PRESERVING THE LAST OF ILLINOIS’ SHORELINE: ECOLOGICALLY-DRIVEN SHORELINE STABILIZATION TECHNIQUES FOR INLAND LAKES

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# INTRODUCTION

The coastal processes of large inland lakes, such as the Great Lakes, vary from that of tidally influenced shorelines. Water level fluctuations within the Lakes have time scales on the order of months and years versus hours. This amplifies the cyclic coastal processes more commonly experienced along tidal waterways such as cross-shore sand movement, dune erosion, inland flooding, and bluff failure. A perfect combination of climatic events led to record breaking water levels within the Great Lakes in 2019-2020 resulting in widespread erosion and damage; the effects of which will be felt for years to come.

Illinois Beach State Park (IBSP) represents the last contiguous 6.5 mile pristine shoreline within the State of Illinois. Conservation efforts in the 1960’s entrusted this land to the State to be held and preserved for all to enjoy. Today the park remains largely undeveloped with 4,160 acres dedicated mainly to natural habitat and passive recreation.

Geologically speaking, the park sits atop a migratory beach-ridge characterized by sand ridges separated by low wetland swales which are home to over 650 species, some of which are rare and threatened. The land itself provides a visual history of the layering of the primary frontal dune marching lakeward as the beach-ridge migrated south. Human development, however, has stabilized the beach ridge to the north, cutting off sand supply to the park. The very coastal process that created this landform will eventually lead to its ruin.

DESIGN OBJECTIVE

The park is maintained and operated by the Illinois Department of Natural Resources. Due to the rapid erosion and loss of rare wetlands associated with historically high-water levels and the projection of further increased water levels due to climate change, they sought shoreline stabilization solutions which would be inline with the character and mission of the park. While the primary goal is to protect the shoreline and adjacent wetland from erosion and inundation, secondarily the natural aesthetic of the park should be maintained through the implementation of low-crested, natural looking structures which provide ecological enhancements.

APPROACH

Approaching this problem, a number of hydrodynamic & sediment morphology numerical models were used to determine the areas of highest erosion rate within the park. Sediment transport rates during periods of higher water level were determined along the entire shoreline to highlight areas of greatest potential of continuous and excessive erosion. When compared against locations of adjacent rare wetland habitat and recreational infrastructure, three zones where coastal intervention would have the greatest influence on the park shoreline as a full system were identified. This approach allowed the State to more wisely apply available construction funds where they would have the greatest impact and keep engineered structures out of areas which are inherently more stable.

As the park is naturally migratory, the goal was not to stop the inherent process of sediment migration from occurring but rather to slow down the rate so that the whole park would become more stable based on balancing transport rate to available updrift sand supply. This would be accomplished through installing a series of offshore structures which have various levels of effectiveness based on the water level. This, in itself, became a challenge as the relative distance of the offshore structure to the waterline fluctuated with the water level resulting in varied long-term impacts (e.g. formation of a salient versus a tombolo).

Shoreline stabilizing structures can be categorized in two types: shore-attached and offshore. Shore attached breakwater form physical barriers to longshore or cross-shore sand movement, highly disrupting sediment migration downdrift until they ‘fill’ and begin to bypass material. Offshore structures, on the other hand, reduce wave energy within their shadow and therefore reduce the potential to lift and move sediment. This process is less disruptive as it still allows storms of greater wave climate to transmit past the structure or diffract around resulting in some level of sediment migration.

The open shoreline and regular impact of waves greater than 3 ft did not allow for a full ‘living shoreline’ solution, yet structural solutions which would jointly provide ecological enhancement in the form of aquatic & avian habitat opportunities was desired. Atypical structural cross sections were developed consisting of various materials, structure slopes, frontal berms, and lee-side pools; all with the potential of attracting aquatic habitat. Recognizing the complexity of wave-structure interaction on these non-traditional structures, each was tested under various water-level & wave conditions within a 2D-wave flume. Results of these tests, coupled with anticipated construction cost implications, guided structure design and layout to maximize the cost-value relationship and led to a better understanding of the impact of ecologically-driven design choices on structure performance.

Once the effective structure cross sections were understood, physical model testing was moved to a 3D-wave basin to examine the combination of transmission and diffraction around the structures and enhancements which could be added to further increase the structures effectiveness. This included two-prong low-crested weirs to interrupt wave phasing and turning the structures into predominate wave directions to maximize structure shadow and trick the resulting diffracted wave along the shoreline into a perpendicular angle thereby limiting sand movement. Over 50 structure layouts were tested across the three zones resulting in a new understanding of shoreline stabilizing structures within a lake environment and how they can be designed to enhance habitat without sacrificing performance.