Coastal Infrastructure Resilience on the Great Lakes: A Case Study for the City of Duluth on Lake Superior

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Background/Objectives. Water levels in the Great Lakes rose to record highs in mid-2019 and 2020, which caused extensive flooding, coastal damage, and economic losses. The high-water levels were exacerbated by prolonged periods of above-average precipitation throughout the Great Lakes basin. Such weather events are consistent with the notion that climate change will likely lead to increased annual and event-specific precipitation rates throughout the Great Lakes basin. Climate change also is likely to reduce winter ice coverage and strengthen storm events, which can further exacerbate future flooding through increased rainfall, winds, and seiche events. In 2018, a severe storm hit the City of Duluth with sustained winds of 35 to 40 mph. Wind gusts over 60 mph and waves reaching 18 to 20 feet were recorded. Near-record water levels on the lake, coupled with the strong winds and storm surge, created waves that were stronger and more destructive than previous storms, contributing to damages to the City shoreline on Lake Superior. Portions of the Duluth shoreline, storm water infrastructure, and recreational areas have been damaged by recent storms, including the 2018 event. Coastal areas in the Great Lakes, and elsewhere, are facing increasing need to managed erosion and improve resiliency against high-energy events in a climate-changing environment.

Approach/Activities. Ramboll is working with the City of Duluth to conduct a risk assessment for coastal erosion and flooding along the shoreline of Lake Superior in the vicinity of the City. The risk assessment involves a geomorphological survey of existing conditions and shoreline erosion; estimates of shoreline erosion rates based on historic trends and predicted future conditions; identification of critical public infrastructure assets, including utility infrastructure, flood or retaining walls, and public gathering spaces, roadways, and recreational areas; a Visual Condition Assessment of critical assets; and development of a risk matrix for assets assessed including current condition, likelihood of failure, and consequence of failure. Infrastructure assets are prioritized and conceptual designs are developed for coastal resiliency alternatives. The City also will address the functional and financial consequences to assets over time if no action is taken.

Results/Lessons Learned. This paper will discuss the outcome of the shoreline erosion assessment and asset valuation process. We also will present design alternatives to enhance the resiliency of the shoreline and thus minimize ongoing coastal erosion processes. The evaluation includes innovative solutions that change the thinking on how best to protect vulnerable assets, using solutions that are both nature-based yet robust and resilient enough to stabilize the shore and adapt to future changing conditions. Some of the innovative approaches include the use of high-resolution remote sensing techniques and hydrologic modeling to inform every stage of the design, including under future conditions, as well as the creation of improved ecological function and services through an in-depth initial ecological survey. Shoreline restoration alternatives may include shoreline/riparian structural upgrades, improved habitat to improve resiliency, offshore structures to reduce wave energy, managed retreat from the shoreline, or combinations of alternatives. Understanding the local ecology provides a design baseline for how and where to incorporate appropriate site- specific native plant communities and other nature-based features to enhance biostabilization, habitat resilience, and habitat creation both on and offshore.