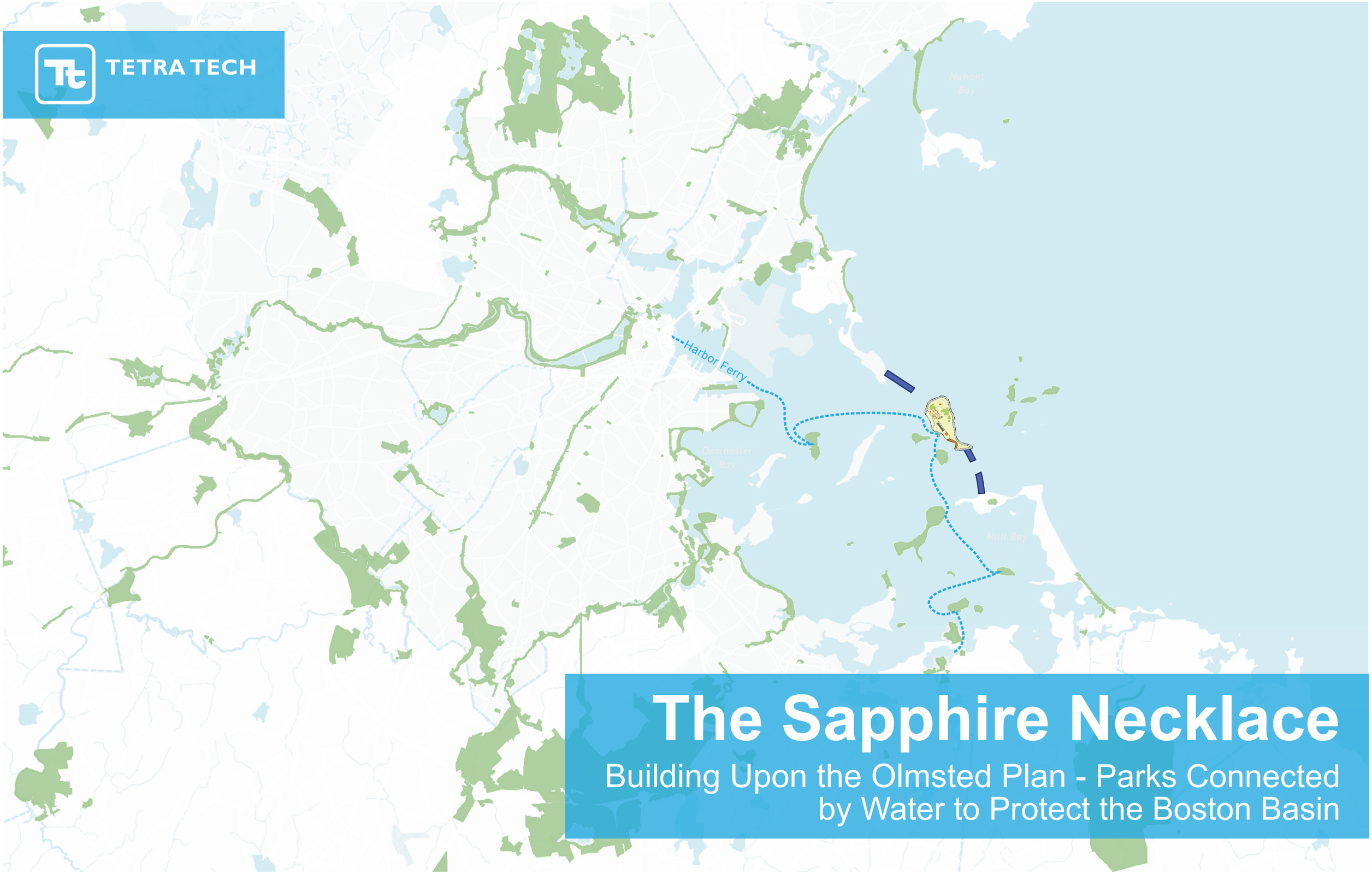
TETRA TECH



The Sapphire Necklace

Building Upon the Olmsted Plan - Parks Connected by Water to Protect the Boston Basin

CLIMATE CHANGE RISK FOR BOSTON

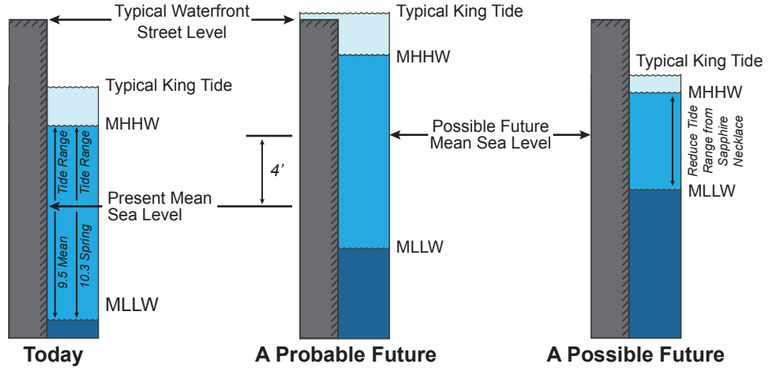
As has been documented in several studies, Boston is particularly vulnerable to flooding from sea level rise and more intense tropical storms because of its history of development. Much of Boston's urban core is located on filled tidelands with surface elevations only a foot or so over today's flood levels. Boston's risk was highlighted in the August, 2013 World Bank Report. "*Future Flooded Losses in Major Coastal Cites,*" which ranked Boston as the eighth most vulnerable in terms of overall cost of damages of the 136 largest coastal cities studied. That is because some of the most valuable real estate in the City, in fact, in the Country, is sitting on these former tidelands.

The Boston District Council of the Urban Land Institute has been convening a public workshop study "Living with Water, the Urban Implications" and published their report of that name in September, 2014. It looks in depth at resiliency strategies in the face of sea level rises of 2-6 feet by 2100 and significantly higher resulting storm surges in the Boston Harbor Basin.

Many of the resiliency ideas fight the flooding risk at the doorstep by raising critical life safety elements in buildings to higher elevations, converting streets to canals or diking off today's water's edge. This paper looks at another idea returning to the planning of Frederick Law Olmsted and his apprentice and successor, Charles Eliot, whose Emerald Necklace and Metropolitan Park System plans protected the basin from the land. The Sapphire Necklace is a water reflection of their land planning and looks to enhance the natural geomorphology of the outer basin to protect Boston.

RISING TIDE SCHEMATICS

Below are three schematic profiles of the Boston Waterfront showing today's 9.5 foot and 10.3 foot, non-storm, mean and spring tide ranges in relationship to the typical street levels along the Harbor and the Back Bay. Also shown are the typical "king" or the "12 foot" astronomical tides which occur every spring and fall. In the possible future of 2 to 6 foot rises in mean sea level, one can see even a 4-foot rise would inundate large areas of the waterfront and the Back Bay during normal king tides. In fact, with a rise of sea levels of 4 feet, even normal moon tides would probably flood low spots through the current drainage system for 3 or 4 days each month. The third profile shows the same 4-foot future sea level rise but with a reduced tide range.

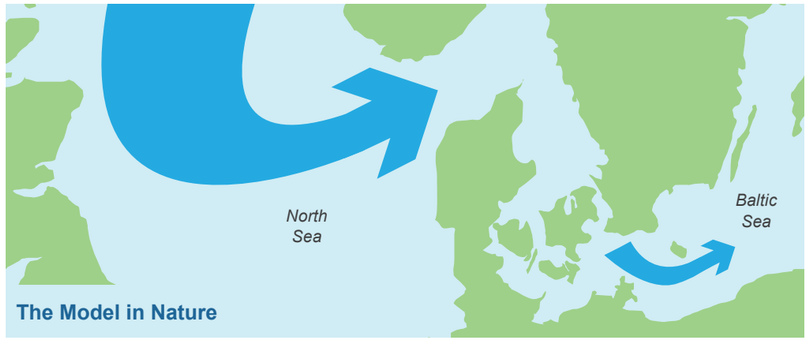


LESSONS FROM NATURE

The idea of the Sapphire Necklace is to work with the natural geomorphology of the rocky outer islands and the glacial residual arms of Winthrop and Hull which separate the Boston Harbor Basin from Massachusetts Bay and the Atlantic Ocean to reduce flooding. As the daily tides reach our shores they are shaped by the bay form and hydraulic character of both the sea floor and the shape of land they encounter. As an example, in the Massachusetts Bay end of the Cape Cod Canal there are 10-foot tides, yet on the Buzzards Bay end, a few miles away, 4-foot tides.

It is possible to change the hydraulic conveyancing capacity of the President Roads channels into the Inner Harbor and Dorchester Bay and of Nantasket Roads leading to Quincy and Hingham Bays, the major basins of Boston Harbor, to reduce the tide range. Thus, even if sea levels were to rise, the ability of the tide to flood and ebb to the 9-12 foot ranges we experience today would be restricted by narrowing the outer harbor mouth.

There are many examples in nature where there coastal restrictions act in this tide range reducing fashion. Of these, the configuration of the Danish Mainland, its major islands and the Skane Peninsula of Sweden pinch off the North Sea from the Baltic Sea. The 15-foot tides of the North Sea ports are non-existent inside the Baltic.

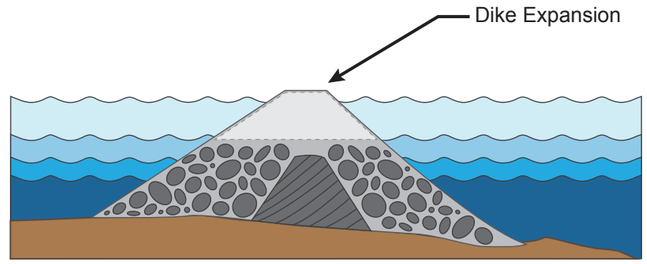


The Model in Nature

Just as Denmark and Sweden create a barrier to the North Sea tides within the Baltic so too could the present opening to Boston Harbor be reduced in its hydraulic capacity to convey the 10 foot tides of Massachusetts Bay to the Boston Basin. The illustrations which follow show the present flow-way for the flooding tide and a possible restricted opening by enlarging Lovell's Island and extending engineered dikes from the Deer Island headland and from Telegraph Hill in Hull.

PINCHING OFF THE TIDE

The concept would be to work incrementally with the near shore topography and geology by filling across the shoal areas to the 3 fathom line (18 feet at low water). Pictured below is a possible rock-filled dike with an impermeable core to seal off tidal flow. As pictured, such dikes could be constructed of graded rock fill with top elevations set for today's storm elevations and be expanded both vertically and horizontally as sea levels rose. The actual form of the dike depends upon the results of future studies and designs. Again, this is the presentation of an idea with proven possibilities and not a design.



Rock-Filled Dike Concept

THE BOSTON TRANSLATION OF THE DENMARK MODEL

The ultimate far future could include dikes extending through a new Lovell's Island completely from Deer Island, Winthrop to Telegraph Hill, Hull with large sea gates for shipping. This could be similar to the Thames Barrier in London, which has been in operation since 1982, and the Oosterscheldekering Barrier, in the Netherlands between Schouwen-Duiveland and Noord-Bevelund Islands placed in service in 1986. Both protect major estuaries from North Sea flooding.


Today's Tide
100% of Cross Sectional Area


A Possible Future
50% Reduction in Flowed Cross Sectional Areas

BUILDING ON THE PLAN

It would, of course, be possible to just construct some type of dike structure between the roughly 4-mile arch between Deer Island and Telegraph Hill, but that would miss a significant opportunity to create a wonderful addition to the Boston Harbor Island Park. Olmstead and Eliot saw the park system as having both socially and environmentally beneficial spaces which could be developed over time. That ideal should be incorporated into the Sapphire Necklace by expanding Lovell's Island to create the central tidal barrier between the President and Nantasket Roads which also becomes a major recreation amenity in the Harbor Park System.

The contributing dike elements would be primarily hydraulic structures but might play a passive recreation role, such as allowing fishing. Regardless, the dikes should be built incrementally; that is, initially extending them from the land across the shoals, as shown on the figure to the right. As greater reduction in the tidal

exchange is needed they could be extended to the shipping channels and finally closing the tidal barrier with the construction of large sea gates, which would be closed in times of flooding threats.

Just as the idea that the dikes could be built in phases over time, so too could Lovell's Island be expanded in stages. If the seaward edge was a rock dike following the 2 fathom line (-12 feet) and built first, then the critical central tidal and storm wave barrier would be complete. Then the flats between the existing island and the new barrier could be filled over time with shipping channel dredged spoils, sea floor mining, or common borrow fill barged from land sites. The final island contours could be shaped to provide an overlook eastward over the beautiful outer islands and historic Graves and Boston Lights, northward along the North Shore but, most importantly, that extraordinary view of the Boston skyline from the sea. The existing Lovell's Island and the historic Fort Standish possess dramatic views of the Boston skyline view looking down the main channel between Long Island head and Deer Island. The new Lovell's Island would have greatly improved views to the west.

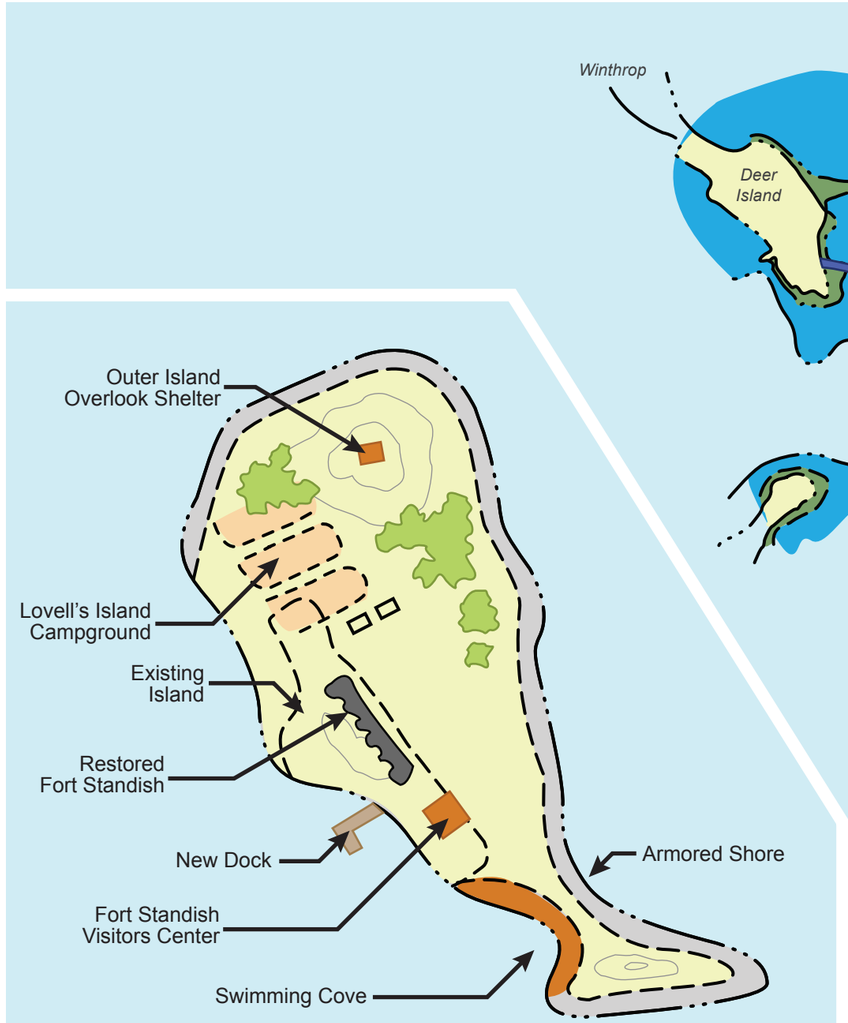
The enhanced island could be served by the existing or an expanded future harbor shuttle linking Boston or Hingham to George's and Lovell's Islands and their historic fortifications. In this initial idea, the new Lovell's Island could contain a visitors' center with information about the islands, the historic fortifications, trails along and through Fort Standish, campgrounds for stays in the outer islands, and swimming and fishing in the cleaned Boston Harbor.

NEXT STEPS

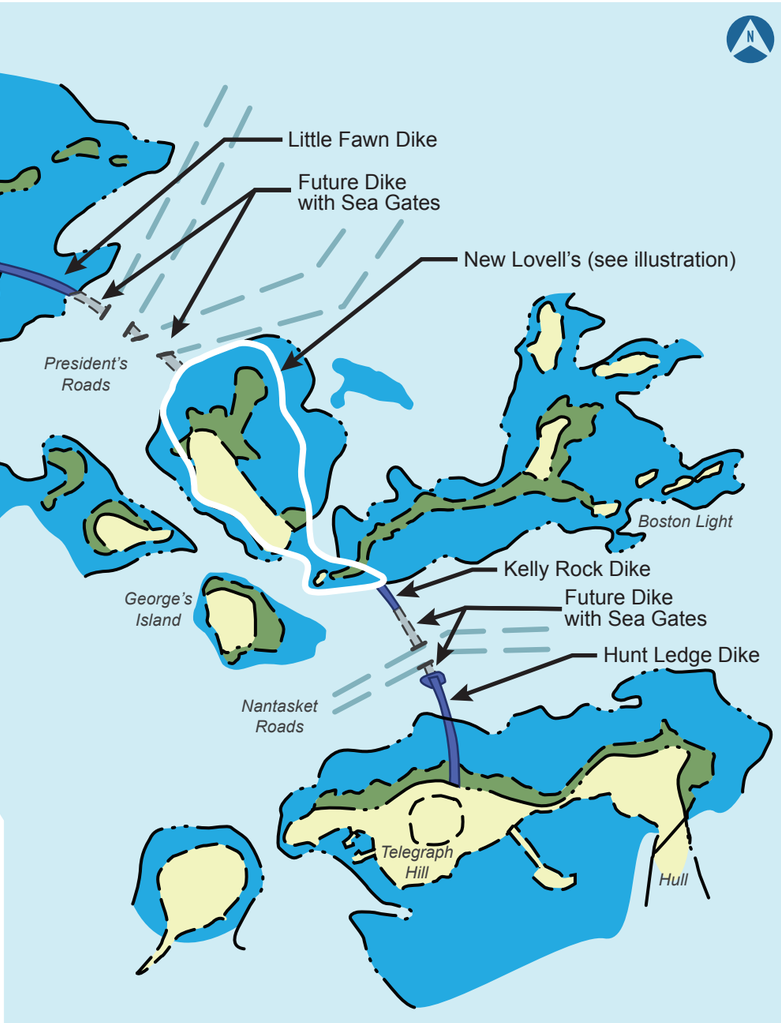
For an idea to become a reality is a journey and as the ancient wisdom says…."*a journey of a thousand miles begins with the first step*". That first step is public engagement and scrutiny. While this idea has proven potential it does not fit neatly into today's regulatory schemes. The public conversations will include the "it's not permitted" voices. That is expected of big ideas.

The important next step is to test the idea, to answer the critical questions: "Does it work?", "How well will it work in phases?" and "How does the tidal barrier work with other Living with Water techniques?". To answer those questions we can build upon the extensive hydraulic models for Boston Harbor and the near shore Massachusetts Bay currents which have been developed by the MWRA for the design and monitoring of their 10-mile ocean outfall tunnel and the inner harbor for their treated combined sewage overflow discharges to assess the effectiveness of the tidal barrier idea. The purpose of this public inquiry is not to prove the Sapphire Necklace is THE ANSWER, but to determine its important role in the many answers of a Living with Water strategy for Boston.

There are lots of potential partners in this public inquiry. Boston is home to several major universities which possess the technical capability and big data computing capacity to assess both the idea's effectiveness of reducing the tide range in the inner harbor as sea level rises and to assess the immediate effectiveness as a storm surge and storm wave "hurricane barrier". As the idea is constructed it will have the immediate benefit of changing the transmitted wave height and velocities in the inner harbor. As even the initial phases are built it would alter today's flood projections for the inner harbor.



New Lovell's Island Illustration



Sapphire Necklace Plan

Another early step is to determine the cost of implementing this idea. But, given the near certainty of some sea level rise and the likelihood of more intense tropical storms, like Super Storm Sandy, the idea will most probably prove cost-effective compared with the risk of flooding the Back Bay, the Harbor Front, the Innovation District, and the harbor and the MBTA tunnels.

This piece is intended to begin the journey by joining the public conversations and testing the idea.

FOR ADDITIONAL INFORMATION

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