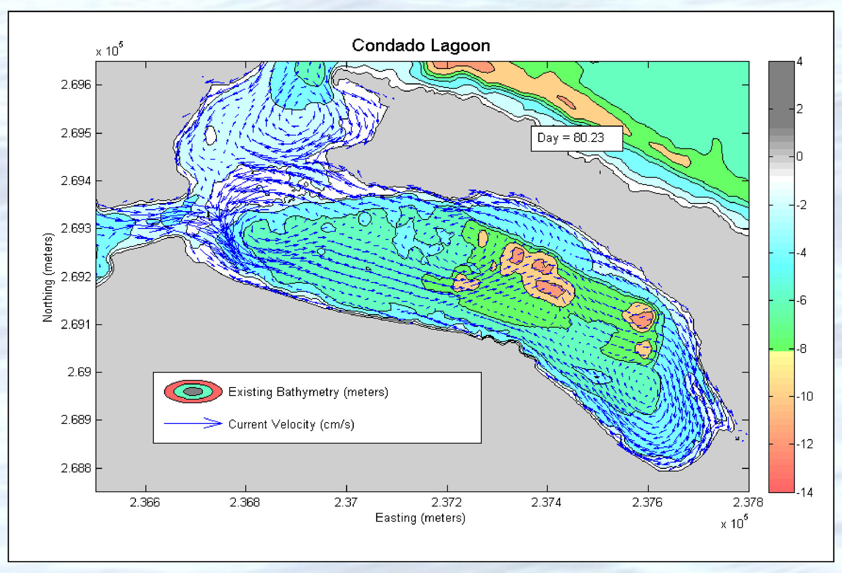
In addition, note the circulation pattern at the southwest corner of the lagoon. Every tidal cycle brings a decelerating, sediment laden current to the area. This results in the deposition of sediment, and the consequent accretion leads to the formation of a beach at this location (See photo below right).

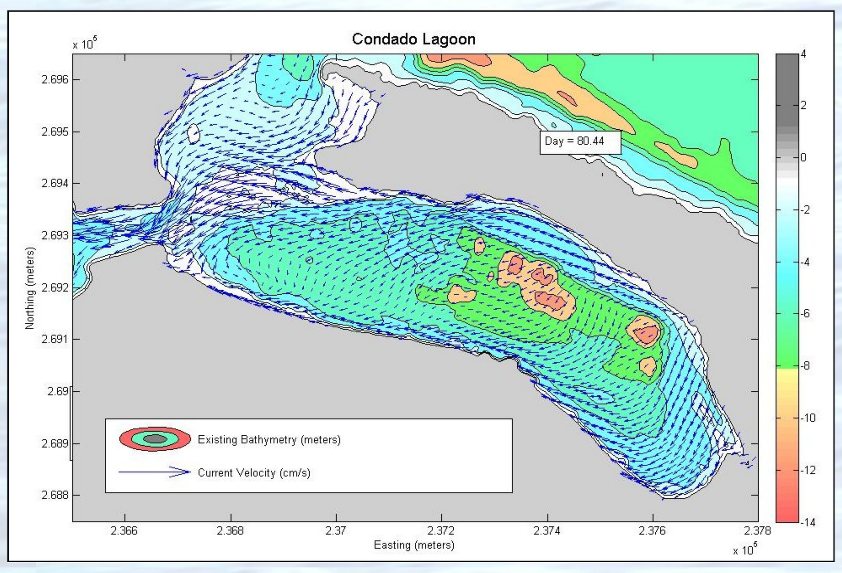
A statistical analysis of the wind records for the area was carried out (See results, bottom left). The model was then driven with winds corresponding to a 98% exceedance scenario. The direction of the shear stress was confirmed to be towards the northeast. In addition, the Shields relation was used to determine the allowable grain size for fill material. It was found that the maximum shear stress occurred at location A-2, where a median grain diameter of 0.46 mm was required for stability. It was also found that any material smaller than the stated minimum would be transported towards the remaining fill locations, where the stability requirements are smaller. Thus the fill material will remain stable and within the restoration area.

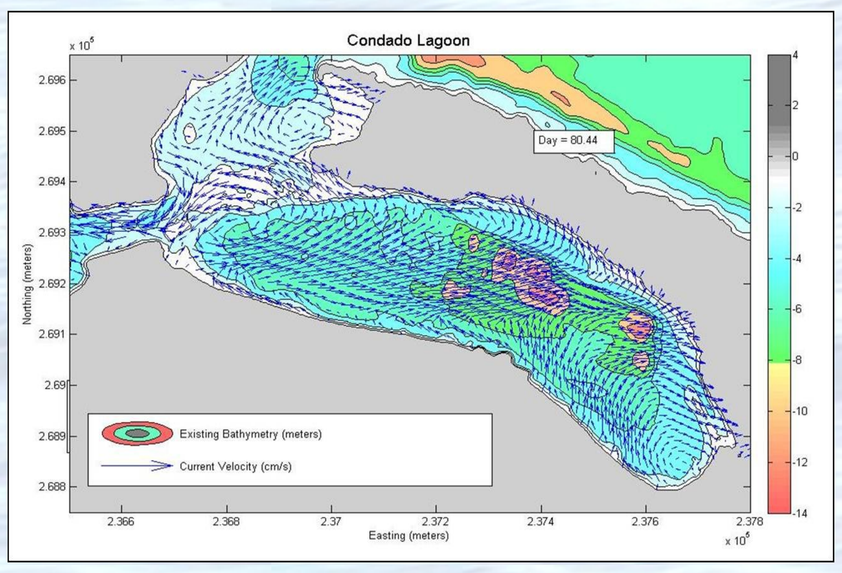
The available material for the restoration exceeds these requirements, so the conclusion of the analysis is that the restoration is feasible as proposed.

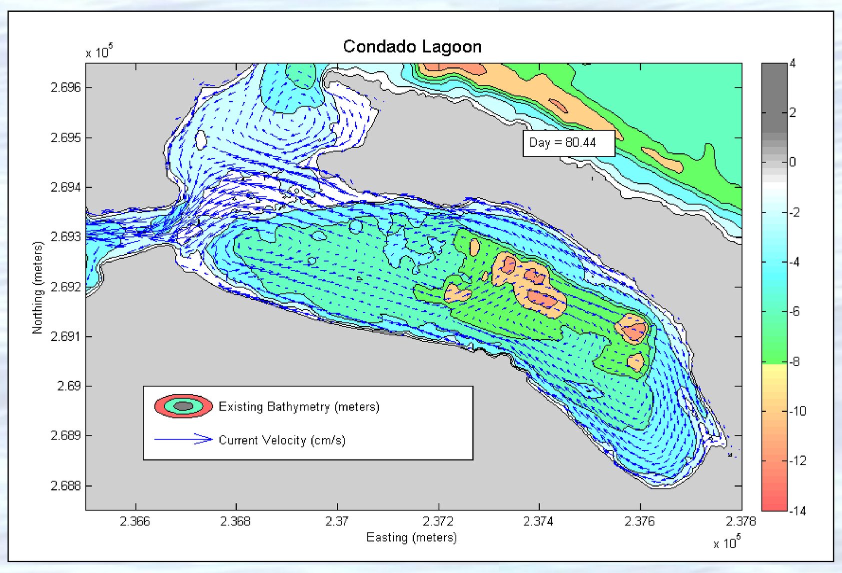






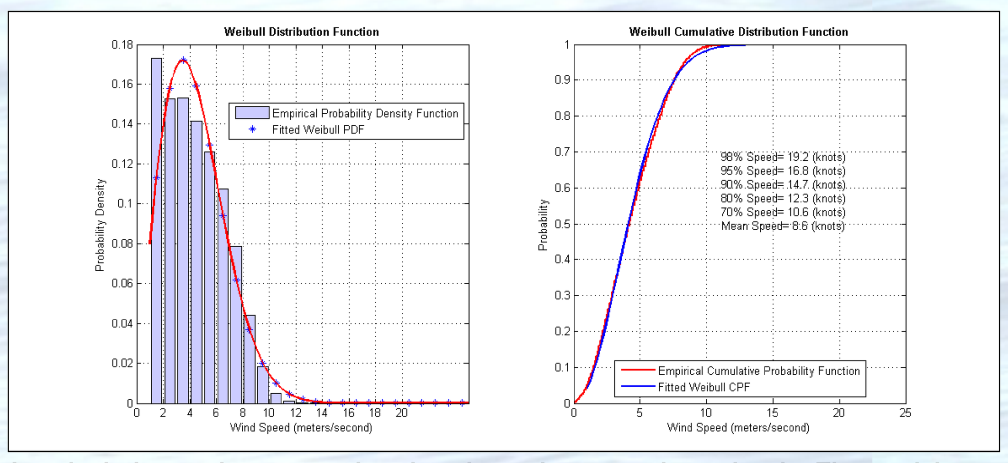




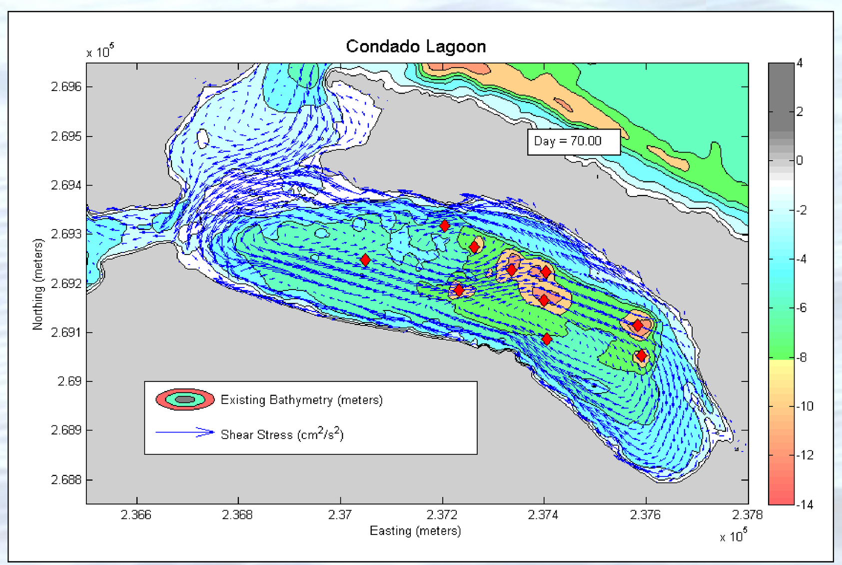


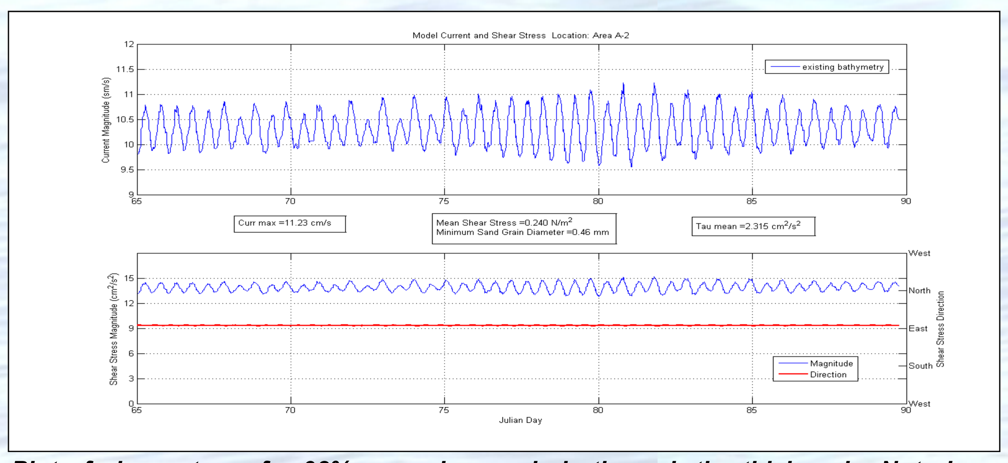
Northwest shore of Condado Lagoon. Note ongoing attempts to keep the shore from eroding.

Southwest shore of Condado Lagoon. Note accreting shoreline.



Local wind records were analyzed to determine exceedance levels. The model was run using various wind speeds, including that corresponding to the 98% exceedance level. The shear stress under such a scenario is shown in the center plot. Note direction of shear stress within the restoration area.





Plot of shear stress for 98% exceedance winds through the tidal cycle, Note how wind dominates shear stress. Under these extreme conditions, medium and fine sediments (d<0.46 mm) will be transported from location A-2 to other locations within the restoration area, where it will become stable.

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