

Introduction:

Sea level rise is one of the most pressing concerns for coastal communities in the world today. It does not respect borders, and the effects of sea level rise will vary depending on location and the natural terrain of the area in question. In some cities around the world, sea level rise will only become a slight nuisance, but in others it can lead to disaster. In the San Francisco Bay Area, there is a predicted 15 to 55 feet of sea level rise, putting not only billions of dollars at risk, but threatening the very way of day-to-day life occurring in the region (EPA, 2016). This thesis is going to explore the regional challenges faced in the Bay Area. It will also provide case studies of what is at risk in the area by presenting cases on different, but interconnected parts of infrastructure that make the San Francisco Bay Area the 19th largest economy in the world. This paper will also assess what can be done to protect these assets.

Climate Change:

Climate change is the literal change in Earth's climate whether it is from hot to cold or cold to hot. According to NASA, \ climate change is the change in usual weather patterns of an area or the very change in Earth's climate (NASA, 2015). Examples of climate change include grasslands turning into deserts, tranquil forests transforming into tundras, or even the erosion of the coast by an increase in storms and tidal activity. Changing temperatures are starting to impact ecosystems around the world, and these temperatures are changing from what modern day humanity has grow accustomed to for the past hundreds of years.

Sea level rise is a global problem, for it causes damages and disruption around the world. However, for such a large-scale problem that plagues so many, the effects of sea level rise, are a byproduct of climate change. Climate change is a sensitive issue for some, and policies created

regarding climate change can drastically change how some individuals live or operate their livelihoods or businesses. This is the reason why there are parts of the world that accept climate change as real and others that do not, creating an ideological battle that branches into many aspects of life and governance. Even when climate change is accepted, thoughts differ on how to combat climate change and what should be done in order to mitigate it. Even in the scientific field where scientists acknowledge the existence of climate change, there is debate over the actual causes of climate change.

Literature Review:

Sea level rise is an issue that plagues any coastal territory regardless of location or national borders. As such, there has been continuous research into what causes sea level rise and how it can be stopped or slowed. Now, scientists have pointed to climate change, and more specifically to global warming, as the cause of sea level rise. However, amongst scholars, there is a divide over the driving force behind sea level rise. This divide is characterized by those that either believe in natural or artificial climate change. The question is whether or not mankind as a species has altered the state of our planet and caused global warming, or if the Earth is entering a natural warming cycle, as it does every few hundred thousand years, which causes a shift in climate. As such the question is raised, “who is right”? Depending on which side is correct, this would dictate where resources are spent in order to fight climate change and along with it, sea level rise.

Scientists look to find the causes of climate change before they look into how either to solve it or lessen its impact, as well as the impacts of processes caused by it, like sea level rise. But this is complicated, for when one looks at the literature, they will find a divide amongst scientists about what is exactly causing climate change. There are scientists who believe that the world is

entering a natural heating cycle and there are others that blame a political agenda that is pushing human causes as the source of climate change. According to Mesarovic (2015), “the United Nations International Panel on Climate Change (IPCC) are criticized as alarmists by scientists that are unsuccessful about applying real science on the effects of human actions in relation to climate change” (Pg.2). However, the IPCC has made its position clear using observational science stating that there is a correlation between greenhouse emissions caused by human activity and warming weather patterns (IPCC, 2013), which is causing the continuous pattern of heating that humanity is experiencing. Each side makes very compelling arguments because both causes of climate change are based on observation.

The main science that speculates on human causes driving climate change is based on the effects of greenhouse gases. According to NASA, “the effects of greenhouse gases is absorption and trapping of heat, which as a result heat cannot naturally be reflected into space causing the planet to heat up”(NASA, 2017, Pg.1). This is further backed up by the EPA which states, “that since the industrial revolution the amount of emissions produced by humanity has skyrocketed and comparing the data of human activity to unpresented warming patterns in recorded history; it can only be concluded that human activity is driving an artificially inflated greenhouse effect causing climate change”(EPA, 2016, Pg.1). This is the main argument as to why human activities are driving climate change and particularly global warming.

The other side advocates that climate change is a naturally occurring event. These scientists are making this claim by using evidence that compare past events and natural occurrences. According to Baum et al (2012), “ice cores taken from polar ice sheets and glaciers have trapped CO₂ which was originally trapped thousands, if not millions of years ago (depending on depth the ice cores are collected from) and by comparing the amount of CO₂ with

current levels today this can paint an accurate picture of past climates” (Pg.5). Using the process of analyzing ice core samples, a pattern was observed, showing that the Earth has undergone various periods of heating and cooling in the planet’s history.

This cycle is explained by the same way seasons occurs. Thompson & Kuo (2012) say, that as the Earth spins around the sun, it does not move in a perfect circular path. As such, the Earth constantly moves either further or closer to the sun, causing natural cooling and heating events (as well as natural occurrences, such as the occasional volcanic eruptions that cool the planet as recorded by ice core samples). The records indicate that the Earth is currently moving closer to the sun. As the Earth is exiting from a cooling period and entering into a heating cycle, the planet will naturally start to warm up. Scientists who believe in the natural theory of climate change use this and state that climate change is occurring because the earth is undergoing a period of heating as part of its natural cycle.

The science that both sides use is sound, with each side presenting evidence to back their claims. What is actually driving climate change can very well be a combination of both natural and artificial events. However, it is important to note that in the scientific community, there is no one that is denying climate change; instead there is disagreement over the causes. This is important because even though the debate over what is causing climate change (and consequently global warming) is going on, the effects are being acknowledged by both parties. Climate change is happening, and the effects are being seen in many different ways. This thesis is going into depth about one part of it, and that is the cause of sea level rise.

Climate Change:

Earth is unique as a planet because of the it’s atmosphere, which is the main reason why life is supported on Earth. One of the most important aspects of Earth’s atmosphere is how gases

are trapped in it. These gases act as insulation for the planet by not only reflecting heat, but also trapping heat, and this in turn creates a greenhouse effect. The term greenhouse effect comes up in various forms of news and literature because of the amount of greenhouse gases that can be tracked and manipulated. The reason is that human activity is a source of blame in creating excess emissions, that exponentially contribute to gases already located in the atmosphere, which results in amplifying the greenhouse effect. Due to this, the term Anthropocene was created, which means “the period of time during which human activities have had an environmental impact on the Earth regarded as constituting a distinct geological age” (Webster, 2017, Pg.1). However, some scientists are debating that humanity did not create the Anthropocene era. Instead what humanity is currently experiencing, climate change, is just a natural occurrence in Earth’s cycle.

The debate for scientists regarding climate change, is whether or not humanity has altered the Earth’s climate by emissions from human activity, or if the planet is going through a natural heating cycle as previously observed in Earth’s history. The first is based on historical evidence and natural process of the Earth, which has been following this same pattern of moving closer or further from the sun. This led to the creation of the Milankovitch theory, which according to NASA, is the theory of how the Earth naturally tilts as it circles the sun. The tilt varies a few degrees every 90,000 to 100,000 years and, as a result, dramatically changes the climate (NASA, 2017). This is the argument, scientists use in proving that climate change is a natural process.

The other side of the argument is from scientists who say that humanity is the cause for climate change. This argument points to the greenhouse effect, and how humanity, since the Industrial Revolution, has been altering the planet's climate. According to the EPA, “since the Industrial Revolution began around 1750, human activities have contributed substantially to

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climate change by adding CO₂ and other heat-trapping gases to the atmosphere” (EPA, 2014 Pg.1). This fact is most widely accepted by science as the main cause for climate change.

Regardless of how the planet is warmed, the effects remain the same. With warmer temperatures two things occur; the first is the melting of land-based ice in Antarctica and Greenland, the second is thermal expansion. These two processes caused by a warming planet contribute to the entirety of sea level rise, with each component causing roughly fifty percent of sea level rise. It is important to note some distinction in regards to these processes.

In regards to melting ice, it is important to make the distinction of how different kinds of melting ice contribute to sea level rise. The best way to visualize this is by imagining the world’s oceans as a glass of water. When a person adds ice to the glass the water level rises. This is also where many people make misconceptions, that sea level will rise with the melting of sea ice. Water that has already been frozen in the ocean won’t contribute to its overall volume, but ice from land will. The reason for this is sea ice is water that was already in the ocean before it froze, but land based ice, once it melts contributes to the overall volume of the ocean, because it was never part of the ocean’s initial volume before it melted. This is why the melting ice caps of Greenland and Antarctica are a major concern, because the ice located in these regions is not sea ice. Instead it is ice that has formed miles thick on land, which contributes to the overall rise in sea level. This is why there is a distinction about the Arctic, which is a mass of frozen seawater that is shrinking by the year, for even if the Arctic melts, the ice from the Arctic will not contribute to overall sea level rise. However, it is important to note that the Arctic still plays a major role in refraction of sunlight, which keeps the ocean temperatures down. This leads into the next major driver of sea level rise, thermal expansion.

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The second force of driving sea level rise is heat. As demonstrated with the glass example, when water is heated up to a certain point it starts to change into steam. This is because water molecules are separating from each other. During this process, water will increase in volume. Before the water can turn into gas, the water molecules are stretched out as far as possible, while still being in a liquid state. This expansion in the overall volume of water itself is taking place in the ocean causing the sea level rise. However, in this case, it is the ocean being heated. This is why the Arctic is important. Ice has the natural property of reflecting and refracting sunlight away from the ocean, thereby reducing temperature. The issue is that since there is less ice in the world's oceans, there is more sunlight hitting the water. As a result, warming the oceans, causing water to thermally expand as a result.

The reason for these driving forces behind sea level rise is climate change. Climate change is the reason why policies are created to combat negative environmental practices. Many countries are advocating for green energy because it will produce fewer emissions and stop the artificial greenhouse effect. These types of policies, regulating the amount of emissions produced by human activity, are widely accepted, because not only is the artificially inflated greenhouse effect believed to be the cause of climate change, but action can be taken against human activity. This is the main reason why the international body tries to pass regulations to limit emissions due to the fact that, unlike a natural occurrence causing climate change, manmade climate change can be mitigated through policy and regulation.

International Opinion:

The international opinion on climate change in comparison to the United States varies based on location. A lot of the focus on preparing for sea level rise is to try to prevent the forces that cause it. Using the Maldives for example, as well as its fellow island nations around the

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world, there is a very vocal outreach in trying to limit emissions and using alternative energy. “Climate change-induced sea-level rise in the world’s 52 small island nations – estimated to be up to four times the global average – continues to be the most pressing threat to their environment and socio-economic development with annual losses at the trillions of dollars due to increased vulnerability” (United Nations, 2014, Pg. 2). However, in countries like Russia, warmer weather brings about new opportunities. The melting of the Arctic, has created a new global shipping route, as well as more fertile land being available, due to warmer climates in areas that were once frigid land. On the international front what is talked about most in regards to climate change are measures to try to cool the planet. Limiting emissions that contribute to the greenhouse effect in turn will limit the influx of melted ice and thermal expansion that is increasing the volume of the world’s oceans.

This international cooperation through environmental accords has created some notable moments in history, from the regulation of emissions to combating climate change. The first such historic occurrence is the worldwide agreement to regulate emissions, the Kyoto Protocol. The Kyoto Protocol was adopted in December 1997 and came into force in 2005. At the time, it was hailed as the most significant step in environmental protection. Various countries signed and ratified the Kyoto Protocol, agreeing to limit their CO₂ emissions. However, there were some flaws, and the reason for this is some countries were not being held accountable. According to Britannica (2016), the two leading producers of emissions in the world, China and the United States, were not bound by the agreement due to technicalities.

China stated that their reasoning was because they fell under the definition of what was considered a developing country. Developing countries were able to continue emitting emissions unchecked, under the premise that they were undergoing a period of industrialization. It was

argued that it would be unethical for first world countries to limit developing countries growth, for during the first world countries periods of industrialization, no one limited their growth. As for other countries like the United States, they simply never ratified the treaty and were therefore not bound by it.

Though the United States is considered worldwide as an industrial country, the U.S. did not ratify the Kyoto Protocol, because the treaty had no component for accountability. As a result, the United States saw no point to the agreement, due to the fact it would be limiting itself while other prominent producers of greenhouse gases like China or India would not be bound by it.

Due to these shortcomings, the Kyoto Protocol was replaced by with another international agreement on climate change, the Paris Agreements. This Agreement entered into force in November, 2016, after garnering enough support in the United Nations. The Paris Agreement was able to avoid the pitfalls of the Kyoto Protocol, allowing a shift in focus of the international community to combating climate change.

The Paris Agreement follows the same goals as its predecessor, but it is important to note that it has made changes to allow more countries to be held accountable, as well as more reasonable goals to achieve its aim of limiting emissions to cool the planet. In the words of the United Nations, “to reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework” (United Nations, 2014, Pg. 1). The focus of the Protocol was to include more countries, as well as help them with their agreements of limiting

their generation of pollution. It is also important to note that, as of now, there are 135 out of 197 countries that have ratified the Paris Agreement (United Nation, 2014). More importantly, the world's biggest players in the creation of emissions have also signed the Paris Agreement as well, most notably the United States and China. This in itself has made the world's largest emitters of greenhouse gases accountable, giving the Paris Agreement a larger impact than the Kyoto Protocol.

With the majority of the world agreeing on how to fight climate change, it is important to note what is happening in the United States. Regionally, in the San Francisco Bay Area, many agencies are looking at one of the major effects of climate change, sea level rise. Each agency is looking at the potential impacts and solutions to avert damage in the region.

Impacts of Sea Level Rise:

The problem with sea level rise, besides the obvious effects of land being reclaimed by the sea and the flooding that naturally occurs further inland as a result of sea level rise, are the issues of erosion and freshwater being inundated by seawater. The reasons these issues are important is because, unlike flooding, in which land is submerged, erosion is the process in which the land itself is being withered away into nothing, by a combination of wind and water over time. Furthermore, with sea level rise there are starting to be cases where seawater is reaching points, where because of high tide, salt water is able to seep into the ground, which taints fresh water in its natural underground reservoirs.

This inundation of groundwater by sea level rise is a major concern. For many communities, their main source of water is groundwater. With seawater seeping into the ground, reservoirs are being affected and tainting the water supply, which effectively disrupts a community's ability to function. Even if the groundwater is tainted the community can still

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survive, but the community will need to use costly alternatives of acquiring water such as surface water transfers. Surface water transfers are the process in which water is physically transferred from one location to another by new engineering solutions. Such solutions include the use of pipelines or the trucking in of freshwater to meet water demands. For areas that have a history of extended groundwater use, the potential threat of saltwater seeping into groundwater can be a very pressing concern, especially for some livelihoods. An example of a livelihood that is gravely affected by this are farmers, who use the groundwater to irrigate their fields. “Unless farmers are able to access alternative sources of water at reasonable prices, they may no longer be able to cultivate their land” (Heberger et al. 2009, Pg. 20). This is especially true in the delta where the land has naturally sunk, and because of groundwater extraction over a period of decades, what is left is vulnerable to inundation by sea level rise. The reason for this is that groundwater extraction, the land has sunk up to 20 feet below sea level in some areas. With the predicted levels of sea level rise, the prospects of land being inundated and by extension groundwater being tainted increases.

Various communities in the Bay Area face a number of threats, but some areas have already started to feel the effects of climate change induced sea level rise. In the case of erosion, there have already been coastal communities that have been impacted. For communities that are built on the edges of cliffs, erosion has literally eaten away the ground in which many buildings were built on. One example is the coastal city of Pacifica, in which people have been evicted from their homes, due to the city condemning these buildings, which have become unstable due to erosion. According to the Pacifica City Manager and Director of Emergency Management Lorie Tinfow, “it is necessary for the safety of the public to proceed with the demolition as

unpredictable weather patterns and high surf continue to threaten the building's structure”(Ravani, Sarah, 2016, Pg.1).

While some structures are being condemned, other structures are being flagged for potential loss due to signs of erosion, which are being spotted. Now, one may ask, why has erosion become such an issue today when in the past this was not the case? This is because erosion is becoming more prominent due to the driving forces that cause erosion are becoming more readily available. The two forces that drive erosion are wind and water, and in the case of coastal communities, the buffer areas that hold back the waves are beginning to disappear. With shrinking beaches and natural barriers (sand bars, islands, wetlands, etc.) being swallowed by the sea, the ocean is now starting to directly hit cliffs and land, which were once at a respectable distance from the sea. This means that with every storm, or in some cases due to sea level rise occurring (in an area), seawater is slamming into the cliffs/ land. This, with the combination of wind, causes erosion to take place at a more accelerated pace.

To combat this, there are many preventive measures that are designed to act as a barrier, in order to protect the land from the driving forces of erosion. The U.S. Army Corps of Engineers, for example, prefers to use beach nourishment and the creation of artificial beaches as a means to protect the shoreline. “The primary purpose of the shore protection program is to reduce the impacts of waves, inundation, beach erosion and hurricanes on developed shorelines” (Hillye, Theodore M. r, 1996, Pg. 37). While the report was created in 1996, the U.S. Army Corp of Engineers still continue to, spends hundreds of millions to continue this process. Along with this comes the recreation of natural barriers, which are manmade structures like seawalls or the reinforcing of cliffs with concrete. These barriers ultimately prevent erosion and increase the lands stability.

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The problem with erosion is the issue of preventing it and minimizing the damages it causes. There are a variety of ways to prevent erosion, but they are costly and have to be maintained frequently. However, the reason why these preventive measures are undertaken, is because once the ground is eroded there will be nothing there. As with the case of Pacifica, once the ground is eroded, whatever building or structure that was there has to be abandoned and demolished due to safety reasons. However for most of the major economic drivers in the Bay Area the main issue is not going to be erosion, but pure flooding due to sea level rise.

OAK Case Study:

The San Francisco Bay Area is home to the 19th largest economy in the world. The Bay Area's workforce is made up of a large mixture of blue and white collar jobs. There is also a variety of major freight generators. These include five seaports, three major airports, two major railroads, and two important trucking corridors. As the battle against climate change is going on, it is important to note the damage that can be caused by sea level rise as a result. Using the Bay Area as an example, there are various organizations that plan and analyze the potential impacts for sea level rise. One of these organizations is Adapting to Rising Tides (ART), which is an organization that was created by a joint effort of NOAA and The Bay Conservation and Development Commission in an effort to identify how current and future flooding will affect communities, infrastructure, ecosystems, and economies in the region. ART has created a few case studies of some of the Bay Area major freight generators, such as the Port of Oakland and Oakland International Airport.

The Oakland International Airport is one of three major airports located in the Bay Area. Oakland International Airport (OAK) encompasses an area of 2,600 acres and is surrounded by the San Francisco Bay on its North-Western and Southern sides. Oakland International Airport is

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divided into two facilities: North Field and South Field. South Field is used by air cargo and commercial air services, while the North Field is used for general aviation. Both runways are at risk of inundation, because of future predictions of sea level rise.

The current risks that Oakland International Airport will face in the future can be divided into two categories, which are in the events of 16 inches of sea level rise and 55 inches of sea level rise. This can be then coupled with three tidal conditions, which are the new daily high tide, the new 100-year extreme water level, and the 100-year extreme water level with storm events that include wind waves.

With 16 inches of sea level rise, North Field (which contains the General Aviation facilities and northern runways) would face frequent flooding at high tide, with up to three to four feet of water. When a storm event is included in this equation, flooding will increase by two feet, which includes the flooding already produced by the normal high tide. It is also important to note that during a storm event, the flooding will reach the South Field. This will mean that during a storm, areas of South Field will be inundated with as little as a foot of water around the maintenance hangars, to seven feet of water on the commercial runways and taxiways (Adapting to Rising Tides (A), 2012).

The second scenario is in the instance of 55 inches of sea level rise. During high tide the flooding depth around maintenance hangars will be around 1 foot in depth, while the commercial runways and taxiways will face a depth of over 7 feet. During storm events, flooding will affect the entirety of the airport. Currently, some of the lower facilities, which include assets such as the jet fuel storage tanks, commercial runways, and air cargo facilities, are already within the daily tidal range, but are protected by tidal gates and levees. However, during storm events at 55 inches of sea level rise, runs a high possibility of water overcoming these barriers via wind

waves. The worst case scenario is that predicted flooding during a storm event at 55 inches of sea level rise, can result in every facility being flooded up to seven feet of water, with the runways and taxiways being flooded up to ten feet (Adapting to Rising Tides (A), 2012).

The damages caused by flooding at Oakland International Airport can be accessed by the economic impact of a shutdown. On the commercial service side of operations, a shutdown will have the potential of affecting regional and national air traffic. This is because of the amount of traffic OAK handles. Using data recorded by the Airports Council International – North America (ACI-NA), (an organization that represents local, regional and state governing bodies that own and operate commercial airports in the United States and Canada), it is recorded that the Oakland International Airport had 9,857,845 passengers flying in and out in 2010, making Oakland International Airport the 33rd busiest airport in the U.S. in terms of total passengers. It is also the 34th busiest in the U.S. in terms of total aircraft movements, with 219,652 landings and takeoffs. If a flood event occurs, this massive volume of traffic will either have to be redirected throughout the region or the flights will have to be canceled altogether (Airports Council International, 2010).

Not only is Oakland International Airport a major transit center for people, it is also a major air freight hub. Stating a statistic from the Airports Council International shows that it ranked Oakland as the 13th busiest airport in the U.S. in terms of air freight in 2015, handling 511,368 metric tons of freight, FedEx (one of OAK tenants) in 2010, averaged 15 flights a day, handling 907 million pounds of cargo (Adapting to Rising Tides (A), 2012).

Oakland International Airport generates around 4.2 billion dollars in business revenue, and 1.9 billion dollars is personal income directly. Coupled with this is the fact that 197 million dollars is provided to the state and locally in taxes, and includes a direct payment of 3.2 million

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dollars to the City of Oakland. The airport is a proven source of revenue for multiple parties based on statistics, as well as for the unaccounted transactions that are made possible abroad due to the services Oakland International Airport provides. Therefore, with such an asset at risk, the potential economic loss becomes evident.

Airports:



As previously mentioned, there are three major airports in the San Francisco Bay Area. Out of the three airports, San Francisco International and Oakland International Airports are at risk of flooding. To give context of how flooding will affect San Francisco International Airport in the Bay Area, the map above depicts flooding in the region. Both Oakland and San Francisco International are major airports are within the purple area in the map. What this illustrates is that without improved fortifications to protect the Bay Area's airports, San Francisco

International will be facing the same type of flooding that will occur in Oakland International Airport, as highlighted by the case study.

To continue to highlight the potential of economic damage caused by sea level rise, it is important to look at seaports, which have historically faced challenges due to sea level rise. The very purpose of a port requires it to be at sea level to service ships and load/offload cargo. This makes ports vulnerable to any noticeable amount of sea level rise. The five ports located in the San Francisco Bay Area are the Port of Benicia, the Port of Oakland, the Port of Redwood City, the Port of Richmond, and the Port of San Francisco. For this reason, ART conducted a study of what is at risk and the potential economic impacts of flooding at the Port of Oakland.

Port of Oakland Case Study:

The Port of Oakland is the largest of a series of ports that service the Bay Area. Naturally, with a port being built on the waterline, the various facilities that are in place are vulnerable to exposure by climate change and sea level rise in particular. The potential damage of sea level rise to the Port of Oakland is based on what the port owns and the potential loss to its leaseholders.

The Port of Oakland operates on a landlord based system, where the port owns and builds the various infrastructure and facilities, but private shipping companies rent out the facilities for their operations. The port contains a number of facilities including shipping berths, container areas, and intermodal rail facilities which makes up around 1200 acres of land. The majority of land is occupied by the four major terminals. These terminals take up 775 acres, which includes the deep water berths, 36 container gantry cranes and space to store containers. The rest of the port is made up mostly of the intermodal rail system with Burlington Northern Santa Fe operating the rail port, in correlation with Union Pacific. The last area of the port encompasses some parts of the former Oakland Army base. The port uses some of this land to carry out some ancillary port services (which include extra storage space to store cargo, as well as converting land for future rail expansion).

In the upcoming event of sea level rise, the two scenarios created for the Port of Oakland are involving 16 inches of sea level rise, and 55 inches of sea level rise. In the event of 16 inches of sea level rise, the Port of Oakland will not face threats to infrastructure during daily tides or even flood events during storms. Instead, what will threaten the Port of Oakland during 16 inches of sea level rise would be wind waves from storm events, which are categorized as the worst possible events. Only small portions of the former army base, the rail yards, as well as only two

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of the four terminals would be impacted by flooding due to wind waves with 16 inches of sea level rise (Adapting to Rising Tides (B), 2012).

The issue of sea level rise will become apparent though for the Port of Oakland with 55 inches of sea level rise. With 55 inches of sea level rise, high tide will start to affect the port by flooding parts of the railyard, former army base, as well as outbound railroad track in general. In a storm event, not only the previous mentioned areas will be affected, but also the terminals themselves. During a storm event, which produces wind waves, all the aforementioned areas will be affected except for one terminal (Adapting to Rising Tides (B), 2012).

The economic risk of having the Port of Oakland shutdown, because of prolonged flooding due to sea level rise will be catastrophic. The Port of Oakland is the third busiest container port on the West Coast of the United States and the fifth busiest in the country. According to the assessment of ART, in 2010, the Port of Oakland exported and imported 39 billion dollars of goods. In the local community, the Port of Oakland produces 444,000 jobs, related to the transportation of goods. While supporting 2.2 billion dollars in total personal income, as well as 2.1 billion dollars in revenue for businesses, the Port also provides maritime services for cargo and vessels. The Port of Oakland also generates about 233 million in state and local taxes (Adapting to Rising Tides (B), 2012).

After considering all the research of sea level rise, it becomes evident through an analysis of the case studies provided the extent of damage that will occur, if nothing is done about sea level rise. The effects alone on Oakland International Airport and the Port of Oakland will cost billions of dollars a day, with effects being felt across the country. When all the other airports, ports, roads, and railroads are factored in, the price of inaction starts to become something incalculable with economic loss rippling across the nation with every business and person will be

affected. The inconvenience of flooding, coupled with the cost of inaction, has the potential of a severe loss of economic activity in the Bay Area by the end of the century when the worst of sea level rise is supposed to occur.

Land Routes:

In the Bay Area, many aspects of the transportation system are being reviewed to find ways to increase capacity due to rising populations. Even now, the Port of Oakland is planning and preparing for increases in population growth. This would result in more cargo traffic to handle, and this will result in the need for the use of the former army base as an area to expand its rail capacity. There are only two ways for cargo to effectively be moved on land to and from the Bay Area, which are by truck or by rail. As it sits now, there is a bottleneck already forming with trying to move freight. However, as stated before, projected sea level rise is already threatening existing railroad capacity, and expansion efforts will soon come under threat of flooding as well.

According to the Department of Transportation, there are only two major railroads of note operating in the Bay Area which are classified as Class I (generating more than \$433 million in annual operating revenues) railroads (Department of Transportation, 2014). The two Class I railroads operating in the Bay Area are Union Pacific (UP) and Burlington Northern



Santa Fe (BNSF) Railway. A study made by the Pacific Institute, a nonprofit research institute, has identified that 60% of railroads that is at risk to sea level rise is located in the San Francisco Bay Area.

The importance of these railroads is in the purpose they serve in the nation's supply chain. The routes for both

companies head west, with Union Pacific trains heading over the Donner Pass and heading to Chicago. As for BNSF trains, they travel via the Tehachapi route, which ties into their transcontinental route serving Chicago, Kansas City, and Memphis. Each line is vital for the regions they serve, and without the railroads, the various ports that line the Bay Area will be rendered ineffective. This will leave only trucking as the sole means of transporting cargo, which will create a ripple of negative impacts as a result. These impacts include increased congestion, increased costs of goods, increased pollution, and lower economic activity due to ship wait time. Furthermore, there are not enough trucks to even move the vast amount of goods from these ports in the first place. This means that the ports will eventually have to slow down their operations because of backlog and the limited amount of space they have to store cargo for transportation.

The other way people and cargo move over land is through the highway system. Around the Bay Area, many of its most critical highways run parallel to the shore and are vulnerable to sea level rise. Caltrans suggests that with six feet of sea level rise there is the potential to cripple the Bay Area, if nothing is done. A study from the London-based Centre for Economics and Business Research puts a price tag of \$124 billion in 2013, with households incur traffic-related costs of \$2,301 per year related to traffic congestion (INRIX, 2014). With sea level rise, the cost of traffic congestion will increase due to flooding, with more and more time spent in traffic for both people and goods due to inaccessible roads.

Many key points of the Bay Area highway system are at risk of sea level rise, where even if some improvements are done to protect highways there will still be some vital key areas that will be shut down paralyzing the movement of goods and people. Due to the geographical terrain of the Bay Area, natural/ manmade barriers (rivers, marshes, urban sprawl, etc.) create a

challenging environment for engineers to work with, in terms of finding solutions for transportation problems. This includes the planning and building of infrastructure to protect transportation. The Bay Area is unique in its highway structure and, according to the Department of Transportation (2014), “The Bay Area’s unique geographical layout and strong dependence on several bridges coupled with a projected population increase from 7 million (in 2011) to 9 million (by 2040) bring their own array of major planning challenges” (Pg.1). The flow of all traffic gets funneled to these bridges and as a result congestion already takes place. However sea level rise poses a new threat. Many of the highways leading to one of these seven bridges and even the entrances of the bridges themselves are at risk of flooding, due to sea level rise.

Furthermore, it should be noted that the most major concerns of sea level rise in regards to road traffic is how flooding will force traffic to be rerouted. Many of the alternative routes that traffic can move though are not other highways, but instead they fall under the categories of backcountry roads. For example, Highway 37 is an important corridor in the northern portion of the Bay Area, which serves Napa and Sonoma County, however it is now regularly flooded as a result of sea level rise. The route that functions as a detour is a back country road with only one lane going in both directions, which becomes gridlocked when highway 37 is flooded.

It can also be predicted that the major highways that serve as the sole major routes between cities in the Bay Area can potentially be flooded as well. For example, Highway 101 is prone to future flooding in the areas around Candlestick Park and beyond. The issue is that this section of Highway 101 is used extensively by residents of the Southern San Francisco Bay to get to work in San Francisco. If this section of Highway 101 is flooded then half of the traffic has to be rerouted to already extremely congested roads that are possibly expecting flooding

themselves. If traffic is rerouted to small back country roads, they will be congested as a result resulting in adding hours to a commute.

To add to this problem, other key corridors, such as Highway 80 are vulnerable to flooding as well. According to flood maps, portions of Highway 80 that surround and connect to the Bay Bridge can be flooded, effectively shutting down traffic in the area. It is also important to remember that sea level rise happens all at once, so that when portions of highway 101 become flooded, so will other important routes such as Highway 80. This means that to get from place to place, the entirety of the Bay Area has to move through either back roads or to the few inland highways that are already faced with daily congestion these are all in an effort to try to circumnavigate the Bay Area, in order to bypass flooded roads to get from place to place.

The map above shows all the areas that five feet of sea level rise will affect. With just five feet of sea level rise, the seven bridges (which the Department of Transportation identified as vital to the Bay Area's highway system), will be under threat from flooding. Just looking at the map, it becomes apparent what the cost of inaction is. With all of the Bay Area's largest cities bordering the coast, inaction in regards to sea level rise can very well lead to the shutdown of the Bay Area. The potential economic impact of this is hard to imagine, as the challenge to get from place to place can take hours, and depending on the location impossible. The flooding of land routes throughout the Bay Area will gravely affect both commerce and personal lives.

State Organizations:

To prevent this from happening, the State of California, as well as various organizations have been focusing on how to prevent such a disaster from happening. The governor's office recognized the impacts of sea level rise, and as a result mandated Executive Order S-13-08. This order entails the bolster of authority for the California Natural Resource Agency in efforts to

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help coordinate sea level responses. Resulting in each of California's coastal agencies coming together to pool resources and create ideas in an effort to come up with an effective plan to deal with the impending issues caused by sea level rise (State of California, 2010).

In California, there are also many other agencies that manage the various coastal aspects of California's coast. These agencies include: The Ocean Protection Council, California Ocean Science Trust, California Coastal Commission Department of Parks and Recreation, State Coastal Conservancy, State Lands Commission, and The San Francisco Bay Conservation and Development Commission. Each agency works together towards a common goal. According to the California Natural Resource Agency, on the fellow state organizations, "The group's shared mission is to maintain the natural beauty, accessibility, economic power, ecological richness, and social diversity of the California coast by reducing risks from sea-level rise, storms, erosion, and other coastal climate change-related hazards" (California Natural Resource Agency, 2014, Pg.128). To do this each agency has listed a range of steps required to fulfill this goal. These steps include gathering funding, coordinating between agencies, keeping up to date with current information, informing the public, and using all legal, policy, and institutional structures to obtain better results.

Currently, the actions that are being undertaken by each agency can be summed up as followed. Each agency is improving its management practices for the coastal and ocean regions under each agency's jurisdiction in order to increase their capacity to withstand and recover from the effects of climate change. This is done by each agency conducting research, in order to better understand how current trends have been evolving in sea level rise and tidal activity. Such predictions in sea level rise and erosion, help make a more informed judgment on what is to be done based on how these trends change the situation, in regards to the effects of the ocean and

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coastal ecosystem and resources. Furthermore, the understanding evolving trends allows the agencies to understand the forces that are causing climate change/sea level rise and what the impacts are going to be, so that plans can be created to limit damage. The current plans most agencies are acting out is the creation of systems that not only share information between one another and the public but also focus on an education aspect to better inform the public of the potential effects and the causes of climate change and sea level rise.

Going on this, state agencies have already begun planning for the next steps to further bolster their plans for sea level rise, paraphrasing the overview of state agencies from the California Natural Resource Agency. The mission of state agencies is a commitment to protect, restore, and enhance coastal and ocean ecosystems and resources in the face of a changing climate. These agencies have presently used their sphere of influences to promote coastal and ocean protection throughout the state. However, for these agencies to continue to fulfill their missions, there is a lack of resources currently. To make significant progress on implementing climate change adaptation measures, these coastal state agencies are lobbying and securing additional funding and staff resources to broaden their capacities, in order to support adaptation in a strategic, coordinated manner (California Natural Resource Agency, 2014). Using the California Natural Resource Agency as a model, the other agencies follow the same goal and promote the same mission of trying to maximize their resources and staff capabilities to combat climate change and sea level rise.

Regional Agencies:

In the Bay Area the agencies that have the most power for coastal issues in the sphere of state government is the San Francisco Bay Conservation and Development Commission (BCDC). Looking into their plans for the future and how they are going to address sea level rise,

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there seems to be a common trend amongst the various cities around the Bay. They all like to act very independently from each other and have their own political arenas that they fight in. Due to this, the Commission's first goal in its plan is to rectify this. As stated in the BSDC (2015) action plan, "Create a regional sea level rise adaptation plan that serves as a framework for implementing future actions, while allowing for immediate early actions to be developed in advance of the plan" (Pg.3). Every city in the Bay Area will be involved in an overarching plan to combat sea level rise, instead of focusing solely on their own area of jurisdiction.

The BCDC recognizes the key issues and realizes that the most effective plan to combat sea level rise is to first get each actor on the same page. There is no point in researching at risk areas and making assessments of these areas, if the assessments were already done by another city/agency. The problem is that each city in the Bay has its own developed culture and has always viewed itself as separate from the others. This leads into a very independent thought process. Because of this each environmental plan are focused and based on local stakeholders and cooperation from the state and federal government in developing and aiding in their environmental plans. One example is San Francisco, their environmental plan on sea level rise states "This SLR Action Plan provides the foundation and guidance to develop a citywide SLR Adaptation Plan. Proactive, thoughtful adaptation planning will allow San Francisco to minimize risks and meet the challenges posed by the rising sea. The innovation, creativity, and inclusivity that have always inspired growth and development in San Francisco will support both SLR adaptation and continued growth as a leading global city" (City of San Francisco, 2016, Pg. 3). this shows an independent mindset is rooted in the culture. The City of San Francisco does acknowledge that if other cities fail in preventing sea level rise, then San Francisco itself will be

negatively affected. Even though the city focuses on its own problems, it still relies on government agencies like the BCDC to cooperate with surrounding entities.

Many of the plans themselves refer to a noticeable lack of central organization, which needs to be corrected. This decentralization in the Bay Area is making it harder for accurate data to be taken in regards to sea level rise and a dynamic shoreline creating gaps in information that is needed to accurately predict future events and needed responses .

Not only are the plans lacking in coordination, but science has given some a false sense of security. The reason is referring to a statement made by climate scientists in regards to the previously mentioned flooding of State Route 37. State Route 37 is a busy highway for tens of thousands of commuters and truckers in and out of California's wine country. Shilling, a co-director of the Road Ecology Center at the University of California, Davis, had forecast it wouldn't be seeing this kind of regular high water for at least another 20 years (Knickmeyer, 2017). Many plans were originally created with out of date information, when looking at the predictions now, the current level of acceleration for sea level rise was never predicted. Experts had once gave a timeline of regular flooding events, stating that they were going to occur twenty years in the future, however due to climate change these flooding events are happening today. Furthermore, with current predictions, the flooding and eventual reclaiming of land by the sea will be worse then what was predicted.

Resilience Theory:

In the battle against climate change, public opinion is a major factor that drives adaption and implementation for plans regarding climate change. The social-psychological theory behind this train of thought is called the resilience theory, which according to Carl Foke (2006) (a transdisciplinary environmental scientist who specializes in economics, resilience, and social-

ecological systems) is the “understanding of social processes like, social learning and social memory, mental models and knowledge–system integration, visioning and scenario building, leadership, agents and actor groups, social networks, institutional and organizational inertia and change, adaptive capacity, transformability and systems of adaptive governance that allow for management of essential ecosystem services” (Pg.4). To better understand this definition is to best apply the definition, it to the current situation.

In the growing problem of sea level rise resilience can be broken down into “social learning”, which is public knowledge. Public knowledge is based on how well the public is educated in understanding the situation and the threats that arise because of sea level rise. “Social memory”, is another way in which groups remember given information and events based on their beliefs. This is important for the understanding of people's thought processes regarding climate change. Because based on a person's beliefs and cultures, they will believe only certain actions should be taken to address the problem. Its priority and even in some cases, not believing there is a problem all together. In comparison, the differences of social learning can be seen in the face of flooding due to sea level rise and the responses taken. The City of New York, in the face of continued destruction from flooding has contributed hundreds of millions of dollars into fortifications so that the city can protect itself from flooding. On the other side of the United States, the City of San Francisco's future environmental plan is the establishment of talks with local stakeholders in the area, to come up with a course of action.

The “mental models” of individuals is based on how a person thinks. This reflects sea level rise as the perceived threat. Based on a study in the Chesapeake Bay and the resident's opinion on sea level rise, “The countywide survey revealed that Anne Arundel residents are aware of local SLR and increased coastal flooding, but uncertain when impacts will become

significant (Akerlofa et al, 2016, Pg.12). This study shows that a general assumption can be made about those who live living in at risk areas of flooding, where the population knows that sea level rise is occurring. But there is a disconnect of what is to come. Furthermore, “knowledge-system integration” is how a person complies various information to come to a conclusion. This goes into the aforementioned disconnect because a person has a difficult time in “versioning” a threat that occurs in a time span of a few decades, which will result in their livelihoods being flooded and underwater.

Transitioning into the “leadership” aspect of climate resilience, a person’s mindset and learned experiences/beliefs largely affect one's decision making. This is why for the subject of “visioning” and “scenario building” it is easy for a specialist to construct ideas of future flood scenarios to create a hard counter and what are the necessary actions to take, However, for others in a different field of study or experts on the subject, it is treated like second hand information, thus it is hard to imagine events that have yet to happen.

A leader who has enough power to make major changes will listen to the various “actors and agents” who may raise the issue of sea level rise, but their attentions may be focused elsewhere. For example the City of San Francisco (2016) and their sea level action plan is to “first, to explain what is at risk. A high-level analysis was completed to identify our exposed risk for both public and private assets. Second, to review the complex regulatory environment that governs coastal planning and development activities. Finally, to identify actions that San Francisco can take now and in the near future to meet the challenge of rising seas, in partnership with its neighbors and regional leaders. ” (Pg.3). The city plan for sea level rise is by acknowledging the problem and what actions that can be taken, but not to create any policy or secure funding for structures to address the problem. A lot of this is rooted in an ideology where

more visual pressing concerns take priority over something that is going to happen twenty to thirty years into the future.

With changing times and the events that follow there is an “institutional and organizational inertia and change” this is how experts and leaders in office are propelled and assert themselves to meet new issues. Looking back to New York for example, the city was slow to adapt to climate change until a large enough event caused a major disruption. From 2011 to 2012 consecutive destructive hurricanes hit the city, and as a result the “mental model” of those living in New York changed by giving them the needed first-hand experience that helped motivate them to make preparation against the effects of climate change a priority. This was immediately followed with a major change in how the city addressed the problem. No longer was the city going to collect data for years, instead they went to directly address the problem with the construction of fortifications and barriers in flood prone areas. This chain of events motivated the local government to allow for effective policy to be created, resulting in not only the building of fortification, but also policy adaptations that looks towards the future and the problems that may occur in the case of flooding.

The component of “social network” for resilience theory is a group of people that an individual is connected to. “Social networks” are deemed important because of the influence it has on an individual. Individuals usually choose their groups based on connections that reflect their beliefs, which are then reinforced, instead of groups that disagree with them. This plays into the resilience theory because just like how change occurred in New York City, once a large enough problem affects multiple members of a “social network” “the thought process and belief of the whole group changes and so does their response.

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This leads into “adaptive capacity”, which is the ability for an individual or group to adapt to new circumstances. This is relevant to resilience theory because it marks the ability for an entity (like an individual or a group) to access a given situation and act on it. This is also “transformability”, which is the actual action that is produced from an entity’s “adaptive capacity”. When an entity is able to transform itself to confront a challenge, in the terms of government this will be the “systems of adaptive governance”, which is where various agencies and powers change and implement various policies and actions to address the current situation.

Public Opinion:

The public opinion in regards to sea level rise is that something should be done to address the situation that results because of sea level rise, but there is little understanding about when sea level rise will occur and what the significant impacts of sea level rise are. As stated in a previously mentioned study based in the Chesapeake Bay Area most people do not really know what should be done or even if they should care about the impacts of sea level rise. In today’s world, for the political will to fund and build the billions of dollars of improvements, requires a shock, which will change the current thought process.

For New York City, it was the damage and destruction of hurricanes Irene and Sandy and a similar sort of situation must take place in the Bay Area, to recognize that sea level rise and flooding is going to be more than just a nuisance in the future. A good example of a predicted shock that could take place in the case of flooding is the shutdown of a major roadway. For example, if the low lying stretch of Highway 101 around Candlestick Park, which leads into San Francisco got flooded, it will cause a need for a call for action from the rest of the Bay Area. Now, the flooding of major roadways is a “when and not an if”. When it happens the majority of the City of San Francisco won’t be able to easily get to work. As for what is going to drive

change and public opinion or “the institutional and organizational inertia and change, adaptive capacity, transformability and systems of adaptive governance”? What is required for this change to occur is a large enough nuisance, which will affect the overall population of the Bay Area, creating a newly formed public opinion, which will then force leaders to adapt and bring about change.

Looking at the future of sea level rise, there is some growing uncertainty. The reason for this is the current change of regime in the federal government, from the Obama Administration to the Trump Administration. What this entails is a great change in existing policy from the federal standpoint from the past eight years. The Obama Administration was characterized for being very environmentally progressive by putting out policies and new areas of funding, which made various government agencies look more in depth into sea level rise and the impacts it can have. This was done by making various agencies create their own plans for dealing with climate change and sea level rise and also includes plans for the conservation of resources, reduction of energy use, and cutting down on pollution. This is similar to how the State of California and regional/local entities like the Bay Area Development Commission or the City of San Francisco have been updating their own plans to incorporate the effects climate change.

Federal Government:

This is one of the legacies of the Obama Administration, which they mandated agencies to consider and plan for climate change in their operations and future planning. According to a statement released by The White House, “To ensure that projects funded with taxpayer dollars last as long as intended, federal agencies will update their flood-risk reduction standards for federally funded projects to reflect a consistent approach that accounts for sea-level rise and other factors affecting flood risks” (Executive Office of the President, 2013, Pg.13). This

is just a portion of what the executive office archived in trying to combat climate change. By allocating taxpayer money, the plan was made to incorporate the latest science and tools to not only properly address areas of concern, but implement plans to make meaningful contributions to combating climate change.

However, the era of the Obama Administration is over, and it is widely predicted that along with its end, there is an end of progressive environmental policies. The Trump Administration, in its first few months has already made an impact. Many members of Trump's cabinet and Department Heads are categorized as climate change deniers and caters to their constituents, which are mostly made of voters and big business. This includes energy producers and manufacturers, who view climate change policy as economically regressive. Coupled with this are the promises of the Republican Party and their desire to reduce government spending by downsizing. These two things leave a stark picture for many environmental issues.

For example, Scott Pruitt, the head of the EPA, is known to have a track record of being a staunch enemy of the agency in which he is now the head of. With sea level rise funding and policy being bundled together with other climate change issues, once the EPA starts to revert and funding gets cut sea level rise initiatives will be affected greatly. There is already a shortage in funding for sea level rise projects, and even routine practices to protect shorelines are costly. As previously mentioned beach replenishment and nourishment costs of the Army Corps of Engineers accounts for over 100 million dollars (Hillye, 1996). As for the actions that are necessary to fix, and protect the coastlines and population centers from sea level rise, they have the potential to run into billions of dollars. Many of these projects will not only take years of planning and construction but many are unique in a sense in which one situation will not fix everything. By looking at the Bay Area Rapid Transit System (BART), the EPA has already has

been looking at its sea level rise vulnerability, as dictated by the state. It concluded that many of its stations and infrastructure need an array of improvements to protect themselves through bulkheads, rising stations, flood wall, and the list goes on this can cost billions of dollars.

The current issue is that many projects in regards to climate change are at risk. With an administration that does not hold climate change as a priority being in place for at least another four years, the current consensus is that projects are going to be halted and funding for these projects are going to get cut. Some optimists remain hopeful about the new Trump Administration as only a few months have gone by since the Trump Administration came into power. Though there are already examples of the President's Administration living up to their campaign promises, which does not bold well for environmentalists, such as the Keystone Pipeline. Moreover, currently the Trump Administration has already begun defunding the EPA, along with other agencies and programs in order to boost spending elsewhere. This has resulted in a cut in staff and has halted the EPA from issuing new grants and funds to projects around the country, including the Bay Area.

Bureaucracy:

After stating the potential damages to the various goals of the entities in the Bay Area, the conclusion can be made that the current system is inadequate. Even with all the agencies securing funding and trying to coordinate more with each other, the core policies of many of these agencies have not changed. The system in place to combat sea level rise and the damages it brings is still in its infancy. This can be said due to the amount of time and effort it takes to approve a single project in the Bay Area.

Going off of an example is the approval needed to create a marsh. A marsh is an adaptive and simple measure to combat climate change. Not only is it natural barrier that will absorb

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flooding, but it will replenish lost habitat for wildlife in the Bay due to destruction of marsh land in the Bay Area. However, to create new marshland, there is a requirement of going through an approval process created by the overlap of many different agencies.

To build a marsh, a contractor has to get approval from the county they are building it in, as well as the following agencies, the Bay Area Development Commission, the Regional Water Quality Board, the State Water Resource Control Board, the California States Land Commission, California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the U.S. Army Corps of Engineers. Just getting the approval of one agency is not enough, a contractor has to get approval from each individual agency. What this means is that the contractor has to apply and go through each agencies approval process, which can vary. A lot of this has to do with the authority each agency has been given over the years.

For any project regardless of impact, each agency has a *raison d'etre* for regulating the coast line in it's jurisdiction. For the county a permit must be issued for any project involving soil movement of 50 cubic yards. On the state side the BCDC (Bay Area Development Commission) requires a permit for any project within 100 feet of the bay's shoreline. The Regional Water Quality Control Board requires an environmental impact report on wetlands before work can begin. The reason for this is because a new marsh needs to have existing levees be breached with alterations to drainage ditches, which will affect seasonal wetlands.

The State Water Resources Control Board requires a waste discharge permit for any work in the bay that may affect water quality due to the potential of altered land (in this case dredged materials and discharge of fill to create the new marsh). The California State Lands Commission requires a commission lease for any project on state land, and because the levee and

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drainage systems in the Bay Area are on state land, a permit is required. The California Department of Fish and Wildlife requires a Streambed alteration agreement and a California Environmental Impact Report, which the state must sign off on. The reason why this is necessary is because wetland restoration will require a levee breach, which will affect tidal flow and a review is needed to see the impacts of this on the area and any mitigation effort is needed.

The U.S. Fish and Wildlife Service require a U.S. environmental impact statement and a biological opinion under the Endangered Species Act. The National Marine Fisheries Service requires a letter of concurrence to biological opinion based on the biological opinion of the U.S. Fish and Wildlife Service. Lastly, the U.S. Army Corps of Engineers needs to do an impact assessment based on the Clean Water Act and National Historic Preservation Act. Each of these agencies need to give their approval for the project to proceed, and if even one agency says no then the project cannot proceed and is scrapped.

For a project to occur, the amount of bureaucracy and checks can be overwhelming. This is the most overwhelming issue that occurs in the Bay Area in regards to building and creating any piece of infrastructure or natural expansion, such as wetlands to protect the coast from sea level rise. This also highlights why projects are not being done in mass. On the other end, one can look at the City of New York, and their ability to adapt so quickly after the devastation of hurricanes Sandy and Irene because they ended up integrating their various agencies and were able to streamline the process of building to protect themselves from natural disasters.

The bureaucracy and red tape that plagues the Bay Area was created with good intentions and reason. Each agency has a purpose and a goal they strive to achieve. To achieve these goals, the need for regulation and policies were put into place. These policies were made to ensure the protection of the environment and insure no major environmental impact is done. This is why

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there are various environmental surveys and permits that exist for work to be done. This was all created with good intentions, but the end result is a legal array of hoops that anyone wanting to do any project in the Bay Area has to jump through. When agencies say they are cooperating with other entities, they are sharing their cooperation and information. But for the contractor to build projects, the processes to get approval has remained unchanged.

Analysis:

What will end up causing the most damage by sea level rise will be inaction by policy makers. As per the literature and analyzing the behavior of current agencies that control the Bay Area, it would not be hard to assume that action will be taken to combat sea level rise only after damages that cannot be ignored occur. The issue of sea level rise can be compared to the experiment of the frog in the boiling pot. A frog will immediately jump out of the pot if it is put into boiling water, but if the frog is put into cool water that is slowly raised to a boil, then the frog will let itself be boiled to death. The Bay Area will be facing similar circumstances, for sea level rise is slow but the effects are already starting to take place. However, the general thought process surrounding these areas of flooding that is starting to take place, is that it is nothing more than a nuisance that will go away.

So far this has been true with the flooding of Highway 37 and various lanes up and down Highway 101 receding after a major storm. The issue that has become apparent is that with current trends, flooding will not only persist, but become permanent and far worse. This is why sea level rise in the Bay Area is just like the frog in the pot, because this plays into one of the worst parts of public opinion and government, which is the inefficiencies of bureaucracy. The problem is going to end up being ignored to the point where the damage will become substantial

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When government gets to a certain size it becomes very reactive to many issues. Instead of proactively preventing an issue from occurring, government will reactively mitigate the damage. This is especially true for the Bay Area, where an official's reelection hinges on their public appearance, are if an official spend billions on infrastructure to combat sea level rise, they may very well not get reelected. The main goal of an elected official especially one without term limits, is to be reelected to keep their job. However, fighting sea level rise is not a glamorous job, furthermore preventative action to control damage can cost billions. With the public opinion being focused on different matters, such as lowering the cost of housing or dealing with homelessness, spending large amounts of money on sea level rise can be a political dead-end. As a result, it is unlikely any politician will actively dedicate themselves to preventing and mitigating the damages of sea level rise.

There for, it can be assumed government will focus on different issues until large enough public outcries are heard. The precedent is New York City, for it wasn't until two hurricanes came and caused hundreds of millions of damages and crippled the city that city leaders decided to take action. This resulted in the updating of the city to become flood resistant, with millions being spent on adaption polices and improvements to face the city's new reality.

This can very well be the future of the Bay Area. Looking at what is at risk though the challenges of salvaging flooded infrastructure will be more challenging then New York. For what New York City faced was flooding brought about from hurricanes driven from climate change where the San Francisco Bay Area is facing is flooding from sea level rise itself, which is affecting some areas, where the effects of sea level rise will result in areas being permanently underwater such as Highway 37.

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Many of the improvements needed are the actually raising of the ground to prevent flooding. However, with the current outlook, it can be safer to assume reclamation efforts are going to occur after the initial period of chaos due to flooding. In the instance of the Bay Bridge, for example Caltrans will most likely build fortifications such as seawalls around the entrance of the bridge, while pumping out any water that may have flooded the area. Regardless of what happens, the situation will be similar around the Bay Area.

With fewer routes to traverse, the accessible roads will be congested making daily commutes turning into longer hours than they are now for some. The main highways that connect the Bay Area's largest cities will be flooded, coupled with the fact that other means of transportation such as rail, air, and sea, will be affected as well. The Bay Area will end up struggling to meet demands at all of the various needs of transportation.

Recommendations:

The best way to protect the Bay Area is to use adaptive measures and fortifications to protect various properties and infrastructure around the Bay Area. By gathering funding and placing protective measures around key points and infrastructures, this would allow the Bay Area to weather the onslaught of sea level rise without having to face massive issues, such as increase in traffic or the shutdown of ports and airports.

The most effective mean of protection is using sea walls and other similar fortifications to protect infrastructure and using adaptive policies such as creating building codes to limit construction in flood prone areas, as for existing buildings, the creation of regulations to make them more flood resistant. By using a combination of fortification and adaption measures, sea level rise can be dealt with, with various added benefits depending on the method used. Adaptive measures are not limited to building codes, but can be natural barriers such as marshes, which

not only create ecosystems, but help prevent erosion. Not only does it offer protection, but new ecosystems create economic opportunities by creating new habitats to increase natural marine species habitats.

Furthermore, to maximize the effectiveness of protective measures it is best to ease and streamline the various requirements that agencies put forth, which currently exist. By having a single set of regulations for a contractor to build preventive structures this can save much of the hassle of preparing for sea level rise. Looking at the current state of project approval, it is in all concerned parties best interests if there was only one or two agencies that need to sign off on a project. A single agency which can just require an overarching reach in accepting and approving proposals will be one of the best solutions, to satisfy the various environmental acts and regulatory agencies in operating place.

This is the most effective way of combating sea level rise. However, it should be noted that the effects of flooding caused by sea level rise are already being seen. As a result, having measures being put in place sooner than later will not only protect more infrastructure and properties in the Bay Area, but will be cheaper also. The more time passes, the harder it will be to create infrastructure in the appropriate places needed. Instead of building on dry land as is possible now, in the future engineers need to either build further inland or create structures in flooded areas, and worst of all, the possibility of abandoning an area completely may become a reality.

Conclusion:

If climate change gets worse and the maximum amount of flooding does occurs, massive changes will have to happen. 55 inches is the worst case scenario, and due to many concerns, many of the more tried and tested methods of protection are not going to be enough. This is

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happening because there are some small scale examples of flooding that have already occurred in the region. The effects of flooding are already starting to appear on major roadways with lanes being closed down after a storm. Furthermore, in the delta, some of the towns there have suffered at the hands of past practices.

The delta was once to be littered with farming communities, who in efforts to supply their farms with fresh water, the farmers pumped out groundwater. This resulted in the sinking of land. In some areas of the delta, the land sunk by 20 ft. Without the groundwater to support it, this lead to the situation today where these older communities are now twenty feet under sea level and the only thing that is protecting them from flooding are hundreds of miles of levees, which are in dire need of repair and updating. But government agencies are underfunded and understaffed, and are unable to help address this problem, along with many others.

With towns being in these types of precarious situations, there are already some that have been abandoned due to these situations. But when one looks at the economic center of the Bay Area, it is unreasonable to think that just building twenty to fifty foot walls would protect critical infrastructure indefinitely, especially with many of the surrounding environmental issues that plague such fortifications. Furthermore, it is unreasonable to believe that the 19th largest economy can be moved in a few decades. Due to this, it is reasonable to assume that adaption and fortification practices will have to be used around the entire Bay Area for it to continue to relatively function.

With how slow bureaucracy works to approve projects and the general issues of funding and current public support, the future of the Bay Area looks grim. It can be stated that with sea level rise threatening billions of dollars in infrastructure, a rippling effect will be felt globally in the result of a shut down. Unfortunately, there is too little being done currently to prevent this

impending disaster. In conclusion the Bay Area will most likely face a period of turmoil before the appropriate emergency measures will be taken to salvage key points and facilities. Flooding will cut off key routes of transportation, and the shutdown critical facilities that maintain a standard of life in the Bay Area, will take place. It is most likely then and only then, will project approval will be streamlined, and in the period of months to a few years the necessary improvements will be created to negate flooding, in order to properly restore the Bay Area to a functioning state.

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