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# Evaluating the Vulnerability of Boston's Inner Harbor Designated Port Areas to Sea Level Rise and Coastal Storms

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# **Evaluating the Vulnerability of Boston's Inner Harbor Designated Port Areas to Sea Level Rise and Coastal Storms**

An Interactive Qualifying Project Report  
Submitted to the Faculty of the  
WORCESTER POLYTECHNIC INSTITUTE  
in partial fulfillment of the requirements for the

## **Degree of Bachelor of Science**

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This report represents the work of four WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see: <http://www.wpi.edu/Academics/Projects>

## **Abstract**

As climate change raises sea levels (SLR) and exacerbates storm surges, the frequency and severity of coastal flooding will increase. Boston's shoreline is increasingly vulnerable to flooding. Industries in the Designated Port Areas (DPAs) of Boston Harbor pose risks to public health and the environment because of toxic chemicals used and stored on-site. The goal of this project was to assess the vulnerability of DPAs in Boston harbor to SLR and coastal storms. We evaluated three different aspects of vulnerability: exposure, sensitivity, and ability to cope on 18 different sites within four of Boston's DPAs. Our report highlights the need for more systematic evaluation and planning by stakeholders to mitigate the risks associated with flooding due to SLR and coastal storm surge.

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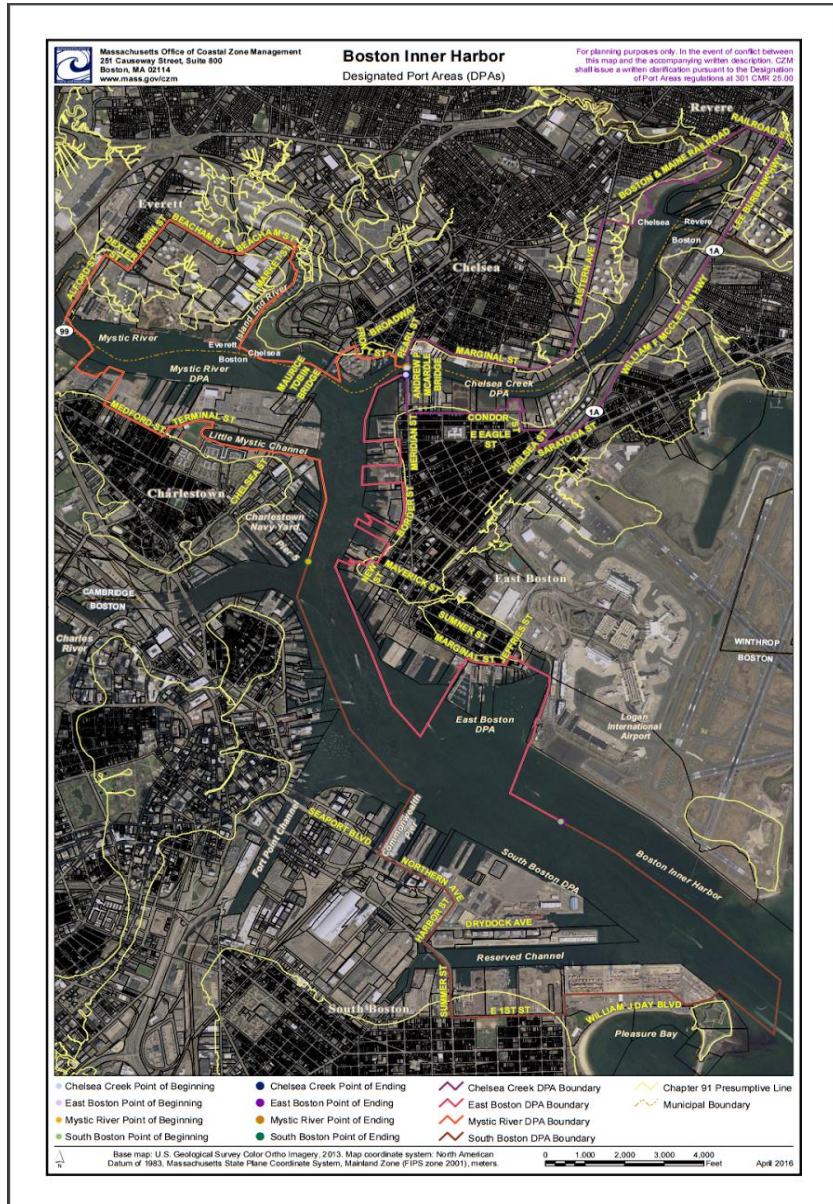
We would like to extend a special thank you to our advisors Seth Tuler and Jennifer deWinter for providing guidance and support. We would also like to thank Jill Valdes Horwood and the rest of Boston Harbor Now for encouraging us and providing us with insight and experience.

## Executive Summary

The goal of this project was to assess the vulnerability of Designated Port Areas in Boston Harbor to sea level rise and coastal storms. Boston is notably vulnerable to flooding events because of its proximity to three rivers and its position on the Atlantic Coast. Since 1991 the City of Boston has experienced 21 flooding events that have triggered federal or state disaster declarations (Climate Ready Boston, 2016, P. 2). Over the entire twentieth century sea levels rose about 9 inches relative to land in Boston (Climate Ready Boston, 2016, P. 8). With the pace of relative sea levels rise accelerating, by 2030 another eight inches of sea level rise may occur, and as much as 3 ft. by 2070 (City of Boston Hazard Mitigation Plan, 2014). Severe flooding in Boston could result in damage to infrastructure, public health, environment and the economy (City of Boston, 2014). The Boston Hazard Mitigation Plan states that “In Boston, Massachusetts, the increase in flooding caused by sea level rise this century could cost up to \$94 billion from damage to buildings, loss of building contents, and associated emergency activities, depending on the amount of sea level rise and adaptation measures taken” (US EPA, n.d.). Areas within Boston Harbor will continue to have accelerated rates of vulnerability unless precautions are implemented to protect the coast from the effects of sea level rise.

Since 2007 Boston has maintained a climate action plan which details measures the city has taken, and intends to take, in order to mitigate the impacts of climate change. The City of Boston’s Climate Ready Report (Walsh, 2014), City of Boston Natural Hazard Mitigation Plan (The City of Boston, 2014), and Greenovate Boston (Greenovate Boston, 2012) are all parts of the city’s climate action plans. The plans that have been implemented come together to reduce the vulnerability to different climate risks. Vulnerability can be defined by three dimensions: the exposure to a threat, the sensitivity to a threat, and the ability to cope with a threat and its impacts. Although these reports and proposals do a thorough job of evaluating the vulnerability of residential and mixed use areas in Boston, they do not complete a thorough evaluation regarding the vulnerability of the working port.

Boston is home to a vibrant working port that deals with a wide array of industries and employs a large number of people (Martin Associates, 2012). Boston specifically has areas classified as Designated Port Areas (DPA), which are set aside for water-dependent industrial uses on Boston’s coast. Our project has focused on the four inner harbor DPAs: Chelsea Creek, Mystic River, East Boston, and South Boston. The impacts associated with sea level rise and storm surge on industrial businesses along the harbor shoreline have not been evaluated (Climate Ready Boston, 2016). Understanding the vulnerability of harbor based industries is a crucial step for Boston to help identify the impacts of sea level rise and allow for better preventative measures to be taken in DPAs in the future.



**Figure i: Inner Boston Harbor DPA Boundaries** courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017

### Assessing the Vulnerability of DPAs

The DPAs of Boston’s inner harbor consist of over 60 water dependent industrial businesses. A representative sample of 18 parcels was investigated in our study. A list of the selected parcel can be seen in Table i.

**Table i: Selected Parcels**

<b>Name Of Business</b>	<b>DPA</b>	<b>Industry</b>
Preferred Freezer	Mystic	Cargo
Distrigas of Massachusetts Everett Marine LNG Terminal Wharf	Mystic	Fuel
Prolerized New England Co. Everett Wharf	Mystic	Cargo
Winnisimmet Landing Pier No. 1-5	Mystic	Mooring
Constellation Mystic Power , LLC Mystic Station Wharf	Mystic	Old Industrial
MA Port Authority, Paul W. Conley Marine Terminal Berth #14-17	South Boston	Vacant
MA Port Authority, South Boston Ship Dock and Barge Dock	South Boston	Old Industrial
Boston Marine Industrial Park Berth No. 6	South Boston	Cargo
Perini Corp. Quarterdeck Marina	Chelsea	Cargo
Global Revco Terminal LLC Revere Terminal Ship Pier	Chelsea	Fuel
Gulf Oil Chelsea Terminal Tanker Wharf	Chelsea	Fuel
Vacant Land with Bulkhead	Chelsea	Vacant
245 & 257 Marginal St. LLC Bulkhead	Chelsea	Vacant/Parking
Channel Fish Co. Inc. Pier	Chelsea	Fishing
Irving Oil Terminals Inc Revere Terminal Pier Global Revco Berth No. 1	Chelsea	Fuel
Mahoney Terminal LLC Chelsea (AKA Eastern Salt Co.)	Chelsea	Salt
Boston Forging & Welding	East Boston	Boat Repair
Boston Towing & Transportation; Boston Fuel Transportation	East Boston	Fuel

The vulnerability of each parcel was assessed by looking at the exposure, sensitivity, and ability to cope to SLR and coastal storm surge. If the parcel was within the predicted flood zone from the Surging Seas: Risk Zone Map, then it was not deemed vulnerable in terms of exposure. Sensitivity was determined by the condition of the flood prevention infrastructure on the parcel and by whether or not the business on the parcel stores chemicals in large quantities. Ability to cope was determined by looking at the net worth of the business, what emergency flood plans the business had in place, and the potential cost of damages the business could receive from flooding from SLR and storm surge. Miscellaneous data was also gathered relating to the effects that DPA flooding could pose on the surrounding area. What we have evaluated are indicators for the corresponding dimensions of vulnerability, they are not direct measurements.

Preliminary information for each of the 18 selected parcels was found online. Area, industry, chemical storage, land and building value, as well as the net worth of the business could all be found on their city's assessor's parcels (Boston, Chelsea, Everett, Revere). The predicted flood zone in and around the parcels was determined using Surging Seas: Risk Zone Map for 5ft of sea level rise by 2100, which is the likely estimate for emissions scenarios used in Climate Ready Boston (Climate Ready Boston, 2016).

We attempted to get in touch with DPA businesses either through email or over the phone. The companies that got back to us were sent emails that contained variations of our

generic interview questions. They were given the option to respond by email or call us to go over their answers. We hoped their responses would give us insight to their day to day operations as well as their opinion of their vulnerability to SLR and coastal storms.

A water taxi was taken out along the shorelines of the parcels that were selected. We took pictures of each site that we were able to visit on the taxi. Photos from the harbor were used in order to understand the current state of SLR infrastructure. We used these photos in conjunction with the 2009 Storm Smart Coasts CZM report to analyze the exposure of sites to SLR and coastal storm surge.

### **Potential Vulnerability and Risks of DPAs**

We determined that Boston's Inner Harbor DPAs are potentially vulnerable to sea level rise and coastal storm surge, as these areas have never fully been investigated. We have also found that this vulnerability has the potential to pose great risk to the city and its inhabitants.

The immediate exposure to SLR and coastal storms greatly increases the vulnerability of the majority of parcels within Boston's working port. Of the investigated parcels, 88% are expected to be in the predicted flood zone for 5 feet of SLR (Global climate change, n.d.). With the DPA's direct access to the waterfront, they are exposed to the effects of SLR and coastal storms more than other areas of Boston.

SLR preventative infrastructure on our selected DPA sites can be improved. Of our 18 selected parcels, only 6 had publicly listed SLR preventative infrastructure (CZM, 2009). Of those 6 parcels, five were ranked as needing a moderate level of action or higher according to CZM (CZM, 2009).

During our water taxi tour, we were able to look at some SLR preventative infrastructure. The high water mark on SLR preventative infrastructure was less than five feet from the top of the structures. Since 5 feet of SLR is expected by 2100, when coastal storms hit, these areas will most likely experience flooding. The SLR preventative infrastructure on these sites demonstrates the exposure to SLR and coastal storms, adding to the vulnerability of these working port areas.

The fact that many businesses within the DPAs store hazardous chemicals on site makes them more sensitive to sea level rise. Many of the companies we evaluated would lose their ability to function for a time should their chemicals be damaged or lost. Ten of the parcels in the sample use chemicals in their day to day operations. We know of nine chemicals that are present in large quantities within the DPAs. The sheer amount of these chemicals along the harbor, in addition to their hazardous nature, is alarming because in extreme events they may find their way into the harbor. For example, within the investigated parcels, there are over 345,811,200 gallons of fuel stored. The issues presented by the release of the chemicals could impact public health, the environment, and the economy of Boston.

Based off of the information available to us, one third of the businesses investigated potentially have the resources to recover from severe flooding events. The sheer cost of the land and infrastructure on many of these parcels would make it difficult for businesses to rebuild after severe flooding. After reviewing the land and building value provided by tax assessor's websites, we identified that out of the parcels investigated, 61% of them were worth over \$1M. Only six of the eighteen businesses that we evaluated were publicly traded and those businesses were all worth well over \$100M. The other twelve parcels are either abandoned or local businesses. During major flooding events, 66% of businesses are expected to have between \$10M-\$100M of predicted damage per acre. The other 33% are predicted to experience between \$1M- \$10M of damage per acre to their property. Since two thirds of all investigated businesses have no public



information on their net worth, one third of the businesses evaluated could possibly have the resources to rebuild after a severe flood.

Based off of interviews and the information available to us, few of the businesses within the DPAs that we investigated have public emergency plans to deal with flooding. Of the 16 businesses that we contacted, only two answered any of our interview questions. One of the businesses that we contacted said that they had an emergency plan in place, but that it was not public information. This lack of transparency regarding emergency planning makes it impossible to make any accurate statement on the level of preparedness that exists within the DPAs.

We found that the regulation of the DPAs is split between MEMA, CZM, USCG, and the EPA. In our research of emergency preparedness plans within the DPAs, we conducted an interview with a hazard mitigation expert from MEMA, we learned that the only regulating body that deals with hazardous materials is local fire departments. Local fire departments enforce EPA regulations concerned with the handling of hazardous materials. The EPA only requires that businesses report the quantity of hazardous materials on their sites to their area fire department and the EPA. The Massachusetts Tier II Reporting Entities main purpose is to “provide the framework and methodology to efficiently respond to hazardous materials emergencies” (Hazardous materials emergency plan, 2011). The current regulations are reactionary in nature, only having plans for chemicals once they spill. We have found no measures in place to help prevent the release of toxic chemicals into the environment. The only other regulatory body that exists within Boston’s harbor is the United States Coast Guard. The Coast Guard is mostly concerned with ships and materials that are moving on the water. They receive hazardous cargo manifests from ships entering the harbor in order to keep updated on the hazardous materials within Boston harbor. From our research it doesn’t seem that there is much communication between these groups. This lack of communication means that in an emergency situation important information may not be available to first responders.

### **Recommendations to Better Prepare DPAs to SLR and Coastal Storms**

There are still major gaps in data concerning vulnerability of Boston to SLR and storm surges. Many of the vulnerability assessments do not address the DPAs in any capacity. As students reaching out to businesses, we found many unwilling to participate or even get back to us. Though we managed to gather a lot of information on DPAs in a short amount of time, there is a lot more data that should be gathered. We recommend that the Massachusetts Coastal Zone Management (CZM) and The Boston Green Ribbon Commission (GRC) continue their partnership and produce a vulnerability assessment of the DPAs. This is the partnership that produces the Climate Ready Boston report, which provides an in depth understanding of Boston’s vulnerability to climate change. With their previous experience, they can conduct a vulnerability assessment to give a more detailed description of the state that the DPAs are in. This report, in conjunction with the Climate Ready Boston report, could create a more complete understanding of the vulnerability of Boston and its harbor to climate change.

Throughout the completion of this project, we found that there is no organization that directly regulates emergency preparedness plans in the DPAs. We recommend that Massachusetts Coastal Zone Management (CZM), the Department of Environmental Protection (DEP), the Massachusetts Emergency Management Agency (MEMA), and the United States Coast Guard (USCG) form a regulatory committee concerned with emergency preparedness plans within the DPAs. The partnership should integrate CZM’s knowledge of businesses and infrastructure within the DPAs, DEP’s experience with brownfield remediation, USCG’s

authority over the harbor and the cargo within it, and MEMAs experience with emergency management in Massachusetts.

The committee should have a set of regulations to enforce on the DPA businesses. The two regulations that we are recommending this committee enforce are: that chemicals and hazardous materials used by businesses within the DPAs must be stored in flood-proof containers, and that more frequent inspections and repairs be performed on the SLR prevention infrastructure within the DPAs. The first regulation would reduce business sensitivity to SLR and coastal storms by reducing the risk of chemical spills. The second regulation would reduce the business's exposure to SLR and coastal storms by ensuring that the SLR prevention infrastructure on the sites are up to date and in good condition.

If these regulations were to be put in place, they could reduce the vulnerability of DPA businesses to sea level rise and coastal storm surges by limiting exposure and sensitivity. This committee and its regulations would ensure that the unique needs of these industrial areas are met, while simultaneously keeping the surrounding communities and environment safe during flooding events.

## **Conclusion**

Over the course of seven weeks we learned a lot about DPAs and their uniquely industrial nature. We understand that our work has limitations stemming from the short amount of time that we had to complete this project as well as the lack of transparency on the part of the DPA businesses. There still remains a gap in knowledge on the vulnerability of the DPAs, and further investigation is needed to fully understand Boston's vulnerability to SLR and coastal storm surge.

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## Chapter 1.0: Introduction

Climate change is a growing problem facing coastal cities. Though climate change is accompanied with many consequences, perhaps the most threatening to the populations of coastal urban cities are the rise in sea levels paired with the rise in coastal storm frequency. The impacts of coastal flooding on a city's infrastructure, public health, environment, and economy have been experienced throughout the country (US EPA,). These impacts can be highlighted during severe hurricanes. For example, during Hurricane Katrina, New Orleans' lack of adequate infrastructure coupled with the severity of the storm would lead to disaster for the city. The City of New Orleans did have levees in place in order to help minimize the effects of severe coastal storms, but those levees were "...built in a disjointed fashion using outdated data"(Hoar, 2006). In addition to major issues to infrastructure sea level rise and coastal storms are dangerous to public health. For example in the aftermath of Hurricane Harvey, flood waters from storms contained many different and dangerous chemicals (Sifferlin, 2017). Harvey's flood waters were dangerous enough in Houston, Texas to cause death from flesh eating bacteria (Astor, 2017). Major flooding events also pose many dangers to the environment. For example, the impacts of Hurricane Sandy has caused significant damage to some local islands flora, an estimated 90% of the mature mangroves have been destroyed, and an estimated 100,000 gallons of fuel has spilled in the Simpson Bay Lagoon from over 120 shipwrecked vessels (Nature Foundation, 2017). Finally, the economy of area can also be greatly impacted by a severe coastal storm and SLR. During Hurricane Sandy, the New York Stock Exchange was forced to shut down for two days (Library, 2016).The impacts on infrastructure, public health, environment, and economy caused by these severe storms highlight some of the negative effects of extreme coastal flooding for modern port cities such as Boston.

Boston is notably vulnerable to flooding events because of its proximity to three rivers and its position on the Atlantic Coast. Since 1991 the City of Boston has experienced 21 flooding events that have triggered federal or state disaster declarations (Climate Ready Boston, 2016, P. 2). Over the entire twentieth century sea levels rose about 9 inches relative to land in Boston (Climate Ready Boston, 2016, pg. 8). With the pace of relative sea levels rise accelerating, by 2030 another eight inches of sea level rise may occur, with about 1.5 ft. by 2050, and as much as 3 ft. by 2070 (City of Boston Hazard Mitigation Plan, 2014). Thus the likelihood of coastal and riverine flooding will continue to increase. With higher sea levels, storm water outfalls may not be able to discharge or may even start to backflow (City of Boston Hazard Mitigation Plan, 2014). Severe flooding in Boston could result in damage to infrastructure, public health, environment and economy similar to that experienced in New Orleans (City of Boston, 2014). The Boston Hazard Mitigation Plan states that "In Boston, Massachusetts, the increase in flooding caused by sea level rise this century could cost up to \$94 billion from damage to buildings, loss of building contents, and associated emergency activities, depending on the amount of sea level rise and adaptation measures taken" (US EPA,). Areas within Boston Harbor will continue to have accelerated rates of vulnerability unless precautions are implemented to protect the coast, infrastructure, and people from the effects of sea level rise.

Since 2007 Boston has maintained a climate action plan which details measures the City has taken, and plans to take, in order to mitigate the impacts of climate change (City of Boston Hazard Mitigation Plan, 2014). The City of Boston's Climate Ready Report (Walsh, 2014), City of Boston Natural Hazard Mitigation Plan (The City of Boston, 2014), and Greenovate Boston

(Greenovate Boston, 2012) are all parts of the city's climate preparedness actions. The plans that have been implemented are intended to reduce the vulnerability to different climate risks, including exposure to threats, sensitivity to threats, and ability to cope after events occur (Bralower, 2017). With this in mind, some of the adaptations being implemented are to increase the amount of permeable ground, improving drainage systems, updating building codes, and restoring building and hazard mitigation infrastructure (The City of Boston, 2014). There are also several proposals being reviewed by the City of Boston with regards to different sea level rise adaptations, such as a large sea wall that completely surrounds the harbor. "City officials are exploring the feasibility of building a vast sea barrier from Hull to Deer Island, forming a protective arc around Boston Harbor" (Abel, 2017).

Although these reports and proposals do a thorough job of evaluating the vulnerability of residential and mixed use areas in Boston, they do not complete a thorough evaluation regarding the vulnerability of the working port.

The goal of this project was to assess the vulnerability of designated port areas in Boston Harbor to sea level rise and coastal storms. Our project focused on the four inner harbor DPAs: Chelsea Creek, Mystic River, East Boston, and South Boston. We selected a sample of DPA businesses to represent each industry and DPA located within the harbor. An analysis of selected sites was conducted, by reviewing tax assessors info, interviewing business representatives, and looking at SLR prevention infrastructure to determine the overall vulnerability of Boston's DPA's. Our assessment resulted in a report that may be used to inform policy and interested stakeholders of the vulnerability of working port areas in Boston Harbor to sea level rise.

## **Chapter 2.0: Background on DPAs and Climate Change**

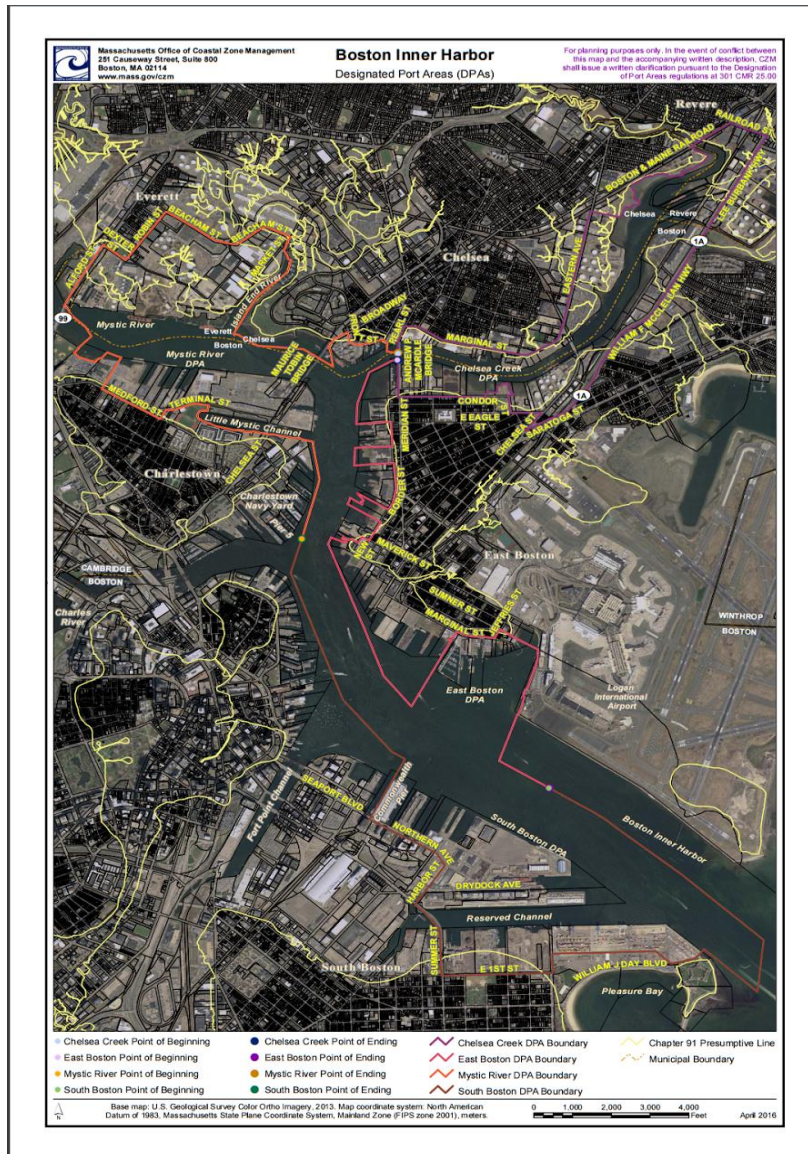
As sea levels rise and coastal storms become more frequent, it is necessary for coastal cities to understand their vulnerability. The City of Boston has done vulnerability assessments focused on residential and mixed use areas but no assessment of the DPAs has been conducted. In order to understand the context in which the DPAs exist, some background information is necessary. We will start by describing Boston Harbor and its designated port areas, then move into why there is an increased risk of severe flooding in the project area. We then address the negative effects that would be experienced during severe flooding events.

### **2.1 Designated Port Areas in Boston Harbor**

Boston is a historic city built around its harbor. Boston Harbor has emerged into a large trading market, which increased the industrialization of the city because of its location on the Atlantic Ocean. The harbor is critical to Boston's economy. In 2012, \$4.6 billion was generated by Boston's port in overall economic value, while the business' themselves generated \$1.2 billion in revenue (Woolhouse, 2014). Due to the port industry's importance to the economic value of Boston, the Commonwealth of Massachusetts wanted to protect more industrial sectors of the port from being displaced by non-industrial uses. Designated Port Areas (DPAs) were the regulatory mechanism created by the Commonwealth to ensure access to the water for water dependent industrial businesses. DPAs were created in 1978 by the Massachusetts Coastal Zone Management (CZM) "to satisfy both the unforeseeable and unanticipated space needs of industrial use that depend on the withdrawal/discharge of large volumes of process water" (New England School of Law, 2009). Site characteristics and infrastructure needs of designated port areas include a developed waterfront, adjacent land suitable for industrial use, and access to land transportation for industrial purposes (Mass.gov, n.d.).

DPAs ensure that water dependent industries have access to Boston Harbor. There are 10 DPA's in Massachusetts, four of which will be the main focus of this project: Mystic River (Appendix A), Chelsea Creek (Appendix B), East Boston (Appendix C), and South Boston (Appendix D). A map of all four DPAs being investigated by our team can be seen in Figure 1. A variety of industries utilize access to the waterfront that these DPAs provide. Some examples of industries within the DPAs are commercial fishing and processing, fuel transportation and storage, as well as import and export businesses.





**Figure 1: Inner Boston Harbor DPA Boundaries** courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017.

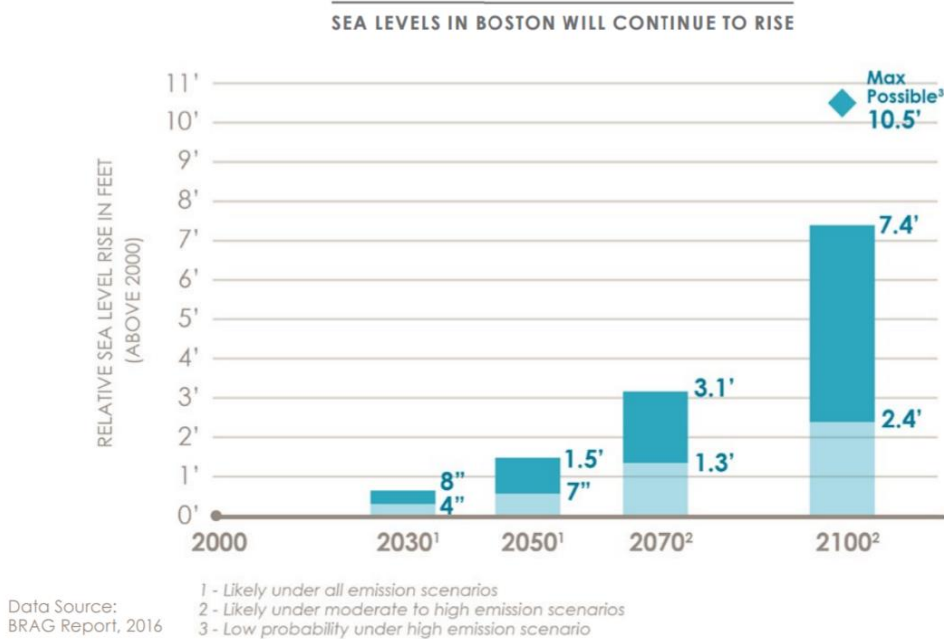
DPAs pose a threat to Boston Harbor. Industrial sites within DPAs often contain hazardous chemicals that if released would pose significant risks to Boston’s public health and environment. These threats are exacerbated with the threat of sea level rise and severe flooding events anticipated as a result of changing climate.

## 2.2 Vulnerability of Coastal Cities to Major Flooding Events in a Time of Climate Change

Impacts from climate change are not a new issue for the City of Boston. The City has been hit by 8 significant hurricanes in the past 75 years and has been developing different hazard mitigation preparations to minimize the risks from storm surge and storm water for over 100 years. But, as the climate continues to change, the risk of coastal urban flooding is continuing to increase, and most cities are not prepared for the up-surgings threats outlined in this section.

### 2.2.1 Sea Level Rise in the Northeastern United States

Cities along coastal Northeastern United States are predicted to encounter escalating sea level rise (SLR). In the Northeast, the relative sea level has risen by approximately one foot, since 1900, which has caused more frequent flooding of coastal areas (Climate Change in the Northeast, 2016). Boston’s sea level is predicted to have a minimum increase of 2.4 feet and a maximum of 7.4 feet, by the year of 2100, as shown in Figure 2 (Climate Ready Boston, 2016). Reducing Boston’s SLR to less than 2.4 feet. by the end of the century would require massive and unprecedented cuts in greenhouse gases worldwide (Climate Ready Boston, 2016). The lower end of this range assumes moderate cuts in global greenhouse gas emissions, with the upper end of this range assuming no changes in global emissions. SLR is driven by a combination of melting land ice, the expansion of water as its temperature increases, and changes in the amounts of water extracted from below ground or stored behind dams (Climate Change Indicators: Sea Level, 2014). Most of the coastal Northeast is expected to exceed the global average sea level rise due to local land subsidence, with the possibility of even greater regional sea level rise if the Gulf Stream weakens (Chapter 16 Northeast, 2014). Rising sea level will result in areas within coastal cities, such as Boston, to become more vulnerable to flooding by exacerbating impacts accompanied with storm surge.



**Figure 2: Predicted Sea Level Rise in Boston** From: (2016). Climate Ready Boston, | City of Boston. Retrieved April 24, 2017

### 2.2.2 Flooding From Storm Surge

Another threat facing coastal urban cities is the predicted increase in severe coastal storms, which is intensifying by sea level rise (Pierre-Louis, 2017). A storm surge is an abnormal rise in sea level accompanying a hurricane or other intense storm, and whose height is the difference between the observed level of the sea surface and the level that would have occurred in the absence of the storm (Hurricane Science: Storm Surge, 2015). With global sea levels

already on the rise, storms will cause more flooding in the future than they would today. This is because “the higher water level provides a higher base for the waves so they are able to strike structures that might otherwise be elevated above the waves; effect and shore erosion caused by sea level rise allows the waves to strike farther inland”(Greenhouse effect and Sea Level Rise, 2007). An example of an overwhelming and unanticipated storm surge coupled with precipitation, occurred during Hurricane Harvey. This hurricane unloaded nearly 33 trillion gallons of water in the U.S (Fritz & Samenow, 2017). This unprecedented amount of water had displaced over one million people and about 185,000 homes have been either damaged or destroyed across the Southeast US (Gallagher, 2017). Storm surges are particularly damaging in cities or other areas with high population densities, such as Boston.

## **2.3 Impacts of Storm Surge and Coastal Urban Flooding**

Coastal urban flooding has many negative Impacts on its surroundings. Impacts of coastal flooding can affect infrastructure, public health, the environment, and the economy of coastal cities and regions.

### **2.3.1 Failed Infrastructure Effects from SLR and Storm Surge**

As flooding severity worsens, the challenge of keeping important SLR prevention infrastructure, such as riprap and bulkheads, in good conditions increases. However, once the upkeep is not continued the infrastructure will deteriorate, putting it more at risk of failure under flooding conditions (Portland, 2014).

Failure of infrastructure during severe flooding events often exacerbates the issues caused by severe flooding. One potentially devastating form of infrastructure failure is the failure seawalls and other sea level rise prevention infrastructure. For example, if New Orleans had maintained their infrastructure, the flooding would not have been as detrimental from Hurricane Katrina: “Flood protection systems such as levee, canal systems, etc., were constructed to safeguard the city of New Orleans. However, these systems were poorly maintained and did not withstand the impact of the hurricane resulting in widespread damage to the city of New Orleans,” (Deshmukh *et al.*, 2011). Upkeep of flood protection systems is critical to helping mitigate the impacts of SLR.

Similarly, the state of a building plays a role in the effect SLR has on it. The City of Boston has fully adopted the International Building Code (IBC) set of standards for building construction. The IBC does not adequately prepare the City of Boston for SLR (International Code Council, n.d.). To combat this, the Commonwealth of Massachusetts has made its own modification to the IBC to be implemented in the state (Massachusetts Board of Building Regulations and Standards, 2010). Although these modifications improve upon the IBC in regards to SLR building code criteria, more research should be done to ensure that buildings are able to withstand more severe coastal flooding. The impacts of collapsed or damaged buildings would not only affect the aesthetic of the city, they could damage the health of the city’s residents.

### **2.3.2 Impacts of Storms and Flooding on Public Health**

Floods pose many threats to the health of a community, including discharging pollutants into water and forcing people to reside within damp toxic living conditions. A major threat to

Boston's public health from DPAs is the use and storage of harmful chemicals. If storage systems were to fail, dangerous chemicals have the ability to contaminate water. Some major hazardous materials that could spill into Boston Harbor are formaldehyde, petroleum, ammonia, and salt (Environmental, Health, and Safety Guidelines for Fish Processing, April 30, 2007). If during a severe flooding event these chemicals were to get into the water, they would have detrimental impacts on people's health.

Public health can also be negatively impacted from increased storms and floods that lead to damp air and living/working conditions (Climate Ready Boston, 2016). If the water does not dry completely, mold and mildew can start to appear in buildings. This was the case after Hurricane Sandy hit areas of New York (Nir, 2013). The dampened conditions lead to increased growth of black mold. Residents are subjected to increased allergen exposure due to mold growth in flooded homes and other structures (Climate Change Impacts in the United States, 2014). Depending on the severity of the mold and mildew exposure, there can be various effects on the health of residents and citizens working in the area. Mold can cause minor effects such as coughing or something as serious as severe lung infections (National Center for Environmental Health, 2014). Many areas directly surrounding DPAs are residential, so flooding from SLR would likely have a negative impact on the public.

### **2.3.3 Impacts of Storms and Flooding on the Environment**

Just as the public health is threatened by what can happen during sea level rise and storm surges, the environment is as well. In May, NOAA predicted a 45 percent chance that the 2017 Atlantic Hurricane season—which runs from June 1 through November 30—would be more active than normal (Pierre-Louis, 2017). With increased water levels and severity of storms, there will be wider areas of ecosystems that will be vulnerable. Vulnerability assessments have been able to start looking at what the potential impacts on the environment could be (Climate Ready Boston, 2016).

Wildlife faces many similar threats that the public does. Petroleum and salt are particularly hazardous to aquatic life. Another threat posed to the environment from SLR is the increase of runoff and sediment into waterways (Huston, 2010). Storm surge can cause more erosion and carry pollutants, into waterways and large bodies of water (Huston, 2010). This increase in pollutants can lead to increases in algal blooms (Huston, 2010) which are already a problem in Boston waterways. Algal blooms are one of the causes of a decrease in dissolved oxygen in water (Hewett, 2016). When there is less oxygen in the water fish and aquatic plants suffer because they do not have access to the needed amount of oxygen. Less oxygen also leads to higher water temperatures, which can cause distress for the aquatic life that is used to cooler temperatures (Hewett, 2016).

### **2.3.4 Impacts of Storms and Flooding on the Economy**

The economy of a region can be affected directly and indirectly by a changing climate. In the above sections, some of the general impacts of sea level rise, flooding, and storms have been described. In the end, all of these impacts can subsequently affect the economy of a region. Some effects from flooding will be more immediate, while others may take a while to appear and be fixed. Figure 3 below shows some of the potential long term or short term impacts that can come from flooding to coastal cities. If important structures fall into disrepair, then they will need to be repaired (Massachusetts Department of Conservation and Recreation, 2009). When Texas was

ravaged by Hurricane Harvey in 2017 many of the oil refineries on the coast were damaged and, “almost 22 percent of current oil production in the Gulf of Mexico has been ‘shut-in’...” (Rosoff, 2017). Oil refining made up a majority of the economy in Texas’s ports, and it is predicted that because of Harvey, “it could be months or even years before the region is experiencing some sense of normalcy again” (O’Keefe & Williams, 2017). Harvey not only affected Texas’ economy, it had an impact on the whole country, “analysts said prices at the pump are likely to rise between 5 cents and 15 cents nationwide in the weeks ahead” (Ivanova, 2017).

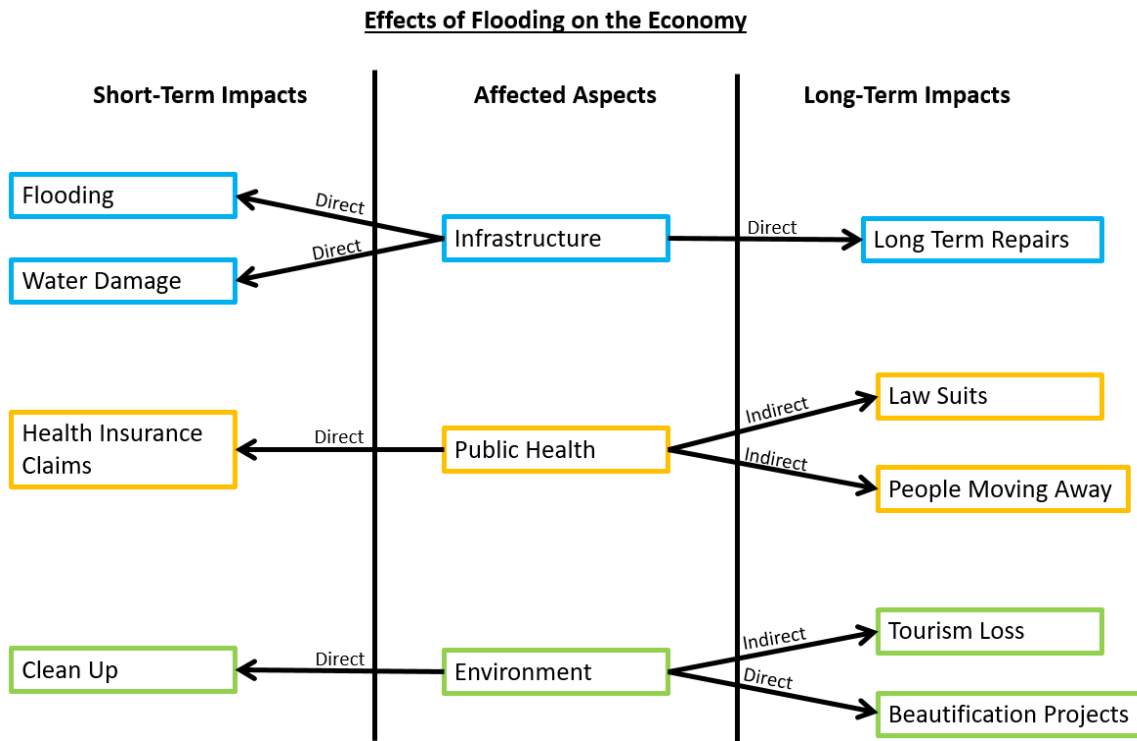


Figure 3: Effects of Flooding on Boston’s Economy

## 2.4 Gaps in Knowledge

The City of Boston has done quite a bit of work to protect residential and mixed-used areas from sea level rise, but there is still one area that the vulnerability assessments has not focused on: DPAs. A vulnerability assessment of the working port on the inner harbor of Boston has not been completed. Gaps in information include the exposure of DPAs to SLR and coastal storms, current state of infrastructure within the DPAs, the toxic chemicals stored within these DPAs and their potential effects on the harbor and its residents, as well as the ability for the working port to recover after damage occurs. Understanding the vulnerability of Boston’s working port to SLR and coastal storms is necessary. This understanding will allow Boston to have a complete idea of the risks posed to the city by SLR and coastal storm surge.

## **Chapter 3.0: Assessing the Vulnerability of DPAs**

The goal of this project was to assess the vulnerability of designated port areas in Boston Harbor to sea level rise and coastal storms. We focused on the four Boston inner harbor DPAs which are Chelsea Creek, Mystic River, East Boston, and South Boston (See Appendices A-D). Within these DPAs we selected a sample of parcels to represent the different industries. The vulnerability of individual parcels was assessed to help determine the vulnerability DPAs as a whole. Our project resulted in a report that has been given to Boston Harbor Now (BHN) for their use to inform policy and interested stakeholders of our findings. In this chapter we outline how we picked parcels and how the parcels were studied and evaluated.

### **3.1 Selecting Parcels for Assessment**

The DPAs of Boston's inner harbor consist of over 60 water dependent industrial businesses. To complete a vulnerability assessment of these parcels, a representative sample of 18 was selected, due the limited timeframe of this project. To reduce bias in our sampling process, we utilized random sampling to select each business. A database of parcels within the four inner harbor DPAs was obtained from Massachusetts Coastal Zone Management (CZM). We classified the businesses in the DPAs into eight different industries: mooring, cargo, fish processing, fuel, boat repair, salt, old industrial, and vacant/parking lots. Each industry is unique in how it operates, making each one vulnerable in different ways from each other.

To accurately represent the DPAs, a variety of each industry needed to be selected. First, we calculated the percentage of land each industry occupied within the DPAs. Based on the percentage of land each industry took up, parcels were selected weighted to that percentage. For example, cargo occupied 20.52% of land within all four inner harbor DPAs, and 20% of 15 parcels is roughly 4 parcels, therefore four cargo parcels were randomly selected (Appendix G).

In order to conduct a random sample, each parcel was assigned a number 1-55, 55 being the total amount of businesses. The parcels were grouped by industry. For example, Boat Repair included parcel numbers 1-9, Cargo was parcel numbers 10-21, and so on. Then to select the specific parcels, we randomly selected numbers using a Python script (Appendix F). We discovered two of the selected parcels were the same parcel but separated into two industries. This resulted in us having selected a total 14 businesses.

After we identified all of the parcels, we discovered that East Boston DPA was not represented. In order to ensure that each DPA and industry was represented in our study, we decided to add more parcels to our selection. Another random sample with just the parcels in the East Boston DPA was conducted, resulting in the selection of Boston Forging and Welding and Boston Towing and Transportation. Two industries were not represented in any of our random parcel selections: salt and fish processing. To select a salt parcel, we again ran the above script to randomly select one of the two salt parcels within the DPAs, which resulted in Eastern Salt Co. There was only one fish processing parcel to choose from: Channel Fish Co. The final selected businesses/parcels can be seen in Table 1 below.

**Table 1: List of Selected Businesses**

<b>Name Of Business</b>	<b>DPA</b>	<b>Industry</b>
Preferred Freezer	Mystic	Cargo
Distrigas of Massachusetts Everett Marine LNG Terminal Wharf	Mystic	Fuel
Prolerized New England Co. Everett Wharf	Mystic	Cargo
Winnisimmet Landing Pier No. 1-5	Mystic	Mooring
Constellation Mystic Power , LLC Mystic Station Wharf	Mystic	Old Industrial
MA Port Authority, Paul W. Conley Marine Terminal Berth #14-17	South Boston	Vacant
MA Port Authority, South Boston Ship Dock and Barge Dock	South Boston	Old Industrial
Boston Marine Industrial Park Berth No. 6	South Boston	Cargo
Perini Corp. Quarterdeck Marina	Chelsea	Cargo
Global Revco Terminal LLC Revere Terminal Ship Pier	Chelsea	Fuel
Gulf Oil Chelsea Terminal Tanker Wharf	Chelsea	Fuel
Vacant Land with Bulkhead	Chelsea	Vacant
245 & 257 Marginal St. LLC Bulkhead	Chelsea	Vacant/Parking
Channel Fish Co. Inc. Pier	Chelsea	Fishing
Irving Oil Terminals Inc Revere Terminal Pier Global Revco Berth No. 1	Chelsea	Fuel
Mahoney Terminal LLC Chelsea (AKA Eastern Salt Co.)	Chelsea	Salt
Boston Forging & Welding	East Boston	Boat Repair
Boston Towing & Transportation; Boston Fuel Transportation	East Boston	Fuel

### 3.2 Gathering Data

To characterize the vulnerability of each parcel, we gathered preliminary data from the internet, we attempted to interview representatives from each business, and conducted site reviews by water taxi.

#### 3.2.1 Gathering Data From Online Resources

Preliminary information for each selected parcel within the DPAs was found online. Area, industry, elevation, chemical storage, land and building value, as well as the net worth of the business could all be found on the respective city’s tax assessor's website (Boston, Chelsea, Everett, Revere). The predicted flood zone in and around the parcels was determined using Surging Seas: Risk Zone Map for 5ft of sea level rise by 2100, which is the likely/ middle of the road for emissions scenarios used in Climate Ready Boston (Climate Ready Boston, 2016). This same sea level rise viewer was used to gather the predicted property exposure, social vulnerability exposure, and the vulnerable population exposure of the population surrounding each parcel.

### **3.2.2 Contacting DPA Businesses Representatives**

Using the contact information available to us, we attempted to get in touch with the businesses either through email or a phone call. We utilized a generic email template and phone script (Appendix H). The companies that got back to us were sent emails that contained variations of our generic interview questions (Appendix I). They were given the option to respond by email or call us to go over their answers.

### **3.2.3 Evaluating Sites from the Water**

A water taxi was taken out along the shorelines of the parcels that were selected. Based on the location of our selected parcels and the location of shoreline stabilization structures, a water taxi route was mapped out (Appendix J). We took pictures of each site that we were able to get to with the taxi. We used these photos in conjunction with the 2009 Storm Smart Coasts CZM report in order to understand the current state of SLR infrastructure.

### **3.3 Data Analysis**

All of the data gathered through interviews and site visits was compiled into a spreadsheet.



**Table 2: Selected DPA Parcel Data**

Vulnerability	Evaluated	Source	Why?
	DPA	CZM Spreadsheet	What DPA the parcel is in.
	Industry	CZM Spreadsheet	What industry the parcel is in.
Exposure	Area (sq ft)	Assessor's Parcel Viewer	More land exposed to flooding.
	In Predicted Flood Zone for SLR by 2100 (5ft SLR) (Y/N)	Surging Seas: Risk Zone Map	Parcel is predicted to be flooded by 2100.
Sensitivity	SLR Preventative Infrastructure	Water Taxi/2009 Storm Smart Coasts	Poor condition of SLR prevention infrastructure adds to sensitivity.
	Chemical Type	CZM Spreadsheet	Different chemicals are dangerous in different ways.
	Chemical Quantity	CZM Spreadsheet	High quantity of chemicals could cause more damage.
	Chemical Storage	CZM Spreadsheet	Proper chemical storage can prevent against chemical spills, lowering overall sensitivity.
	Building Condition	Interviews	Poor building condition adds to the parcels sensitivity to SLR and storm surge.
Ability to Cope	Predicted Property Exposure 5ft Sea Level Rise (Price per acre)	Surging Seas: Risk Zone Map	Expensive damages require more money to repair.
	Net Worth of Business	Assessor's Parcel Viewer	Smaller businesses may not be able to afford repairs.
	Emergency Plans	Interviews	How well a company can respond to flooding events and related outcomes affects their ability to cope.
Misc.	Social Vulnerability Exposure 5ft SLR	Surging Seas: Risk Zone Map	The citizens in the surrounding area's ability to prepare and respond to flooding.
	Vulnerable Population Exposure 5ft SLR (People per square mile)	Surging Seas: Risk Zone Map	More vulnerable people surrounding parcel.
	Land and Building Value (\$)	Assessor's Parcel Viewer	Higher valued land/buildings may cost more to repair.

The vulnerability of each parcel was assessed by looking at the exposure, sensitivity, and ability to cope to SLR and coastal storm surge. If the parcel was within the predicted flood zone from the Surging Seas: Risk Zone Map, then not was deemed vulnerable in terms of exposure. Sensitivity was determined by the condition of the flood prevention infrastructure on the parcel and by whether or not the business on the parcels stores chemicals in large quantities. Ability to cope was determined by looking at the net worth of the business, what emergency flood plans the business had in place, and the potential cost of damages the businesses could receive from

flooding from SLR and storm surge. Miscellaneous data were also gathered relating to the effects that DPA flooding could pose on the surrounding area shown in Table 2. What we have evaluated are indicators for the corresponding dimension of vulnerability, they are not direct measurements.

## **Chapter 4.0: Potential Vulnerability and Risks of DPAs**

Boston's Inner Harbor DPAs are potentially vulnerable to sea level rise and coastal storm surge. There is a gap in knowledge as these areas have never fully been investigated. We have also found that this vulnerability has the potential to greatly impact the city and its inhabitants.

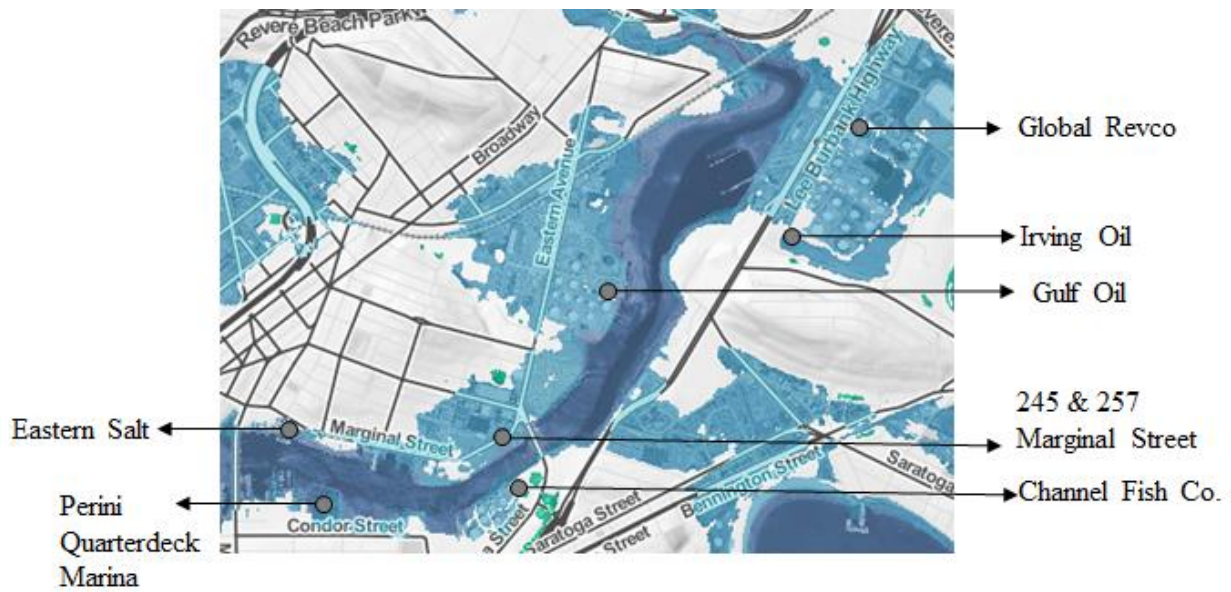
This chapter outlines our findings relating to the three dimensions of vulnerability: exposure, sensitivity, and ability to cope. Within each of these dimensions, we have evaluated many different variables that all contribute to the parcels overall vulnerability. We also discuss the DPA's potential impact on the city of Boston during flooding events. We then highlight the lack of transparency throughout the businesses within the DPAs in regards to contacting representatives and gathering information.

### **4.1 - Exposure of DPAs to SLR and Coastal Storms**

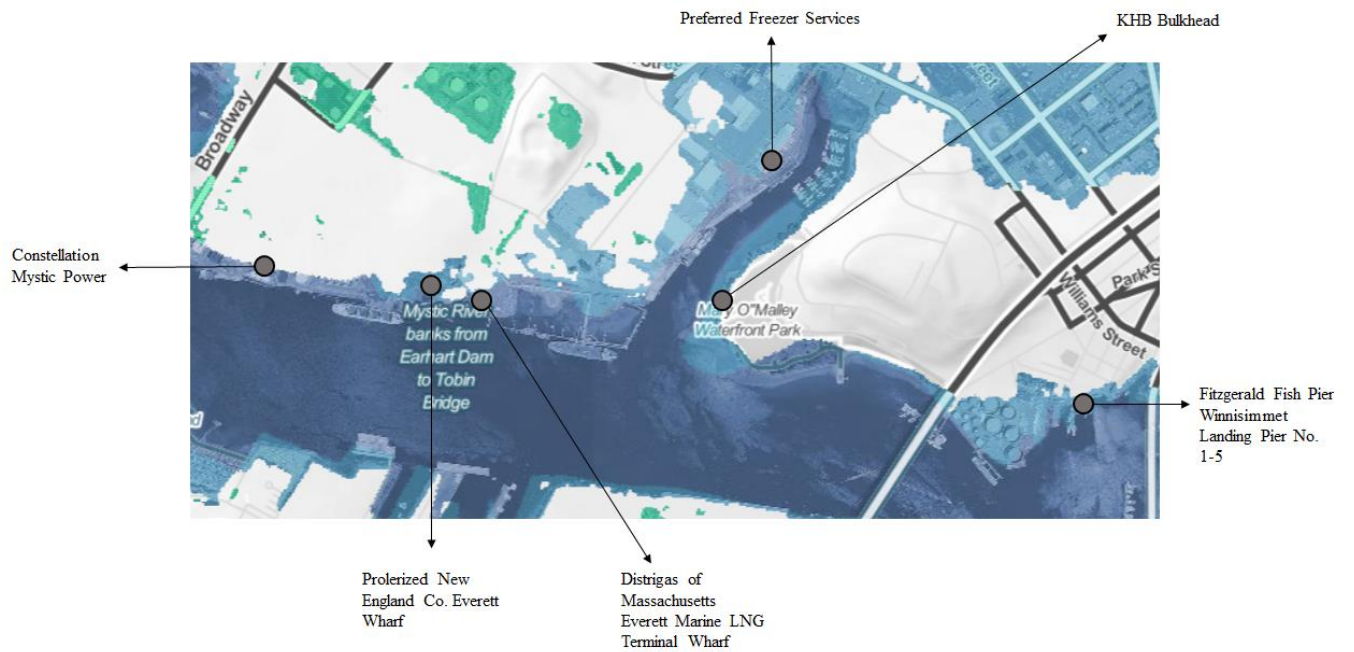
In order for an area to be vulnerable to SLR and coastal storms, it needs to be exposed to SLR and coastal storms. A sites location within Boston Harbor greatly affects its potential exposure. Depending on a sites elevation and proximity to the harbor, it will be exposed to different levels of flooding.

#### **4.1.1 - Predicted Flood Zones**

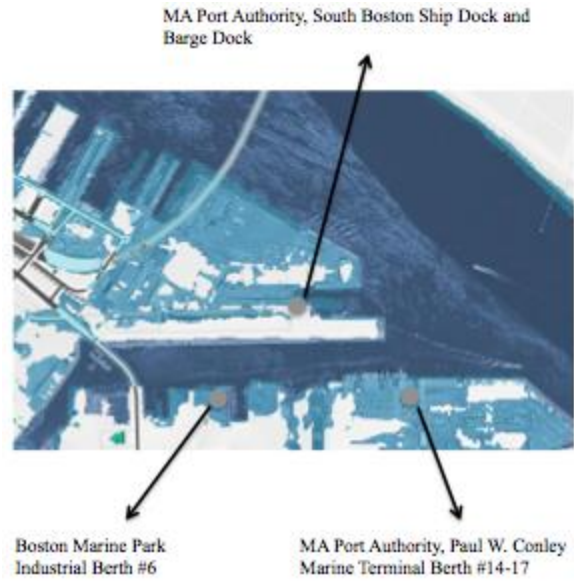
The exposure to SLR and coastal storms greatly increases the vulnerability of the majority of parcels within Boston's working port. With moderate cuts in carbon emissions, the likely amount of sea level rise by the year 2100 is 5 ft (Global Climate Change, n.d.). Of the investigated parcels, 88% are expected to be underwater by 2100. With the DPA's situated directly on the water, they are more exposed to the effects of SLR and coastal storms than other areas of Boston. Figures 4-7 are maps of the four DPA's, showing the predicted flood zones (PFZ) during 5 ft SLR.



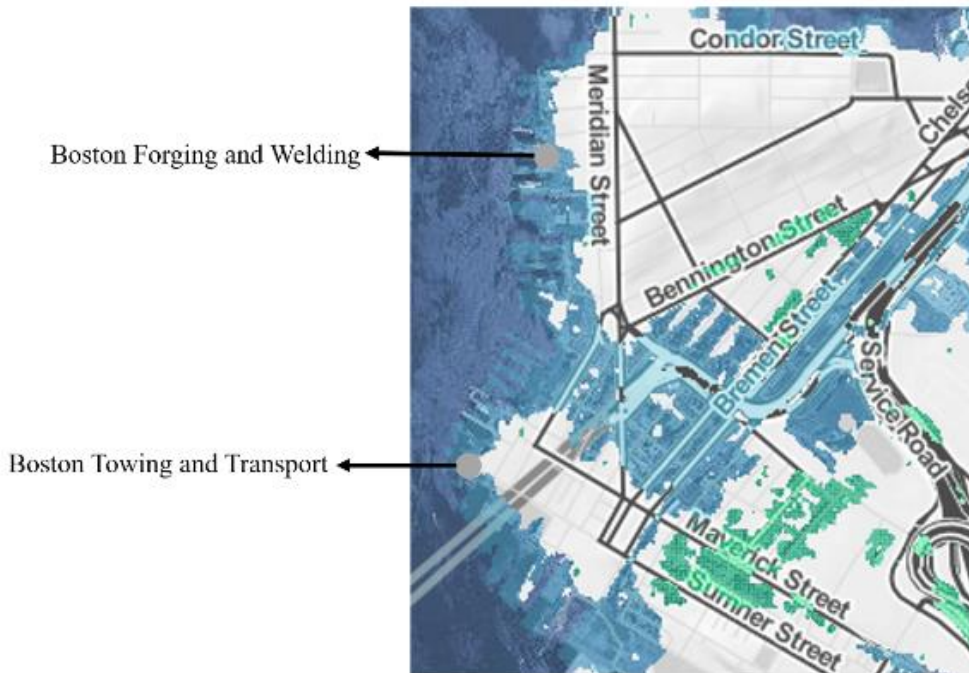
**Figure 4: Chelsea Creek DPA Flood Zone** From: (2017). *Surging Seas: Risk Zone Map*, | NOAA. Retrieved April 5, 2017



**Figure 5: Mystic River DPA Flood Zone** From: (2017). *Surging Seas: Risk Zone Map*, | NOAA. Retrieved April 5, 2017



**Figure 6: South Boston DPA Flood Zone** From: (2017). *Surging Seas: Risk Zone Map*, | NOAA. Retrieved April 5, 2017



**Figure 7: East Boston DPA Flood Zone** From: (2017). *Surging Seas: Risk Zone Map*, | NOAA. Retrieved April 5, 2017

#### 4.1.2 - DPA Business Interview Response Regarding Exposure

In response to our interview questions, a representative from Channel Fish Co. Inc. said that he was very concerned for his business's safety regarding SLR and coastal storms. This

representative stated “We are very concerned that our backyard could flood and portions of the property could be damaged by severe storms.”

Channel Fish Co. is located in the East Boston DPA, with direct access to the waterfront along Chelsea Creek. The East Boston area has been prone to serious erosion along the coast, and is located within the boundaries of the PFZ with regards to 5 feet SLR, shown in Figure 7 above. The representative stated that his business has been prone to flooding in the past, with an example of this flooding shown below in Figure 8. In regards to flooding on this property, the representative said “It’s been pretty severe at times: the most recent occurrence on Aug. 2, the standing water was about a foot tall. It’s also gotten into our basement in the past.”

It is evident this business located within the DPA has extreme exposure to flooding, increasing its overall vulnerability to SLR and coastal storm surge.



**Figure 8: Flooding Within East Boston August 2, 2017** From: Margaret Farmer

## **4.2 - Sensitivity to SLR and Coastal Storms**

A sites vulnerability to SLR and coastal storms is also a function of its sensitivity. For the purpose of this project, the sensitivity analysis is based on the state of the infrastructure on the parcel. The infrastructure that we evaluated included both the sea level rise prevention infrastructure, chemical type, chemical storage, and chemical quantity. These are all indicators of sensitivity that contribute to the overall vulnerability of a parcel.

### **4.2.1 - Infrastructure Evaluations**

SLR preventative infrastructure on DPA our selected DPA sites can be improved. Of our 18 selected parcels, only 6 had publicly listed SLR preventative infrastructure (CZM, 2009). Of those 6 parcels, five were ranked as needing a moderate level of action or higher according to CZM (CZM, 2009) (Appendix K). After our water taxi tour, we did not have an adequate amount of information to correctly correlate each parcels SLR prevention infrastructure to the previous CZM report.

During our water taxi tour, we were unable to visit all of the parcels from our sample due to limited time and travel restrictions. We were able to look at some SLR preventative infrastructure near some of the sites. Figure 9 shows riprap located on Prolerized. It can be seen that the high water mark on the rocks is more than halfway up the structure. We were not able to gain the exact measurements of the height of the rip rap, but we can safely estimate there is less than 5 feet of riprap above the high water mark. This is concerning due to the fact that 5 feet of SLR is expected by 2100, and if coastal storms hit the area, they will most likely experience more than 5 feet of coastal storm surge, resulting in the Prolerized site being flooded. Similar flooding would be experienced at the Eastern Salt site under the same future conditions. As seen in Figure 10, the Eastern Salt parcel has bulkheads. However, the high water mark is also located less than 5 feet from the top of the structure. The quality of SLR prevention infrastructure on these sites demonstrates the exposure to SLR and coastal storms, adding to the vulnerability of these working port areas.



**Figure 9: Riprap located at Prolerized**



**Figure 10: Bulkhead located at Eastern Salt**

#### 4.2.2 - Sensitivity due to Chemical Storage

The fact that many businesses within the DPAs rely on large amounts of chemicals stored on site to function makes them more sensitive to sea level rise. Different types of chemicals are stored differently. The condition of the storage facilities can contribute to how vulnerable the site is to flooding. The worse the condition is the more vulnerable the area is. Unfortunately we were unable to analyze the condition of the storage facilities themselves. Since we could not analyze the storage facilities we investigated which companies would lose their ability to function for a time should they damage or lose the chemicals. Ten of the parcels that we investigated use chemicals in their day to day operations. The companies that store chemicals on these ten parcels would not be able to function normally without their chemicals. This limit in their ability to function is what makes them vulnerable in the sense of chemical storage.

**Table 3: Chemical Storage Information**

<b>Business</b>	<b>Chemical Type</b>	<b>Chemical Quantity</b>	<b>Chemical Storage</b>
Preferred Freezer	Ammonia	N/A	N/A
Distrigas of Massachusetts	Liquid Natural Gas (LNG)	25,000 gallons	2 Cryogenic, 3 Tanks
Constellation Mystic Power	Petroleum/ LNG	590,000 barrels	4 Tanks
MA Port Authority South Boston Ship and Barge Dock	Petroleum Molasses	2,292,000 barrels 4,437,000 Gallons	26 Tanks 12 Steel Tanks
Boston Marine Industrial Park Berth 6	Cement	N/A	2 Storage Silos
Global Revco Terminal	Petroleum	1,400,000 Barrels	24 Steel Tanks
Gulf Oil	Petroleum	1,677,600 Barrels	21 Steel Tanks
Channel Fish Co. Inc. Pier	Salt Formaldehyde Ammonia	N/A	N/A
Irving Oil Terminal	Petroleum	1,300,000 Barrels	18 Steel Tanks
Eastern Salt	Salt Coal	170,000 Tons	Pile



### **4.3 Parcel's Ability to Cope with SLR and Coastal Storms**

A site's vulnerability is also a function of its ability to cope after a major flooding event has happened. If a site can respond and recover quickly from SLR or a major storm, they are less vulnerable to it. Things such as a business's worth and income can give some indication on a business's ability to reconstruct their site. Emergency plans that are in place when flooding occurs also will reduce that sites vulnerability to SLR and coastal storms. If a site has the ability to cope with SLR and coastal storms both during and after they occur, they are consequently less vulnerable.

#### **4.3.1 Financial Aspects**

The sheer cost of the land and infrastructure on many of these parcels would make it difficult for businesses rebuild after severe flooding. After reviewing the land and building value provided by tax assessor's websites, we identified that out of the parcels investigated, 61% of them were worth over \$1M. Only six of the eighteen businesses that we evaluated were publicly traded and those businesses were all worth well over \$100M. The other twelve parcels are either abandoned or local businesses. During major flooding events, 66% of businesses are expected to have between \$10M-\$100M of predicted damage per acre. The other 33% is predicted to experience between \$1M- \$10M of damage per acre to their property. Since two thirds of all investigated businesses have no public information on their net worth, one third of the businesses evaluated could possibly have the resources to rebuild after a severe flood, this is still undetermined.

#### **4.3.2 - Emergency Plans**

To our knowledge, few of the businesses within the DPAs have publicly available emergency plans to deal with flooding. One of the businesses that we contacted said that they had an emergency plan in place, but that it was not public information. Businesses are not required to make their emergency plans public, due to risks associated with terrorism. Through an interview with a hazard mitigation expert from MEMA, we learned that the only real regulating body that deals with hazardous materials is local fire departments. Local fire departments enforce EPA regulations concerned with the handling of hazardous materials. The EPA only requires that businesses report the quantity of hazardous materials on their sites to their area fire department and the EPA. According to the Massachusetts Tier II Reporting Entities, a source referred to us by MEMA, the hazard mitigation plan's main purpose is to "provide the framework and methodology to efficiently respond to hazardous materials emergencies"(Hazardous materials emergency plan, 2011)(template version of Hazardous Materials Emergency Plan can be seen in Appendix L). The current regulations are reactionary in nature, only having plans for chemicals once they spill. We found no regulatory requirements to help prevent the release of toxic chemicals into the environment.

The only other agency that regulates industrial activities within Boston's harbor is the United States Coast Guard. The Coast Guard is mostly concerned with ships and materials that

are moving on the water. They receive hazardous cargo manifests from ships entering the harbor in order to keep updated on the hazardous materials within Boston Harbor.

We learned that the regulation of the DPAs is split between MEMA, CZM, USCG, and the EPA. From our research it doesn't seem that there is much communication between these groups. This is based off of our experience with these agencies representatives. We were continually being referred to different people within various state agencies, none of whom knew much about regulations within the DPAs. This lack of communication means that in an emergency situation important information may not be available to first responders.

#### **4.4 DPAs Impacts on Boston During Flooding Events**

DPAs vulnerability to SLR and coastal storms is a problem, but the effects that those flooded DPAs may have on the surrounding areas is another issue. Populations that live behind these DPAs are at risk due to their proximity to the water as well as being exposed to the toxic chemicals that are stored on some DPA properties. The impacts of flooded DPAs on the surrounding areas of Boston is also a threat.

##### **4.4.1 Populations at Risk from Flooding in DPAs**

Residential populations located directly behind the DPA's can be vulnerable to the effects SLR. If you refer to the vulnerable populations table (Appendix M), you can see many of the inhabitants surrounding the DPA parcels will be exposed to the effects of SLR. Using the Surging Seas: Risk Zone Map we were able to apply Social Vulnerability and Vulnerable Population layers. The Social Vulnerability Exposure ranks how the population can prepare and react to SLR and flooding events. The businesses that have a rank of "Low" have populations behind them with low exposure, meaning they have a better ability to prepare and respond to the flooding. "High" means that the population surrounding the parcel are not able to respond and prepare well for flooding events. The Vulnerable Population Exposure is how many people per square mile that would be impacted by a 5 foot sea level rise. These show that the populations behind the DPA's are vulnerable to SLR and coastal storms. During major flooding events, floodwater from the DPA's pose the risk of spreading contaminants to the surrounding areas. This has the potential to exacerbate the impacts of flooding on the already vulnerable residential populations.

**Table 4: Vulnerable Residential Populations Surrounding DPA's**

<b>Business</b>	<b>Social Vulnerability Exposure 5 ft. SLR (Ability to prepare and respond to flooding)</b>	<b>Vulnerable Population Exposure 5 ft. SLR (People per square mile)</b>
Preferred Freezer	Medium	None
Distrigas of MA Everett Marine LNG Terminal Wharf	Medium	None
Polarized New England Co. Everett Wharf	Medium	None
Winnisimmet Landing Pier No. 1-5	High	1000-9999
Constellation Mystic Power, LLC Mystic Station Wharf	Medium	None
MA Port Authority, Paul W. Conley Marine Terminal Berth #14-17	N/A	None
MA Port Authority, South Boston Ship Dock and Barge Dock	N/A	None
Boston Marine Industrial Park Berth No. 6	N/A	1000-9999
Perini Corp. Quarterdeck Marina	Low	1000-9999
Global Revco Terminal LLC Revere Terminal Ship Pier	Low	1000-9999
Gulf Oil Chelsea terminal Tanker Wharf	Medium	None
Vacant Land with Bulkhead	High	Below 100
245 & 257 Marginal st. LLC Bulkhead	Low	1000-9999
Channel Fish Co. Inc. Pier	Low	None
Irving Oil Terminals Inc Revere Terminal Pier Global Revco Berth No. 1	Low	None
Mahoney Terminal LLC Chelsea (AKA Eastern Salt Co. )	High	None
Boston Forging & Welding	High	None
Boston Towing & Transportation; Boston Fuel Transportation	High	None

Info taken from Climate Central. (2016). Surging seas: Risk zone map. Retrieved from <https://ss2.climatecentral.org/#12/40.7298/-74.0070?show=satellite&projections=0-RCP85-SLR&level=5&unit=feet&pois=hide>

#### 4.4.2 Risks Posed by Chemicals in the DPA

Many of the chemicals located in the harbor could have detrimental effects on Boston and the other cities bordering the harbor, demonstrated in Table 5. We know, from the CZM spreadsheet of parcels, of nine chemicals that are present in large quantities within the DPAs. The sheer amount of these chemicals along the harbor, in addition to their hazardous natures, is alarming because in extreme events they may find their way into the harbor. For example, within the investigated parcels, there are over 345,811,200 gallons of fuel stored. The issues presented by the release of the chemicals could impact public health, the environment, and the economy.

**Table 5: Chemical Effects on Public Health and Environment**

<b>Chemical</b>	<b>Public Health</b>	<b>Environment</b>
Petroleum (CHEMTREC, n.d.)	Toxic	Acute aquatic toxicity, flammable
LNG (Elengy, 2014)	Frostbite, severe burns	Flammable
Liquid Nitrogen(Airgas, 2016)	Frostbite, severe burns	N/A
Salt (MSDS, n.d.)	Skin irritant, eye irritant	N/A
Cane Molasses (Sugar Australia, n.d.)	Eye irritant	Depletes Oxygen levels in Water
Ammonia (Airgas, 2017)	Frostbite, severe burns	Acute Aquatic Toxicity
Formaldehyde (MSDS, n.d.)	Toxic, Carcinogen	Flammable
Coal (URSI, 2008)	Carcinogen	Flammable
Portland Cement (PPC, 2016)	Skin irritant	Lowers pH of water

Of the nine chemicals that we know are present in the harbor, six of them are would cause harm to a person if they were exposed. Petroleum oil and formaldehyde are the only toxic chemicals to humans, while formaldehyde and coal dust are classified as carcinogens. The other three chemicals that we identified as being dangerous to public health are ammonia, liquid natural gas, and liquid nitrogen. These chemicals are stored under great pressure in their liquid form, once exposed to the atmosphere, they would vaporize, making them less likely to be ingested. Despite this, they can still be very harmful. Each can cause severe burns similar to frostbite. They are also dangerous if inhaled and can cause unconsciousness. Rock salt, portland cement, and cane molasses are all relatively safe for humans to be around. The first two can cause skin irritation while all three can cause eye irritation. Chemicals pose many dangers to the environment as well.

Flooding could cause facilities' chemical storage to leak. Petroleum and ammonia are both chemicals that are acutely toxic to aquatic life. Portland cement can change the pH of the water and the molasses will lower the oxygen levels; these effects would lead to a heightened mortality of aquatic life. In addition to being toxic and unstable, four of the chemicals are highly flammable. Should they get into the harbor many of them will not mix with the water. Should this mixture of chemicals somehow come into contact with a spark or flame, it could cause a large portion of the harbor to catch on fire. Leakage of chemicals could also cause a detrimental effect on the economics of region.

Both salt and petroleum would impact the economy of the surrounding area in more severe ways than the other chemicals that we are aware of. The salt pile in Chelsea is the main

source of rock salt for the roads in the Greater Boston area. If the large portions of the salt were to be washed away, the Boston Metropolitan Area would need to obtain salt from elsewhere in short notice. Boston could also lose a large amount of petroleum during major flooding events. With Logan International Airport being one of the largest consumers of petroleum in the area, with over 38,000 passenger flights in August 2017 alone (MassPort, 2017), it would be greatly impacted should the petroleum in the DPAs be lost. Planes would not be able to refuel at the airport for some time, effectively shutting it down.

#### **4.5 Lack of Transparency Within the DPAs**

The businesses in the DPA lack transparency about flooding preparedness. Of the 16 businesses that we contacted, only two responded to us. We emailed a set of 15 different questions to the businesses. The response below was all we had received from one of the business representatives.

In response to your questions below, the... [Parcel]...has not had a problem with flooding at this facility in the past, nor do we foresee any problems for the future. This facility is highly regulated, and those regulations call for contingency plans to cover all types of scenarios, from natural disasters to manmade events. These contingency plans are not public information.

This shows how difficult it has been for us to get information from these businesses. We were unable to gather a lot of data about different businesses beyond what is publically available online. This lack of transparency makes it impossible to make any accurate statement on the level of preparedness that exists within the DPAs. Without clear communication from DPA businesses about their SLR preparedness, neither the city of Boston nor a third-party could accurately predict the effects of flooding in the Boston area. This lack of transparency may come down to the fact that we are college students and businesses may not have been sure of our intentions, possibly afraid of self-incriminating answers.

## **Chapter 5.0: Recommendations to Better Prepare DPAs to SLR and Coastal Storms**

Within Boston's inner harbor DPAs, many improvements can be made to planning and regulations in order to reduce their vulnerability to SLR and coastal storms. Further research can also be conducted in order to further evaluate the vulnerability of DPAs in the harbor. A committee that could regulate DPA businesses' emergency preparedness plans as well infrastructure evaluations could help to decrease their vulnerability.

### **5.1 Recommendations to Better Understand Vulnerability within DPAs**

Major gaps in data concerning vulnerability of Boston to the sea level rise and storm surges still exist. The vulnerability assessment, Climate Ready Boston does not address the DPAs in any capacity. As students reaching out to businesses, we found many unwilling to participate or even get back to us. Though we managed to gather a lot of information on DPAs in a short amount of time, a lot more data regarding the businesses in the DPA's should still be gathered.

We recommend that the Massachusetts Coastal Zone Management (CZM) and The Boston Green Ribbon Commission (GRC) continue their partnership and produce a vulnerability assessment of the DPAs. This is the partnership that produces the Climate Ready Boston report, which provides an in depth understanding of Boston's vulnerability to climate change. With their previous experience, they can conduct their own vulnerability assessment that will give a more detailed description of the state that the DPAs are in. This report, in conjunction with the Climate Ready Boston report, will create a more complete understanding of the vulnerability of Boston and its harbor to Climate Change.

#### **5.1.1 Use of More Sophisticated Models for Vulnerability Assessments**

To complete our initial vulnerability assessment of the given DPA's parcels we utilized the Surging Seas: Risk Zone Map to gather information about potential flood zones. Using this source we were able to gather some preliminary information about sea level rise and its effects on the harbor, but no detailed information such as flood depths were available for our group. According to Paul Kirshen, a professor at the University of Massachusetts Boston, the Surging Seas: Risk Zone Map uses the "bathtub model" to predict sea level rise. This model is not the most detailed and or accurate ways to predict sea level rise. As we neared the end of our project, we were given access to an extremely accurate sea level rise viewer that is not open to the public, courtesy of the Massachusetts Department of Transportation. Due to the lack of time we were not able to utilize these GIS maps to their fullest potential. An example of this GIS can be found below in Figure 11. We recommend that whoever continues this research within the DPA's should utilize this resource as it will add extremely accurate and in depth data.



Figure 11: Potential Flooding of 5 Feet with Spring Tide From: given citation (2017). MassDOT-FHWA Pilot Project Report, | Bosma *et. al.*. Retrieved October 3, 2017

## 5.2 Centralized Regulations for Emergency Preparedness Plans

Throughout the completion of this project, we found that no existing organization directly regulates emergency preparedness plans in the DPAs. We believe this to be a serious issue. During Hurricane Harvey the Akema chemical plant in Crosby Texas lost power to its refrigeration units. These units were critical as without them, the stored chemicals would ignite and explode (Gallagher, 2017). Had the Akema chemical plant been required to keep an updated flood preparedness plan, it may not have lost power to its refrigeration units.

Without a centralized organization governing emergency preparedness in these industrial areas, the City of Boston cannot be certain that the businesses will be prepared to handle flooding events. We recommend that Massachusetts Coastal Zone Management (CZM), the Department of Environmental Protection (DEP), the Massachusetts Emergency Management Agency (MEMA), and the United States Coast Guard (USCG) form a regulatory committee concerned with emergency preparedness plans within the DPAs. The partnership should integrate CZM's knowledge of businesses and infrastructure within the DPAs, DEP's experience with brownfield remediation, USCG's authority over the harbor and the cargo within it, and MEMA's experience with emergency management in Massachusetts.

The committee should have a set of regulations to enforce on the DPA businesses. The two regulations that we are recommending this committee enforce are: that chemicals and hazardous materials used by businesses within the DPAs must be stored in flood-proof containers, and that more frequent inspections and repairs be performed on the SLR prevention infrastructure within the DPAs. The first regulation would reduce business sensitivity to SLR and coastal storms by reducing the risk of chemical spills. The second regulation would reduce the business's exposure to SLR and coastal storms by ensuring that the SLR prevention infrastructure on the sites are up to date and in good condition.

If these regulations were to be put in place, the city could be more confident that the DPA businesses may better withstand flooding events. These regulations could reduce the vulnerability of DPA businesses to sea level rise and coastal storm surges by limiting exposure and sensitivity. This committee and its regulations would ensure that the unique needs of these industrial areas are met, while simultaneously keeping the surrounding communities and environment safe during flooding events.



## Chapter 6.0: Conclusions

The goal of this project was to assess the vulnerability of designated port areas in Boston harbor to sea level rise and coastal storms. By selecting a sample of representative parcels within the four inner Boston Harbor DPA's, we were able to gain a representative sample of DPA businesses that could then be analyzed for their vulnerability to SLR and coastal storms. Three dimensions of vulnerability were considered for each parcel: exposure, sensitivity, and ability to cope to SLR and coastal storms.

In spite of data limitations, we discovered that many of the sites in Boston Harbor are within the predicted flood zone for 2100, and many things including chemicals, poor infrastructure, and lack of planning on those sites cause them to be more vulnerable to SLR and coastal storms. The reluctance of businesses to answer questions puts further emphasis on the importance of this problem. Also, the lack of central regulation of emergency preparedness plans within the Boston Harbor DPAs is very concerning. The combination of these problems may put Boston in an underprepared state to deal with SLR and coastal storms.

Boston Harbor's ecosystem could be damaged, billions of dollars could be lost, homes destroyed, and lives threatened. The City of Boston has started to prepare for SLR and coastal storms with their reports such as Climate Ready Boston and Greenovate Boston, but a plan for industrial port areas does not yet exist. This gap in planning is a problem for Boston. Our group concludes that a committee be developed in order to review and regulate DPA businesses emergency preparedness plans, as well as that further research be conducted into this topic. Boston Harbor's DPAs are multifaceted areas that vulnerability needs to be more fully evaluated.

Modern port cities, such as Boston, are being increasingly threatened by SLR and coastal storms. Major cities around the country, such as New York, Houston, and New Orleans, have been impacted by hurricanes throughout the past 20 years. The storms that hit these cities caused major negative impacts to the area's infrastructure, public health, environment, and economy, devastating the region. For example, in 2012 when Hurricane Sandy hit Staten Island, 23 people died, many by drowning in flood waters (Sandy and its Impacts.2012). When Hurricane Harvey hit Texas in 2017 much of the oil refining that made up a majority of the economy in Texas's ports, was damaged. "It could be months or even years before the region is experiencing some sense of normalcy again" (O'Keefe & Williams, 2017). In 2005 when Hurricane Katrina hit New Orleans, the lack of adequate infrastructure coupled with the severity of the storm lead to disaster for the city. The City of New Orleans did have levees in place in order to help minimize the effects of severe coastal storms, but those levees were "...built in a disjointed fashion using outdated data"(Hoar, 2006). Storms such as Hurricane Katrina, Sandy, Harvey, and Irma highlight the imminent threat that SLR and coastal storms pose to coastal cities. Port cities around the world need to learn from these storms and prepare for coastal flooding to help reduce the negative impacts.

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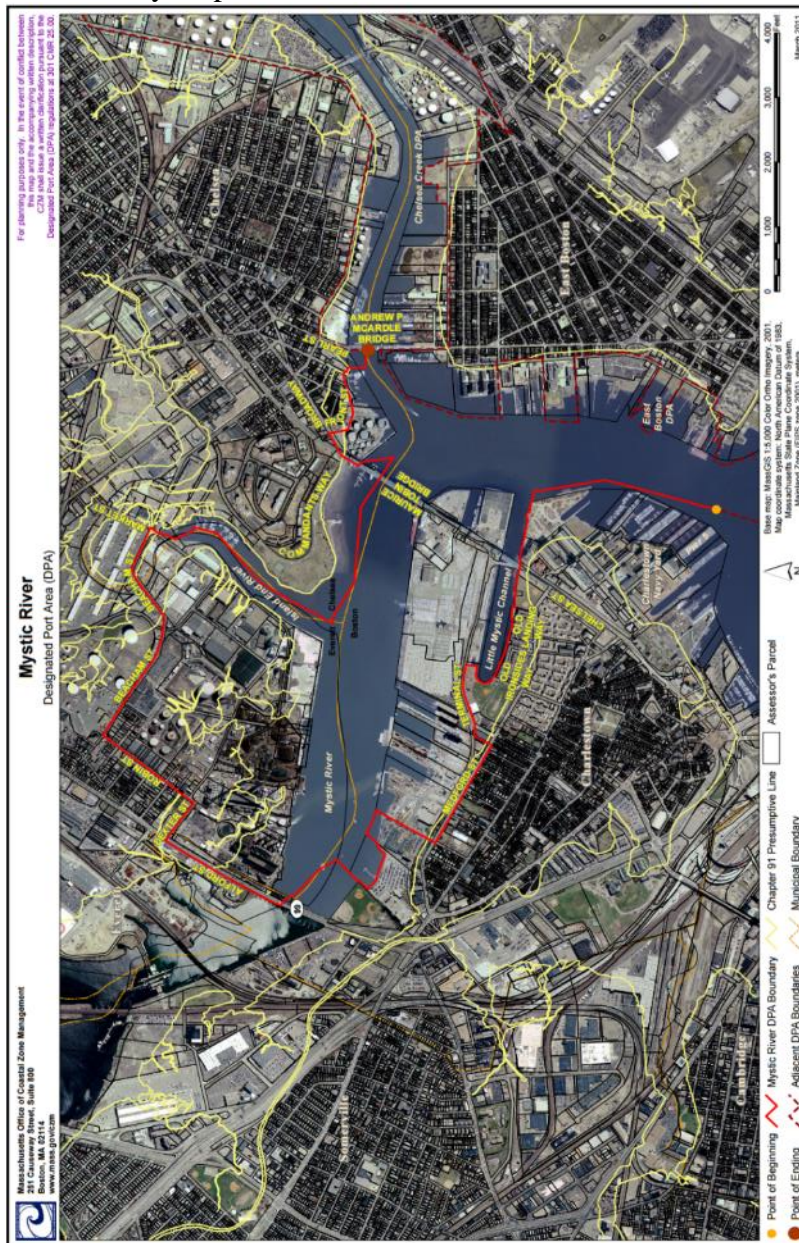
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# Chapter 8.0: Appendices

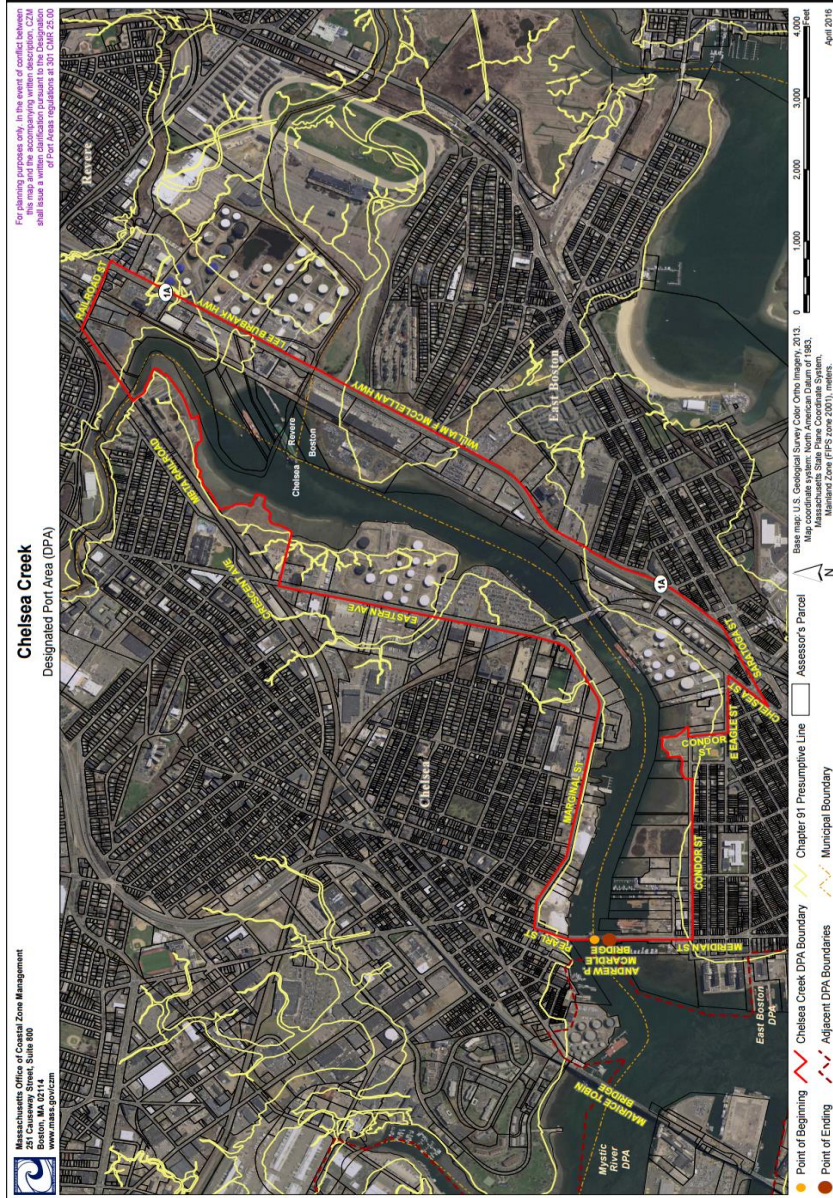
## Appendix A: Mystic River DPA Boundaries

The following DPA boundary maps outline DPA boundaries.



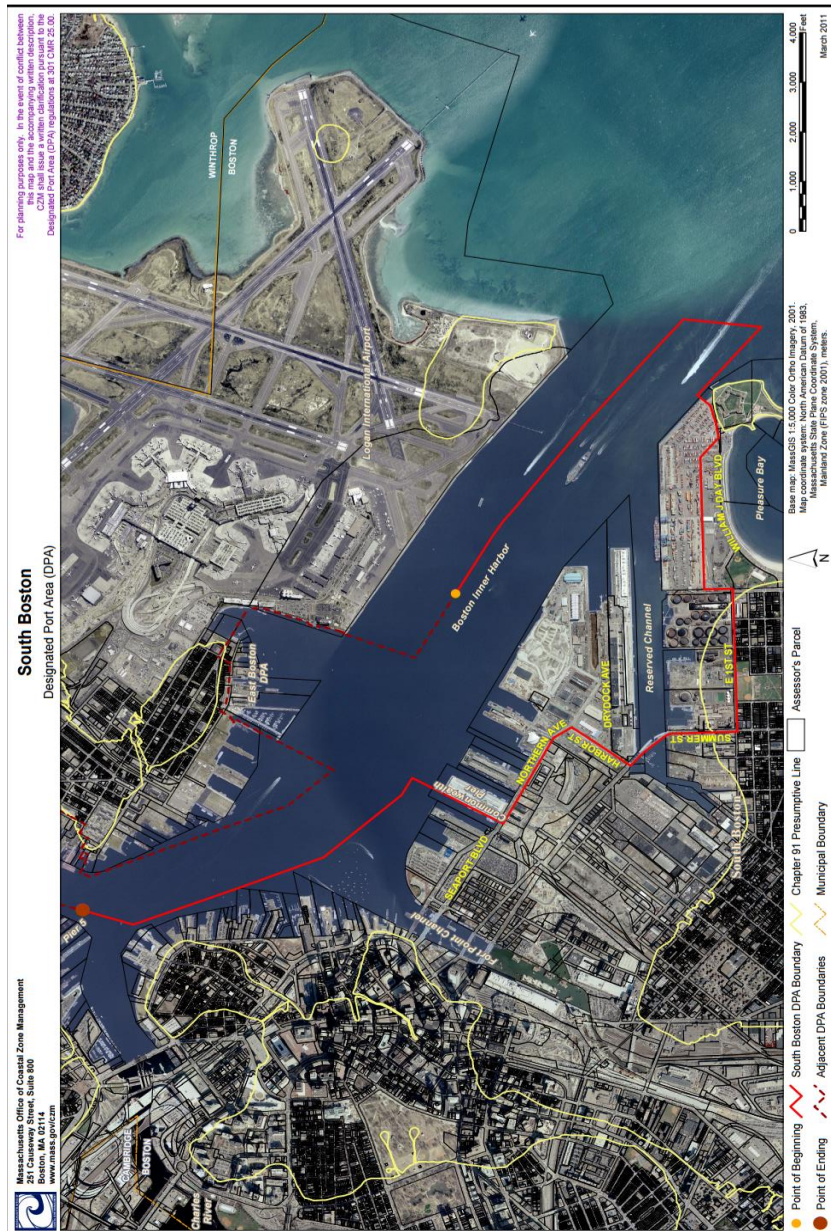
**Mystic River DPA Boundaries** courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017.

## Appendix B: Chelsea Creek DPA Boundaries



Chelsea Creek DPA Boundaries courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017.

# Appendix C: South Boston DPA Boundaries



South Boston DPA Boundaries courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017.

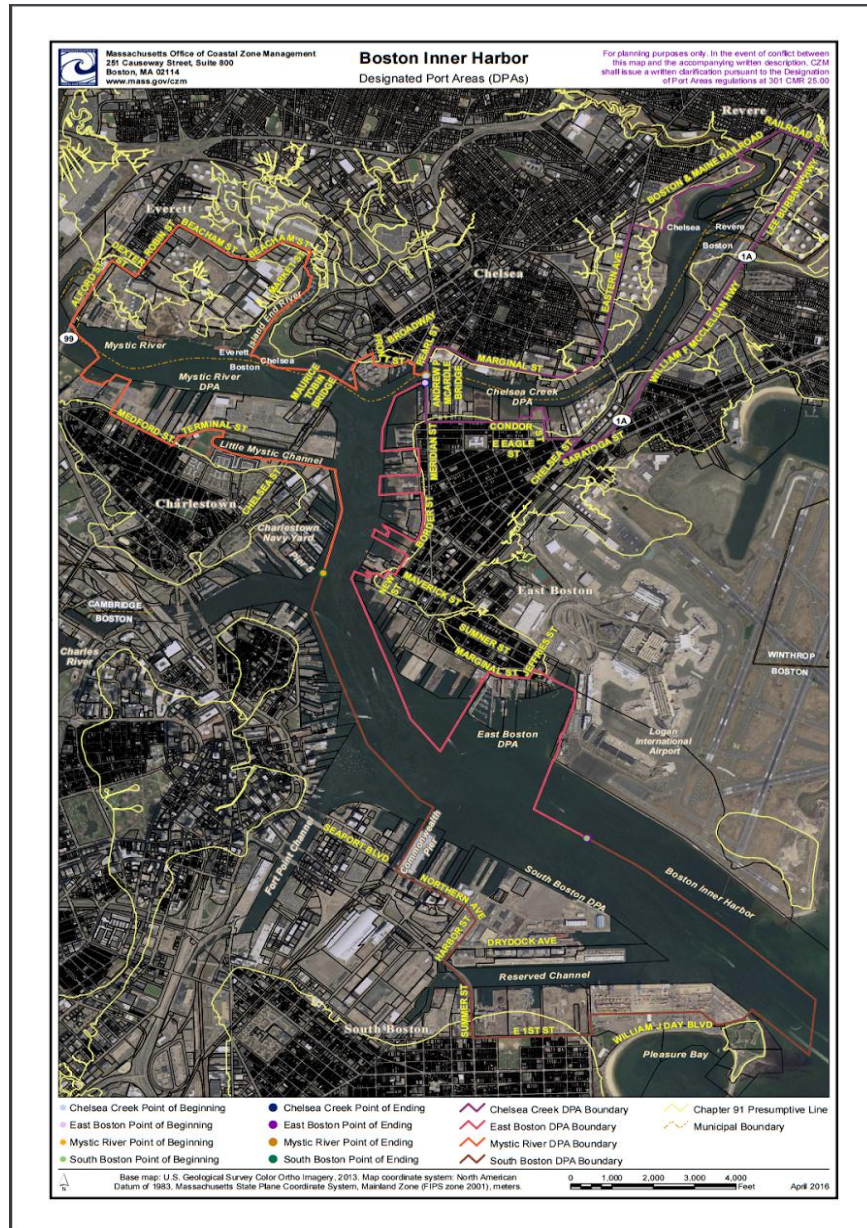


## Appendix D: East Boston DPA Boundaries



East Boston DPA Boundaries courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017

## Appendix E: Boston Inner Harbor DPA Boundaries



**Inner Boston Harbor DPA Boundaries** courtesy of Massachusetts Government. (2016). Chapter 91, The Massachusetts Public Waterfront Act | MassDEP. Retrieved April 24, 2017.

## Appendix F: Python Code

```
def RandomPicker():
    n=int(input('How many numbers would you like to generate? '))
    a=int(input('What is the lower bound? '))
    b=int(input('What is the upper bound? '))
    c=r.sample(range(a,b),n)
    print(c)
RandomPicker()
```

This is the Python 3.5 code for our parcel picking process

## Appendix G: Parcel Land Use

Industry	% of land used	Number of parcels selected
Boat Repair	9.72	0
Cargo	20.52	4
Fish Processing	0.28	0
Fuel	35.25	5
Mooring	7.83	1
Old Industrial	16.52	2
Salt	0.59	0
Vacant/Parking	9.13	3

This is a table showing the percentage of land in the DPAs used by each industry. These percentages were used to weight our random sample.

## **Appendix H: Generic Email and Phone Script**

Dear \_\_\_\_\_,

We are a team of four Worcester Polytechnic Institute (WPI) students completing our Interactive Qualifying Project (IQP), which is a research project all students are required to complete in order to graduate. For our project, our sponsor is the nonprofit Boston Harbor Now. We are gathering data about specific businesses within the Designated Port Areas of Boston Harbor and we were hoping to ask you a few questions about your business. We are on a tight schedule and it would be helpful if we could hear back from you by September 15th. If you would be willing to meet with us either in person or over the phone it would be greatly appreciated. You can contact us at [boston17harbor@bostonharbornow.org](mailto:boston17harbor@bostonharbornow.org).

Thank you,

Austen Crawford, Caroline Warchol, Jacob Bouchard, And Kyle Whittaker

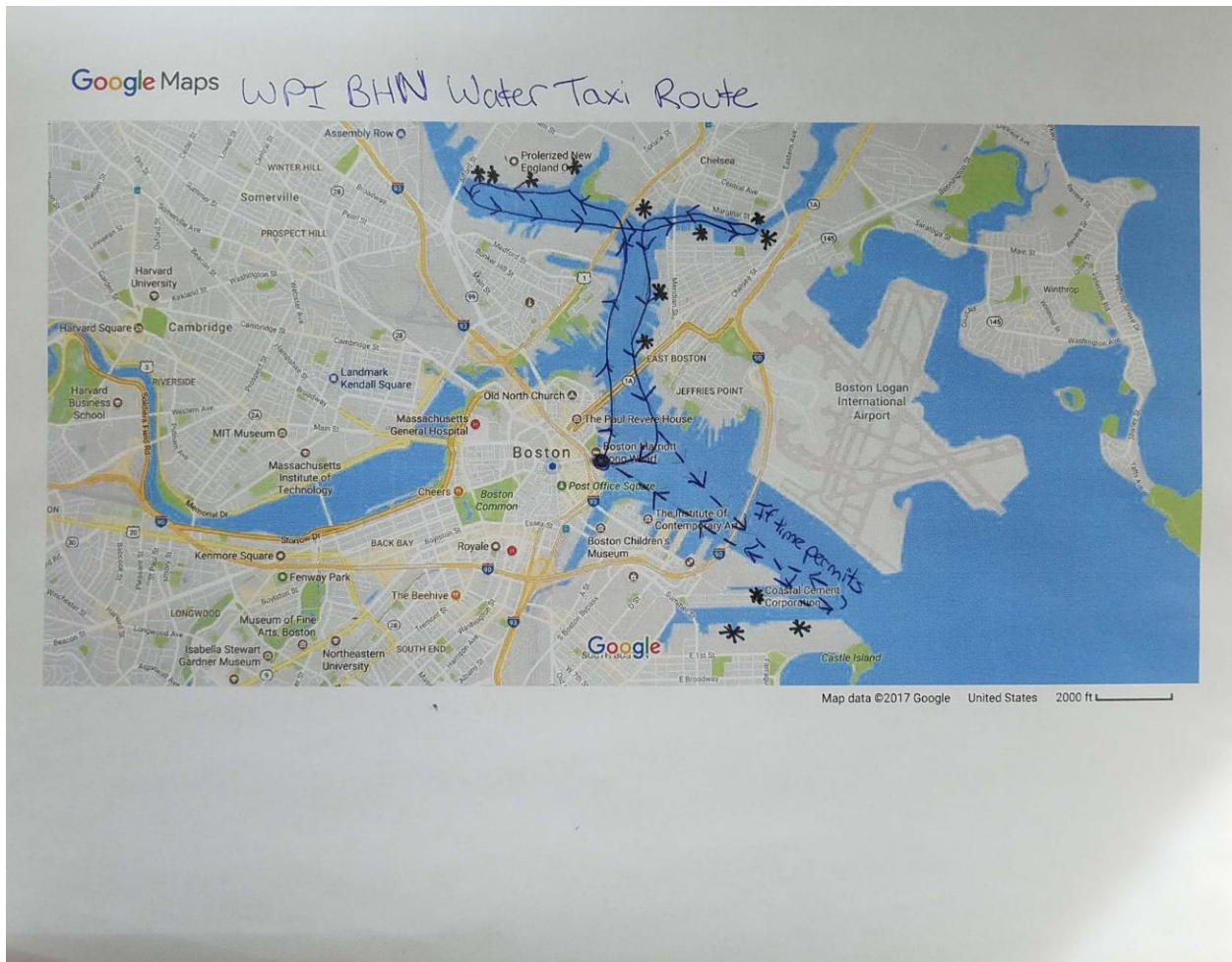
This is the generic email that we initially sent out to each DPA business that we wanted to talk to.

## Appendix I: Generic Questions

1. How long have you been working at\_\_\_\_\_?
2. What is your job here?
3. What does your business “do” (have specific questions based on the business)
4. Have you experienced flooding in the past?
  - a. If so, how severe was it and how did you cope?
  - b. What are your emergency flooding plans at this company?
5. Are you familiar with the SLR prevention infrastructure on your property?
  - a. If so, do you believe it to be in good condition?
  - b. Did it help to prevent/ lessen the flooding
6. When was this building last refurbished/updated?
7. What types of chemicals does this company use?
  - a. How are they stored?
  - b. Has your company thought about changing the way chemicals are stored?
8. Is your company concerned about SLR or severe storms?
  - a. Are there any plans being made to address these concerns

This is the list of generic questions that we asked businesses to answer either over the phone or through email.


## Appendix J: Water Taxi Route



This the map of the route that we planned to take on our water taxi. In reality we did not go as far up Chelsea Creek.

## Appendix K: CZM Infrastructure Sheets

These structure assessment forms were taken from CZM's Coastal Infrastructure Inventory and Assessment. The below forms are for structures on our selected parcels.

CZM Coastal Infrastructure Inventory and Assessment		Town: <u>Chelsea</u>	
Structure Assessment Form		Structure ID: <u>011-015-000-004-100</u>	
Key: community-map-block-parcel-structure			
Property Owner: <u>State</u>	Location: <u>Eastern Avenue</u>	Date: <u>7/24/2007</u>	
Presumed Structure Owner: <u>State</u>	Based On Comment: 		
Owner Name: <u>MA-DCR</u>	Earliest Structure Record: <u>1986</u>	Estimated Reconstruction/Repair Cost: <u>\$22,433.00</u>	
Length: <u>55</u> Feet	Top Elevation: <u> </u> Feet NAVD 88	FIRM Map Zone: <u>A3</u>	FIRM Map Elevation: <u>N/A</u> Feet NGVD
Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Concrete</u>	Primary Height: <u>10 to 15 Feet</u>	
Secondary Type: <u>Revetment</u>	Secondary Material: <u>Stone</u>	Secondary Height: <u>10 to 15 Feet</u>	
			
Structure Summary :			
A granite block wall that is capped with approximately 2 feet of concrete. The structure has a riprap slope comprised of mostly cobbles and small boulders with an average stone size of 1 foot diameter. The structure appears to generally be in good condition.			
<i>Condition</i>	B	<i>Priority</i>	II
<i>Rating</i>	Good	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Minor	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure observed to exhibit very minor problems, superficial in nature. Minor erosion to landform is present. Structure / landform adequate to provide protection from a major coastal storm with no damage. Actions taken to prevent / limit future deterioration and extend life of structure.		<i>Description</i>
		Inshore Structures Present with Limited potential for Significant Infrastructure Damage	
Structure Images:		Structure Documents:	
<u>011-015-000-004-100-PHO1A.JPG</u>		<u>MA-DCR</u> <u>January 198</u> <u>Design of Riprap</u> <u>011-015-000-004-100-DCR1A</u>	
<u>011-015-000-004-100-PHO1B.JPG</u>			

Prepared By: Bourne Consulting Engineering



**Structure Assessment Form**

Property Owner: State	Location: Eastern Avenue	Date: 7/24/2007
Presumed Structure Owner: State	Based On Comment:	
Owner Name: MA-DCR	Earliest Structure Record: 1986	Estimated Reconstruction/Repair Cost: \$93,773.00

Length: 120 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: A3	FIRM Map Elevation: N/A Feet NGVD
Primary Type: Revetment	Primary Material: Stone	Primary Height: 10 to 15 Feet	
Secondary Type:	Secondary Material:	Secondary Height:	



**Structure Summary :**

A combination of concrete debris mixed with approximately 1 foot diameter stones and granite blocks that have been loosely dumped on an existing slope. It is in fair condition with movement of stone and cement pieces evident.

<i>Condition</i>	C	<i>Priority</i>	III
<i>Rating</i>	Fair	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Moderate	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure is sound but may exhibit minor deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure adequate to withstand major coastal storm with little to moderate damage. Actions taken to reinforce structure to provide full protection from major coastal storm and for extending life of structure. Moderate wind or wave damage to landform exists. Landform may not be sufficient to fully protect shoreline during a major coastal storm. Actions taken to provide addition material for full protection and extended life.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings ( <1 dwelling impacted / 100 feet of shoreline)

<b>Structure Images:</b> 011-015-000-004-200-PHO2A.JPG	<b>Structure Documents:</b> MA-DCR   January 198   Design of Riprap   011-015-000-004-200-DCR2A
---	--


**Structure Assessment Form**

Town: Boston

Structure ID: 006-010-366-8000-100

Key: community-map-block-parcel-structure

Property Owner: <u>Local</u>	Location: <u>East Boston - Border Street</u>	Date: <u>7/3/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: <u></u>	
Owner Name: <u>Boston</u>	Earliest Structure Record: <u>1973</u>	Estimated Reconstruction/Repair Cost: <u>\$247,447.00</u>

Length: <u>910</u> Feet	Top Elevation: <u></u> Feet NAVD 88	FIRM Map Zone: <u>A2</u>	FIRM Map Elevation: <u>10</u> Feet NGVD	
Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Stone</u>	Primary Height: <u>5 to 10 Feet</u>		
Secondary Type: <u>Revetment</u>	Secondary Material: <u>Stone</u>	Secondary Height: <u>5 to 10 Feet</u>		

Structure Summary :  
A granite block wall with a typical block size of 3 feet by 2 feet by 2 feet with riprap behind it with an average stone size of 1 foot diameter. In places there is placed riprap in front of the seawall.

<i>Condition</i>	B	<i>Priority</i>	II
<i>Rating</i>	Good	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Minor	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure observed to exhibit very minor problems, superficial in nature. Minor erosion to landform is present. Structure / landform adequate to provide protection from a major coastal storm with no damage. Actions taken to prevent / limit future deterioration and extend life of structure.	<i>Description</i>	Inshore Structures Present with Limited potential for Significant Infrastructure Damage

<b>Structure Images:</b>	<b>Structure Documents:</b>			
<u>006-010-366-8000-100-PHO1A.JPG</u>	<u>USACE</u>	<u>August 1973</u>	<u>Plan Accompanying</u>	<u>006-010-366-8000-100-COE1A</u>
<u>006-010-366-8000-100-PHO1B.JPG</u>	<u>DEP</u>	<u>May 1974</u>	<u>Plan Accompanying</u>	<u>006-010-366-8000-100-LIL1A</u>
<u>006-010-366-8000-100-PHO1C.JPG</u>				
<u>006-010-366-8000-100-PHO1D.JPG</u>				
<u>006-010-366-8000-100-PHO1E.JPG</u>				

Prepared By: Bourne Consulting Engineering

**Structure Assessment Form**

Property Owner: <u>Local</u>	Location: <u>East Boston - Border Street and Condor Street</u>	Date: <u>7/3/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: <u></u>	
Owner Name: <u>Boston</u>	Earliest Structure Record: <u></u>	Estimated Reconstruction/Repair Cost: <u>\$153,153.00</u>

Length: <u>255</u> Feet	Top Elevation: <u></u> Feet NAVD 88	FIRM Map Zone: <u>A2</u>	FIRM Map Elevation: <u>10</u> Feet NGVD
Primary Type: <u>Revetment</u>	Primary Material: <u>Stone</u>	Primary Height: <u>5 to 10 Feet</u>	
Secondary Type: <u></u>	Secondary Material: <u></u>	Secondary Height: <u></u>	



**Structure Summary :**

A granite block seawall with an approximate block size of 4 feet by 2 feet by 2 feet. The wall shows some signs of movement. The wall also supports the roadway directly behind it.

<i>Condition</i>	C	<i>Priority</i>	IV
<i>Rating</i>	Fair	<i>Rating</i>	High Priority
<i>Level of Action</i>	Moderate	<i>Action</i>	Consider for Next Project Construction Listing
<i>Description</i>	Structure is sound but may exhibit minor deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure adequate to withstand major coastal storm with little to moderate damage. Actions taken to reinforce structure to provide full protection from major coastal storm and for extending life of structure. Moderate wind or wave damage to landform exists. Landform may not be sufficient to fully protect shoreline during a major coastal storm. Actions taken to provide addition material for full protection and extended life.	<i>Description</i>	High Value Inshore Structures with Potential for Infrastructure Damage and/or Moderate Density Residential Dwellings ( 1-10 dwellings impacted / 100 feet of shoreline)

**Structure Images:**

006-010-367-9000-100-PHO1A.JPG

006-010-367-9000-100-PHO1B.JPG

**Structure Documents:**

**Structure Assessment Form**

Property Owner: <u>Local</u>	Location: <u>South Boston - East First Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: <u></u>	
Owner Name: <u>Boston</u>	Earliest Structure Record: <u></u>	Estimated Reconstruction/Repair Cost: <u>\$531,828.00</u>

Length: <u>340</u> Feet	Top Elevation: <u></u> Feet NAVD 88	FIRM Map Zone: <u>A2</u>	FIRM Map Elevation: <u>10</u> Feet NGVD
Primary Type: <u>Revetment</u>	Primary Material: <u>Stone</u>	Primary Height: <u>10 to 15 Feet</u>	
Secondary Type: <u></u>	Secondary Material: <u></u>	Secondary Height: <u></u>	



Structure Summary :  
A coastal bank. The slope is covered with debris, small cobbles 6 inch-8 inch diameter and is vegetated 2 feet above high tide line. This would generally provide little protection during a major storm.

<i>Condition</i>	D	<i>Priority</i>	II
<i>Rating</i>	Poor	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Major	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	Inshore Structures Present with Limited potential for Significant Infrastructure Damage

Structure Images: <u>006-060-281-7020-100-PHO1A.JPG</u> <u>006-060-281-7020-100-PHO1B.JPG</u>	Structure Documents: <u></u>
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**Structure Assessment Form**

Property Owner: Local	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: Local	Based On Comment:	
Owner Name: Boston Redevelopment Authority	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$257,400.00

Length: 150 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: A2	FIRM Map Elevation: 10 Feet NGVD
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Primary Type: Bulkhead/ Seawall	Primary Material: Steel	Primary Height: Over 15 Feet
Secondary Type:	Secondary Material:	Secondary Height:



Structure Summary :  
A steel sheetpile wall that runs behind a pile supported wharf. The sheet pile is in a fair condition with active corrosion.

<i>Condition</i>	C	<i>Priority</i>	II
<i>Rating</i>	Fair	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Moderate	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure is sound but may exhibit minor deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure adequate to withstand major coastal storm with little to moderate damage. Actions taken to reinforce structure to provide full protection from major coastal storm and for extending life of structure. Moderate wind or wave damage to landform exists. Landform may not be sufficient to fully protect shoreline during a major coastal storm. Actions taken to provide addition material for full protection and extended life.	<i>Description</i>	Inshore Structures Present with Limited potential for Significant Infrastructure Damage

Structure Images:  
006-060-267-4000-110-PHO11A.JPG

Structure Documents:

**Structure Assessment Form**

Property Owner: Local	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: Local	Based On Comment:	
Owner Name: Boston Redevelopment Authority	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$162,835.00

Length: 80 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: A2	FIRM Map Elevation: 10 Feet NGVD
Primary Type: Bulkhead/ Seawall	Primary Material: Concrete	Primary Height: 10 to 15 Feet	
Secondary Type: Revetment	Secondary Material: Stone	Secondary Height: 10 to 15 Feet	



Structure Summary :

A concrete bulkhead with riprap in front, mixed size stones. The stone sizes vary from 2 feet by 2 feet by 4 feet blocks to cobbles. The placed blocks appear to be in good condition but other areas where stone has been loosely dumped are at higher risk to erosion.

<i>Condition</i>	C	<i>Priority</i>	II
<i>Rating</i>	Fair	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Moderate	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure is sound but may exhibit minor deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure adequate to withstand major coastal storm with little to moderate damage. Actions taken to reinforce structure to provide full protection from major coastal storm and for extending life of structure. Moderate wind or wave damage to landform exists. Landform may not be sufficient to fully protect shoreline during a major coastal storm. Actions taken to provide addition material for full protection and extended life.	<i>Description</i>	Inshore Structures Present with Limited potential for Significant Infrastructure Damage

Structure Images: 006-060-267-4000-120-PHO12A.JPG 006-060-267-4000-120-PHO12B.JPG	Structure Documents:
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**Structure Assessment Form**

Property Owner: <u>Local</u>	Location: <u>South Boston - Summer Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: 	
Owner Name: <u>Boston Redevelopment Authority</u>	Earliest Structure Record: 	Estimated Reconstruction/Repair Cost: <u>\$1,053,360.00</u>

Length: <u>420</u> Feet	Top Elevation: <u> </u> Feet NAVD 88	FIRM Map Zone: <u>A2</u>	FIRM Map Elevation: <u>10</u> Feet NGVD
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Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Steel</u>	Primary Height: <u>10 to 15 Feet</u>
Secondary Type: <u> </u>	Secondary Material: <u> </u>	Secondary Height: <u> </u>



**Structure Summary :**

The steel is corroding and starting to bow outward. There is a steel sheetpile wall with a small concrete cap. The bowing out of the structure indicates that it is in need of repair and in poor condition.

<i>Condition</i>	D	<i>Priority</i>	III
<i>Rating</i>	Poor	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings (< 1 dwelling impacted / 100 feet of shoreline)

Structure Images:  
006-060-267-4000-200-PHO2A.JPG

Structure Documents:

**Structure Assessment Form**

Town: Boston

Structure ID: 006-060-267-4000-400

Key: community-map-block-parcel-structure

Property Owner: <u>Local</u>	Location: <u>South Boston - Summer Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: _____	
Owner Name: <u>Boston Redevelopment Authority</u>	Earliest Structure Record: _____	Estimated Reconstruction/Repair Cost: <u>\$2,545,620.00</u>

Length: <u>1015</u> Feet	Top Elevation: <u>      </u> Feet NAVD 88	FIRM Map Zone: <u>V4</u>	FIRM Map Elevation: <u>14</u> Feet NGVD
Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Steel</u>	Primary Height: <u>10 to 15 Feet</u>	
Secondary Type: <u>      </u>	Secondary Material: <u>      </u>	Secondary Height: <u>      </u>	



Structure Summary :

A steel sheetpile wall with a concrete cap and timber piles in front. The bulkhead is deteriorating and corrosion has caused holes to form in the structure.

<i>Condition</i>	D	<i>Priority</i>	III
<i>Rating</i>	Poor	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings ( <1 dwelling impacted / 100 feet of shoreline)

- Structure Images:**
- 006-060-267-4000-400-PHO4A.JPG
  - 006-060-267-4000-400-PHO4B.JPG
  - 006-060-267-4000-400-PHO4C.JPG

- Structure Documents:**
- \_\_\_\_\_
  - \_\_\_\_\_
  - \_\_\_\_\_



**Structure Assessment Form**

Property Owner: Local	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: Local	Based On Comment:	
Owner Name: Boston Redevelopment Authority	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$3,950,100.00

Length: 1575 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: V4	FIRM Map Elevation: 12 Feet NGVD
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Primary Type: Bulkhead/ Seawall	Primary Material: Concrete	Primary Height: 10 to 15 Feet
Secondary Type:	Secondary Material:	Secondary Height:



**Structure Summary :**

A derelict concrete drydock. The walls are in poor condition with many areas of cracking, spalling, and section loss. Associated hardware such as railings and walkways are also corroding. The lock at the entrance is closed and the dock is currently dry.

<i>Condition</i>	D	<i>Priority</i>	III
<i>Rating</i>	Poor	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings ( <1 dwelling impacted / 100 feet of shoreline)


**Structure Images:**

- 006-060-267-4000-500-PHO5A.JPG
- 006-060-267-4000-500-PHO5B.JPG
- 006-060-267-4000-500-PHO5C.JPG
- 006-060-267-4000-500-PHO5D.JPG
- 006-060-267-4000-500-PHO5E.JPG

**Structure Documents:**

**Structure Assessment Form**

Property Owner: Local	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: Local	Based On Comment:	
Owner Name: Boston Redevelopment Authority	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$2,583,240.00

Length: 1030 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: V4	FIRM Map Elevation: 14 Feet NGVD	
Primary Type: Bulkhead/ Seawall	Primary Material: Steel	Primary Height: 10 to 15 Feet		
Secondary Type:	Secondary Material:	Secondary Height:		
Structure Summary :				

A steel sheet pile cell construction with timber sheeting in front of the the cells to form concrete that was placed as a repair for the corroding steel. There are multiple sinkholes located within the cells indicating some kind of cell failure which could not be seen from this survey.

<i>Condition</i>	D	<i>Priority</i>	III
<i>Rating</i>	Poor	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	<i>Description</i>		Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings ( <1 dwelling impacted / 100 feet of shoreline)

Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.

Structure Images:	Structure Documents:
006-060-267-4000-600-PHO6A.JPG	
006-060-267-4000-600-PHO6B.JPG	
006-060-267-4000-600-PHO6C.JPG	

**Structure Assessment Form**

Town: Boston

Structure ID: 006-060-267-4000-700

Key: community-map-block-parcel-structure

Property Owner: <u>Local</u>	Location: <u>South Boston - Summer Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: <u></u>	
Owner Name: <u>Boston Redevelopment Authority</u>	Earliest Structure Record: <u></u>	Estimated Reconstruction/Repair Cost: <u>\$551,760.00</u>

Length: <u>220</u> Feet	Top Elevation: <u></u> Feet NAVD 88	FIRM Map Zone: <u>A2</u>	FIRM Map Elevation: <u>10</u> Feet NGVD
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Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Steel</u>	Primary Height: <u>10 to 15 Feet</u>
Secondary Type: <u></u>	Secondary Material: <u></u>	Secondary Height: <u></u>



Structure Summary :

A steel sheetpile wall with a concrete cap, the sheet piles are corroded and fill is actively eroding from behind the wall.

<i>Condition</i>	D	<i>Priority</i>	IV
<i>Rating</i>	Poor	<i>Rating</i>	High Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Next Project Construction Listing
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	High Value Inshore Structures with Potential for Infrastructure Damage and/or Moderate Density Residential Dwellings ( 1-10 dwellings impacted / 100 feet of shoreline)

Structure Images:  
006-060-267-4000-700-PHO7A.JPG

Structure Documents:

**Structure Assessment Form**

Property Owner: <u>Local</u>	Location: <u>South Boston - Summer Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: _____	
Owner Name: <u>Boston Redevelopment Authority</u>	Earliest Structure Record: _____	Estimated Reconstruction/Repair Cost: <u>\$359,713.00</u>

Length: <u>2290</u> Feet	Top Elevation: _____ Feet NAVD 88	FIRM Map Zone: <u>V4</u>	FIRM Map Elevation: <u>14</u> Feet NGVD
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Primary Type: <u>Revetment</u>	Primary Material: <u>Stone</u>	Primary Height: <u>10 to 15 Feet</u>
Secondary Type: _____	Secondary Material: _____	Secondary Height: _____

**Structure Summary :**

A riprap slope with a varying stone size from 4 inches to 2 feet by 2 feet. There is larger stone on the outer face that has an average stone size of 4 feet by 2 feet. The whole structure is generally in good condition.

<i>Condition</i>	<b>B</b>	<i>Priority</i>	<b>II</b>
<i>Rating</i>	<b>Good</b>	<i>Rating</i>	<b>Low Priority</b>
<i>Level of Action</i>	<b>Minor</b>	<i>Action</i>	<b>Future Project Consideration</b>
<i>Description</i>	Structure observed to exhibit very minor problems, superficial in nature. Minor erosion to landform is present. Structure / landform adequate to provide protection from a major coastal storm with no damage. Actions taken to prevent / limit future deterioration and extend life of structure.	<i>Description</i>	<b>Inshore Structures Present with Limited potential for Significant Infrastructure Damage</b>

**Structure Images:**

- 006-060-267-4000-800-PHC08A.JPG
- 006-060-267-4000-800-PHC08B.JPG
- 006-060-267-4000-800-PHC08C.JPG
- 006-060-267-4000-800-PHC08D.JPG

**Structure Documents:**

**Structure Assessment Form**

Property Owner: <u>Local</u>	Location: <u>South Boston - Summer Street</u>	Date: <u>7/12/2007</u>
Presumed Structure Owner: <u>Local</u>	Based On Comment: _____	
Owner Name: <u>Boston Redevelopment Authority</u>	Earliest Structure Record: _____	Estimated Reconstruction/Repair Cost: <u>\$7,207,200.00</u>

Length: <u>2100</u> Feet	Top Elevation: <u>88</u> Feet NAVD	FIRM Map Zone: <u>V4</u>	FIRM Map Elevation: <u>14</u> Feet NGVD
Primary Type: <u>Bulkhead/ Seawall</u>	Primary Material: <u>Steel</u>	Primary Height: <u>Over 15 Feet</u>	
Secondary Type: _____	Secondary Material: _____	Secondary Height: _____	



Structure Summary :

A steel bulkhead that is in poor condition with a concrete cap and concrete and timber piles in front that have mostly failed but support a pier extending off the wall. There is a small section that has riprap dumped in front of the sheeting as a repair.


<i>Condition</i>	D	<i>Priority</i>	III
<i>Rating</i>	Poor	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Major	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure exhibits advanced levels of deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure has strong risk of significant damage and possible failure during a major coastal storm. Structure should be monitored until repairs/reconstruction can be initiated. Actions taken to reconstruct structure to regain full capacity to resist a major coastal storm. Landform eroded, stability threatened. Landform not adequate to provide protection during major coastal storm. Actions taken to recreate landform to adequate limits for full protection from a major coastal storm.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings (<1 dwelling impacted / 100 feet of shoreline)

- Structure Images:
- 006-060-267-4000-900-PHO9A.JPG
  - 006-060-267-4000-900-PHO9B.JPG
  - 006-060-267-4000-900-PHO9C.JPG

Structure Documents:

**Structure Assessment Form**

Property Owner: State	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: State	Based On Comment:	
Owner Name: Mass Highway Department	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$174,220.00

Length: 315 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: A2	FIRM Map Elevation: 10 Feet NGVD	
Primary Type: Revetment	Primary Material: Stone	Primary Height: 10 to 15 Feet		
Secondary Type: Bulkhead/ Seawall	Secondary Material: Stone	Secondary Height: Over 15 Feet		

**Structure Summary :**

A placed granite stone revetment with an average stone size of 2 feet in diameter. On top of the revetment is a granite block wall with an average block size of 2 feet by 2 ft by 4 feet. The structure is in a good condition with only a few signs of weathering.

<i>Condition</i>	B	<i>Priority</i>	II
<i>Rating</i>	Good	<i>Rating</i>	Low Priority
<i>Level of Action</i>	Minor	<i>Action</i>	Future Project Consideration
<i>Description</i>	Structure observed to exhibit very minor problems, superficial in nature. Minor erosion to landform is present. Structure / landform adequate to provide protection from a major coastal storm with no damage. Actions taken to prevent / limit future deterioration and extend life of structure.		<i>Description</i>
			Inshore Structures Present with Limited potential for Significant Infrastructure Damage

<b>Structure Images:</b>	<b>Structure Documents:</b>
<a href="#">006-060-267-4008-100-PHO1A.JPG</a>	
<a href="#">006-060-267-4008-100-PHO1B.JPG</a>	
<a href="#">006-060-267-4008-100-PHO1C.JPG</a>	

**Structure Assessment Form**

Property Owner: Local	Location: South Boston - Summer Street	Date: 7/12/2007
Presumed Structure Owner: Local	Based On Comment:	
Owner Name: Boston Redevelopment Authority	Earliest Structure Record:	Estimated Reconstruction/Repair Cost: \$708,510.00

Length: 565 Feet	Top Elevation: Feet NAVD 88	FIRM Map Zone: A4	FIRM Map Elevation: 12 Feet NGVD
Primary Type: Bulkhead/ Seawall	Primary Material: Concrete	Primary Height: 10 to 15 Feet	
Secondary Type:	Secondary Material:	Secondary Height:	



Structure Summary :

A concrete wall in front of an old steel sheetpile wall. The concrete still has timber forms on it. From what was evident of the structure it appears that it is in fair condition.

<i>Condition</i>	C	<i>Priority</i>	III
<i>Rating</i>	Fair	<i>Rating</i>	Moderate Priority
<i>Level of Action</i>	Moderate	<i>Action</i>	Consider for Active Project Improvement Listing
<i>Description</i>	Structure is sound but may exhibit minor deterioration, section loss, cracking, spalling, undermining, and/or scour. Structure adequate to withstand major coastal storm with little to moderate damage. Actions taken to reinforce structure to provide full protection from major coastal storm and for extending life of structure. Moderate wind or wave damage to landform exists. Landform may not be sufficient to fully protect shoreline during a major coastal storm. Actions taken to provide addition material for full protection and extended life.	<i>Description</i>	Inshore Structures with potential for Infrastructure Damage and/or Limited Residential Dwellings (<1 dwelling impacted / 100 feet of shoreline)

Structure Images:  
006-060-267-4010-100-PHO1A.JPG

Structure Documents:

Prepared By: Bourne Consulting Engineering

**Appendix L: Hazardous Materials Emergency Plan**

**THE COMMONWEALTH OF MASSACHUSETTS  
EXECUTIVE OFFICE OF PUBLIC SAFETY AND SECURITY**

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**MASSACHUSETTS EMERGENCY MANAGEMENT AGENCY  
400 Worcester Road Framingham, MA 01702-5399**

**TO: Massachusetts Tier II Reporting Entities**

**FROM: Kurt N. Schwartz  
Director, Massachusetts Emergency Management Agency  
Chair, Massachusetts State Emergency Response Commission**

**THROUGH: Massachusetts State Emergency Response Commission**

**CC: Massachusetts Emergency Planning Committees and Fire Departments**

**RE: Tier II Reporting Year 2016: Massachusetts State Emergency Response  
Commission Reporting Requirements**

**DATE: December 29, 2016**

Facilities covered by the reporting requirements of the federal [Emergency Planning and Community Right-to-Know Act \(EPCRA\)](#) must submit Tier II reports to their: [Emergency Planning Committee \(EPC\)](#), their [Local Fire Department](#), and the [State Emergency Response Commission \(SERC\)](#) annually. Tier II Reports for 2016 must be filed by March 1, 2017.

The Massachusetts Emergency Management Agency (MEMA) has, per Governor's Executive Memorandum, been designated as the State Emergency Response Commission (SERC) in Massachusetts.

This memorandum is being sent to Massachusetts Tier II reporting entities on behalf of the Massachusetts SERC. This memorandum is specific to the Massachusetts SERC Tier II reporting requirements for Reporting Year (RY) 2016.

For Reporting Year 2016, the Massachusetts SERC will require filers to submit reports via



the web-based Tier II Manager System. The SERC will not accept reports developed or submitted via other means.

This only affects how Tier II reports are submitted to the Massachusetts SERC; this does not change any Massachusetts EPC and/or Fire Department reporting requirements.

Filers should contact their respective EPC and Fire Department regarding their reporting requirements.

The fact that you are receiving this memorandum does not necessarily mean you are required to file a Tier II report. It does mean you should determine whether the federal Tier II regulations are applicable to your facility. Please use the reference table below to assist in this determination.

**Tier II reporting thresholds:**

Extremely hazardous substances (EHS)*	500 pounds (227 kg) or threshold planning quantity, whichever is less.
All other hazardous substances:	10,000 pounds (4,540 kg) for any material that has an SDS
*You may obtain a list of EHS substances on the EPA website here: <a href="https://www.epa.gov/epcra/final-rule-extremely-hazardous-substance-list-and-threshold-planning-quantities-emergency">https://www.epa.gov/epcra/final-rule-extremely-hazardous-substance-list-and-threshold-planning-quantities-emergency</a>	

**Use of the Tier II Manager System:**

The Tier II Manager System is now ready for 2016 reporting. The URL for the Tier II system is: <http://massachusetts.idsimaps.com>.

New filers must first register to use the Tier II Manager System. Registration is a one-time process; if you have already registered you do not need to do so again.

To register, please follow the steps outlined within MEMA's **Tier II Manager System: Filer Registration Process** memo, which may be found on MEMA's website at: <http://www.mass.gov/eopss/agencies/mema/resources/serc/>. This memo also contains the system requirements needed to use the Tier II Manager System. Once you have successfully registered, you may use the Tier II Manager System.

**If you have lost or forgotten your Username and/or Password, you may re-set them via the System's website.**

**If you have filed a Tier II report with MEMA in a prior year, but do not see this in the System please contact MEMA for assistance.**

**A User's Guide (comprised of powerpoint slides and FAQ's) and training video will be available on the Tier II Manager System website. To access the User's Guide materials, log-in to the System, click Continue, then click the green '?'**

**A link to the training video will be on the Tier II Manager System's home page. The training video provides an overview on how to access and use the System, including changes to the System's 'export tool'. MEMA highly recommends that filers review the User's Guide materials and/or training video prior to developing their RY 2016 report.**

**To facilitate use of the Tier II Manager System by filers, MEMA is providing a 'Tier II Submit export tool' within the Tier II Manager System. There have been some changes to this tool, and directions on use of this tool may be found within the User's Guide materials and training video.**

**Once a filer completes and submits a report via the Tier II Manager System, the export tool will convert their report into a format that may be used with the EPA's Tier II Submit software and CAMEO.**

**The converted file may then be submitted – by the filer – to its respective EPC and Fire Department per their reporting requirements.**

**As a change from last year, the exported reports function will work off-line. This is being done to minimize disruptions to the System. Detailed instructions on use of the export tool may be found in the User's Guide materials and training video. As an additional change, exported reports will be converted directly into a .t2s format that is compatible with the EPA's Tier II Submit software.**

**Once you have created a file using the Export Tool it is important that you carefully review the export file to ensure that it is accurate. In particular, if converting a Tier II Manager file to a Tier II Submit file, you may receive Tier II Submit validation errors for: attachments over 2MB; latitude and longitude coordinates; NAICS codes; or facility contact last name. If you receive a validation error, you must open the Tier II Submit file and manually correct the information before the file is sent to the EPC and/or FD.**

**Massachusetts-Specific Tier II Reporting Fields:**

Massachusetts uses state-specific Tier II data fields and guidance on how filers should complete these fields is found within the Tier II Manager System.

**Other SERC Tier II Reporting Information:**

The following apply to the Massachusetts SERC. Your EPC and/or Fire Department may have different reporting requirements.

§ If you submit a report via the Tier II Manager System you will receive an automatic reply acknowledging receipt.

§ Submitting a report via the Tier II Manager System does NOT fulfill your EPC and Fire Department reporting requirement. Filers must still submit reports to their respective EPC and Fire Department.

§ There is no filing fee for the SERC.

§ The SERC does not require submission of SDS' or facility site plans.

§ A list of EPCs in Massachusetts may be found on MEMA's website here: <http://www.mass.gov/eopss/docs/mema/resources/serc/all-epc-spreadsheet-november-2016.pdf>

If you have any questions regarding this memorandum please contact Mayra Quintana (508.820.204; [Mayra.Quintana@state.ma.us](mailto:Mayra.Quintana@state.ma.us)); Jeff Timperi (508.820.2019; [Jeff.Timperi@state.ma.us](mailto:Jeff.Timperi@state.ma.us)); or Paula Krumsiek (508.820.1424; [Paula.Krumsiek@state.ma.us](mailto:Paula.Krumsiek@state.ma.us)).

From: <http://www.mass.gov/eopss/agencies/mema/resources/serc/>

## Appendix M: Vulnerable Population Maps



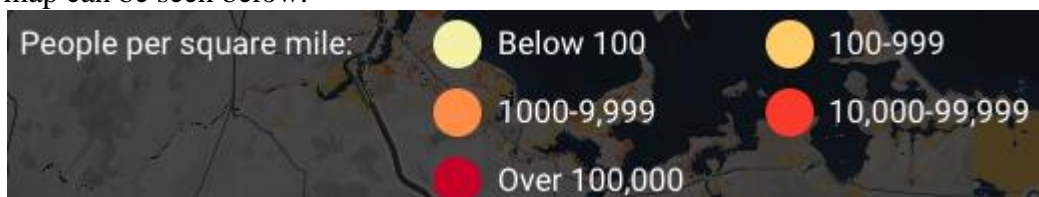
**Boston Inner Harbor Vulnerability Population Exposure Map** From: (2017). *Surging Seas: Risk Zone Map*, | NOAA. Retrieved April 5, 2017

This map defines social vulnerability as the ability of communities to prepare and respond to hazards like flooding. "High" and "low" indicate the 20% most and least vulnerable in coastal areas of each state during a 5 ft. SLR scenario. The yellow color represents low exposure, orange represents medium exposure, and red represents high exposure. Census tract resolution data. Data source: Hazards and Vulnerability Research Institute (HVRI)'s Social Vulnerability Index. (Map layer currently available only within the U.S.)



**Boston Inner Harbor Affected Population Map** From: (2017). Surging Seas: Risk Zone Map, | NOAA. Retrieved April 5, 2017

This map shows the people per square mile exposed to flooding events during 5 ft SLR. The key for this map can be seen below.



## **Appendix N: Authorship**

Abstract - Primary Writer: All, Primary Editors: All

1.0 Introduction – Primary Writers: All  
Primary Editors: All

2.0 Background – Primary Writers: All, Primary Editor: All

2.1 – Primary writer: Austen Crawford

2.2 – Primary writer: Kyle Whittaker

2.3 – Primary writer: All

2.4 – Primary writer: All

3.0 Methodology – Primary Writers: All, Primary Editor: All

3.1 - Primary writer: Austen Crawford and Jacob Bouchard

3.2 - Primary writer: All

3.3 - Primary writer: Caroline Warchol, Kyle Whittaker, Jacob Bouchard

4.0 Findings - Primary Writers: All, Primary Editor: All

4.1 - Primary writer: Jacob Bouchard and Kyle Whittaker

4.2 - Primary writer: Austen Crawford and Caroline Warchol

4.3 - Primary writer: All

4.4 - Primary writer: Caroline Warchol and Kyle Whittaker

4.5 - Primary writer: Jacob Bouchard and Kyle Whittaker

5.0 Recommendation - Primary Writers: All, Primary Editor: All

5.1 - Primary writer: Jacob Bouchard and Kyle Whittaker

5.2 - Primary writer: Jacob Bouchard and Kyle Whittaker

6.0 Conclusion- Primary Writers: All, Primary Editor: All

7.0 References - Primary Writer: Jacob Bouchard

8.0 Appendices - Primary writer: All