A Comparative Cost Analysis of Ten Shore Protection Approaches at Three Sites Under Two Sea Level Rise Scenarios

Executive Summary

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The Hudson River

Sustainable Shorelines Project

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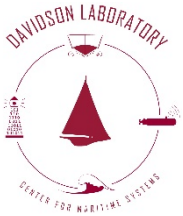

Executive Summary

The Hudson River Estuary is an extremely diverse, biologically rich, and economically vital body of water extending 152 miles from the southern tip of Manhattan north to the Federal Dam at Troy. Like many urban estuaries, the Hudson River Estuary has been modified significantly to serve the needs of the growing population centers located along its banks. As a result, the shorelines of the Hudson River Estuary have been dramatically altered over the last 150 years to accommodate development and industry, with over half of the shoreline having been engineered using traditional approaches such as rip-rap, revetments, bulkheads, or timber cribbing. The Hudson River Sustainable Shorelines Project is a multi-year effort led by the New York State Department of Environmental Conservation Hudson River National Estuarine Research Reserve in cooperation with the Greenway Conservancy for the Hudson River Valley with the overall objective of developing science-based recommendations for shore zone management that preserve, and where necessary, restore the balance between natural benefits and human use. Prior work completed under this project includes:

- The development of a demonstration site network;
- A comparison of the ecological benefits of various shore types;
- A literature review of sheltered shoreline stabilization alternatives;
- A characterization of the physical forces within the Hudson River Estuary;
- An analysis of the economic tradeoffs of various shoreline stabilization approaches;
- An analysis of the legal framework in the shoreline decision making process.

All prior work is accessible from the Hudson River National Estuarine Research Reserve, Sustainable Shorelines site: http://www.hrnerr.org/hudson-river-sustainable-shorelines/. The present work adds to the expanding body of knowledge by presenting a framework for analyzing the long-term costs associated with various shoreline stabilization options. This framework was then applied to perform a comparative cost analysis of ten shoreline stabilization alternatives at three specific sites under two sea level rise scenarios.

The framework was developed to ensure a consistent, repeatable, representative, and transparent analysis. Enough detail is presented in the full document to allow for rapid identification of the different cost components. In addition, sensitivity analyses were conducted to illustrate the impact of changing some of the assumptions used in the analysis.

The three sites that were selected represent a cross-section of sites typical within the Hudson River Estuary. Bowline Point Park along Upper Haverstraw Bay is a gently sloped site abutting a very wide, shallow section of the estuary, whereas the Poughkeepsie site has steep banks adjacent to a deep narrow section of the Hudson. The Henry Hudson Park site lies between the

two extremes defined by Bowline Point Park and Poughkeepsie. In order to enable a comparison across sites, a five hundred foot stretch of shoreline was considered at each location.

At each site, ten different stabilization methods were considered, ranging from traditional approaches such as bulkheads, crib walls, and rip-rap, to less frequently utilized alternatives such as vegetated geogrids and sills. Several of the options considered represent ecologically enhanced versions of some of the traditional approaches such as biowalls, live crib walls, and joint planting. A seventy year time frame was selected for the analysis and two separate sea level rise scenarios were considered. All costs are calculated in 2012 dollars and follow the federal guidelines for inflation and discounting in effect at the time of the analysis.

The seventy year timeframe enables a more complete consideration of cost which goes beyond just the initial construction cost. Each cost estimate includes consideration of important, yet frequently neglected, costs such as maintenance costs, replacement costs, and damage costs. Initial costs are calculated based on the site characteristics and either a bulk cost or unit/quantity method. Maintenance costs are estimated as a percentage of the initial cost and represent the cost associated with routine inspections and performing basic maintenance. Replacement costs refer to the cost of completely replacing a shoreline stabilization approach once it has reached the end of its serviceable life. For simplicity, replacement is assumed at the full cost of the initial structure adjusted for inflation and discounting. Damage costs are also formulated as a percentage of the initial cost and are costs outside of the typical maintenance costs that are associated with damage during extreme storms. All of the long term costs were formulated in terms of the initial cost to ensure consistency across methods and sites, and to facilitate any changes to any of the underlying assumptions.

The impacts of sea level rise are realized primarily through the damage costs, which are the costs associated with restoring the original function of the selected approach after a storm. Given the uncertainty surrounding sea level rise estimates, two scenarios which bracket the range of sea levels likely to occur over the seventy year analysis period were selected. The first is simply an extrapolation of the current trend, while the second is the so-called “rapid ice-melt” scenario utilized by the New York City Panel on Climate Change among others. Extrapolating the current trend results in a sea level rise of approximately 7.5” by 2080, while the rapid ice melt scenario predicts 48” by 2080. In both scenarios, the frequency with which damaging storms (here defined solely on the basis of water level) occur, and hence the frequency with which damage costs are incurred, increases with time.

Overall, a total of forty cost estimates were prepared. The results are summarized in Table 1. No one approach was found to be consistently cheaper than the others. The analysis did identify a few interesting trends; some of which are fairly intuitive, others less so. Not surprisingly it was found that the cost to stabilize the more mild sloped, sheltered shorelines at Henry Hudson Park

and Bowline Point Park were generally less than that for the steeper, more exposed Poughkeepsie shoreline. Because of the way in which costs were calculated (i.e. root systems were not assumed to have a significant stabilizing effect – see the full cost analysis for a more complete discussion), the relatively higher costs associated with the joint planting alternative (and to some extent the other vegetative approaches) is driven by the damage costs associated with replanting the vegetation after moderate storm events. On the other hand, the cost of many of the traditional approaches (bulkheads, cribbing, and even biowalls) is driven by a combination of the high initial cost and the ultimate replacement of the structure at some point over the seventy year period.

Table 1 - Summary of Cost Estimate.

Current Sea Level Rise Scenario						
		Poughkeepsie		Henry Hudson Park		Bowline Point Park
Wooden Bulkhead	$	375,292	$	271,348		N/A
Steel Bulkhead	$	1,255,906	$	989,845		N/A
Revetment	$	340,984	$	315,930	$	313,642
Rip rap	$	318,896	$	143,292	$	325,113
Crib Wall	$	308,531	$	232,515		N/A
Live Crib Wall	$	372,794	$	287,733		N/A
Joint Planting	$	491,088	$	231,799	$	496,511
Vegetated Geogrid	$	300,315	$	269,136		N/A
Bio Wall	$	1,102,131	$	569,330		N/A
Sill		N/A	$	241,874	$	173,106
Rapid Sea Level Rise Scenario						
		Poughkeepsie		Henry Hudson Park		Bowline Point Park
Wooden Bulkhead	$	688,203	$	497,593		N/A
Steel Bulkhead	$	2,372,407	$	1,869,818		N/A
Revetment	$	1,081,098	$	1,001,664	$	994,407
Rip rap	$	1,133,764	$	509,442	$	1,077,429
Crib Wall	$	765,821	$	577,137		N/A
Live Crib Wall	$	1,074,401	$	829,252		N/A
Joint Planting	$	1,826,545	$	862,150	$	1,846,714
Vegetated Geogrid	$	648,316	$	581,007		N/A
Bio Wall	$	2,185,780	$	1,129,114		N/A
Sill		N/A	$	464,930	$	332,745

Costs for all of the shoreline stabilization approaches increase significantly under the rapid sea level rise scenario primarily because the number of damaging storms, and therefore the damage costs increase markedly. When the current seal level rise scenario is considered, the initial cost generally makes up around 50% of the total lifecycle cost. Under the rapid sea level rise scenario however, this number drops to approximately 25%, as the maintenance costs, damage costs, and replacement costs make up the bulk (~75%) of the total cost.

Generally, the results show that when a complete accounting of all of the costs of stabilizing a shoreline over a seventy year period are considered, many of the non-traditional or ecologically enhanced approaches are cost-competitive, if not less expensive than some of the more traditional approaches. This result is consistent with a recent NOAA report entitled *Weighing Your Options,* which determined the costs of many "living shorelines" stabilization approaches were on par with bulkheads. While encouraging, the results also highlight the importance of thinking beyond the typical ten, twenty, or even thirty year timeframe on which most shoreline stabilization decisions are made.