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Developmental History of Return-Flow Channels Caused by Hurricane Harvey at San Jose Island, Texas, USA

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We investigate the erosional development of return-flow channels that were cut across the seaward side of San Jose Island during storm surge ebb following the landfall of Hurricane Harvey in 2017. These channels have multiple upstream heads with single, elongated downstream necks. Some channels have smaller side channels perpendicularly attached to the main necks. Bathymetric transect measurements along and across four channels show the channel-bottom elevations ranging from 0.78 m to 1.95 m below mean sea level, with the deepest parts being near their upstream heads and knickpoints. These deep spots resemble plunge pools of horseshoe waterfalls, suggesting a similar set of developmental mechanisms associated with flow focusing. Scours preserved on the landward side of coastal dune ridges record a seaward flow direction. Four large barges drifted across the island during return-flow, coming to rest on the coastal dune complex without producing erosional features on the island surface. A rack line of debris was observed ~ 4 m above mean sea-level on the landward side of the dune ridges. The rack line and the barges are interpreted as indicators of a high and slowly draining water level during channel formation. Vegetation density appears to have controlled erosion rates as sediment samples collected at seaward and landward points along the channels show a similar grain-size distribution. A pre-hurricane airborne lidar survey collected by the U.S. Army Corps of Engineers in 2016 and a post-hurricane survey flown by the Bureau of Economic Geology at UT-Austin in 2017 are used to quantify beach morphological change associated with channel formation. The 2017 lidar survey shows the development of 22 return-flow channels. The estimated total minimum volume of channel erosion from the difference map of the two surveys is 957,429 m3. The mean values of the maximum and the minimum main channel lengths are 287 m and 235 m, respectively. The mean values of the maximum and the minimum main channel widths are 94 m and 66 m, respectively. The main and side channel widths show a positive linear correlation with their corresponding main and side channel lengths. The side channel widths show a positive linear correlation with their corresponding main channels widths. A return-flow channel model was constructed using ANUGA, a hydrodynamic modeling suite. A simplified channel of constant elevation was superimposed onto the 2016 lidar survey with the head of the channel being between two dune ridges. The model was run by releasing the flow from the bay into the ocean. The model illustrates flow focusing through saddles in the back dune ridge. This implies that channels took advantage of these low points during their initiation. Estimated velocities are always greatest at the channel head due to significant focusing of the flow. Capturing of lateral flow by the incipient channel defines the mechanism for development of perpendicular side channels. Velocity fields will be used to estimate acceleration fields, which in turn will be used to estimate the patterns of sediment erosion and deposition that produced the channels during the return-flow event.