1. Background and Problem Statement:

The University of Massachusetts Boston (UMB) is situated on a landfill that was part of the expansion of Boston during the 19th and 20th centuries. The original 14-acre spit of land jutted southeasterly into Dorchester Bay. It was used for the grazing of cattle between 1630 and 1869, providing the peninsula's first name as the Calf Pasture. Subsequent years, up until 1962, the peninsula was used widely as a garbage dump for the City of Boston. Large-scale landfill operations began at what has become known as Columbia Point in the 1920s and continued until 1962. This filling expanded the size of the peninsula to 350 acres of land and added 30 feet of additional depth (Master Plan pg. 16). As part of the expansion of Columbia point rip rap was emplaced to stabilize the banks that defined the perimeter of a newly created peninsula. However normal erosional processes have resulted in the deterioration of the original bank stabilization material placed along the north-east face of Columbia Point. The majority of this face of the peninsula is maintained by either Harbor Point Community Apartments (Harbor Point) or the John F. Kennedy Presidential Library and Museum (JFK Library). Both entities have maintained their respective shores, and currently have structurally sound shoreline protection in the form of rip rap revetments. The approximately 550 linear feet of shoreline stabilization described in this project has deteriorated to the point of complete failure, resulting in continued erosion, and is now in need of significant repairs (Figure 2).

UMB has acknowledged the need to repair this section of shoreline and is considering constructing a rip rap revetment in order to prevent the imminent loss of upland and coastal property. In 2008, UMB hired the Pare Corporation to conduct a preliminary investigation of the feasibility of several shoreline protection alternatives, which resulted in a report entitled "Preliminary Shoreline Protection Study Parking Lot D to the JFK Library" (Pare Report pg. 1). The investigation considered two types of shoreline protection: rip rap revetment and steel sheetpile bulkhead. The report was successful in providing a rough estimate of the effectiveness and cost of installing either of those alternatives, however the scope of the investigation was restricted to an evaluation of simply protecting the shoreline and additional opportunities to enhance the surrounding environment were not considered or evaluated.

The surrounding five acre parcel of undeveloped land (Herein after referred to as the Calf Pasture), has the potential to be substantially improved upon, both environmentally and recreationally. The goal of any project is to maximize output and minimize input, so it is logical that the university is only investigating the most cost effective means of stabilizing the bank. However, UMB has developed a 25 year master plan (Hereinafter referred to as Master Plan) which has estimated the total cost of redeveloping the entire UMB campus at approximately $160 million (Master Plan pg. 6). The findings of the Pare Report estimated a maximum cost of only $2.75 million for stabilizing the abovementioned shoreline. Further, the Master Plan has recognized that "the picturesque quality of the water's edge is in stark contrast to the bulwark character of the UMass Boston campus. Any opportunity to mitigate the disparity between the campus and its surrounding landscape would help to reduce UMass Boston's image as a formidable fortress." It has also preliminarily discussed improvements to the Calf Pasture, defining it as a proposed "key campus landscape" (Master Plan pg. 76). Further, the bank stabilization project that is described in the Pare Report includes the permanent filling of waters below the high tide line, converting it to dry land. It is reasonable to expect regulatory agencies to require mitigation to offset those impacts before authorizing such a project. This project recommends that the University investigate the potential to incorporate the conversion of degraded wetlands on site to healthy salt marsh into the design of a shoreline stabilization project. Such a component would enhance the environmental functionality of wetlands on site while still accomplishing the University's expressed goals of stabilizing the shoreline.

The Master Plan, as discussed above, has recognized that "The future campus design and orientation should take full advantage of the natural beauty of Columbia Point" and also recognizes the value in re-conceptualizing space in order to support the enhancement of the student experience at UMB. The Calf Pasture includes a combination of isolated urban forest, construction staging area, a grassy knoll and a recreational dirt path walkway. Within this area there is evidence of two separate freshwater wetlands that appear to have very limited functionality. Both of these wetlands also appear to drain towards the shoreline and could potentially be converted from degraded freshwater wetland systems to fully functional tidal wetlands.

Salt marshes are ecosystems highly protected by regulatory agencies at the local, state, and federal levels because of their highly productive nature. Wetlands experts consider them to be "among the most productive ecosystems in the world" (Mitsch pg. 261). The wetlands in the Calf Pasture currently appear to be highly degraded systems isolated and juxtaposed in a highly urban environment. This limits any wildlife within them to transient species and/or those species adapted to urban settings. Converting these degraded wetlands to salt marsh would result in a direct connection to the much larger and more productive Boston Harbor. Incorporating a tidal exchange system into the design of any future bank stabilization project would help UMB to both stabilize an eroding shoreline and accomplish their goal of "enhance[ing] existing open space and natural systems that may also serve to become a valuable resource for recreation and sustainability" (Master Plan pg. 65). Further, it would benefit research, education and outreach efforts at UMB. This project itself was developed as the result of similar research efforts at UMB such as the "Green Boston Harbor Project" and "Teaching and Learning with Nature by Using a Biomimicry Approach to Restore Three Keystone Habitats: Salt Marsh, Eelgrass and Shellfish Beds" (Frankic et al). Redeveloping the site also has the potential to create a living lab as part of the university, which could provide a hands-on venue for reinforcing and applying curriculums currently limited by their classroom settings.

1.1 Objectives of this Research:

The UMB Facilities department has been receptive to the concept of both incorporating a tidal wetland feature into the design of a shoreline protection project, and the redevelopment of the Calf Pasture in general. However, at this time, no formal research has been conducted to evaluate the feasibility of such a feature. The purpose of this project is to provide a tangible framework for creating a salt marsh behind the shoreline by completing the follow tasks:

- Assess the existing conditions of the site including the shoreline and any wetlands present.
- Propose a possible rehabilitation scenario for the site
- Develop a list of tasks for initiating and completing that scenario

1.2 Constraints and Caveats:

In order to install a tidal exchange system and create a tidal salt marsh on site, significant engineering and designing is necessary; requiring funding that is well beyond the scope and feasibility of this project. This project does not intend to present a comprehensive analysis of the existing conditions, evaluate the physical processes and structural integrity of various shoreline protection designs or develop a complete and buildable design for creating a wetland in the Calf Pasture. This project does however, seek to present information currently available regarding the site and make assumptions where information is not available in order to help provide UMB with a list of tasks that would need to be completed in order for this concept to become a reality.

2 Assessment of Existing Conditions:

2.1 Site description:

The project is located along the shoreline between Parking Lot D and the JFK Library, and includes the five acre parcel of undeveloped land immediately upland of this coastline, on the UMB campus. It is between the approximate coordinates of 42.3172 N 71.0362 W and 42.3166 N 71.0347 W (Figure 1).

The shoreline in need of repair is approximately 550 linear feet and covers approximately 14,000 square feet (see highlighted area in Figure 1). Presumably the shoreline was originally a designed rip rap revetment put in place during the expansion of Columbia Point. Since being built that revetment has deteriorated from natural processes leaving the existing conditions. Although there is evidence of a once structurally sound revetment, the majority of the revetment is now comprised of an accumulation of granite, concrete, brick and boulders. Based on the lack of weathering on the majority of that stone and the ornamental design of most of the granite, it can also be assumed that the site has been recently been used as a disposal site for excess building materials which doubled as an interim measure to maintain shoreline protection.

The Calf Pasture itself shows evidence of two separate degraded wetland systems. Located on the northern portion of the site is what appears to be a manmade drainage ditch of approximately 10,000 square feet (Hereinafter referred to as Wetland 1) (Figure 3). Aerial photography depicts an approximately 50,000 square foot area (Hereinafter referred to as Wetland 2) that is dominated almost exclusively by Common Reed (*Phragmites australis*), spanning the southern portion of the site. This area appears to be a naturally formed swale draining stormwater from the surrounding elevated topography. Both sites appear to provide limited functionality.

2.2 Site Assessment Methodology:

The United States Army Corps of Engineers is one of the federal agencies responsible for overseeing the development of water resources of the United States; specifically fill in waters and wetlands of the United States in this case. That being the case there are several supplemental publications developed by the Corps that define wetland types and their importance as water resources relative the public interest. The Highway Methodology Workbook Supplement specifically defines the following thirteen functions and values (U.S. Army Corps of Engineers pg. 4-5):

- Groundwater Recharge
- Fish and Shellfish Habitat
- Nutrient Removal/Retention/Transformation
- Sediment/Shoreline Stabilization
- Recreation
- Uniqueness/Heritage
- Threatened or Endangered Species Habitat
- Floodflow Alteration
- Sediment/Toxicant/Pathogen Retention
- Production Export
- Wildlife Habitat
- Educational/Scientific Value
- Visual Quality/Aesthetics

The site assessment in this project has been conducted to be consistent with the Highway Methodology Workbook Supplement, as it is an appropriate indicator of the basic functions and values of any wetlands present on the site. It can also provide a format to adequately compare the value of the existing conditions to the future conditions of a proposed salt marsh creation. It should be noted that this project uses the Highway Methodology Workbook Supplement to conduct a cursory evaluation of these resources for the purposes of proposing a salt marsh creation on site. Future development of such a project should include a complete wetland delineation including a more comprehensive analysis of the functions and values described in this section.

The Highway Methodology also does not account for a description of features appurtenant to the actual design of a successful salt marsh creation such as the grading, sediment composition, or water salinity. While the functions and values are important as far as expressing the need for site improvements, they do not constitute a formal suitability determination for the successful establishment of salt marsh on site. The most important factor to consider when developing a salt marsh is the tidal influence. Formal data collection for sediment composition, and expected water quality/salinity will be required in order to better estimate the future success of a salt marsh.

2.3 Wetland 1:

Wetland 1 (Figure 4) is approximately 10,000 square feet. It is comprised of two sections of a man-made drainage ditch; a 3,500 square foot area which is adjacent to the Boston Harbor and a 6,500 section located to the landward side of the dirt-path walkway on site. The waterward section has no landform disconnecting it from the harbor. However, it is clearly elevated above the mean high water mark and appears to be elevated above the high tide line as well, thus it receives no tidal inundation during any period of the tidal cycle. This section of Wetland consists primarily of clear cut woody vegetation whose stumps have remained in place as well as a collection of associated leaf litter and dead vegetative debris. An approximately 24 inch corrugated plastic pipe connects the waterward section of wetland 1 to the landward section. This pipe culverts drainage under the berm on which the abovementioned dirt-path walkway exists. Similarly to the waterward section, the landward section of Wetland 1 is a man-made drainage ditch. The current hydrologic inputs appear to be the result of intermittent flow of stormwater through the system, as evidenced by the remnant outfall on the northwestern berm, as well as the domination of wetland facultative upland (Fac-Up) species, such as Multiflora Rose (*Rosa multiflora*) and occasional Red Maples (*Acer rubrum*) throughout the ditch. Adjacent to the southeastern side of the ditch is a spoils pile that has begun to mature into forested upland and defines that boundary of the wetland.

2.3.1 Groundwater Recharge/Discharge:

"This function considers the potential for a wetland to serve as a groundwater recharge and/or discharge area. Recharge should relate to the potential for the wetland to contribute water to an aquifer. Discharge should relate to the potential for the wetland to serve as an area where groundwater can be discharged to the surface" (U.S. Army Corps of Engineers pg. 4).

Wetland 1 has no apparent groundwater recharge or discharge function. It is an isolated urban wetland draining directly into Boston Harbor and does not appear to be connected to any private or municipal water supplies.

2.3.2 Floodflow Alteration:

"This function considers the effectiveness of the wetland in reducing flood damage by attenuation of floodwaters for prolonged periods following precipitation events" (U.S. Army Corps of Engineers pg. 4).

Wetland 1's primary function is that of floodflow alteration. The berm that defines the southeastern limit of the wetland appears to be side cast material, and the outfall and culvert within the wetland suggest that the area was originally developed as a drainage ditch. It is unknown whether the existing culvert under the walkway is of adequate diameter for the volume of stormwater it receives. However, given the domination of Fac-Up vegetation, it appears that the area receives infrequent and/or limited volumes of stormwater. Wetland 1 has high berms on both sides. Therefore it has the potential to retain or otherwise channel a significant amount of stormwater. Whether it in fact receives high volumes has yet to be determined, and baseline data should be collected to better understand and estimate the true volume of stormwater Wetland 1 receives.

<u>2.3.3 Fish and Shellfish Habitat</u>:
"This function considers the effectiveness of seasonal or permanent waterbodies associated with the wetland in question for fish and shellfish habitat" (U.S. Army Corps of Engineers pg. 4)

The wetland is ephemeral. Therefore no fish or shellfish habitat currently exists within the wetland.

<u>2.3.4 Sediment/Toxicant/Pathogen Retention</u>:
"This function reduces or prevents degradation of water quality. It relates to the effectiveness of the wetland as a trap for sediments, toxicants, or pathogens" (U.S. Army Corps of Engineers pg. 4).

Wetland 1, particularly the waterward section where there is a significant deposit of vegetative debris, appears to provide sediment and toxicant retention functions. It does not appear to receive much stormwater though, limiting its functionality in this regard.

<u>2.3.5 Nutrient Removal/Retention/Transformation</u>:
"This function relates to the effectiveness of the wetland to prevent adverse effects of excess nutrients entering aquifers or surface waters such as ponds, lakes, streams, rivers, or estuaries" (U.S. Army Corps of Engineers pg. 4).

Given the urban setting there is not likely to be nutrient enriched runoff entering the site, hence nutrient retention and removal does not appear to be a significant function of Wetland 1.

<u>2.3.6 Production Export</u>:
"This function relates to the effectiveness of the wetland to produce food or usable products for humans or other living organisms" (U.S. Army Corps of Engineers pg. 5).

Wetland 1 does not show any signs of significant food production for humans or other living organisms.

<u>2.3.7 Sediment/Shoreline Stabilization</u>:
"This function relates to the effectiveness of a wetland to stabilize stream banks and shorelines against erosion" (U.S. Army Corps of Engineers pg. 5).

The existing wetland appears to have very limited shoreline stabilization functions. Wetland 1 is adjacent to Boston Harbor and is likely susceptible to wave energy during storm events. During these times the stumps still in place can provide limited shoreline stabilization functions. Because the wetland is located above the high tide line elevation though, it provides limited stabilization functions during normal tidal cycles.

<u>2.3.8 Wildlife Habitat</u>:

"This function considers the effectiveness of the wetland to provide habitat for various types and populations of animals typically associated with wetlands and the wetland edge. Both resident and/or migrating species must be considered" (U.S. Army Corps of Engineers pg. 5).

Wetland 1 provides wildlife habitat for birds and small mammals. Through my own investigations American Goldfinches (*Carduelis tristis*), Northern Mockingbirds (*Mimus polyglottos*), Eastern Gray Squirrels (*Sciurus carolinensis*) and Eastern Cottontails (*Sylvilagus floridanus*) have been identified on the site. A comprehensive wildlife evaluation could more accurately determine which species are currently using the site, but the wildlife habitat present appears to be limited to transient species and/or species adapted to urban environments.

2.3.9 Recreation:
"This value considers the effectiveness of the wetland and associated watercourses to provide recreational opportunities such as canoeing, boating, fishing, hunting, and other active or passive recreational activities. Consumptive activities consume or diminish the plants, animals, or other resources that are intrinsic to the wetland, whereas non-consumptive activities do not" (U.S. Army Corps of Engineers pg. 5).

The surrounding location provides recreational benefits; specifically use of the Harborwalk walkway for jogging, walking, and bike riding. Benches and a grassy knoll on site also provide passive recreational benefits associated with a waterfront vista. Wetland 1 itself however, does not provide any noticeable recreational benefits. It is aesthetically unpleasing and filled with generally nuisance/hazardous vegetation in the form of thorns, stumps, etc., which detract from the site's recreational value.

2.3.10 Educational/Scientific Value:
"This value considers the effectiveness of the wetland as a site for an 'outdoor classroom or as a location for scientific study or research" (U.S. Army Corps of Engineers pg. 5).

The site does not currently present any educational or scientific value outside of any data collection associated with redeveloping the site. However, a restored salt marsh system could offer opportunities for both education and scientific values to the university and surrounding communities.

2.3.11Uniqueness/Heritage:
"This value relates to the effectiveness of the wetland or its associated waterbodies to produce certain special values. Special values may include such things as archaeological sites, unusual aesthetic quality, historical events, or unique plants, animals, or geologic features" (U.S. Army Corps of Engineers pg. 5).

The site is adjacent to the JFK Library property and the soon to be constructed Edward M. Kennedy Institute (EMK Institute). The prestige associated with this neighbor should be taken into consideration when designing any modifications to the landscape. Also the recently acquired pump house immediately southwest of Wetland 1 is on the state register of historic properties. Wetland 1 itself however does not currently offer any uniqueness/heritage associated value.

2.3.12 Visual Quality/Aesthetics:

"This value relates to the visual and aesthetic qualities of the wetland" (U.S. Army Corps of Engineers pg. 5).

Wetland 1 provides no positive aesthetic values. The combination of clear cut woody vegetation, debris and vine-like species has a negative aesthetic impact on Wetland 1. Also the stone debris along the shoreline exacerbates the generally unmaintained appearance of the site.

2.3.13 Threatened or Endangered Species Habitat:
"This value relates to the effectiveness of the wetland or associated water bodies to support threatened or endangered species."

According to the U.S. Fish and Wildlife Service (FWS) there is no known Threatened or Endangered species habitat on site (U.S. Fish and Wildlife Service pg. 1).

2.3.14 Topography: A topographic map of the entire UMB property was prepared by Nitsch Engineering in 2006 (Pare Corporation fig. 2 of 5). Due to the scope of the survey plan, it may not provide adequate resolution of the elevations within Wetland 1.

2.4 Wetland 2:
Wetland 2 (Figure 5) is approximately 50,000 square feet, located on the southern portion of the site and abuts both the JFK Library and the EMK Institute site. It appears to be a naturally formed drainage swale fed from all directions by the neighboring uplands and drains over the existing dirt-path walkway into the harbor. Wetland 2 has an almost 100% vegetative cover of Common Reed, with occasional Red Maple saplings along the fringes of the system. It is difficult to determine exactly where the swale is because of the density of current vegetation, but it seems as though there is one primary low lying area that remains relatively permanently wet; Common Reed spreading outward from that swale. To the immediate north of the swale is a seemingly naturally formed berm that includes a combination of mature trees including alders, maples and scrub shrub vegetation. Invasive species such as Multiflora Rose are present in the surrounding fringe wetlands and uplands.

2.4.1 Groundwater Recharge/Discharge:
Wetland 2 has no apparent groundwater recharge or discharge function. It is an isolated urban wetland draining directly into Boston Harbor and does not appear to be connected to any private or municipal water supplies.

2.4.1 Floodflow Alteration:
Wetland 2's primary function appears to be floodflow alteration, as it has seemingly developed naturally over time as a path of least resistance for stormwater drainage. The core low lying area of the wetland, which appears to remain relatively permanently wet, is approximately 300 feet long and 20 – 30 feet wide. Wetland 2 provides significant floodflow alteration, and has the potential to be enhanced in that regard as part of a stormwater management system.

2.4.3 Fish and Shellfish Habitat:
Currently there are no fish or shellfish resources within the wetland.

2.4.4 Sediment/Toxicant/Pathogen Retention:

In addition to providing floodflow alteration wetland 2 appears to provide significant sediment/toxicant retention. A primary source of hydrology through Wetland 2 is runoff from both the 2.5 acre parking lot to the southwest and from the construction stockpile area to the west.

2.4.5 Nutrient Removal/Retention/Transformation:
Given the urban setting there is an inherent lack of nutrient enriched runoff, and this does not appear to be a significant function of Wetland 2.

2.4.6 Production Export:
Wetland 2 does not show any signs of significant production export for humans or other living organisms.

2.4.7 Sediment/Shoreline Stabilization:
Wetland 2 does not appear to provide any sediment or shoreline stabilization function as it is not found along the shoreline.

2.4.8 Wildlife Habitat:
The site provides wildlife habitat for birds and small mammals. American Goldfinch, Northern Mockingbird, Eastern Gray Squirrel and Eastern Cottontail have been identified on the site. A comprehensive wildlife evaluation could more accurately determine which species are currently using the site, but the wildlife habitat present appears to be very limited, as the area is comprised almost entirely of Common Reed.

2.4.9 Recreation:
The surrounding landscape provides recreational benefits; specifically use of the Harborwalk walkway for jogging, waling, and bike riding. Benches and a grassy knoll on site also provide passive recreational benefits associated with a waterfront vista. Wetland 2, itself however, does not provide any recreational benefits. It is aesthetically unpleasing and filled with unsightly invasive species.

2.4.10 Educational/Scientific Value:
The site does not currently present any educational or scientific value outside of any data collection associated with redeveloping the site. However, a restored salt marsh system could offer opportunities for both education and scientific values to the university and surrounding communities.

2.4.11 Uniqueness/Heritage:
The site is adjacent to the JFK Library property and the soon to be constructed EMK Institute. The prestige associated with this neighbor should be taken into consideration when designing any modifications to the landscape. Also the recently acquired pump house immediately southwest of Wetland 2 is on the state register of historic properties. Wetland 2, itself however, does not appear to have any uniqueness/heritage associated values.

2.4.12 Visual Quality/Aesthetics:
Wetland 2 provides no positive aesthetic values. The wetland itself is a monoculture of Common Reed which is not generally regarded as having positive aesthetic values. The adjacent forested berm also provides little aesthetic value, as the native species are being dominated by vine-like vegetation, creating an unsightly and unmaintained appearance. Also the stone debris along the shoreline exacerbates the generally unmaintained appearance of the site.

2.4.13 Threatened or Endangered Species Habitat:
According to the U.S. Fish and Wildlife Service (FWS) there is no known Threatened or Endangered species habitat on site (U.S. Fish and Wildlife Service pg. 1).

3. Potential Rehabilitation Scenario:

Wetlands in general are highly protected areas that regulatory agencies make almost completely undevelopable. Generally speaking, the only permitable development within a wetland system is likely going to be limited to the enhancement and/or conversion to a fully functional wetland. Wetlands 1 and 2 both appear to be degraded freshwater systems that would greatly benefit from some sort of rehabilitation. UMB as part of its Master Plan has begun to design plans for the redevelopment of the shoreline that also provide an opportunity to enhance the wetlands found in the Calf Pasture. Accordingly, this project has proposed the following scenario which would aim to improve upon the existing conditions of Wetlands 1 and 2 while staying within the confines of UMB's preliminary plans for redeveloping the area (Figure 6).

3.1 Convert Wetland 1 to Salt Marsh:

Where UMB has begun to design a new shoreline to be constructed between Parking Lot D and the JFK Library the opportunity has presented itself to use the new shoreline as a catalyst for the enhancement of the Calf Pasture. The design of a new shoreline at this location could include features that would introduce tidal flow to the wetlands located behind it, thus creating salt marsh. Also, the preliminary designs have suggested that a significant amount of new fill would be placed in Boston Harbor to facilitate the construction of a new shoreline. Enhancing wetlands on site could be proposed as a mitigative measure used to offset the impacts of permanently filling tidal waters. The primary purpose of this scenario is to stabilize the bank and create a salt marsh behind the shoreline by regrading the existing topography, creating a tidal connection and eradicating the invasive plant species from the existing freshwater wetland.

In order to accomplish this, the design of a shoreline stabilization project at this location would need to include some form of tidal exchange system conveying salt water from the harbor into the wetland. The topography within the wetland would then be regraded to consist of three different elevations: high marsh elevation, low marsh elevation and a tidal channel. The majority of both wetlands is comprised primarily of emergent and scrub shrub wetlands, including invasive species. Multiflora Rose is one of the primary invasive species found in wetland 1, occurring sporadically throughout the majority of the area. Meanwhile, Wetland 2 is dominated by Common Reed. This scenario would aim to eliminate the invasive species via mechanical means, as well as through the introduction of tidal flow. Lastly a planting plan would be developed to include both low marsh and high marsh vegetation. This restoration scenario is expected to require the following design features.

3.1.1. Bank Stabilization:

The shoreline on site, as previously stated, is in need of immediate repair to prevent further erosion. Popular shoreline stabilization methods in coastal areas include bulkheads or seawalls, hard structure revetments, and "soft" or "living" shorelines. All of these methods have their unique advantages and disadvantages.

Bulkheads and seawalls are vertical structures, so they require fewer materials to build and directly impact a smaller area than an equivalent revetment or living shoreline. Resultantly they have the shortest horizontal transition from dry land to water (important for operations requiring frequent machine to boat interaction). Because they are vertical structures though, they receive the direct force of any wave energy, which limits their wave attenuation efficiency. Wave energy is generally displaced vertically and can undermine the substructure of the bulkhead. Any wave energy displaced laterally can result in erosion from behind the structure. As a result, significant additional design measures might be required when considering a bulkhead or seawall, such as the placement of toe structures and returns or wingwalls, in order to prevent the structure from failing.

"Soft" or "living" shorelines are becoming a more widely considered shoreline stabilization methodology in both coastal and riverine systems. Vegetation and natural materials can be used to build structurally sound banks that also provide the values of naturally occurring wetland systems. Such a shoreline can provide additional habitat, aesthetic values of a natural system and if successfully designed, they are self-sustaining. Living shorelines require multiple growing seasons to mature into stable banks though, and are generally sensitive to wave energy.

Stone revetments, like seawalls and bulkheads, are hard, man-made structures that provide shoreline protection. They are not vertical though and generally consist of a toe stone and filter layer which serve as the foundation for a primary armoring layer. Rip rap revetments are sloped and have a rough surface so they are more effective in dissipating wave energy than a bulkhead, seawall. Rip rap revetments are also able to withstand minor damages without compromising functionality, so they require relatively minimal maintenance. Rip rap is not always considered aesthetically pleasing though, it can invite people to walk on what is an inherently hazardous surface, and it is generally not as biologically productive as a living shoreline.

In the case of UMB, the shoreline in question is facing a northeast direction in Boston Harbor, and is exposed to wind and wave energy generated by nor'easters, the predominant major storm system in this area. In addition the neighboring hard structured revetments are likely directing and exacerbating that energy directly into the site; as evidenced by the erosional activity currently present on site. That being said, from an ecological perspective, a living shoreline might be a preferred stabilization method, and an investigation of its potential success might be warranted. This project however, assumes that the university is pursuing the two stabilization methods described in the Pare Report. Similarly, it assumes that the university will attempt to maintain consistency with the neighboring properties. Therefore a rip rap revetment extending from the JFK Library to Parking Lot D is proposed for this scenario.

The existing bank is currently setback from the revetments of the abutting properties to the east and west. This scenario, as suggested in the Pare Report, would extend the shoreline waterward in order to better align it with those revetments. Also described in the Pare Report, a revetment would be constructed using gravel borrow, filter fabric and stone rip rap, and the design could be consistent with that found at the JFK Library waterfront.

3.1.2. Tidal Exchange System:

Both Wetlands on site are currently freshwater systems with hydrology being supported primarily from surface water during storm events. Creating a source of tidal inundation is essential to the establishment of a healthy salt marsh. Therefore this scenario includes the development of a hydraulic connection between Wetland 1 and Boston Harbor, and a second connection between Wetland 2 and Boston Harbor. Currently Wetlands 1 and 2 are both elevated above the tidal range, and the construction of a new shoreline is expected to create a physical barrier, further disconnecting them from Boston Harbor. Consequently, a tidal exchange system would need to be built into the shoreline protection if a salt marsh is to be created behind it. This scenario includes the installation of two tidal exchange systems that could include, but need not be limited to one of the following: Open box culverts, box culverts with sluice gates, or self regulating tide gates (Figure 7).

An open box culvert is the simplest tidal exchange system considered. It includes the placement of one concrete opening that is sized according to the flooding needs of the salt marsh. This is a cost effective system which requires relatively little to no regularly scheduled maintenance, and it ensures that the tidal range behind the embankment will be consistent with that which is observed on the seaward side of the revetment. An open box culvert does not however, have the ability to be regulated. Other systems can be adjusted to reduce or increase the amount of tidal inundation behind the revetment which is particularly important during storm events that may result in flooding of the system. An open box culvert may also leave the salt marsh susceptible to wave energy during storm events capable of washing out the vegetation.

A box culvert with a sluice gate is a similar design to the open box culvert, but with the addition of a gate that slides over the face of the culvert and allows the culvert to be fully opened, partially opened or fully closed. Whether the sluice gate is operated manually or electronically, this design allows for all of the benefits of an open box culvert, but also provides the regulatory benefits that an open box culvert cannot. The benefits of sluice gates can be outweighed however, by their more expensive design (especially if electronically operated), improper operation and more frequent/expensive maintenance.

Additionally, self regulating tide gates should be considered for this scenario. The self regulating tide gate is significantly more complex than the box culvert and sluice gate designs. It consists of a culvert with a top mounted flap gate and has buoys attached to it. During incoming tides the floats open the flap, allowing for tidal inundation. As the tide falls so do the floats and the flap gate, retaining the tidal water on the back side of the revetment as it slowly empties back into the harbor. The self regulating tide gate has similar benefits as the sluice gate, with the added benefit of operating on its own. These are expensive and complex designs though, and also require significant maintenance.

3.1.3. <u>Debris Removal</u>:

Concrete, granite and brick debris are scattered below the high tide line across approximately 7,500 sf of beach on site. Any stones that could be used for the new revetment should be salvaged and stored on site until construction began. Any other debris should be removed from site and disposed of at an upland location. Equipment used would access the debris via the existing paved walkway. Also, as described above, Wetland 1 is comprised of two separate areas connected via a culvert under the existing dirt path walkway. The entire waterward side of that existing culvert includes vegetative debris and stumps from previous clear cutting activities that were never grubbed. This scenario would include the grubbing/stumping of this area prior to any future regrading activities. The spoils of which should be disposed of off-site, in case there are remnants of invasive species found within the debris.

3.1.4. <u>Removal of Existing Berm/Dirt Path Walkway</u>:

The berm with a 24” culvert that allows the dirt path walkway to cross over Wetland 1 would constrict the tidal flushing of the landward portion of the wetland in this scenario. Accordingly, this scenario should include the removal of the entire berm, thus creating one, 10,000 sf contiguous wetland. Retaining the continuity of the Harborwalk is essential to any redevelopment of the Calf Pasture though. Therefore, this scenario should also include the construction of a new paved walkway running along the shoreline, which would include the chain and pollard design found along the JFK Library’s portion of the Harborwalk.

3.1.5. <u>Regrading of topography</u>:

The proposed restoration area will be excavated to the grades most suitable for the successful establishment of salt marsh vegetation. A grading plan would need to be developed to ensure that a majority of the restoration area will be frequently flooded so as to facilitate invasive species control, low marsh development and high marsh development. The basic grading plan for this area should be designed relative to the expected mean tide line (MTL) and mean high water (MHW) elevations, which depending on the form of tidal exchange system used and its associated constrictions, could vary from the tidal range observed within the harbor.

Ideally a salt marsh has three major topographic zones; high marsh, low marsh and the tidal channel. The cost of excavation may influence the ratio of high marsh vs low marsh, but ideally the resultant configuration would include the following:

Wetland 1:

- Tidal channel running the length of the wetland (approximately 200-225 lf)
- Approximately 4,500 sf of low marsh
- Approximately 3,500 sf band of high marsh along the perimeter of the low marsh

Wetland 2:

- Tidal channel running the length of the wetland (approximately 350 lf)
- Approximately 10,000 sf of low marsh
- Approximately 10,000 sf of surrounding high marsh

Tidal data provided can be found through the National Oceanographic and Atmospheric Administration (NOAA) Tides and Currents website (http://tidesandcurrents.noaa.gov/). "Spartina alterniflora is positively correlated with mean tidal range (the elevation difference between low and high water), which explained ~70% of the statistical variation in upper and lower limits of growth. These researchers also found that Spartina alterniflora growth range differs by latitude among marshes with similar tidal ranges. Therefore, it is essential that tidal elevations be determined specifically for individual restoration sites" (Niedowski pg. 35). Accordingly, the grade of the low marsh should be between the MTL and MHW, with the high marsh grade being slightly above the MHW elevation. A more accurate estimation of the exact elevations necessary for the successful establishment of both marsh zones can be determined by surveying existing salt marshes in the area. The key distinction between high marsh and low marsh is that low marsh is expected to be inundated during the majority of the tidal cycle, where high marsh is only expected to be inundated during the highest of tides.

3.1.6. <u>Eradication of Invasive Species</u>:

Associated with the creation of salt marsh on site, this scenario should include the eradication of invasive species in the area. As described above, Common Reed is the dominant plant species currently found within the Wetland 2, occurring as a mono-typical stand throughout the majority of the wetland. Invasive species such as Multiflora Rose were found in both wetlands. In this scenario the Common Reed would be chemically treated with glyphosate (glyphosate is an herbicide formulation approved by the U.S. Environmental Protection Agency for use in wetlands) and mowed for 2 growing seasons prior to construction. Any remaining stands in the area at that time would be spot treated as necessary and/or removed via excavation during construction. Any excavated materials that potentially contain Common Reed rhizomes will be buried at an upland area in order to minimize the chance for the species to persist elsewhere. Following the construction, when a tidal connection has been established, the regular inundation of salt water should prevent any reestablishment of the invasive species currently inhabiting the area.

3.1.7. <u>Seeding</u>:

A healthy salt marsh depends on the presence of both Smooth Cordgrass (*Spartina alterniflora*) and Saltmeadow Cordgrass (*S. patens*). These grasses provide habitat for juvenile and adult crustaceans, mollusks, and birds, and provide organic nutrients for the entire salt marsh system. As such, after the completion of topographic alterations and channel excavations, the wetlands should be planted and/or seeded with theses two types of salt tolerant vegetation. The low marsh would be planted with Smooth Cordgrass, and the high marsh with Saltmeadow Cordgrass.

Saltmeadow cordgrass is inhabited by many small animals and is a food source for birds such as ducks and sparrows. This plant is also important to marsh health due to the organic material it contributes during decomposition. Similarly smooth cordgrass is the most productive of the marsh grasses. "Located in low marsh areas, it is flooded twice daily by the tidal action of the estuary. The complex root system of the smooth cordgrass helps bind it to the banks, preventing the tide from eroding the shoreline. Although it relies primarily on groundwater absorbed through the roots, smooth cordgrass is able to extract fresh water from salt water when the need arises" (Rhode Island Habitat Restoration Portal http://www.edc.uri.edu/restoration/html/gallery/saltmarsh.htm).

3.1.8. Stormwater Management:

UMB, as part of its Master Plan is intending to reconfigure the traffic infrastructure on campus through a project known as the Utility Corridor Roadway Project. Personnel from UMB's Facilities Management department, who are responsible for the development of the Master Plan, have preliminarily determined that the main traffic artery will be relocated to the east, and closer to the Calf Pasture. Expected to be included in this roadway project is the development of a stormwater management system to accommodate the new road. The location of the wetlands on site and the increased flood retention capacity of a newly created salt marsh draining into Boston Harbor would make it an ideal location for the placement of a new drainage outfall. Assuming a direct hydrologic connection with Boston Harbor is made through this scenario, the Master Plan should also expand the breadth of on site investigations to include the potential incorporation of a stormwater management system.

The University of New Hampshire Stormwater Center (UNHSC; http://www.unh.edu/unhsc/) has developed and studied innovative methods for reducing stormwater effluents' impacts to surrounding environments; some of which could be used in the development of the stormwater management system of the Utility Corridor Roadway Project. In a report entitled "Protecting Water Resources and Managing Stormwater: A Birds Eye View For New Hampshire Communities," UNHSC describes four general strategies that can be used to improve upon a landscape's ability "to manage stormwater in order to protect public health, property and natural resources" (Peterson pg. 3). These strategies are the use of land conservation, riparian buffers, minimization of impervious cover, and implementation of low-impact development (see figure 8).

The purposes of land conservation and riparian buffers are essentially the same, in that naturally occurring soils and vegetation will slow down, absorb and evapo-transpire stormwater and toxicants, thus reducing their impacts to downstream water resources. In the case of the Calf Pasture land conservation and riparian buffers could be relatively easily incorporated. The exiting buffers such as mature vegetation should be preserved regardless of any redevelopment of the site. Also, the inherent inability to develop wetlands due to regulatory constraints provides a general conservation of these systems. To further preserve them though, the university could place deed restrictions and/or conservation easements on the systems, in order to protect them in perpetuity. Provided it did not disturb a newly created salt marsh, a new stormwater management system on campus could be directed towards the Calf Pasture, taking advantage of the wetlands' natural ability to alleviate stormwater impacts on campus and the surrounding environment.

"Impervious cover is considered one of the biggest challenges to water resource protection because of its effect on the quantity, distribution and quality of water and its association with urbanization" (Peterson pg. 18). This includes any surfaces that do not allow stormwater to enter the soils and subsurface of developed areas. When designing a new roadway UMB should wherever practicable, minimize the amount of impervious roadways, walkways, parking lots and any other developed surfaces exposed to stormwater. Reducing the amount of runoff on site will reduce stormwater impacts both to UMB and the surrounding environment.

Similarly, low-impact development (LID) strategies seek to reduce the amount of impervious cover and mitigate for those unavoidable impacts. Examples of such strategies include but are not limited to the use of rain gardens, gravel wetlands, porous pavements, tree filters and vegetated swales (see figure 9). All of these design measures can be combined to effectively increase the volume of water that can be stored in the substructure of developed areas. They can be installed both as part of new development projects or as retrofits to existing developments.

The development of stormwater management strategies for the proposed Utility Corridor Roadway Project and their incorporation to the design of a new shoreline projection project provides benefits that are secondary to the purpose of stabilizing the bank. However, considering and evaluating these secondary benefits when designing a new shoreline epitomizes the comprehensive analysis that should be used to optimize the functionality of both the Calf Pasture and the overall UMB Master Plan.

4 Implementation Steps

The steps described in this section are those that must be taken to achieve the various components described in this scenario.

4.1. Stabilize the shoreline and install tidal exchange systems:

a. Determine the ideal shoreline stabilization design.

Selecting the appropriate stabilization for this method will require a comprehensive analysis of the physical processes found on site, as well as the costs of each method. This report briefly described some of the pros and cons of three popular coastal bank stabilization methods (bulkhead/seawall, rip rap revetment, soft/living structure). The Pare Report preliminarily analyzed the costs and impacts associated with two different configurations of both a rip rap revetment and a steel sheetpile bulkhead, but being a preliminary report did not include a comprehensive analysis of the wave energy and other physical process associated with its location in Boston Harbor. Such an analysis needs to be conducted in order to determine the exact configuration and amount of materials necessary to construct a structurally sound shoreline at this location. This will also result in a more accurate assessment of the costs of each potential design, which will need to be considered in the evaluation of an ideal design.

b. Determine the appropriate tidal exchange system:

Selecting the appropriate tidal exchange system will need to consider the following factors: structural integrity when combined with the shoreline stabilization design, ability to provide adequate tidal flushing, and cost. Any potential tidal exchange system incorporated will need to be designed in a manner that does not compromise the structural integrity of the ideal stabilization design. Any suggested systems must be evaluated in order to estimate how, if at all, they will alter those same physical processes analyzed when determining the stabilization design.

Adequate tidal flow is essential to establishment of a healthy salt marsh system. Different culvert systems are used depending on site-specific conditions in order to provide enough saltwater into the wetland system without exacerbating any flooding conditions of the surrounding upland areas. Such an analysis should include the following components:

i. Conduct topographical survey: Both wetlands are clearly at higher elevations than the HTL which means they will need to be excavated in order for a salt marsh to be created. The cost of the project will be significantly impacted by the amount of cutting and regrading that needs to take place. The Pare Report included a topographic map excerpted from the plans entitled "Existing Conditions Plan – University of Massachusetts Boston Campus –Boston, Massachusetts" prepared by Nitsch Engineering in 2008. This map, as shown in the Pare Report, is half sized and it is difficult to determine whether the elevations provided for the Calf Pasture are precise enough to accurately estimate the elevations within Wetland 1. The original copy should first be obtained from Nitsch Engineering. If necessary a more precise survey that focuses on just the area of concern should be conducted.

ii. Conduct tidal survey. Tidal flow and elevations, specifically, HTL, MHW and the range of tides are essential to the development of a salt marsh. Tidal data is available through the National Geodetic Survey program of the NOAA. This data needs to be applied to the topographical survey to develop a model of tidal flooding within the wetlands.

iii. Install piezometers. Monitoring piezometers over tidal cycles will help to understand the interaction of the groundwater and the surrounding Harbor water.

When the tidal range, size of the proposed wetland, and the interaction between the groundwater are comprehensively analyzed, then a determination can be made as to how much tidal exchange is needed; thus contributing to a decision as to which tidal exchange system will optimize hydrology within the new system.

Lastly, a final cost estimate of the various tidal exchange systems needs to be conducted to determine which systems fit into UMB's budget for the Master Plan.

c. Conduct a Cost Estimate for relocating the dirt-path walkway:

Pending the design of the revetment, the goals the university has for the redeveloping the Calf Pasture and the project budget, relocating the walkway along the waterfront may or not be feasible. Ideally, for the purposes of designing one contiguous wetland system behind the revetment, the walkway would be relocated along top of the stabilized bank; similar to the walkway that currently exists along the JFK Library's waterfront. A cost estimate needs to be conducted for this portion of the project, as it may affect the stabilization and any wetland rehabilitation designs.

4.2. Regrade topography

a. Collect core samples for physical and chemical analyses:

Physical analyses should include grain size, Atterberg limits, and hydrometer. Chemical analyses should include CAM 14 metals, Polycyclic aromatic hydrocarbons (PAHs), pH, and TOC. The cores will help determine both the likelihood of successful vegetation at the site as well as the suitability for disposing any excavated material. It will also determine whether new, more suitable sediments would need to be imported to promote healthy salt marsh.

b. Combine tidal and topgrpahic data:

As described above, tidal information and topographic information are necessary to determine the expected tidal flows within a newly created salt marsh. That same information needs to be used to develop cross sections for existing elevations throughout Wetlands 1 and 2, relative to the tidal range. Subsequently cross sections of the existing elevations and proposed elevations would need to be developed. From that, a total volume of excavated material can be estimated.

c. Perform cost estimate for excavation and disposal:

Once the amount of soil needed to be excavated is determined, an estimated cost of dollars per cubic yard can be applied to the overall feasibility determination. Equally important to the equation is the cost of disposal. Where UMB is currently in the process of redeveloping the entire campus through their Master Plan, the potential exists for the reuse of some or all of the spoils. However, the potential also exists for none of the spoils being reused on site, thus requiring proper off-site disposal. If all of the materials need to be disposed of off-site, the toxicology of the existing sediments becomes increasingly important, as the disposal costs of contaminated sediment could push the project beyond feasible.

4.3. Incorporate stormwater system for expected roadway improvements:

a. Perform baseline studies:

In order to begin designing a stormwater management system on campus that ties into the wetlands found in the Calf Pasture, baseline studies such as the following should be conducted to establish existing conditions and areas in need of improvement.

i. Daily, Monthly, and Annual precipitation data.
ii. Establish flow duration curves for the existing stormwater system on campus.
iii. Develop an estimated water balance for the existing conditions of the Calf Pasture in order to determine its current flood storage capacity.
iv. Estimate sediment load displaced through the existing stormwater system.
v. Perform chemical analysis of existing stormwater and sediment load.

b. Estimate proposed flood storage capacity:

The second component of designing the new stormwater management system is the prediction of stormwater that will travel through the new system after it is constructed and how the proposed wetlands will respond to those changes. The following studies should be performed in this analysis in order to determine a maximum volume of stormwater that can be discharged into the Calf Pasture.

i. Estimate the increased drainage area resulting from a new stormwater system on campus and its associated increased volume of stormwater input.
ii. Use proposed conditions of Wetlands 1 and 2 (topography, sediment composition, and vegetation) to estimate a new water balance within the system.

iii. Estimation of the proposed wetlands' threshold in response to increased sediment load, water toxicity and salinity inputs without significantly altering their capacity to function as a healthy salt marsh.

4.4. Permitting Processes:

a. The Massachusetts Environmental Policy Act (MEPA):

According to Chapter 301 of the Code of Massachusetts Regulations "The purpose of MEPA and 301 CMR 11.00 is to provide meaningful opportunities for public review of the potential environmental impacts of Projects for which Agency Action is required, and to assist each Agency in using (in addition to applying any other applicable statutory and regulatory standards and requirements) all feasible means to avoid Damage to the Environment or, to the extent Damage to the Environment cannot be avoided, to minimize and mitigate Damage to the Environment to the maximum extent practicable."

b. Chapter 91 License:

Chapter 91 Authorization is required for structures in tidelands, Great Ponds (over 10 acres in natural state) and certain rivers and streams. The construction of a new shoreline in Boston Harbor is expected to fall into this jurisdiction. (310 CMR 9.03) and (M.G.L. c. 91)

c. Section 404 Authorization:

Pursuant to Section 404 of the Clean Water Act, Section 404 authorization is required for the discharge of dredged or fill material into waters of the United States (33 CFR 323.1). Any bank stabilization or regrading activities located below the high tide line are expected to require a Section 404 permit (See Chapter 33, Part 323 of the Code of Federal Regulations for associated definitions).

d. Section 10 Authorization:

Pursuant to Section 10 of the Rivers and Harbors Act, Section 10 authorization is required for structures or work in or affecting navigable waters of the United States (33 CFR 322.1). Those portions of the project located below the mean high water mark are expected to require a Section 10 permit (See Chapter 33, Part 322 of the Code of Federal Regulations for associated definitions).

e. Water Quality Certification:

Pursuant to Section 401 of the Clean Water Act, any applicant seeking a license or permit to conduct any activity including that may result in any discharge into the navigable waters, shall provide the licensing or permitting agency a certification from the State in which the discharge originates (33 CFR 320.3). If Section 404 authorization is required, it is expected that a state water quality certification will also be required.

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Delaware County Engineer http://www.co.delaware.oh.us/engineer/projects/centerburgbridge.htm

University of New Hampshire Stormwater Center http://www.unh.edu/unhsc

FIGURES

Figure 2: Failed Shoreline Protection

Figure 1: Project Locus

Figure 3: Project Features

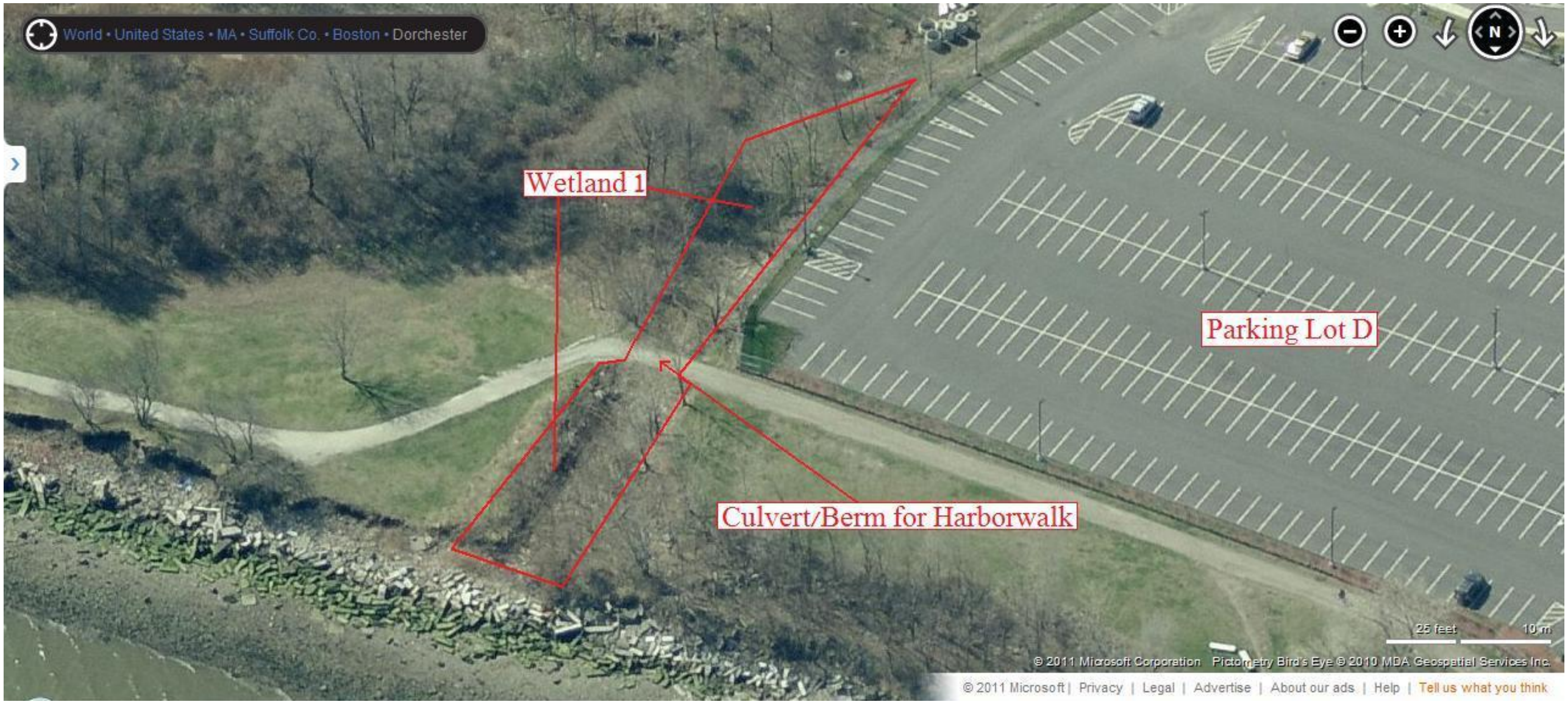


Figure 4: Wetland 1

Figure 5: Wetland 2

Figure 6: Proposed Conditions

Flap Gate

Sluice Gate

Self Regulating Tide Gate

Open Box Culvert

Figure 7: Tidal Exchange systems

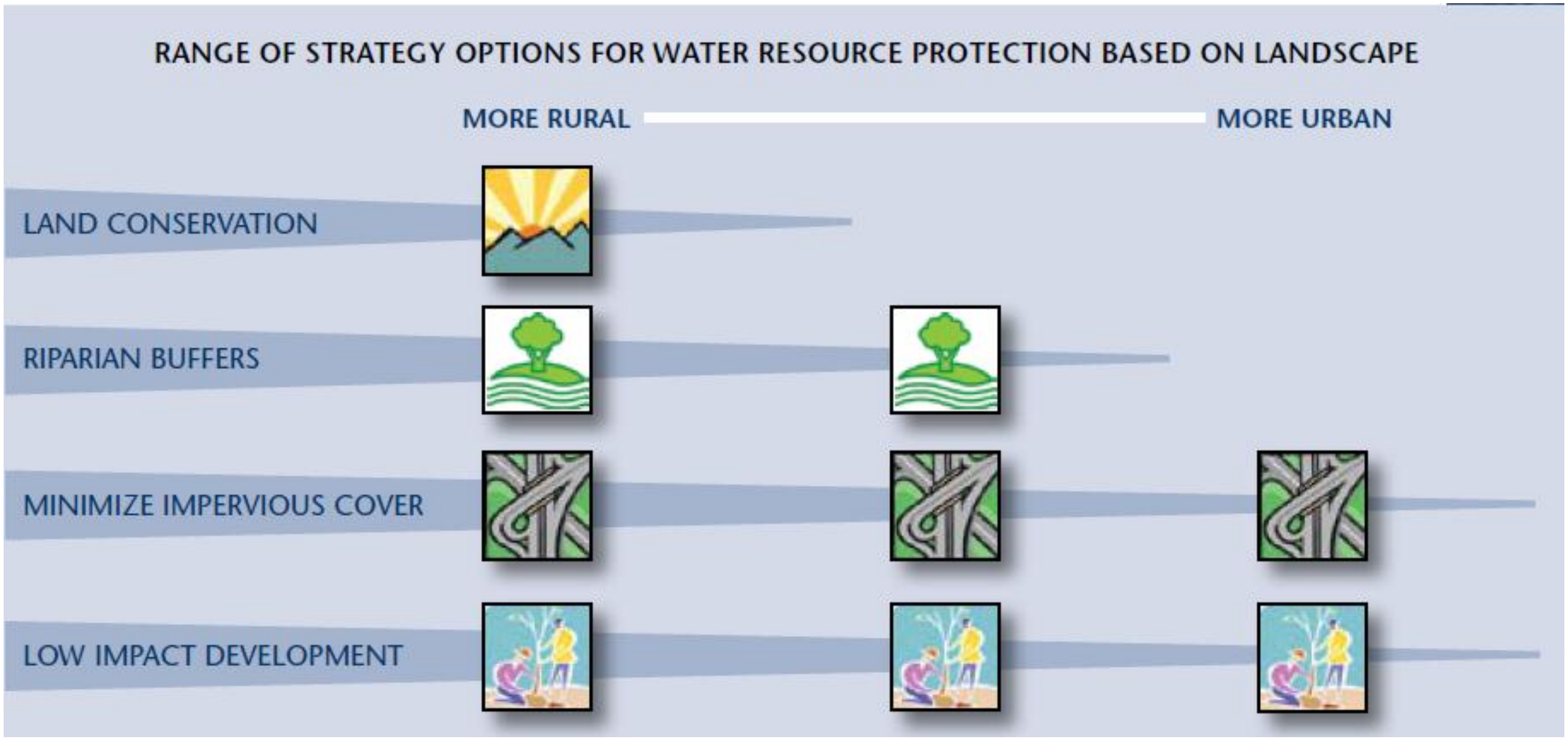
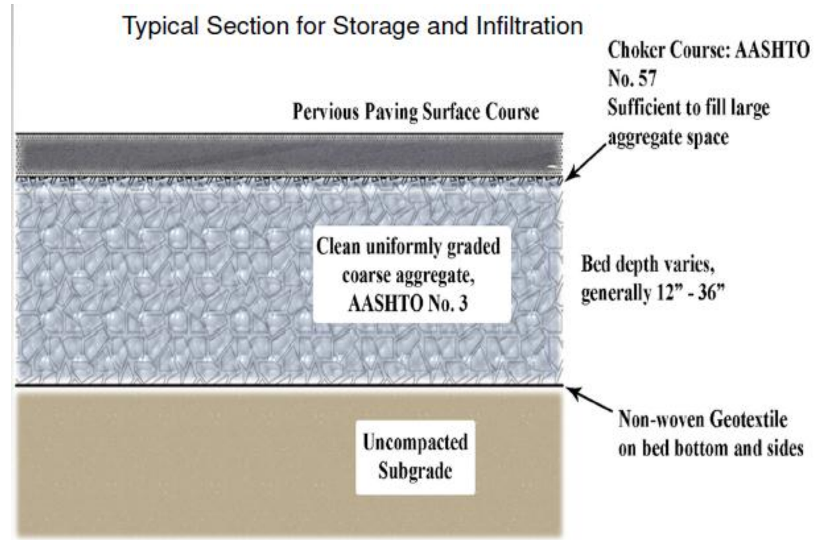


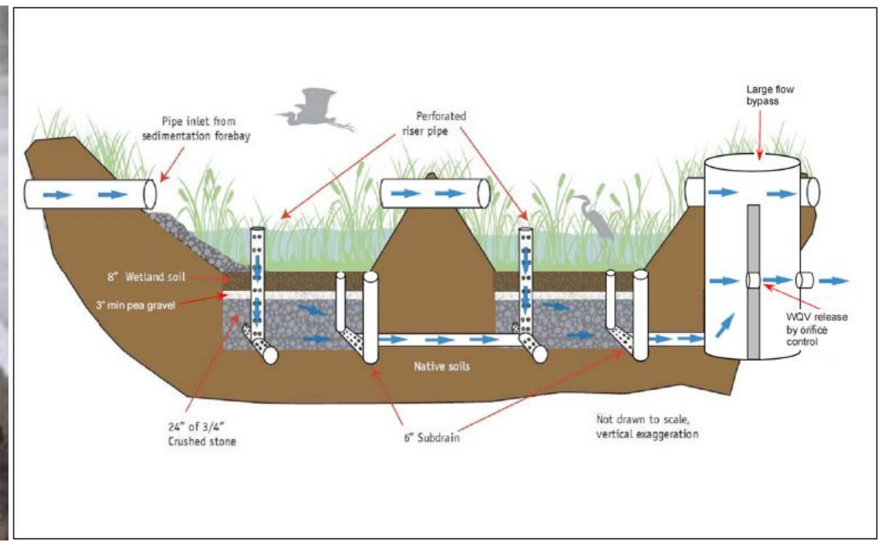
Figure 8: With increased development comes a reduced ability to mitigate for stormwater impacts

Tree Filter



Porous Pavement Cross Section

Bio-retention Median Strip



Gravel Wetland Cross Section

Figure 9: LID design measures