Sediment Management in Savin Hill Cove

Image source: Google Maps

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Environmental, Earth, & Ocean Sciences Department

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and a Component of the Green Boston Harbor Project

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Table of Contents

TABLE OF CONTENTS CONT.

INTRODUCTION

The Environmental Protection Agency (EPA) has enlisted the help of the University of Massachusetts Boston (UMB) in its efforts to restore Boston's urban watersheds, and improve overall water quality. Excitingly enough, Professor Anamarija Frankic of UMB's Environmental, Earth and Ocean Sciences (EEOS) Department, and founder of the Green Boston Harbor (GBH) Project (Frankic, 2011), has engaged her Capstone students in developing proposals that address specific sites within Boston's degraded watersheds. The pilot sites include Draw Seven Hill in Somerville, Sandy Beach, Pier 5 in Charlestown; and to be addressed in detail in this report, Savin Hill Cove located adjacent to UMB in Dorchester, MA.

As a partnership we strive to discover alternative sediment management solutions that are more ecologically beneficial, less damaging, and more permanent than conventional dredging methods. Knowing stakeholders could choose conventional dredging, we also strive to suggest more efficient uses of dredge material.

OBJECTIVES

There is no definite or prioritized "to do" list for Savin Hill Cove, other than periodic dredging that has been used as a short-term solution to the heavy sedimentation. Researching and choosing alternative sediment management techniques requires an intimate knowledge of the area and its environment. Gaps in information and data are commonplace, but the lack of knowledge and baseline data for Savin Hill Cove makes it difficult to create and fit within given parameters. Our project plans to address these concerns. One intention is to investigate and assess different aspects of our site to get a better understanding of its current condition. We will research the history of the site, paying close attention to anthropological changes that have occurred there. We will also gather information about the biology, sediment conditions and pollutant levels of Savin Hill Cove to better understand its current issues. Identifying possible sediment sources is also of major concern to this project, so that we are able to stop the problem from its points of origin. Another major objective is also to clearly identify the problems affecting the cove and its stakeholders, and propose the most ecologically friendly and beneficial solutions. The current problems affecting Savin Hill Cove include sediment accumulation in navigation channels used by UMB's research vessel as well as Savin Hill Yacht Club members; the reduced efficiency of UMB's heating and cooling system's intake pipe due to sediment and biota inundation; and a lack of biodiversity.

To find long term solutions to the above-mentioned issues we will turn to more ecologically beneficial solutions. We will research possible soft structures to be implemented at the site, which consists of natural vegetation and living coastlines. We will also research the possibilities of hard structures, and how both hard and soft structure implementation around Savin Hill Cove would be most beneficial. We do recognize that the stakeholders may ultimately choose conventional dredging so we will also research how to dredge in more efficient, less destructive ways.

The objectives of this project vary greatly but all work in conjunction to improve the current environmental conditions at Savin Hill Cove. This project will address the concerns with sediment accumulation in the cove and will suggest solutions to keep sediment out, keep sediment moving, and remove sediment (Davis, 2010). We will consider solutions that also improve water quality, water movement, and biodiversity as well as manage sediment. Involving students and faculty at UMB in future implementing and monitoring of solutions in Savin Hill Cove is an essential component to this project as well. This project will provide inventive, less damaging solutions to problems that are common in harbors around the world.

Our Mission

To minimize the impact of sedimentation in navigation channels, and to restore the degraded ecosystem.

BACKGROUND INFORMATION

Savin Hill Cove is located in between Morrissey Boulevard and University Drive, along the southern coast of UMB's campus.. At first glance, Savin Hill Cove appears to be no more than a small, shallow inlet of the greater Dorchester Bay, revealing expansive sandy and muddy flats at low tide. A Google map image of Savin Hill Cove and its surroundings are provided in the Appendix, as figure 1, to better acquaint the reader with our site. Look again, and notice the Savin Hill Yacht Club at one end and UMB's campus at the other; both significant landmarks in the Savin Hill area. Both Savin Hill Yacht Club and UMB are the two primary stakeholders in future developments in Savin Hill Cove. The cove seems to have survived Boston's urban development, but just barely.

Upon further inspection however, it can be seen that Savin Hill Cove has been degraded to a point far beyond its natural state and this is having negative consequences environmentally, socially, and economically. The most pressing issue being the build-up of sediments in the cove that continually clog the university's heating and cooling system's intake pump, and that must be periodically dredged to allow passage of vessels as well as the neighboring yacht club's boats.

The spectrum of Savin Hill Cove's distress is broad, as are their sources, implications, and solutions. Constant man-made alterations to the land in the area have affected the cove greatly beginning in the 1800s. Its surrounding area, which is now the UMB's campus, was once a landfill area known as Cow Pastures (Manzo, ca. 2000). Roadway and building construction, in the past and more recently, play a major role in the destruction of Savin Hill Cove's ecosystem. The rapid accumulation of sediment and debris is the result of a multitude of factors. The effects of this build up are far reaching and a proper solution will need to be multidimensional and flexible. The goal is to properly assess the Cove, rehabilitate the environment, and preserve its natural services through funding, education, and community involvement.

To determine the optimal solutions for Savin Hill Cove, it was first necessary to get to know the area, its history and environmental, ecological and social significance. Our site is affected by and is a part of many larger systems; thus the creation of a successful management plan requires a comprehension of all factors affecting the cove

HISTORY

As early as the late 1800s we can find records of man-made alterations to Savin Hill Cove and its surrounding environment, including Patten's Cove, Columbia Point, and a marsh area connected to Savin Hill Cove. The main contributor to these alterations was the fill-in of Columbia Point, to be discussed later, and the construction and remodel of Savin Hill Yacht Club. Savin Hill Yacht Club was established in 1875, under the name Savin Hill Beach Association (Black, et al., 1975). The first clubhouse was situated in Patten's Cove and after growth of membership the club decided to expand its clubhouse in 1890. Yacht club members also expressed concerns for additional train stops and widening of the roads so access to the club was more readily available to their growing members (Black, et al., 1975). Savin Hill Cove was already experiencing the effects of man-made construction in the late 1800s (Manzo, ca. 2000). In 1906 another major development for Savin Hill Yacht Club was underway. Savin Hill Yacht Club was to move from its original location to Fox Point. During this time major environmental changes occurred as a result of construction of the new clubhouse and lockers. An area of marshland between the club road to the beach was filled; the filled area was 350 ft by 150ft in total (Black, et al., 1975). Additional road and sidewalk construction also took place during this time to provide better access to the new clubhouse.

In response to the community's interest in Savin Hill Yacht Club, the Eastern Dredging Company was contracted to dredge an eighty foot wide basin along with an inner and outer channel, thirty-six feet and fifty feet wide respectively (Black, et al., 1975). This proved to be a costly project in which Savin Hill Yacht Club paid nothing. Continual construction of buildings occurred throughout the 1900s, when interest in the yacht club increased. In the process of building the boulevard in 1926 it is recorded that mud was being dumped in the yacht club's basin, Savin Hill Cove (Black, et al., 1975). In 1929 Public Works announced its plan to transfer a drainage sewer outlet to Fox Point, where Savin Hill Yacht Club called home. Members of the Massachusetts Bay Yacht Club Association opposed this plan and changes were to have the drainage site moved to Patten's Cove (Black, et al., 1975). During the 1970s construction of UMB, dredging was once again used in the area (Black, et al., 1975). Constant alterations for the yacht club were being made, and it seems all at the expense of the environment. The dredging and filling of this area that once was a marshland has made it almost unrecognizable in present day from pre-1800s alterations. Savin Hill Cove, maybe unintentionally, has been completely transformed from a marsh into an unhealthy mudflat.

Specific interest is also paid to how urban development and the filling in of land affect this site. Industry and dams upstream the Neponset River have altered the water quality and flow into the cove, and its shape has been changed over time due to land fill and other nearby development. Human activity like the recent construction of a storm water drain into Savin Hill Cove, or dam removals upstream have resulted in an increase of sediment and debris. Meanwhile the depositing of landfill has decreased the circulation of the area and is exaggerating the accumulation.

THE NEPONSET RIVER WATERSHED: A SOURCE FOR SEDIMENT

We are interested in understanding the connection of our site, Savin Hill Cove, to the Neponset River. Water and sediments are transported from the Neponset River into the Boston Harbor. This water enters the harbor near the National Grid gas tank, a local Boston landmark, where it later reaches our site of interest, Savin Hill Cove. Not only water is passed through here; garbage, sediments, salt from winter roadways and marine life all travel through this waterway. The transportation of water and sediment in this area is of importance to this project in understanding why and how sediments are accumulating in Savin Hill Cove at excessive amounts. Stabilizing sediment sources is a critical component of sediment management and a critical component to this project (Davis, 2010). The Neponset River Watershed Association is also proposing the removal of the Tileston & Hollingsworth (T&H) Dam and the Baker Dam to improve water quality and allow migration for marine species (The Neponset River Watershed, 2011). We are interested in how the water quality, biodiversity and sediment transport will affect Savin Hill Cove in the future by these impending dam removals. We speculate that sediment accumulation could increase with the removal of dams farther up the Neponset River. However, it is also a possibility that the dam removals could improve water movement, which in turn would lessen sediment accumulation in Savin Hill Cove.

Salt Marshes in Savin Hill Cove

Before the numerous man-made changes that occurred around Savin Hill Cove the natural environment was one of a marsh. The ecosystem services and significance of salt marshes and other coastal wetlands are taken for granted, especially in Massachusetts where 25%-50% of coastal wetlands have been destroyed over the last few centuries (Taylor, 2003). Salt marshes are located where rivers meet the ocean, and this mix of fresh and salt water creates unique habitats that are home to a diverse variety of plant and animal life, and function as a buffer zone between the land and sea. Acting as a nursery for many open ocean species, as well as a year-round home to more stationary creatures and filter feeders, salt marshes are also necessary for maintaining water quality (Pendleton, 2008). Without salt marshes, our coasts are unprotected from a myriad of problems such as toxic runoff and pollution from roadways, chronic erosion, and a lack of biodiversity. Figures 2 and 3, found in the Appendix, show the stark difference between Savin Hill Cove's coast lines in the past, and now.

Salt marsh restoration is at the top of most environmental agendas, and has been successfully implemented along many coasts. A man-made salt marsh is a complicated process, requiring changes in management and policy at multiple levels of government, and the need for community support. It is also a measurable task to recreate an ecosystem from scratch, and setbacks, sometimes failure, can be expected within the first few years. However with proper attention, man-made salt marshes can closely mimic their natural counterparts and revive degraded areas. They key to these and other effective restorations is consistent, long term monitoring of the hydrology, bathymetry, and vegetation of an area (Taylor, 2003). Monitoring will be discussed later in the *Results* section.

METHODOLOGY

Various sources and approaches were necessary to compile all of the information needed to assess possible solutions to the sedimentation problems affecting Savin Hill Cove. Both environmental and socio-economic assessments are essential to further implementation of solutions at Savin Hill Cove. Information on completed dredging projects from the past was important so we could evaluate costs, permits and other details of the past dredge to assemble a guideline for a possible future dredging schedule. A sediment accumulation rate at the site is also needed to better propose future dredging possibilities. Other important information needed for this project concerns the possible alternative solutions we hope will be implemented. A variety of solutions needed to researched and discussed before they could be proposed for Savin Hill Cove.

The environmental assessment became a base for the research of this project. Using an environmental assessment that was prepared by Normandeau Associates of Falmouth, MA in 2006 was crucial in our understanding of the environmental conditions at Savin Hill Cove. This environmental assessment was completed for the construction company, Bourne Consulting Engineering, hired for the 2006 dredge at Savin Hill Cove. After analyzing the environmental assessment it became clear that the conditions at Savin Hill Cove were more than undesirable. The muddy sediment provided little oxygen for benthic organisms, showing how unacceptable the environmental conditions really were at this site. This environmental assessment points out that habitat quality at Savin Hill Cove has time and again been evaluated as the poorest of any station in the Massachusetts Water Resource Authority (MWRA) study (Normandeau Associates, 2006). The simple fact that dredging, a process usually thought of as environmentally destructive, could be more helpful than harmful to this environment was a key indicator that this ecosystem was severely suffering. This environmental assessment was also helpful in deciding the appropriate months for dredging to be implemented at the site. As part of the environmental assessment, each description of species that lived in the cove was given opportunistic time periods when they would be less likely to endure negative impacts from dredging activities (Normandeau Associates, 2006). Before future dredging projects can be completed, a new environmental assessment will need to be conducted. If not completed necessary permitting may not be acquired, delaying or preventing future dredging projects. Although this project did not actively prepare or collect information for a socio-economic assessment we have come to the conclusion that one is necessary for the further research and implementation of solutions at Savin Hill Cove.

Another crucial component to our research of Savin Hill Cove was the collection of information regarding the most recent dredging project in the cove. After research in flora, fauna, sediment cores and sediment contamination, a 2006 dredging project was implemented at Savin Hill Cove to increase water depth, clean the harbor, enhance navigation channels, and remove unwanted sediments that were inundating the UMB's heating and cooling in-take pump (Sweeny, 2005). Two sites were chosen for dredging in Savin Hill Cove, one being dredged at 10 feet below mean low tide and the other at 8 feet below mean low tide, totaling in 22,000 cubic yards of sediments removed. After examining the quality of the sediment the Army Corps of Engineers delivered a memorandum permitted dredging and offshore disposal of the sediments. See Figure 8 in the Appendix for a copy of this memorandum. Although this was the overall cheapest option for disposal, the dredging project still cost $3 million (Sweeney, 2005). In the past dredging has been the go to solution for sediment accumulation issues at Savin Hill Cove, a costly process that physically removes sediments, and all life and debris in it, from unwanted areas. In fact, dredging seems to be the main solution for all harbors that experience unwanted sediment accumulation in navigational channels. We will tackle the same issues that were pressing for the 2006 dredging project, because they are relevant economic and social issues that are still a concern to stakeholders such as UMB, its pump-house facility and marine operations department, as well as the Savin Hill Cove Yacht Club. Ultimately, dredging is harmful to benthic organisms, decreases water quality, is costly, and is never the end-all solution to sediment management in navigation channels or other coastal inlets. Figure 4 of the Appendix outlines the various negative impacts of dredging in different ecosystems.

Past rates of sediment accumulation are available, but new rates are needed desperately if we are to propose a future dredging date. The most recent estimates of the rate of sediment accumulation at the site was estimated by comparing dredge feasibility maps of the area from 1983 and 2004, and was estimated at 1 inch of sediment accumulation per year (Sweeney, 2005).

From observation it appears that this rate may have increased, due in part to the new Morrissey Blvd storm drain that empties into the cove, but without future monitoring of sediment accumulation we cannot be positive. We tried to compare feasibility maps from 1983 and 2005, but it did not prove to be easy. After analyzing and comparing the maps personally, and then consulting Professor Anamarija Frankic, we realized that there was an uncertainty in the comparability of the maps. We were informed that the mean low tides, which are the mark at which depths were measured and recorded on the maps, may have changed between the years of 1983 and 2005. Unfortunately we were unsuccessful at determining a new rate of sediment accumulation for the navigation channels of interest in Savin Hill Cove.

Meeting with stakeholders proved to be the most beneficial way for us to gather information. We scheduled two meeting with the director of Marine Operations at UMB, Chris Sweeney. He worked closely on the 2006 dredge at Savin Hill Cove and was a vital resource for us in researching the past dredge. We were also able to obtain the environmental assessment that was completed for the 2006 dredge from Mr. Sweeney, described above. Mrs. Zehra Schneider Graham, UMB Environmental Health and Safety Deputy Director provided us with insight on UMB's Master Plan (2009), which proposes vast construction changes to the existing campus. This gave us a better understanding of the possibility of solutions actually being implemented. We hope that current plans for the alteration of the campus and its roadways will benefit the chances for implementation of certain solutions we propose, such as bio-retention areas. Professor Allen Gontz of UMB's EEOS department was also kind enough to allow one of us to accompany him and some of his students as they collected sediment samples from Savin Hill Cove at low tide. There, he was able to point out some of the sources of sediment and debris and give us a better impression of how they flow through the cove. Contact with the Environmental Protection Agency was also attempted but we could not get a response. Meetings with Professor Anamarija Frankic were also crucial to our methodology. She provided us with resources and suggestions throughout the project that proved to be extremely helpful. Each contact we reached out to concerning this project was essential in consider what the most functional and environmentally beneficial solutions might be to solve the complex issues affecting Savin Hill Cove. We found that our contacts were eager to help us, and eager to see Savin Hill Cove finally addressed beyond the scope of dredging. Professor Anamarija Frankic reached out to us about the possibility of reclassifying Savin Hill Cove as a Brownfield site, to increase chances and funding for environmental restoration efforts. As we learned earlier from investigating the history of our site, the area was once Cow Pasture, where disregarded material of all kinds was stored. This gave us hope for implementation of our proposed solutions since construction was already set to occur and the environment had been significantly degraded because of past land use.

Past history of Savin Hill Cove was also essential to understanding its current conditions and issues it faces. We relied on information provided on the Savin Hill Yacht Club website, (http://savinhillyc.org/index.php?option=com_content&task=view&id=16&Itemid=30). This provided us with history of changes around the cove from the 1800s up until present day. The information we focused on, which was the history of Savin Hill Yacht Club, was also printed for the Savin Hill Yacht Club's 75th anniversary yearbook. We also researched basic information on the Neponset River Watershed and its dam removal proposals (2009), to better understand the impacts it has and will have in the future on Savin Hill Cove.

To assess possible alternative sediment management solutions we then turned to various projects around the country to compile successful projects that incorporated the solutions we are proposing. We also gathered information from general website and EPA documents for the logistics of each solution we are proposing. With this information we were able to better judge which solutions may or may not work well at Savin Hill Cove. All methods of research played a vital role in our understanding of the site, its issues and the possible solutions we can propose to address them.

RESULTS

We believe that as students our intentions for this project are sincere, and unbiased. The goal is not designed with self-interest, rather to explore multiple solutions to an environmental and economic issue that will benefit all parties involved and create a sustainable future for a neglected system. After researching the many aspects of our site's issues we have decided that there are two categories of solutions we can propose, soft structures and hard structures. We have also come to the conclusion that the best solution would be one that incorporates both. We also investigated the possibility of continued dredging at Savin Hill Cove and how we could use this method in a more efficient and cost effective way.

Alternative Sediment Management Solutions

A main goal of this project was to determine the best innovative, natural solutions for sediment management to implement at Savin Hill Cove. We find more promise for success in natural solutions because not only do they address sediment management issues, they also address biodiversity and water quality issues which are also affecting Savin Hill Cove. When looking at alternatives to dredging, there are three key factors that must be kept in mind: keeping sediments out, keeping sediments moving, and safe removal of accumulated sediments and debris (Davis, 2010). While methods other than dredging can be used to remove sediment from Savin Hill Cove, it would be ideal to act in a preventative manner and focus also on keeping sediments out of the cove. The solutions we have researched range from natural, soft structures, hard structures and solutions which utilize both hard and soft structures. By choosing the best solutions from this variety, we believe the environment of Savin Hill Cove as well as socio-economic issues can be successfully managed.

Soft Structures: Restore natural salt marshes

One alternative that is of interest of this project is the implementation of a salt marsh environment in Savin Hill Cove. Salt marshes are known to accrete sediment to build up their foundations. The relocation of sediment accumulation to a restored salt marsh environment would be one goal of this solution. By relocating the sediment to a salt marsh environment we could minimize the sediment accumulation in unwanted areas of the cove such as the navigation channels and UMB's pump-house intake. This solution would also improve water quality of Savin Hill Cove by utilizing plant and animal life to filter the water. A salt marsh would also encourage more life to inhabit Savin Hill Cove and enrich its biodiversity and the environment as a whole; as well as act as a natural buffer against storms and unusually high tides. If strategically placed, the salt marshes may also be able to capture sediment that is transported by runoff, which again would reduce sediment accumulation in unwanted areas. Fellow students, Nicole Proia and Alyssa Hardiman, are working more in depth on the possibility of implementing salt marsh restoration to Savin Hill Cove and its surrounding area.

Given the current shallow depth of the cove, we believe that at least one more session of dredging is necessary before any alternatives or restorations take place. Again we look to the case of the Hackensack Meadowlands where dredging to increase flow was needed in preparation for salt marsh restoration (Mogensen, 2000). Fortunately the dredge spoil can be used as a foundation and as nourishment for new salt marshes. This use of dredge spoil to reconstruct salt marshes was proposed in 2006 for Duxbury Beach in southern Massachusetts (Rosen, et al 2006). The authors of the proposal, titled "Balancing natural processes and competing uses on a transgressive barrier, Duxbury Beach, Massachusetts" recommended the use of dredge spoil that was silty, which is the sediment size of the soil. Laboratory reports on the material dredged from Savin Hill Cove in 2006 show that the dredge spoil is between 50% and 60% silt and clay. The lab reports can be found as figures 6 and 7 in the Appendix. If dredging is a necessary evil, we can begin to mitigate its negative effects by reusing the dredge spoil instead of dumping it at sea. Furthermore, by reusing the silty sediment to nourish the re-growth of natural vegetation, we can revive the natural ecosystem services that will decrease sedimentation and stop the need for dredging.

However difficult it may be, efforts to recreate and restore salt marshes are proving to be worth the time and capital. In 2003, researchers in the Gulf of Maine found that man-made salt marshes can be as productive as natural marshes within ten years (Taylor, 2003). Another case of success can be seen in the Hackensack Meadowlands District in northern New Jersey. There, an isolated and deteriorated section of wetland, 120 acres, was dredged to increase flow, and salt marshes restored. It is now a highly functional salt marsh, capable of mitigating the harms of nearby industry (Mogensen, 2000). The case of Hackensack demonstrates the ecologically positive effects of restoring flow to an area laden with sediments and debris accumulation.

BIO-RETENTION AREAS

Sometimes sediments cannot be properly stabilized, even in the presence of salt marshes, so this project will also explore methods to either trap incoming sediment or simply block them from entering Savin Hill Cove.

Another solution we have found to be greatly beneficial to Savin Hill Cove are bio-retention areas. These areas are considered a best management practice (BMP), created in the Prince George's County, MD, Department of Environmental Resources (EPA, 1999). Bio-retention areas are planned out areas of vegetation, including trees, shrubs, grasses and flowers, which remove pollutants and sediment through physical, biological and chemical processes (Quality Assurance for Nonpoint Source Best Management Practice, 2005). They have been used successfully in places such as Maryland, North Carolina and Virginia, mainly to combat storm water runoff, which is also a concern for this project. Bioretention areas consist of different mediums, which all serve their own purpose in runoff this management process.

The first section of bio-retention areas consists of grass buffers. The grass buffers first reduce the velocity of runoff water as well as begin to filter out particulates. After the grass buffer comes the sand bed which act to reduce the velocity of runoff water, filter out particulates and additionally spread runoff evenly over the length of the ponding area. The ponding area contains an organic layer of mulch layer on top of underlying planting soil (EPA, 1999). The mulch layer is most responsible for the most of the heavy metals removed in a bio-retention area. Field studies completed by the University of Maryland suggest that heavy metals such as copper, zinc and lead can be reduced by 90% or higher, through the use of bio-retention areas. The mulch layer also provides an environment ideal for the growth of microorganisms which break down petroleum-based products (Quality Assurance for Nonpoint Source Best Management Practices, 2005). The ponding area acts as a temporary runoff storage which infiltrates the underlying clay and planting soil over a period of a few days. The voids in the planting soil allow the stored runoff water and nutrients are then used by plant uptake. The ponding area is graded with a center depression to allow these processes to occur. Runoff water that is not stored and used by plants is evapotranspired (EPA, 1999). Studies conducted by the University of Virginia found that 86% of Total Suspended Solids can be captured in the ponding area of a bio-retention area (Quality Assurance for Nonpoint Source Best Management Practices, 2005). This result is of special interest to our project, as we look for more natural ways to keep sediment out of Savin Hill Cove. Planted ground cover, as well as the mulch layer, reduces erosion which will reduce sediment inundation of Savin Hill Cove. The use of clay adsorbs hydrocarbons, heavy metals, nutrients and other pollutants (EPA, 1999). All components of a bio-retention area serve a specific purpose in managing storm water runoff, the pollutants it contains and the sediment it erodes.

When considering the potential costs of implementing bio-retention areas they appear to be much less costly than other storm water and sediment management solutions. Retrofitting of a bio-retention area appears to be to most costly part of the project, costing up to $6,500 per bio-retention area. Bio-retention areas 400 square feet in size, completed in Prince George's County, MD, costs $500 each. However this estimate only includes costs for excavating and vegetation (EPA, 1999). Inspection, repair and replacement of components of a bio-retention area must be conducted to maintain their efficiency and should also be considered in the overall cost of the project. The EPA's Storm Water Fact Sheet provides specific information on when certain components should be inspected for efficiency (EPA, 1999). Overall the costs are minimal when considering the multi-million dollar projects such as the 2006 dredging project and pump-house repair in Savin Hill Cove that have previously been done to address sediment accumulation issues.

With major changes already set to occur in roadway construction through UMB's Master Plan (2009), we hope bio-retention areas can be more easily implemented. The EPA's Storm Water Fact Sheet suggests that the best place to implement bio-retention areas are sites where construction and excavation are already planned, much like the campus of UMB. The most suitable areas for this best management practice include median strips, parking lot islands and swales (EPA, 1999). We suggest the incorporation of these areas between the roadways and Savin Hill Cove as well as in parking lot islands on UMB's campus.

Micro-scale bio-retention areas can also be applied to sidewalks to essentially perform most of the same duties of larger areas. Planted boxes of grasses, flowers, shrubs and sometimes trees can line sidewalks to collect runoff from streets. These planted boxes also can incorporate a storm water drains or storage which leads to a storm water drain providing cleaner water being released in Savin Hill Cove and other storm water drainage sites. This is especially useful if excessive runoff is an issue at the site, much like it is on Morrissey Blvd. which borders Savin Hill Cove. Sedimentation accumulation increases from runoff during periods of frequent flooding on Morrissey Blvd. currently drop out into Savin Hill Cove and Patten's Cove. Planted box bio-retention areas along the roadway could collect some sediment. Sidewalk bio-retention units can also reduce the thermal pollution of runoff before it enters storm water drains or the surrounding environment. Runoff can be heated when it travels over impervious surfaces such as roadways but these vegetated sidewalks can cool runoff water by 12° Celsius (Quality Assurance for Nonpoint Source Best Management Practices, 2005). These sidewalk bio-retention areas would be most beneficial along Morrissey Blvd. as well as the section of University Drive that borders Savin Hill Cove.

Larger bio-retention areas incorporating a diversity of native tree, shrub, flower and grass species would be ideal in the area between University Dr. and the waterfront. Implementing multiple bio-retention areas will ensure the efficiency of the units as well as leave open space and bench areas so the community can enjoy these beautifully vegetated areas. It is important to note that the bio-retention areas should only contain native species. Invasive species have the possibility to disrupt the native environment. The randomness of trees and shrubs should also come into consideration when designing bio-retention areas. If scattered at random, the larger bio-retention areas can more effectively mimic a natural forest (EPA, 1999).

Maintenance of all bio-retention areas must be considered to maintain their efficiency as well as when considering overall project costs. However, combined construction, material and upkeep costs of bio-retention areas would be significantly lower than costs for conventional dredging. Where conventional dredging in 2006 at Savin Hill Cove cost $3 million, using past project estimates of $500 per 400 sq ft area suggest, multiple bio-retention areas that could be implemented on and around UMB's campus would cost significantly less.

HARD STRUCTURES: TRAINING DAMS, SEAWALLS, PNEUMATIC BARRIERS SILLS AND SILT SCREENS

Another alternative to sediment management this project we will investigate are pneumatic barriers. This solution focuses on keeping sediments out of Savin Hill Cove by using pressurized air movement underwater to disturb water flow and sediment accumulation, and producing an air barrier for incoming sediment. This method is conventionally used to contain oil spills and to keep oil from settling into the sediment. However we believe pneumatic barriers could be beneficial in stopping sediment from settling down through the water. Strategically placed pneumatic barriers bordering the navigation channels in Savin Hill Cove could be used to address the unwanted sediment build-up in these channels. Studies conducted in New York and New Jersey showed how effective pneumatic barriers or air curtains can be in reducing sediment accumulation. They used sites that were usually dredged every three to five years to deal with this issue and concluded that the costs and benefits of using pneumatic barriers outweigh those of dredging (Chapman, et al., 1999). This research gives up hope for successful implementation of pneumatic barriers in Savin Hill Cove.

Training dams can also be used to increase flow and circulations, which in turn keep sediments suspended or are used to divert sediment-laden currents. Training dams could be used in conjunction with salt marsh restoration, to direct sediment into the growing salt marsh. Training dams could also be implemented further up the Neponset River. If salt marsh restoration started to become more accepted and understood, possible implementation of salt marsh restoration along the Neponset River and the implementation of training dams to divert sediment into the marshes could be incorporated here as well. Not only would it improve the quality of water and life in the river, the success would of the salt marshes would reach Savin Hill Cove and benefit its ecosystem.

Regarding man-made sediment management techniques like silt screens and training dams, we ran into several issues when assessing the feasibility of each option. Training dams and rip raps have been successfully implemented in many areas, but we have determined that Savin Hill Cove is much too shallow for these options, and that boat navigation will be further complicated by such structures.

Sills, previously called Marsh Enhancement Breakwaters, are hard structures which work to protect soft structures such as salt marsh habitats. Sills can be constructed out of rock or wood and run parallel to the shoreline. These hard structures act as a barrier for newly planted salt marsh environments to protect them from wave energy while vegetation is still taking root (North Carolina Division of Coastal Management, 2009). This hard structure would be useful to protect the proposed salt marsh restoration sites for Savin Hill Cove while they are young to promote a successful rehabilitation. More will be discussed on the benefits of sills in the upcoming section concerning the combination of hard and soft structures use at Savin Hill Cove, which is the ideal implementation of solution for the site.

Silt screens were researched as an alternation sediment management solution. We came to the conclusion that they might present several problems if implemented in Savin Hill Cove; primarily the matter of access for yachters and UMB's vessels. A silt screen where the cove meets Dorchester Bay will not be as effective in controlling accumulation levels, as silt screens placed closer to the opening of Patten's Cove and the Morrissey Blvd storm drain outfall; which are primary sources of sediment and debris that affect the cove. However we cannot be certain that preventing sediment from certain areas could also cause negative impacts. Starving the marshland of Patten's Cove is a possible negative outcome of implementing a silt screen. Overall not enough information has been collected to determine if silt screens would be more beneficial or harmful to Savin Hill Cove but future sediment management proposals for the cove should investigate this solution further.

Currently one side of Savin Hill Cove is separated from land by a sea wall. Sea walls are constructed to prevent erosion damage to shorelines of interest. However, unlike salt marshes they cannot absorb the energy of the waves for a long time. Eventually sea walls will deteriorate or become damaged by high energy storms and eventually result in more erosion of shorelines. The energy reflected from the sea wall also negatively affects the adjacent shoreline by eroding it more severely. Sea walls also cannot adapt to changing sea levels like other natural solutions can. We cannot suggest taking down the seawall, as that would be too costly and erosion prevention is still needed for the UMB campus, but we can propose the implementation of natural vegetation where energy is reflected from the sea wall. This could lessen the erosion caused by the sea wall and it is a natural solution that can also benefit the ecosystem. We next suggest the combination of soft structures and hard structures to minimize negative effects of hard structures and to creating a more holistic and beneficial solution to the issues we are addressing.

IDEAL SOLUTION: COMBINE ALL

The possible implementation of vegetation and hard structures along Morrissey Blvd., University Drive and the Harbor Walk, to trap and filter water and sediments before they enter Savin Hill Cove, we believe to be the best option for sediment management at Savin Hill Cove. A problem with numerous causes requires multifaceted solutions. We learned from Professor Anamarija Frankic, in several previous EEOS courses, that by combining hard and soft structures, man-made and natural elements, we can address many issues at once. Our vision of Savin Hill Cove is displayed in Figure 5 of the Appendix. Natural elements can encourage the restoration of the ecosystem and divert sediment from navigation channels, while hard structures serve to protect and manage the area and divert sediment into new natural solutions such as salt marsh environments.

Not only did this project strive to investigate and propose the best alternative sediment management solutions for this site, it also examined how the combination of the various solutions we have proposed may be the best implementation of all. We would like to propose the implementation of pneumatic barriers, sills, salt marsh restoration and bio-retention areas. The use of pneumatic barriers will specifically address the unwanted sediment accumulation in navigation channels. By bordering the navigational channels with pneumatic barriers, sediment will be suspended and will not accumulate at the bottom. This solution puts little strain on the environment of Savin Hill Cove, except for initial construction to install the devices. Before this solution can be implemented more research on the use of pneumatic barriers in such shallow waters will have to be conducted. This solution keeping sediment moving so unwanted accumulation does not occur or occurs at slower rates.

Salt marsh restoration sites will work together with the existing seawall and proposed rock sills. The salt marsh and rock sill will absorb energy that is reflected off of the existing seawall, which will minimize erosion of the shoreline. The rock sills, running parallel to the shoreline, will protect the newly planted salt marsh species and encourage successful rooting of plants. Salt marshes themselves will be beneficial to the cove in numerous ways. Salt marshes would attract sediment to use for its growing peat base, filter pollutants from water resulting in improved water quality, improve bioturbation in sediment and increase the biodiversity of Savin

Hill Cove. Although we find dredging to be an unfit solution to sediment management we do feel that it is necessary to implement one more dredge before any restoration can take place. If dredging is carried out we suggest using the dredge spoil for a sediment foundation for the salt marsh restoration sites. This option will be further discussed in a moment so we can present all dredging possibility suggestions. The use of bio-retention sites we proposed would be used to keep sediment out of the cove. We found that bordering sections of Morrissey Blvd. and University Dr. would be the most effective uses for micro-scale bio-retention areas, such as planted boxes discussed earlier. Larger bio-retention areas can be implemented in the grassy area between University Dr. and the Harbor Walk. This area already has a natural slope that will work well in bio-retention areas and current plans for construction allow easy implementation of the areas. Suspended solids along with pollutants will filter out of the runoff water in the planted sidewalk boxes as well as the larger bio-retention areas. Pollutants and sediments that manage to pass through will then be able to be filtered in the salt marsh site of Savin Hill Cove. This will provide two separate filtration systems for runoff water that enters Savin Hill Cove. All the alternative sediment management solution we have chosen complement each other to return Savin Hill Cove to a functioning, ascetically pleasing environment. However we do acknowledge the fact that conventional dredging could ultimately be the option chosen for the site. We have come up with some suggestions to make dredging more efficient and less environmentally degrading if it is used again.

Future Dredging

We have come to the conclusion that one more dredge of navigation channels should be implemented before any other sediment management solutions are implemented. This would clear out the navigation channels to avoid frequent dredging, remove debris captured in the sediment, as well as possibly supply soil for the salt marsh restoration sites. Before any future dredging project can be implemented it must undergo a new environmental assessment. The previous environmental assessment for the 2006 dredge emphasized how appalling the environment was, from sediment conditions to benthic and pelagic life. We are skeptical of the assessment being bias in the favor of dredging, because the company who completed the environmental assessment was hired by the dredging company. Future environmental assessments should avoid this bias if at all possible, as to not put Savin Hill Cove and its inhabitants in jeopardy. If dredging becomes the go-to solution in the future permitting will have to be acquired each individual dredge, as well as individual environmental assessment.

Dredging spoil could be used as a soil base for propose salt marsh restoration sites. This option was brought to our attention by Professor Anamarija Frankic. Although more assessment of soil composition and contamination levels must be completed to use dredge spoil for salt marsh foundations, preliminary investigations which we have conducted provide evidence that this option could be successful in Savin Hill Cove. As mentioned above, Duxbury Beach in Massachusetts is a success story for salt marsh restoration using dredge spoil. This restoration used and suggested the use of silty sediments to compile salt marsh foundations. During the 2006 dredging project, sediment composition testing was completed and found silty and clay-like sediment accounted for 43.1%-68% of sediment, which varied with each navigation channel. These 2006 laboratory reports can be found in our Appendix as Figures 6 and 7. Silty sediment has been proven successful in salt marsh rehabilitation (Rosen, et al 2006), which gives us hope that dredge spoil from Savin Hill Cove could be used to accomplish this. The contaminate level of sediment in the cove another factor giving us hope for the reuse of dredge spoil. The dredge spoil from 2006 was fit enough for offshore disposal and did not need remediation beforehand (See Figure 8 in Appendix for a memorandum regarding ocean disposal of dredge spoil from 2006). Although the sediment from Savin Hill Cove is not perfect, it may be sufficient enough to reuse for salt marsh foundations, or to use in combination with other materials. This would both eliminate costs of offshore disposal as well as eliminate some cost for salt marsh foundation sediments. Material from other sites would have to be transported to Savin Hill Cove for the salt marsh restoration sites otherwise. If dredging continues in the future, we hope stakeholders will consider our suggestions that are ecologically and economically beneficial, rather than disposing the spoil offshore.

We identified how using multiple solutions, natural or soft structures and hard structures, as well as dredging, will impact the cove environmentally and how future costs of sediment management of the cove will be impacted. By suggesting the use of multiple solutions including, pneumatic barriers, salt marshes, sills and bio-retention areas we can better manage

Savin Hill Cove. The goal of using a holistic solution would be to reduce future dredging needs and to increase water movement, sediment transportation, water quality, and biodiversity at Savin Hill Cove.

SAVIN HILL COVE AS A BROWNFIELD SITE

We also suggest further examination of classifying Savin Hill Cove as a Brownfield would be environmentally, socially and economically beneficial to the future of this project. As defined by section 101 of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 U.S.C. 9601). "The term 'Brownfield site' means real property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant" (EPA, 2009). By reclassifying Savin Hill Cove as a Brownfield site we hope to relieve stresses and complications of implementing aquatic vegetation as well as gain support and funding from the community and government agencies. We are hoping to provide solutions that will ultimately save UMB money when dealing with the issues at the cove.

We believe that Savin Hill Cove qualifies as a Brownfield site for several reasons. The EPA defines a Brownfield as a property with the "presence of hazardous substance, pollutant, or contaminant (EPA: "About Brownfields", 2010). In 2004, UMB's campus was classified as a Brownfield site for oil contamination (Mass DEP website). Figure 9 of the Appendix provides specific details on the UMB campus as a Brownfield site. The point of contamination was near the UMB research vessel dock; this immediate proximity to Savin Hill Cove leads us to believe that runoff of the pollutant has landed in Savin Hill Cove. Furthermore, we know that in the 1600s to the late 1800s when Columbia Point was used to pasture calves, locals also used it as a dump (Manzo, ca. 2000). Given the early time period, there was probably little discretion with this dumping and many toxic chemicals and pollutants that are now illegal may still be under the surface. As land was filled on Columbia Point, this garbage was not removed, it was simply filled over. There is concern that over time, toxins may leech if they are not already (Manzo, ca. 2000). The EPA's Brownfield website states that one of the goals of a Brownfield site is to allow stakeholders and the local communities to most efficiently assess, manage, and/or reuse a degraded and polluted area, with some financial assistance and other support from the EPA (2010); our project aims to do exactly this. Another key qualifier for Savin Hill Cove is that it is intended for redevelopment. (EPA: "About Brownfields", 2010). The cove is currently an area with little biodiversity that is being used by the yacht club to store boats, and by UMB to heat and cool its campus and dock its research vessels and sailing boats. Man-made changes to the cove have destroyed the areas natural abilities to protect itself and foster the life that it should. We intend to redevelop it into a thriving coastal ecosystem with a natural salt marsh that can become a tourist destination and a hands-on component to many UMB courses and programs. We would like to see Savin Hill Cove become an example of a healthy coastal ecosystem, and a model for coastal restoration around the world. The activities of the yacht club will not be interrupted, and we believe their membership will increase as the area becomes healthier and more beautified. Savin Hill Cove will be redeveloped from an area that needs constant attention, dredging, and maintenance, to a healthy coastal ecosystem.

MONITORING

Any of the solutions that we have recommended above will undoubtedly cost a significant amount, and will affect all stakeholders. Thus it is necessary to properly monitor a variety of factors and indicators that will reveal how effective these solutions are, and what adjustments might be necessary. Furthermore, the monitoring may be performed by UMB students and faculty, and incorporated into the curriculum of the EEOS program. Consistent monitoring of this sort can also help to establish missing baseline data. Professor Anamarija Frankic provided us with lists of natural and socioeconomic indicators that she compiled based on a 2005 report published by the United Nations Educational, Scientific, and Cultural Organization. The following are several natural indicators to be monitored:

- **Currents, changes in bathymetry, and surface waves:** In the case of training dams, pneumatic barriers, and other such alternatives, we would expect to see an increase in currents and tidal activity in the relatively stagnant area.

- **Salinity:** Given that Savin Hill Cove is the meeting point for fresh river water and salty ocean water, it is important to maintain consistent salinity levels if we wish to bring life back to the area. Also, the installation of a salt marsh will affect salinity and this must be monitored so that we know *how*.

- **Sediment grain size:** Because the main issue is sediment accumulation, this indicator carries heavy significance.

- **Benthic biomass and sediment organic content:** We would like to see an increase in benthic biomass and organic content

- **Changes in shoreline position:** This is likely to occur with the installation of natural vegetation/salt marshes.

- **Dissolved oxygen and inorganic nutrients:** Currently, Savin Hill Cove does not support much life. We hope that monitoring will show an increase in dissolved oxygen and nutrients.

- **Seabird and fish abundance:** This will tell how successful the project has been at restoring the natural habitats that once existed at Savin Hill Cove

- **Total production levels:** A healthier cove will lead to healthier ecosystems and hopefully more life, especially is a salt marsh is revived.

- **Total suspended solids:** Again, this relates to sedimentation as a primary issue.

- **Trace metals and other toxins:** As dams become decommissioned and removed up the Neponset River, it is important to monitor what they are sending downstream. Many dams in Massachusetts are quite old and were installed before laws restricted dumping into rivers. Thus, as dams are removed we fear that large amounts of illegal and harmful toxins will be released and flow into Savin Hill Cove.

As stated before, the implementation of new sediment management techniques will carry a cost and affect UMB, Savin Hill Yacht Club, JFK Library, Boston College High School, Dorchester residents, and many others. The following are some social and economic indicators that we suggest be monitored as well:

- **Land use/land cover:** We would like to see the percent of land covered with natural vegetation increase, both around Savin Hill Cove and on the UMB campus.

- **Changes in user conflicts:** This will monitor the relationships between UMB, Savin Hill Yacht Club, and other local residents and establishments as changes are made to the area.

- **Percent of coast altered:** The majority of Savin Hill Cove's coast has been altered by man, and we would like to return it to a more natural state.

- **Non-use value of coastal habitats:** Installing a salt marsh will increase the natural services of the cove.

- **Water dependent use industry/coastal industry:** It is important to monitor the business of the Savin Hill yacht Club to be sure that none of our activities are affecting their business.

- **Fertilizer use in watershed:** The Neponset River watershed is vast and undoubtedly carries fertilizer runoff into Savin Hill Cove. A salt marsh would help to trap and process these chemicals.

- **Coastal energy production:** We would like to see the cost of heating and cooling for UMB decline, since a main goal of this project is to prevent sediments from clogging the system's intake pipe, which requires costly repairs.

- **Number/value of recreational fishing days:** Savin Hill Cove is currently not an optimal fishing site, and we would like to change that.

- **Property** values: An increase in ecological services, and aesthetically pleasing natural vegetation could possibly increase local property values.

- **Number of tourists/day:** Sometimes an increase in tourism can have negative effects to an area. But in the case of Savin Hill Cove, and increase in tourism means an increase in awareness, and that the cove is now a desirable destination.

- **Number of vessels entering/transiting coastal waters:** This indicator may change given the workings of the Savin Hill Yacht Club. More boats may indicate that the cove has become more navigable, but we must also be careful to ensure that these boats do not bring excess pollution and upset a young salt marsh.

Along with these indicators we also find it important to monitor the dam removal projects proposed along the Neponset River. The possible effects these dam removals can reach all the way to Savin Hill Cove. Changes in sediment load, water flow, transport of Polychlorinated biphenyls (PCBs) and other possible alterations should be monitored throughout the Neponset Watershed including at Savin Hill Cove.

DISCUSSION

Soft structures and natural vegetation provide some of the most beneficial outcomes of all proposed solutions. One-time dredging can increase circulation that will decrease sedimentation and the dredge spoil can be used to stabilize and nourish salt marshes. Salt marshes will improve water quality, sediment transport and biodiversity of Savin Hill Cove. Rock sills will provide protect for the newly planted salt marsh grasses. Bio-retention areas provide storm water runoff treatment and storage, sediment storage, shade and wind breaks. They also help to absorb noise pollution and improve the site's intrinsic value. They should also be more easily implemented due to planned construction and excavation of UMB's campus, through the UMB Master Plan (2009). Smaller bio-retention areas in the form of planted sidewalk boxes would also be beneficial in trapping sediment from run off as well as filtering runoff before it enters Savin Hill Cove.

Pneumatic barriers can be an alternative to costly dredging in navigation channels. Pressurized air along the channels can prevent unwanted sediment from accumulating. This solution is also much less environmentally damaging and less costly than conventional dredging would be. The implementation of this solution should be one aspect of sediment management at Savin Hill Cove.

A key objective of our project is to provide future students and faculty at UMB with hand-on projects or classes that involve implementing solutions, monitoring, and reevaluating conditions at Savin Hill Cove. It has already become clear that the lack of data concerning current rates of sediment accumulation is an obstacle in determining a future dredging schedule. Getting students and faculty involved in the monitoring of Savin Hill Cove is essential to rehabilitating this environment, and is a cost free method to collect this necessary data. The community could also learn about gardening and the native species of the area by taking advantage of the proposed bio-retention areas. Both small and large scale bio-retention areas could serve the community. This community involvement could provide free basic upkeep for the small-scale bio-retention areas, as frequent clogging of debris could result from being placed in a high traffic area such as Morrissey Blvd. The project also aims to improve the community's understanding of the issues facing Savin Hill Cove and the involvement of university students and faculty can help to expand this understanding in a useful way.

After becoming aware of the proposed dam removals farther up the Neponset River, we find it necessary to understand how future dam removals farther up the Neponset River will affect water and sediment movement at Savin Hill Cove. The removal of the Baker Dam of Lower Mills Dorchester and Milton and Tileston and Hollingsworth (T&H) Dam of Hyde Park and Milton pose the most concern to the future of Savin Hill Cove. Their proposed removal could change many aspects of Savin Hill Cove's environment. First, it could change sediment flow into the cove, which could be negative or positive. More sediment flow could encourage the growth of our proposed salt marsh habitats but it could also increase the inundation of sediment into UMB's heating and cooling intake pump as well as sediment accumulation in navigation channels. Secondly, removal of the dams could increase water flow which could benefit the Neponset River and Savin Hill Cove by keeping sediment suspended in the water flow. PCB contamination is also of concern when removing these dams. Because these dams were constructed near industrial sites the sediments that have built up around the dams contain PCBs (Neponset River Watershed Association, 2009). Proper management of this contaminated soil must occur before any dam removal to avoid PCBs being transported further down the river and possibly into Savin Hill Cove. All affects of future dam removal must be considered when examining future conditions of Savin Hill Cove.

The possibility of Savin Hill Cove reclassified as a Brownfield site should not be overlooked. The history of the site's land use provides evidence that this site is heavily polluted. Cow Pasture was once a landfill used to store all varieties of garbage material. This area is now occupied by the UMB campus and there appears to be little doubt that Savin Hill Cove was also affected by this previous use of the land. When Savin Hill Cove was dredged in 2006 it was evident that much more exists in the muddy sediment of the cove. Large pieces of metal, wood and plastic were all evident at the site and a large amount of this debris currently sits under the muddy cove's sediment. We hope that reclassifying Savin Hill Cove as a Brownfield site would gain community and government support as well as providing necessary funding to aid restoration projects. The technicalities of reclassification must be research to confirm this possibility. New sediment core samples should be taken to test their contamination levels to provide evidence of a severely degraded environment. Reclassifying Savin Hill Cove as a Brownfield site would ultimately better the chances of future restoration projects being implemented.

Implementation of improved management solutions should be incorporated into UMB's current Master Plan (2009). In the face of tuition and fee hikes for UMB students and continual decreases in state funding for the university, we believe that is in UMB's best interest to solve the intake pipe clogging problem; this could potentially save millions of dollars. This unique opportunity gives us hope that alterations in the plan could be made to incorporate our proposed solutions. The future of Savin Hill Cove will continue to be of concern for its stakeholders such as the UMB and the Savin Hill Yacht Club. We hope that when the time to make a decision about future sediment management possibilities stakeholders consider alternative solutions that are more natural and ecologically beneficial to Savin Hill Cove.

ACKNOWLEDGMENTS

We are grateful to the Director of UMB Marine Operations, **Chris Sweeney** for being a reliable contact, taking time to meet with us on several occasions; and providing data, primary sources, documentation, and maps.

We would like to thank the Deputy Director of UMB's Environmental Health and Safety Office, **Zehra Schneider Graham**, for meeting with us and for also providing critical information and exploring alternatives with us.

We would also like to thank **Professor Allen Gontz** from UMB's Environmental, Earth, and Ocean Sciences Department for meeting with us and sharing his intimate knowledge of Savin Hill Cove, as well as allowing us to shadow him and his students as they collected sediment samples from the cove.

Last but not least, we would like to deeply thank **Professor Anamarija Frankic** of UMB's Environmental, Earth, and Ocean Sciences Department for devoting so much of her time and energy to guide us and our classmates through this project. As the founder of the Green Boston Harbor Project, she possesses an intimate knowledge of, and passion for understanding, restoring and protecting the environment. We thank her for standing behind our ideas, always being available, and providing invaluable resources and contacts.

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APPENDIX

Table 1: List of Commonly Used Abbreviations

Abbreviation	**Full Term**
DEP (or *Mass* DEP)	Department of Environmental Protection (or *Massachusetts* DEP)
EEOS	Environmental, Earth, and Ocean Sciences
EPA	Environmental Protection Agency
GBH	Green Boston Harbor Project
MWRA	Massachusetts Water Resource Authority
PCB	Polychlorinated biphenyls
UMB	University of Massachusetts Boston

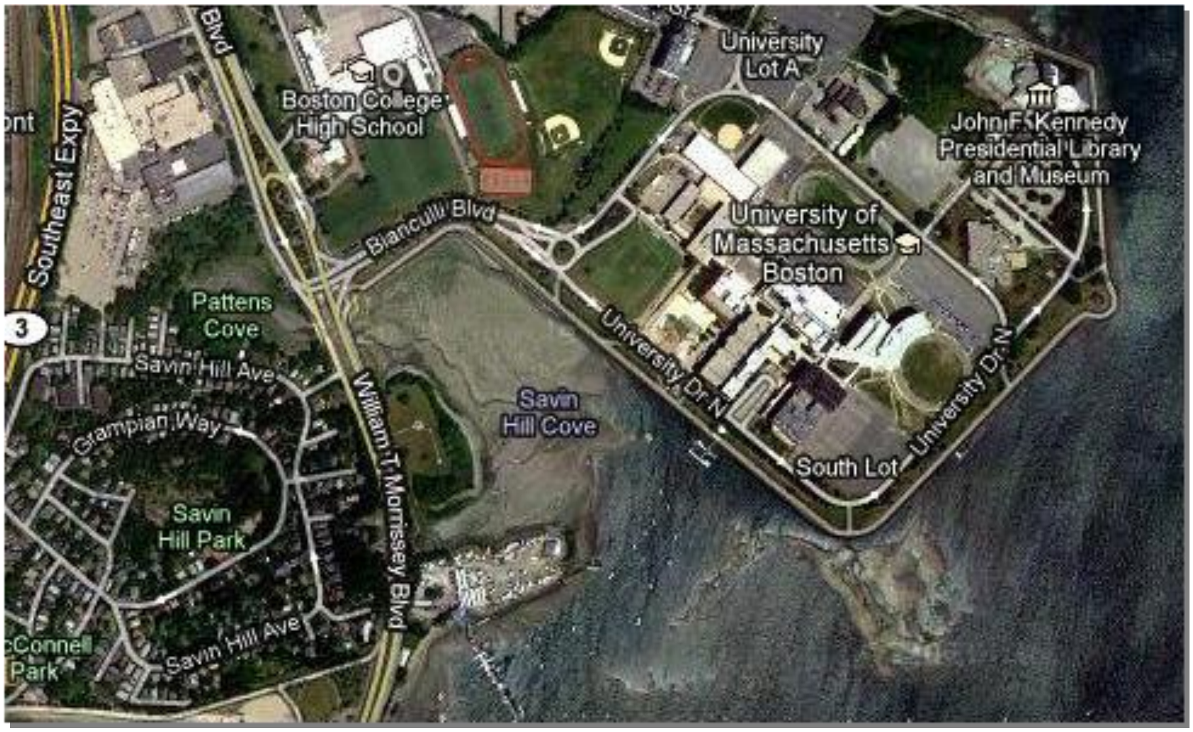


Figure 1: A satellite image of Savin Hill Cove and its surroundings (Image Source: Google Maps)

Figure 2: Savin Hill Cove (Pre-1970) with vegetated shorelines. (Image Source: http://www.lib.umb.edu/archives/digital/?p=collections/controlcard&id=2524)

Figure 3: Savin Hill Cove's shoreline today, lined by a seawall. (Image Source: http://www.graduateguide.com/images/561/U_Boston_6.jpg)

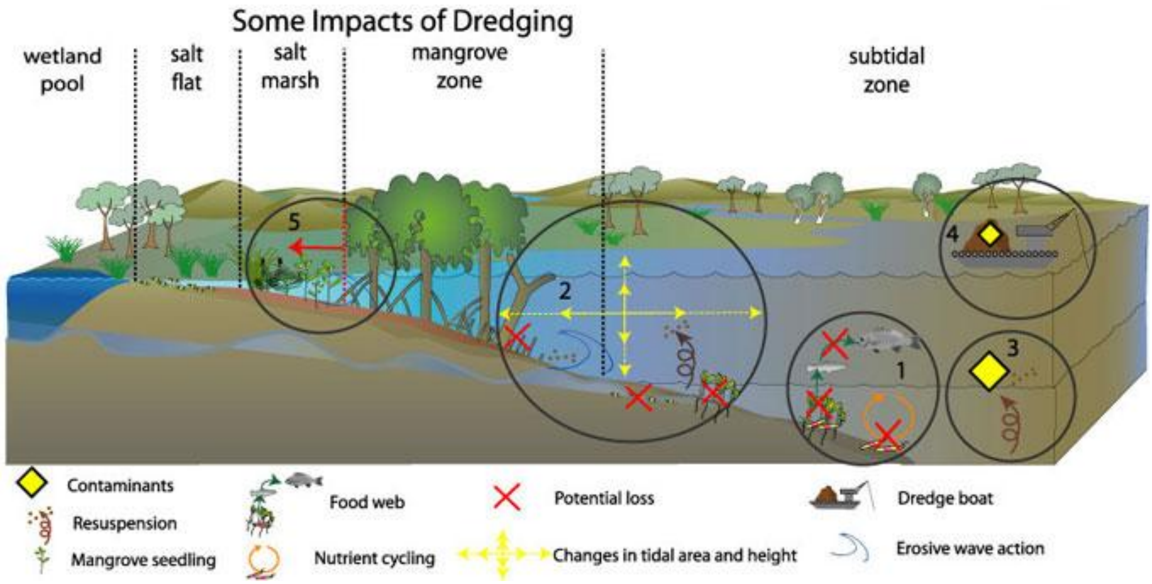


Figure 4: Impacts of Dredging. (Image Source: http://www.ozcoasts.org.au/conceptual_mods/threats/images/dredging.jpg)

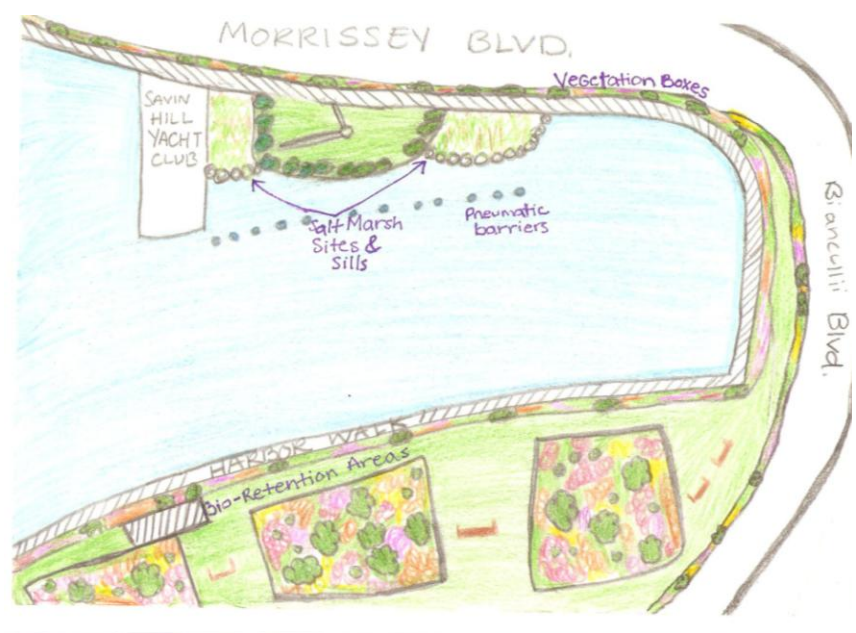
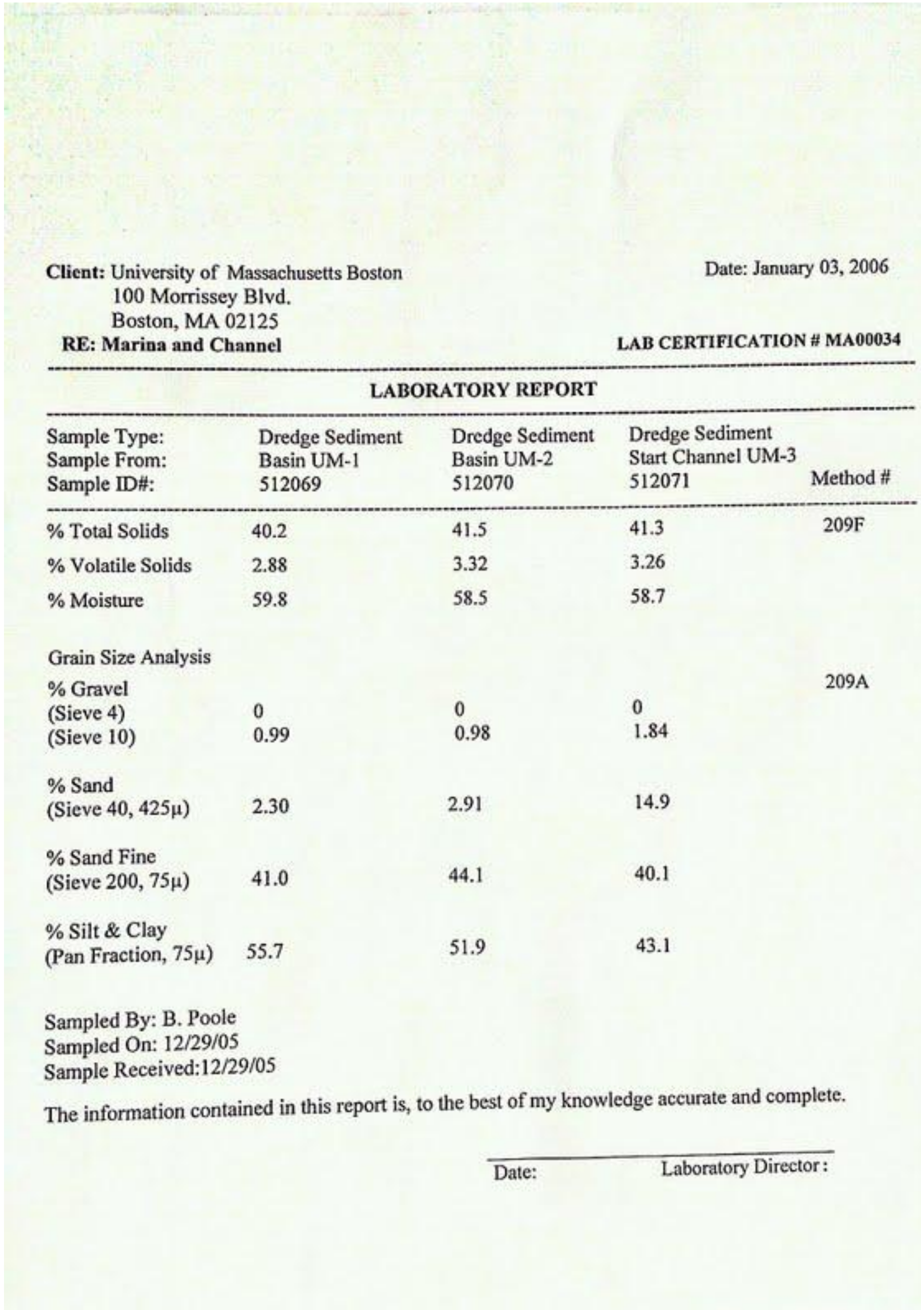


Figure 5: Sketch of proposed combination of solutions if implemented in Savin Hill Cove (Illustrated by Caitlyn Mello)



Client: University of Massachusetts Boston
100 Morrissey Blvd.
Boston, MA 02125
RE: Marina and Channel

Date: January 03, 2006

LAB CERTIFICATION # MA00034

LABORATORY REPORT

Sample Type:	Dredge Sediment	Dredge Sediment	Dredge Sediment	
Sample From:	Basin UM-1	Basin UM-2	Start Channel UM-3	
Sample ID#:	512069	512070	512071	Method #
% Total Solids	40.2	41.5	41.3	209F
% Volatile Solids	2.88	3.32	3.26	
% Moisture	59.8	58.5	58.7	
Grain Size Analysis				
% Gravel				209A
(Sieve 4)	0	0	0	
(Sieve 10)	0.99	0.98	1.84	
% Sand (Sieve 40, 425µ)	2.30	2.91	14.9	
% Sand Fine (Sieve 200, 75µ)	41.0	44.1	40.1	
% Silt & Clay (Pan Fraction, 75µ)	55.7	51.9	43.1	

Sampled By: B. Poole
Sampled On: 12/29/05
Sample Received:12/29/05

The information contained in this report is, to the best of my knowledge accurate and complete.

Date: Laboratory Director:

Figure 6: Lab report indicating the silty quality of sediment dredged from Savin Hill Cove in 2006. (Source: Chris Sweeney, UMB Marine Ops.)

Client: University of Massachusetts Boston
100 Morrissey Blvd.
Boston, MA 02125
RE: Marina and Channel

Date: January 03, 2006

LAB CERTIFICATION # MA00034

LABORATORY REPORT

Sample Type: Sample From: Sample ID#:	Dredge Sediment Mid Channel UM-4 512072	Dredge Sediment End Channel UM-5 512073	Dredge Sediment UM-5 Dup 512074	%RPD	Method #
% Total Solids	45.5	48.7	48.6	0.20	209F
% Volatile Solids	2.90	2.91	2.86	1.73	
% Moisture	54.5	51.3	51.4	0.20	
Grain Size Analysis					
% Gravel					209A
(Sieve 4)	0	0	0		
(Sieve 10)	0.80	0	0		
% Sand (Sieve 40, 425μ)	8.16	1.19	1.08	9.56	
% Sand Fine (Sieve 200, 75μ)	36.2	34.2	30.8	10.5	
% Silt & Clay (Pan Fraction, 75μ)	54.8	64.5	68.0	5.34	

Sampled By: B. Poole
Sampled On: 12/29/05
Sample Received:12/29/05

The information contained in this report is, to the best of my knowledge accurate and complete.

Date: Laboratory Director:

Figure 7: Another lab report indicating the silty quality of sediment dredged from Savin Hill Cove in 2006. (Source: Chris Sweeney, UMB Marine Ops.)

June 27, 2006

MEMORANDUM

TO: Mr. Joe Hanlon
Bourne Consulting

CC: Chris Sweeney
U. Mass Boston

From: Bruce M. Poole
SP Engineering, Inc,

Re: U. Mass Boston Tissue Bioaccumulation Data

I have received all the analysis data from Spectrum Analytical, transformed it into tables and performed statistical analyses on the data. The tissue analyses did not detect any PCB's, PAH's or mercury in the control reference or test sediments. The tissues did contain traces of 4,4 DDT and Dieldrin (1.0 – 3.0 mg/ kg) compared to non detectable levels in the reference tissue. The statistical comparison to a below detection limit reference set is difficult because:

1) There is very little variation in the detection limits on the analyses, while there is always variation in the actual test data and
2) The ACOE recommends using ½ the MDL for statistical comparison. The use of ½ MDL skews the data further apart and especially if there is a non detect in the test group it increases the variance beyond parametric assessment.

Because of these factors, we calculated the data three different ways, and the most representative was using the actual MDL's for comparison. Some of the pesticide data was still non parametric and the values were transformed to the natural log. The Statistical Summary Table shows all the significant values for bioaccumulation. This is a draft document as we may perform additional non parametric analyses.

The statistics show significant bioaccumulation of Dieldrin in clam and worm tissue exposed to Test B Sediments. The analysis of the metal tissue levels show only lead was significantly accumulated by clams exposed to Test A & B sediment. The significant differences exhibited in this test series does not necessarily exclude the sediment from ocean disposal, as the values are very low and below the action thresholds and fish consumption health advisory limits. This will be discussed in the report.

Please call if you have any questions.

Very truly yours,
SP Engineering, Inc.

Bruce M. Poole
President

BMP/cr

Figure 8: Memorandum stating that the quality of 2006 dredge spoil from Savin Hill Cove was sufficient for open ocean dumping. (source: Chris Sweeney, UMB Marine Ops.)

	Site Information
Site Number:	3-0024048
Site Name:	UMASS BOSTON CAMPUS
Address:	100 MORRISSEY BLVD
Town:	BOSTON-DORCHESTER
Zipcode:	02125-0000
Official notification date:	7/14/2004
Initial status date:	7/14/2005

Site Information		
	Category:	TWO HR
	Release Type:	RAO
	Current date:	9/14/2004
	Phase:	
	RAO Class:	A1
	Locationtype:	ROADWAY,SCHOOL
	Source:	VEHICLE

Response Action Information	
Response Action Type:	RNF Release Notification Form Received
Status:	REPORT Reportable Release or Threat of Release
Submittal Date:	9/14/2004
RAO class:	
Activity & Use Limitation:	
Response Action Type:	RAO Response Action Outcome - RAO
Status:	RAORCD RAO Statement Received
Submittal Date:	9/14/2004
RAO class:	A1
Activity & Use Limitation:	NONE
Response Action Type:	IRA Immediate Response Action
Status:	APORAL Oral Approval of Plan or Action
Submittal Date:	7/14/2004
RAO class:	
Activity & Use Limitation:	
Response Action Type:	REL Potential Release or Threat of Release
Status:	REPORT Reportable Release or Threat of Release
Submittal Date:	7/14/2004
RAO class:	
Activity & Use Limitation:	

Chemicals

Chemical	Amount	Units
DIESEL FUEL	10	GAL

LSPs

LSP#	Name
3497	SIMPSON, DANA A

RAO Detail

Class	Method	GW Category	Soil Category
A1	N		2

Figure 9: A compilation of screen shots from Mass DEP's Brownfield website; the shots are from a webpage dedicated to UMB's campus as a Brownfield site. (Image Source: http://db.state.ma.us/dep/cleanup/sites/Site_Info.asp?textfield_RTN=3-0024048)