Development of Sustainable Solutions to Mitigate Sediment and Contaminant Re-suspension During Storm Surges and Tidal Inundation

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An Investigation into the Restoration of Savin Hill Cove

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Introduction and Current Status

Savin Hill Cove is located in Dorchester, Massachusetts found in between UMass Boston, Morrissey Boulevard and the Savin Hill Yacht Club. It is a bare tidal flat that is fully exposed at low tide and submerged at high tide. It has been recognized as one of the most polluted sites in the Boston Harbor. The cove was anthropogenically cultivated in order to accommodate Morrissey Boulevard and the South East Expressway. At the time, the sediment quality was unknown and because it was from construction projects and there is a good chance it was unclean from the beginning. As Morrissey Boulevard and the South East Expressway became more and more popular as transportation routes, runoff and pollution in the cove increased exponentially. Land use characteristics play a key role in the current status of Savin Hill Cove. It is surrounded by a densely residential area, two school systems and Morrissey Boulevard; a heavily trafficked highway used by millions of vehicles daily. Historically, areas with high population density produce more bacteria forming units. This becomes significant in understanding the state of the cove and will be discussed in relation to its condition throughout this paper.

The cove is a habitat for many important coastal organisms including a fringing salt marsh and other salt tolerant plants, sea grasses, shrubs, oysters, soft shell and hard shell clams, and many different species of birds and worms. The health and condition of the cove is currently under threat due to the water and sediment quality that plagues the area. Turbidity is the amount of suspended particles in the water column, and it is a key identifier for overall water quality. When visiting the site, the observed turbidity on any given day is deplorable. During low tide events when the bed of the cove is exposed, the observed sediment is anoxic muck with limited and partial areas of sand. A more
comprehensive expression of water and sediment quality will be explored in the *Early Research* section of this paper.

The objective of this project is to develop sustainable solutions to mitigate sediment and contaminant re-suspension during storm surges and tidal inundation. Recent research data and information suggests that the quality of sediment in Savin Hill Cove is notably contaminated with bacteria such as fecal coliform and heavy metals. Salt marshes are a crucial component to coastlines and rely on clean sediment for nutrients and overall health. During storm surges and high tides, these sediments are aggravated, transported and deposited throughout the fringing salt marsh. This process of accretion proves to be detrimental to the health of the existing salt marsh and the future development of similar ecosystems. The target of this project entails a brief analysis of sediment quality in the affected area, potential solutions to divert sediment and to greater understand and appreciate the Savin Hill Cove salt marsh system.

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**Early Research**

Savin Hill Cove is located adjacent to a thickly settled residential neighborhood. Historically, one of the most significant sources of contaminants near coastal regions is from stormwater runoff tracked from these types of locales and their attributed sub-watersheds (EPA). In 2007, the Boston Water and Sewage Commission implemented the Morrissey Boulevard Drainage Conduit Project (MBDC) as a means to provide better management of stormwater runoff. The project included the construction of four main components. A better understanding of the forthcoming description can be seen in Figure 1 of the *Figures* section of this presentation. The MBDC directs runoff southward from
the upper watershed underneath Morrissey Boulevard, discharging it into Savin Hill Cove. The North Dorchester Bay CSO Storage Tunnel (NDBST) collects the “first flush” of stormwater runoff and transports flow northward away from residential areas and beaches. The third component, Special Manhole D contains a weir wall that directs lower flow levels to the NDBST and directs levels of high flow or overflow into the MBDC. Lastly, the sluice gate manhole located on Carson Beach was implemented to control flow from the NDBST to the abandoned outfall BOS087. Throughout the drainage system, particle separators were employed inside all tributary conduits to reduce the impact of pollutants and contaminants. Before the assembly of the project, all stormwater runoff from the upper watershed discharged into Carson Beach and North Dorchester Bay from BOS087. Post-construction, the unaffected lower watershed continues to drain directly into Savin Hill Cove. Because thickly settled residential areas are a point source for contaminants, we are concerned with the assessment of these particle separators and the management of high-level stormwater runoff directed into Savin Hill Cove.

This multifaceted project included the MWRA-required implementation of the Savin Hill Cove Water Quality Monitoring Project (WQMP), which began two years prior to construction in order to study and evaluate water quality and sedimentation/erosion impacts from stormwater discharges into Savin Hill Cove (ES). Bathymetric surveys were conducted between 2005 and 2013 and water quality sampling was employed congruently, excluding 2008 and 2009 due to the construction of the MBDC where sampling equipment could not be installed and results would be erratic and unpredictable. The water sampling, conducted by the Horsley Witten Group, tested for
fecal coliform bacteria, total suspended solids and salinity. These three variables cause unfavorable conditions for coastal ecosystems and biologic life.

Results of the testing concluded that post-MBDC fecal coliform levels were “at or below what might be expected for an urban watershed” (Executive Summary p.11) and total suspended solid concentrations were found to be “well within the ranges reported in NURP (Nationwide Urban Runoff Program) and NSQD (National Stormwater Quality Data)” (Executive Summary p.16). While this is the expected range for a typical location much like Savin Hill Cove, the contamination index is still objectionable. The conclusions drawn from this information are not ideal because both FC and TSS is particularly variable under a number of different circumstances including density of residential area, antecedent dry periods, land use characteristics, snow and ice control and rainfall intensity. If thorough research were commissioned to observe and delineate these possible variables, a more distinguished and reputable result would be yielded. Although the location of study is manageably small in size, the factors that contribute to acquiring concrete data are exceptionally dynamic and it is necessary to investigate their influence and involvement in the sample data. Salinity was also measured throughout this period. These salinity measurements implied the potential influence of tides on the sampling site due to water level and flow fluctuations. In spring 2011, the sampling intake was reconfigured to acquire more proper measurements.

Along with the sampling, bathymetric surveying also took place to measure changes in sedimentation or erosion of Savin Hill Cove. Results of the surveying concluded no strong correlation between the recent changes in stormwater management techniques and sediment accumulation. Although no fluctuations were present, this is still
a positive incidence because altering stormwater management at times will result in sediment aggradation in areas under threat. Additionally, while these new implementations are not problematic in sediment accumulation, it is crucial to our understanding of the location that we discuss the subject.

The basic appearance of the Cove is unpleasant: The western section of the cove is a naturally occurring entrapment of unused and unwanted human debris which raises toxicity levels and decreases ecological health and water quality, and the sediment that can be visited at low tide across the sum of the cove is anoxic muck with partial areas of sandy material. Two comparative hydrographic studies performed in 1983 and 2004 indicated a historical decrease in water depth over this period; roughly 1 inch per year of sediment aggradation. Chris Sweeney, the Director of Marine Operations at UMB noted in 2005 that approximately every two years the pumps at Fox Point are removed and often replaced entirely due to deterioration from marine growth, sedimentary and contaminating materials from the sea (Sweeney, 2005). Another separate study performed and evaluated continuously by the MWRA between 1992 and 2005 revealed that the habitat continued to show signs of stress with little evidence of sustained improvement (Normandeau Associates). These variables became the initial prompt to enhancing Savin Hill Cove’s water and sediment quality.

One year before the MBDC Project was applied in 2007 UMass Boston and Bourne Counseling Engineering executed a massive dredging operation in Savin Hill Cove. Marine dredging is an excavation activity performed in shallow waters to remove bottom sediment and transport to a different location. The aim of the project was to increase overall water depth within the cove, remove sediment from the intake corridor of
UMass Boston’s pump house (the aperture location of the school’s HVAC system) and create navigation channels in the proper locations for appropriate drainage techniques. A better understanding of this operation can be seen in Figure 2 of the *Figures* section of this presentation. This project included but was not limited to the removal of 22,000 cubic yards of sediment that was approved by the Army Corps of Engineers for offshore disposal. The sediment was transported and deposited roughly 11 miles offshore, two miles further than the diffuser pipes belonging to the Deer Island treatment plant. Two sites were selected for dredging; one resulting in 10 feet below mean sea level and the other about 8 feet below mean sea level. Navigation channels were strategically developed to transport sediment back out to the Harbor during low tide events. This two-year operation yielded a cost of 3 million dollars. The project also incorporated a thorough restoration of UMB’s pump house that resulted in another 4.5 million dollars in cost. Two years and 7.5 million dollars later, the operation was regarded as successful.

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**Dredging: Cost/Benefit Analysis**

Dredging is a marine operation typically used in shallow waters to manually remove unwanted or contaminated sediment from the floor of a given area. Dredging is an activity that is criticized and condemned by environmental scientists, yet it is crucial to this project that a cost/benefit analysis is illustrated to show the positive and negative effects of the procedure.

Dredging is economically high in cost and is stereotypically harmful to the ecology of the location. Dredging also only removes sediment temporarily; nature abhors holes and attempts to fill them in continuously. After dredging projects are taken place,
the lack of continuous monitoring can end up being detrimental to the ecosystem once again as contaminated or polluted sediment accretes. Traditionally, dredging operations can re-suspend contaminants found in bottom sediment. Although in former case studies the re-suspension of these pollutants is minimal, it is worth noting as a negative effect.

Positive effects of dredging should not to be overlooked. While dredging only removes sediment temporarily, it is at most times the only way to remove sediments and a high percentage of contaminants and solids. Dredging is a process that can be used with highly consolidated, dense, cohesive sediments. In the case of Savin Hill Cove, the sediment content falls directly under this category. With the right procedures and precautions, dredging can allow a new, cleaner sediment bed to be formed. Another way increasing water depth can have a positive effect is making easier access for boats. Although at first glance this does not seem like an ecologically friendly outcome, easier access for boats means longer distance from boats to the bottom sediment, which entails less turbidity in the water column.

While dredging can be a costly and ecologically harmful practice, the procedure was necessary to provide a new foundation for the care and upkeep of Savin Hill Cove. Concerns regarding sediment accretion in the Cove are still present and deserve attention. Professor Allen Gontz of the School for the Environment at UMB recently worked with students at this location, specifically at the navigation channel sites to determine more current rates of sedimentation. His research showed that 3 to 4 centimeters of additional sediment per year was accumulating at these channels (Gontz). Chris Sweeney stated that another dredging project will need to be undertaken within the next ten years, but current research may suggest that the next operation ought to take place sooner. This became an
incentive to determine the concerns with previous practices and techniques and to begin considering sustainable solutions to these issues.

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**Issues with Practices and Techniques**

Reviewing the investigations into previous water quality and sediment accumulation tests and results we find fundamental concerns. The inconclusive results of the Savin Hill Cove Water Quality Monitoring Program raise apprehension for current techniques. It should also be noted that the program was only retrieving samples from large storm events and no sampling was taking place during intermittent periods. Although this data may have not been conclusive, all measures should be taken to remain conversant with the cove and its condition. It should also be remarked that the sampling was only done in sample sites belonging to the drainage conduits and no recurrent sampling was taken directly in the cove. These issues in water quality monitoring need to be reviewed and revised for further action to take place.

The dredging operation performed by UMass Boston was successful in the sense that it met the goals and expectations provided in the proposal, but it is important to remember the sheer cost of the operation and the money that could be saved if forthcoming procedures became obsolete. As was discussed earlier, dredging does not actually enhance sediment and rather just removes it. Savin Hill Cove is a natural “trap” for sediment solely because of its location and tidal properties. This also implies that the cove has no protection from storm surges and tidal inundation that becomes an unsettling issue when developing solutions to deter sediment accumulation. Lastly, as was noted with Professor Allen Gontz, the dredge channels are currently accumulating at a
relatively alarming rate. Eliminating sediment accumulation and restoring water quality
in accordance with each other becomes a single key issue we aim to solve.

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**Sustainable Solutions**

This project seeks to develop sustainable solutions to mitigate sediment and
contaminant re-suspension during storm surges and tidal inundation. This means we are
looking at practical, affordable and appropriate strategies that could be applied to our
scenario. This entails researching resolutions that are able to endure heavy tidal action
and intense storm surge events. Solutions that have provided positive results and
displayed accurate improvement in other affected areas are imperative to future planning.
Though we aim to be sustainable, we must remind ourselves that nearly all sustainable
solutions require varying levels of maintenance and upkeep. Upon exploring diverse,
unique and distinguishing methods for sediment mitigation and water quality
improvement strategies, one structure or technique may not be enough.

Research on sediment mitigation yielded many results, but as was mentioned
earlier, appropriateness of these approaches is key. Two notable methods for sediment
containment became the groundwork in future planning. Silt screens (or turbidity screens)
are floatable filtering devices used to contain oil spills and generally used in coastal
construction projects. Silt screens are extremely versatile and can be modified in multiple
ways according to the needs and requirements of a given containment area. These devices
are effective in preventing sediment accumulation in unwanted areas and deter suspended
sediment from entering a specific zone. Another implementation that appeared to be
beneficial to our topic is known as a pneumatic barrier. A pneumatic barrier is a structural
pipe placed in drainage channels that percolates and diffuses air bubbles. This is also effective in preventing sediment aggradation, specifically in dredge navigation passages.

Although this project is focused on sediment mitigation, some practices were found to be advantageous to improve water quality as well. Reef blocks (or reef balls) are rough hollow concrete structures generally around one meter long and one meter wide that are submerged near coastlines. Due to the coarse surface of these blocks, they are ideal habitats for Oysters. Oysters are known to filter ocean water and improve overall water quality. These structures would not only be the home for Oysters that recuperate water quality in the cove; they could be used as barrier systems to combat intense wave action and heavy storm surges if placed in the right locations. Another structure that seemed favorable to our subject is known as a ReefBLK system. These are triangular steel structures are filled with bagged oyster shells and submerged in water. Oyster shells have a rough surface that is appealing for other oysters to attach to. ReefBLK systems, similarly to reef balls or reef blocks, provide a habitat for oysters to begin repopulation and can alleviate the influence of tidal inundation and strong wave action. ReefBLK systems have been proven successful and are currently being used on the Alabama coastline to attract oyster larvae.

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**Proposed Timeline**

The mechanisms examined in the previous section meet the criteria of being practical, sustainable, affordable and appropriate solutions to our current issues with Savin Hill Cove. As was revealed in the cost/benefit analysis of dredging section, another dredging operation is anticipated to begin within the next ten years. The first suggestion I
would propose would be to dredge a comparatively small area eight feet below mean sea level in order to widen the preexisting navigation channel (see Figure 3). This would allow a subsequent pneumatic barrier installation that will be discussed in the next paragraph. Before any project or projects take place, the investigation of necessary permits is needed. The bureaucracy behind Savin Hill Cove is extensive and quite perplexing, as was noted in Stephen Norris and Kevin Carpenter’s recent work done on the *Assessment of policy conditions, constraints, and consequences in the process of shellfish restoration: the complex permitting process for restoration of urban harbors* (2013). It is my conviction that the exploration of these vital permits and legislations can be completed before the next dredging operation takes place. This would allow us to begin the foundation of these proposed solutions directly after completion of the dredging and essentially “start fresh”.

The first recommended installation would be a Pneumatic barrier placed in the newly dredged navigation channel (see Figure 4). This would run in a straight line from the mouth of the UMass Boston pump house across the base of the newly proposed dredge channel. The barrier would percolate during low tide events to deter sediment accumulation in the channel. One suggestion I would offer is to install an Arduino software program to regulate the activity of the barrier in accordance with the changing tides. I have currently been working with remote sensing equipment on Thompson Island and using Arduino; it is a simple software program that when installed and updated, is able to turn a given mechanism on and off according to the time of the tides. In the case of Thompson Island, we use remote sensing cameras positioned on an eroding bluff that turn the devices on 30 minutes before high tide and shut them down 30 minutes after high
tide. If the Arduino software was applied to the pneumatic barrier it could power it up during low tide events to deter sediment from accumulating and serve as an energy efficient complement to the system.

Once the structure is implemented, we will assemble the turbidity screen. The barrier would be attached to the northernmost tip of the Savin Hill Yacht Club and to the rock wall directly outside of the UMass Boston pump house. Granite Environmental Incorporation of Florida provides a numerous amount of specifications and modification options for particular projects and undertakings on their site, erosionpollution.com. Some of the options for their turbidity screens include flexible doors and curtains that do not have to reach the bottom of the assumed site. Because this device is floatable, it is able to endure strong storm events and threatening wave action. This would allow for typical boat access for Savin Hill Yacht Club, and the transmission of aquatic life such as fish and crabs. Because we are concerned with turbidity, a silt screen with no bottom curtain is satisfactory.

After these structures are applied, ongoing water quality testing and sediment accumulation monitoring is crucial to the success of the project. If and when we see positive results from this development, we are able to begin the next stage of improvement. The first is the construction of a reef block system placed in the mouth of the inlet of the cove closest to Morrissey Boulevard. This would gather an oyster population to serve as water quality reformers while alleviating wave attacks from storm surges on the fringing salt marsh. Furthermore, we will construct a ReefBLK system a few feet off of the neighboring coast. This would serve to protect the marsh in an
identical fashion, defending the marsh from wave confrontations and purifying the water of the cove. See figure 5 for an illustration of this proposal.

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**Looking Ahead and Moving Forward**

Savin Hill Cove represents an essential fragment of our local ecosystem and illustrates the need to study the processes that govern its wellbeing. Salt marshes are crucial components of our shorelines and the attributed biodiversity of the area illuminate its importance and significance in our environment. The consequence of neglect in this location has emerged and it is up to the local community to prevent further devastation and protect its welfare. The proposed plan drawn out in this project is an assembly of resolutions that must be taken on by stakeholders, students, researchers and scientists alike. Outlined in this project are not only sustainable solutions to improve the degrading health of the marsh, but also opportunities to use some of the features as a catalyst for new examination and research. With the new Integrated Sciences Complex set for completion in the near future along with the recent foundation and persistent enlargement of the School for the Environment, it seems irrational and senseless not to influence students to study Savin Hill Cove.

Ongoing water quality sampling and sediment accumulation monitoring could be followed out by undergraduates and graduate students; giving them an opportunity to learn about ecosystems and engage in field study in their own “backyard”. Examination and assessment of total suspended solids, fecal coliform and even colored dissolved organic matter are examples of possible projects. Captured sediment could be analyzed using an elemental analyzer to determine definite sediment composition. Tracking salt
marsh restoration progress, biodiversity evaluation and tracing the rate of oyster
repopulation are also brilliant examples of endeavors that students from UMass Boston
and the School for the Environment could assume. These concepts would eventually gain
interest, attention and support from the local community, students and stakeholders.

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Figure 1: Morrissey Boulevard Drainage Conduit Project
(Image source: Savin Hill Cove Water Quality Monitoring Program Executive Summary)
Figure 2: 2007 Post-dredge
(Image Source: Chris Sweeney et al.)

Figure 3: Proposed dredge supplement
Figure 4: Proposed pneumatic barrier installation
(Image Source: Google Maps)
Figure 5: Proposed Reef block and ReefBLK system (Image Source: Google Maps)