Physical Vulnerability Assessment Findings

AdaptLA

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Introduction

A climate change physical vulnerability assessment evaluates the degree to which important community assets are susceptible to, and unable to accommodate, the adverse effects of climate change. This document identifies potential impacts of sea level rise and the sea level rise vulnerabilities of critical assets that the City of Los Angeles owns, maintains, or manages.

This document seeks to inform policymaking by not only identifying the sectors and systems that are likely to be affected by the impacts of sea level rise, but also by enhancing understanding of the sources and components of each sector's vulnerabilities. Understanding asset vulnerabilities will help the City develop strategies to increase resilience. This document also assesses the consequences of impaired assets to help understand connections between systems and prioritize future strategies to build resilience.

This report discusses the impacts of sea level rise, the methodology that ICLEI used to assess vulnerability, and then provides both the key findings and detailed descriptions of the vulnerabilities of each sector.

Sea Level Rise Planning Scenario

This assessment evaluates long-range vulnerabilities using a sea level rise scenario based on USGS data collected from a storm that occurred in January 2010 and a projection of sea level in 100 years. More specifically, this scenario is a 10-year storm event (a storm with a 10 percent chance of occurring in any given year) coupled to 1.4 meters of sea level rise.

Sea Level Rise Impacts

Sea level rise is generally associated with a number of different impacts, including storm-related coastal flooding, daily tidal flooding, permanent inundation, interaction with groundwater, and erosion. This section briefly describes these impacts.

Flooding and Inundation

Flooding refers to the circumstance of normally dry land being covered by water for a limited period of time due to a high water event. The scenarios considered in this report used a 10-year storm, or a storm with a 10 percent chance of occurring each year, which includes local sea level factors such as El Niño effects and storm surge, but does not account for precipitation and river flooding. In addition to storm-related flooding, sea level rise could result in certain dry locations around coastal Los Angeles being flooded by daily high tides. Inundation, on the other hand, occurs when land that was once dry becomes permanently wet.

Erosion

Erosion, which is defined as the wearing away of earth's surface by any natural process, often occurs at the intersection of land and water. In coastal areas, there are two major

erosion processes: episodic erosion and chronic erosion. Episodic erosion occurs during major storm events and results in extreme shifts in shorelines. Natural environments typically recover from these episodic shifts, returning to their pre-storm state over time. However, if the frequency or intensity of these events were to increase, a natural system might not be able to recover. Chronic erosion is the slow migration of sand away from the shore or to a different location. Sea level rise, which will alter daily high tide conditions, could also exacerbate chronic erosion of non-hardened surfaces.

Interaction with groundwater

It is generally understood that if sea levels were to rise, the water table could also rise, impacting subsurface infrastructure. A rising water table would pose risks to underground infrastructure, such as storm water and wastewater facilities, potable water distribution, and transportation facilities as well as other utility and communications infrastructure

Assessment Methodology

This physical vulnerability assessment provides a snapshot of the vulnerabilities of various systems and assets managed by the City of Los Angeles by analyzing three components of vulnerability relative to sea level rise: exposure, sensitivity, adaptive capacity, and consequences.

A critical component of vulnerability is **exposure**, or a determination of whether community assets will experience a specific changing climate condition. City staff members were provided with exposure maps developed by Patrick Barnard of USGS, which they used to determine if their assets would be exposed to sea level rise impacts under the scenario described above. The assets included in this assessment fall within the mapped exposure zone.

Sensitivity is the degree to which assets would be impaired by a climate impact, if they were exposed to that impact. Assets that are greatly impaired by sea level rise have a high sensitivity, whereas assets that are minimally impaired by the same change in sea level have a low sensitivity.

Adaptive Capacity is the ability of an asset to make adjustments in response to a climate impact in order to maintain its primary functions. This does not mean that the asset must look the same as before the impact, but it must provide the same services and functions as it did before the impact occurred.

Consequences are the adverse effects that occur as the result of an asset being impaired by a climate impact. Survey respondents were also asked to describe consequences for the economy, environment, and communities and populations. Respondents were asked to consider the magnitude of the consequence, such as a size of the population, land area, or resources that would be affected.

ICLEI employed a qualitative and participatory methodology to gauge the sensitivity and adaptive capacity of the sectors and assets addressed in this report. This participatory method ensures that the information comes directly from the experts

who work with these assets and systems on a daily basis. In addition, City staff members become more aware of the risks of sea level rise through participating in this process. Specifically, ICLEI used a survey method, whose steps are outlined in greater detail below:

1. Several technical experts from key City departments were identified and invited to serve on the City Adaptation Leadership (CAL) team.

2. ICLEI provided the CAL team with a training and information packet explaining the tenets of sensitivity and adaptive capacity.

3. A detailed survey on sensitivity, adaptive capacity, and consequences was developed in Qualtrics, an online survey tool. The survey required that respondents take some time to think about and answer guiding questions related to a system's sensitivity, adaptive capacity, and consequences. The survey questionnaire can be found in Appendix I. The following City of Los Angeles Departments participated in the survey:

- Los Angeles Department of Water and Power
- Port of Los Angeles
- Bureau of Sanitation
- Recreation and Parks
- City Planning

4. Based upon answers to the survey and subsequent follow-up conversations with City staff, ICLEI determined the primary asset vulnerabilities for each sector. Complete assessments of asset vulnerabilities for each sector are presented below.

Summary of Findings

The table below describes the primary vulnerabilities for the sectors evaluated based on the sea level rise scenario and exposure definitions described above. Vulnerabilities and mitigating activities are described in more detail in later sections.
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Primary Vulnerabilities by Sector

Wastewater Management
• Collection systems (sewers) in low lying areas are vulnerable to flooding and groundwater inflow, which could exceed their designed capacity, causing temporary wastewater discharges into the ocean. • Treatment and pumping plants would be vulnerable to flooding, which could damage electrical equipment, generators and/or process operations, resulting in partially treated wastewater discharged into the ocean.
Storm Water Management
• The storm water management system is vulnerable to coastal flooding and inundation, which could impair storm water management facilities and exacerbate flooding from storm water runoff in low-lying areas.

Potable Water
• The potable water system is vulnerable to flooding, inundation, and groundwater, which make accessing underground assets, such as pipes, extremely challenging and raise public health concerns.
Port of Los Angeles
• Although the Port's assets are sensitive to flooding and inundation, the port has low vulnerability because of its limited exposure in the near term, and high capacity to adapt by building future infrastructure at a higher elevation.
Energy Facilities
• Energy facilities have low vulnerability to the impacts of sea level rise, because all coastal energy assets were designed to withstand exposure to water. In addition, replacement schedules and system redundancies reduce vulnerability.
Recreation and Parks
• Parks and open space have low to moderate vulnerability to flooding, because they can be restored relatively quickly or can change to cope with new environmental conditions. • Coastal structures, including bathrooms, recreation centers and museums have higher vulnerability to flooding and inundation, because the structures could be damaged and become inoperable, and/or inaccessible.
Land Use and Transportation
• Roads near the shoreline are highly vulnerable to flooding, inundation, and undermining from erosion and rising groundwater, which could result in reduced access for residents and impaired regional transport. • The building stock is most vulnerable to flooding and inundation in Venice, where it is located very near sea level and there are many older structures.

Sector Vulnerabilities

This section presents the vulnerability assessment findings in greater detail. Assets included in the section were identified as exposed to flooding under the sea level rise planning scenario described above.

Wastewater & Storm Water Management

Overview

In the City of Los Angeles, the Bureau of Sanitation (BOS) manages both storm water and wastewater. Wastewater and storm-water management facilities are highly-vulnerable to the impacts of sea level rise. Wastewater and storm water collection systems are impacted by inflows from high tides, storm-related floods, and groundwater, which reduce their conveyance capacity. In addition, wastewater treatment plants and pumping plants are vulnerable to flooding because their electrical equipment and process operations can be damaged.

The BOS has recognized that climate change effects may impact assets and operations and has identified Strategic Planning Goals and outcomes to lessen these impacts. Additionally, the BOS includes capabilities for upgrades and replacement of equipment, facilities and infrastructure in its planning and capital improvement programs. BOS operations personnel are capable of taking actions necessary for spill response, emergency response and in repairing and restoring operations. The BOS has undertaken prior studies related to climate change impacts and is continuing this work to better understand what can be expected and how to prepare.

The BOS has undertaken some efforts to make their assets more resilient to sea level rise, and especially storm-related flooding. Two years ago, a microburst storm event caused sewage stormwater to back-up into homes in a handful of locations. This storm event became the impetus to initiate a study to examine how the impacts of sea level rise could impact the Venice Pumping Plant and sewer storm drains in San Pedro. In the case of San Pedro, the Department of Public Works has taken action to reroute the storm drains and reduce the number of turns that the water flows through until it reaches an outlet. This area now has greater capacity to safely move storm runoff. The BOS continuously assesses and addresses storm event effects to improve performance and builds into its operations program improvements in conveyance and water treatment infrastructure.

BOS also has emergency plans that include relocating portable generators, vacuum trucks and staffing to respond quickly in the event of storm related flooding. As to long range capital improvements, the recently approved Sewer Service Charge (SSC) rate increase will allow additional projects to be developed for asset protection, plans performance improvements and redundancy will be implemented.

This sector has relatively high level of social resources for adapting to sea level rise. The BOS staff is involved with different groups, such as the Los Angeles Collaborative for Climate Action and Sustainability (LARC), which provides opportunities to collaborate and learn from efforts in other cities in the region. The BOS has economic, technological, and environmental resources for adapting to sea level rise, but BOS has substantial fixed coastal assets that would be difficult to fully protect or relocated, and is not prepared for a catastrophic system wide failure. The BOS made a case for a rate charge to consumers to finance capital improvement projects, which was approved and has provided some additional economic resources for adaptation, but this is a very new source of funding for the department. Like many City departments, the BOS budget is highly constrained and has a large scope, servicing four million residents and businesses and 29 contract cities using 6,500 miles of pipeline and four wastewater treatment plants

Wastewater Management Asset Vulnerabilities

Hyperion Wastewater Treatment Plant (HTP)

HTP is located across from Dockweiler State Beach at approximately 32 feet above sea level. The facility treats approximately 290 million gallons per day of wastewater. The major treatment processes at this plant include screening, grit removal, primary sedimentation, and secondary treatment. The treated secondary effluent is discharged

via a five-mile outfall into Santa Monica Bay.

Sensitivities: HTP would be sensitive to flooding under the sea level rise scenario, which could impact equipment and operations due to damage of electrical pumps and panels if exposed to water. In addition, a dramatic increase in sea level could reduce the plant's ability to gravity-discharge effluent and may increase the pumping hours of the effluent pumping station. As part of the Plant's redundancy, HTP also has a one-mile outfall that can be used during emergencies to discharge wastewater offshore.

While erosion could result in some loss of the beach in front of the plant, the plant itself is not very sensitive to undermining from erosion or interaction with the groundwater because it is built on top of a large cement catacomb.

Adaptive Capacity: The plant's ability to continue to function if it is partially disabled depends on the severity of the impacts. Any release of partially treated wastewater would be of short duration. Built-in redundancy and emergency preparedness provide the facility with the capacity to continue wastewater treatment and discharge offshore. Emergency diesel generators have been placed at all critical facilities and the Bureau of Sanitation is building its own on-site power source using a renewable energy source. In addition, at current plant flow rate, HTP has some additional capacity that can be used to handle the quantity of wastewater entering the plant.

Consequences: The primary economic consequence would be repairing the plant which, depending on the severity of the impact, may be quite significant. Impacts to individual pieces of equipment would cost significantly less than the loss of the entire facility. The facility has an estimated total replacement value of $3 billion. In addition, the primary environmental consequence would be the discharge of partially treated wastewater into the Santa Monica Bay. In addition to impacting habitat and wildlife, this could also have negative economic impacts due to the recreational value of the beaches. Any release of partially treated wastewater would be of short duration. The BOS continues to ensure this asset is protected and is of highest priority for improvements since this is the key to protecting public health and the environment.

Terminal Island Water Reclamation Plant (TIWRP)

TIWRP is a tertiary/advanced water reclamation plant that treats municipal and industrial wastewater. It is located on Terminal Island, and is situated on a 19.8-acre site. Wastewater reaches the plant through a series of pumping plants and force mains. The plant provides preliminary, primary, secondary, tertiary and advanced water treatment. TIWRP also has a solids handling facility. TIWRP currently discharges tertiary treated effluent through an outfall within Los Angeles Harbor.

Sensitivities: TIWRP is sensitive to coastal flooding, which could cause equipment damage and operations failures. In fact, the plant is already impacted by extreme high tides during which pumps are employed to mitigate these impacts. A storm-related event combined with higher mean sea levels could exceed the design capacity of the plant, flooding galleries and potentially damaging equipment. As a result, partially or untreated wastewater could be discharged into the Los Angeles Harbor. At current flow

of 15 MGD, the plant has some spare capacity to deal with increased flow during storm events.

Adaptive Capacity: Depending on the equipment damaged caused by high water levels, the plant may be temporarily or partially disabled and would require emergency generators or pumps to be used to ensure that wastewater continues to be discharged to the outfall. Engineering studies that include assumptions about flood depth and duration would help to refine an evaluation of adaptive capacity and allow for enhanced planning.

Consequences: As with any fixed asset, the economic consequences of impairment of TIWRP could be high depending on the extent of the damage. If the pumps are inundated with seawater, it could be costly to repair or install new equipment so that the plant is fully functional and wastewater is treated to full capacity. In addition, some partially or untreated wastewater could spill into the San Pedro Harbor, temporarily affecting fishing communities as well as recreational opportunities.

Wastewater Pumping Plants

Pumping plants are located underground and move wastewater from a lower elevation to a higher one, so that it can be transported through municipal sewers for eventual processing at a treatment plant. There are approximately 21 plants located in the exposure zone. During a storm event, some urban runoff or rain may enter the system through infiltration.

Sensitivities: The wastewater pumping plants are currently designed to handle wastewater and stormwater flow during storm events and during high tides. However, they may be impacted by sea level rise over time. Higher water levels could contribute to localized overflows. If electrical equipment is inundated, it might fail resulting in a temporary wastewater overflow.

Adaptive Capacity: The system is continuously evaluated for deficiencies. These plants are of high priority and are redesigned and upgraded due to changes in local conditions over time. For long term planning and asset protection, the BOS has the ability to modify and improve the individual pumping plants as wastewater volumes change and sea level rise projections and observations become more certain. In the event that an electrical system fails or a pump is disabled, there are back up generators on site and additional resources would be provided to reduce the impacts to the coastal system and ensure public health is protected. The BOS is undertaking efforts to make these plants more resilient to flooding.

Consequences: Impairment of these plants would have moderate to high economic consequences. If the entire facility were destroyed, each of these 21 plants has an approximate $2 million replacement value. However impacts to individual pieces of equipment would cost significantly less than the loss of the entire facility. In addition, damage to these plants could result in sewage spills, with economic and environmental consequences.

Venice Collection System

The Venice Wastewater Collection System is anchored by the Coastal Interceptor Sewer, which runs along the coast from West Los Angeles to the Hyperion Treatment Plant.

Sensitivities: The Venice collection system is sensitive to coastal flooding and to interaction with groundwater, because water can infiltrate the collection system at the pipe joints during high water events. Ultimately, this effect could reduce the capacity for transporting wastewater to HTP. Although most of the pipes lie under the roads, heavy erosion could damage the pipes.

Adaptive Capacity: Although it may be at reduced capacity, the collection system can continue to function even if partially disabled, and continue to convey wastewater into the Venice Pumping Station and Hyperion Treatment plant. Depending on the damage caused by any single event, the repairs and replacement may extend the time that portable emergency equipment is required. If the flow rate or damage exceeds certain thresholds, the system cannot restore itself easily. The BOS is currently conducting a study to learn about challenges in capacity and the potential volume of groundwater and flood water that could enter the Venice Collection System. This area is a high priority and BOS is planning and preparing capital improvement projects to include further protection of the area's infrastructure.

Consequences: The economic consequences of impairment to this asset include the costs of repairing the system and the local impacts. Damage to the system may cause spills into storm drains that empty into Santa Monica Bay, which would have environmental impacts and raise public health concerns.

Storm Water Management Asset Vulnerabilities

Venice Storm Water Pumping Plant (VSPP)

The Venice Storm Water Pumping plant is designed to move storm water/urban runoff from a lower elevation up to a higher one, so that it can be transported through pipelines by gravity for eventual processing at a treatment plant during low flows and discharge into the ocean during storm flows.

Sensitivities: The VSPP is sensitive to coastal flooding and undermining from erosion. In fact, the plant is currently affected by both impacts. The plant is located between the beach and a channel, so the plant could potentially be flooding from both sides of the facility.

Adaptive Capacity: The plant has been identified as an asset that is functioning at capacity. The BOS is working to make the plant more resilient to storm-related flooding through proactive maintenance and functional improvements. In addition, BOS has

emergency plans, so that power and pump function can be restored quickly with onsite back up generators during a power loss.

Consequences: The greatest economic consequence of impairment of the VSPP would be the potential for storm-related flooding of streets and other infrastructure in the Venice area. Flooding would have high social consequences including possible displacement of residents and public health concerns. The replacement value of the plant in its entirety would be $10 million. However impacts to individual pieces of equipment would cost significantly less than loss of the entire facility.

Low Flow Diversion Pumping Plants

There are four low flow diversion pumping plants located in the exposure zone, and they are designed to move urban runoff during low flow periods from lower to higher elevation, so it can be transported through pipes by gravity for eventual processing and cleaning at a treatment plant, eliminating or reducing discharges directly on the beach or the adjacent ocean. They do not usually operate during storm events.

Sensitivities: These plants could be sensitive to coastal flooding, which could impact electrical components and thus make them unable to pump urban runoff during the dry season.

Adaptive Capacity: The plants would not normally operate during a storm event. Long term, sea level rise may impact the plants but the BOS indicates that they will be evaluated for inclusion in the capital improvement program as impacts are indicated. Additionally, the facilities would continue to function even if partially disabled; the plants can be quickly restored if they are impaired by storm coastal flooding. The BOS has efforts underway to make them more resilient to flooding.

Consequences: The primary economic consequence would be repair or replacement of the plants if destroyed; the replacement value is $1.5 million each. However, impacts to individual pieces of equipment would cost significantly less than loss of the entire facility.

San Pedro Storm Water Collection System

The San Pedro storm water collection system includes the storm drain network in the San Pedro area, with many trunk lines located below sea level.

Sensitivities: This system is sensitive to coastal flooding, because if large amounts of water enter the system, capacity could be exceeded, causing neighborhoods to flood.

Adaptive Capacity: The system is able to function if partially disabled, because it can continue to convey storm water at a reduced capacity. The ability of the system to be quickly restored depends on the severity of the storm and the functionality of other connected facilities in the system. In fact, this system has been impacted by storm-related flooding and the Department of Public Works was able to reroute, relocate and resize the pipes, as well as removing some turns which had constrained the flow.

Consequences: The consequences of an impaired system are high due to the economic consequences of flooded homes and streets. Impairment of the system could also result in the transport of additional urban pollutants from localized flooding into the ocean. The BOS estimates a replacement cost of $1.37 million.. However impacts to individual pieces of equipment would cost significantly less then loss of the entire facility.

Potable Water

Overview

The Los Angeles Department of Water and Power (LADWP) manages the potable water system. LADWP is the largest municipally owned utility in the U.S., serving a 464 square-mile area with a population of 3.8 million people. LADWP's water infrastructure distributes water supply to 676,000 active service connections through a distribution network of over 7,200 miles of pipelines. About 500 miles of pipe in the distribution system is 24 inches or larger in diameter (trunkline). The remaining pipes have a diameter of less than 24 inches (mainline). LADWP also manages water regulatory valve stations, but there are none located in the exposure area.

This sector's assets are vulnerable to coastal flooding, and interaction with groundwater, because these conditions would make accessing these primarily underground assets extremely challenging. Erosion could also damage many of the assets.

The system has some short-term adaptive capacity that includes pumping out water to improve access or re-routing water to other parts of the network. However, once the assets are impaired, it might be difficult to bring them back into a full functioning state quickly.

LADWP's objectives with respect to emergency preparedness, response and recovery are to maintain an organization that is capable of taking decisive action to restore and maintain water service to the City of Los Angeles in a safe and timely manner. The Emergency Response Plan covers the administration, mitigation, preparedness, and response and recovery efforts to respond to emergencies.

Asset Vulnerabilities

Pipes

There are approximately 186,961 feet of pipe in the exposure zone. Pipes carry water through the distribution system to customers.

Sensitivity: Pipes are sensitive to coastal flooding and interaction with groundwater because the presence of water makes it difficult for crews to access the buried pipes, thus impairing construction and maintenance. The pipes are also sensitive to undermining from erosion, because the loss of ground stability could damage or break

the pipes, thus impairing operation.

Adaptive Capacity: By pumping water out from flooded areas, the pipes could continue to function even if partially disabled. Crews can also limit construction and maintenance to low tide periods. Lastly, because the pipes are part of a networked system, LADWP could potentially bypass an impaired section of the network.

The functionality of the pipes, however, might not be quickly or easily restored, because major excavation and construction is required to restore operations. There are no current efforts in place to make the pipes more resilient to these impacts.

Consequences: Impairment of pipes from sea level rise impacts would have high economic consequences because it affects construction and reduces the life span of the pipes. In addition, there are public health concerns regarding salt water, groundwater, or other substances potentially infiltrating the potable water system. Lastly, pipe failure could potentially exacerbate flooding in flat areas with poor drainage.

Water Services

The approximately 4,228 water services in the exposure area connect water mains to customers. This asset includes connections between the water mains, meters, and meter boxes.

Sensitivities: Many water services are located below ground. Thus, if they were submerged in water, such as from flooding or interaction with groundwater, the water would need to be pumped out before the asset could be placed back into operation. These impacts could impair construction, maintenance, and operation of water services.

Adaptive Capacity: By removing the water to a minimum level needed for operations, the water services could continue to function even if they were partially disabled. In addition, there is some redundancy and flexibility in the system, which provides some resilience, but this is highly dependent on the location. If impaired, however, the functionality of water services might not easily or quickly restored. The DWP has undertaken some efforts to make water services more resilient by installing some of the larger services above ground.

Consequences: These impacts have high economic consequences because they affect construction and reduce the life span of these assets. In addition, there are public health concerns resulting from salt water, groundwater, and/or other substances potentially infiltrating the potable water system. Lastly, failure could exacerbate flooding in flat areas with poor drainage.

Fire Hydrants

There are approximately 249 fire hydrants in the exposure area that provide high pressure water for fire fighting efforts and temporary water services.

Sensitivities: Fire hydrants are sensitive to flooding, because if the hydrants are

submerged in water, firefighting personnel will not be able to access or operate them. Fire hydrants are also sensitive to undermining from erosion, because the loss of ground stability could damage the fire hydrant and render it inoperable.

Adaptive Capacity: Fire hydrants can function if partially disabled, because they will continue to work in semi-submerged conditions. The function, however, cannot be restored quickly or easily if impaired and there are no current efforts in place to make hydrants more resilient to these impacts.

Consequences: Flooding would have moderate economic consequences because it impacts the life span of the asset. In addition, there are public health concerns regarding salt water, groundwater, or other substances potentially infiltrating the potable water system, since fire hydrants are connected to the potable water system. Lastly, failure of fire hydrants could exacerbate flooding in flat areas with poor drainage because water at high pressure could spill from a broken hydrant.

Port of Los Angeles

Overview

Assets at the Port of Los Angeles would be significantly vulnerable to flooding and inundation if they were exposed, and impairment of the assets could potentially have significant economic impacts if cargo shipments are delayed or re-routed. The Port has recognized this source of vulnerability and is currently identifying the risks of sea level rise and strategies for responding to those risks through a report commissioned with the Rand Corporation.

The Port's vulnerability is mitigated by its relatively strong capacity to adapt, which comes primarily from the Port's economic resources. The Port is an important driver of economic activity in the region, providing $6 billion in tax revenue and $63 billion in trade. The Port has a (AA) Bond Rating, which is the highest credit rating for any stand-alone U.S. port and reflects confidence of the rating agency in the financial strength of the Port. In the future, the Port could incorporate sea level rise into their engineering and planning process, building future infrastructure at higher elevations, thus becoming more resilient.

Asset Vulnerabilities

Container Terminals

Container terminals are the facility where cranes load cargo containers to and from ships and load them onto trucks or trains for onward transportation. This facility also provides storage for containers in stacks while awaiting transport.

Sensitivities: Container terminals are sensitive to flooding, which could render the

terminals inaccessible and non-operational with unsecured containers and no power supply for equipment.

Adaptive Capacity: In the short-term, container terminals have low adaptive capacity, because they cannot continue to function if partially disabled and their functionality cannot be restored quickly after suffering damage. However, in the long-term the terminals could be redesigned and re-built at higher elevations.

Consequences: The economic consequences of impaired container terminals are very significant. They are the port's highest revenue generating resource and they have a $2.85 billion replacement value. Furthermore, the economic impacts would ripple through the economy as shipments would be delayed or re-routed. Quantifying the economic consequences of impaired container terminals is extremely difficult because it depends on a variety of factors. According to the National Oceanic and Atmospheric Administration 2008-2017 Strategic Plan, the cost of a shutdown of the POLA/POLB would cost $1 billion per day in regional economic losses[1].

Electrical Infrastructure

Sensitivities: The Port's electrical infrastructure could be severely damaged by coastal flooding, because is not designed to be exposed to water.

Adaptive Capacity: In the short term, this asset has low adaptive capacity, because it cannot function if partially disabled and the functionality is not quickly or easily restored if impaired. However, in the long-term, the electrical infrastructure could potentially re-designed and relocated to higher elevations.

Consequences: This infrastructure is vital to port operations and impairment would cause equipment, such as cranes, to be non-operational. This could cause delays and disruptions in cargo loading and offloading. This asset has a $343,750,000 replacement value.

Breakwater

The breakwater is an 8.5-mile rock structure that prevents waves from entering the harbor. It has two openings to allow ships to enter the port areas behind it.

Sensitivities: The breakwater is sensitive to higher water levels and erosion. With sea level rise, the breakwater could be overtopped by high tides or scoured out by wave action, and then cease to hold back waves from the harbor area.

Adaptive Capacity: The breakwater could potentially function if partially impaired. For example, if a portion of the breakwater is eroded, the rest of the structure would continue to block waves. Also, if the breakwater is inundated only during high tide, it would continue to function during low tide.

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[1] http://www.pmel.noaa.gov/pubs/PDF/bern3168/bern3168.pdf

Consequences: An impaired breakwater would have high economic consequences, because it could cause damage to the port. There could also be environmental damage to the shallow water habitat adjacent to breakwater, which is a built ecosystem that supports eelgrass, fish, and bird life. The breakwater has a $500 million replacement value and is managed by the Army Corps of Engineers.

Transportation

Transportation assets include roads, rails, and grade separations that help move cargo to and from the Port.

Sensitivities: Transportation assets are sensitive to coastal flooding, undermining from erosion and rising groundwater. These impacts could cause the assets to be damaged and thus unusable.

Adaptive Capacity: Compared to other port assets, roads can be re-built relatively quickly. In addition, if only one lane is affected by flooding or undermining from erosion, the road can potentially still continue to function.

Consequences: Impaired transportation facilities would have a high economic consequence, because they are vital for transporting cargo from terminals to their final destinations. It could also have a high impact on communities living in San Pedro, Wilmington, and permanent residents in the marina due to reduced access. The transportation assets are estimated to have a $1 billion replacement value.

Marinas

Sensitivities: Marinas are sensitive to coastal flooding and undermining from erosion, because they would be damaged by such impacts.

Adaptive Capacity: Marinas are relatively resilient to storm-related flooding, because they float on the water, but their groundings would become deteriorated from daily tidal flooding and chronic erosion. In addition, these impacts could reduce access to the marina.

Consequences: The consequences of impaired marinas primary relates to their recreational value. They also have an estimated $180 million replacement value. Lastly, permanent residents of the marinas could potentially be displaced.

Energy Facilities

Overview

The Department of Water and Power (DWP), the largest municipally owned utility in the country, manages energy facilities in the City of Los Angeles. Most energy assets located in the exposure zone are not sensitive to the impacts of sea level rise, because as coastal assets, they were designed to withstand exposure to coastal flooding and erosion. All outdoor equipment is water resistant, indoor equipment has pumps, and spare equipment is kept on hand.

This sector also has high levels of resources for adaptive capacity, which reduces vulnerability. In terms of economic resources, the DWP has a strong mechanism for raising funds. In terms of governance resources, DWP works closely with other agencies and is involved with communities regarding environmental protection procedures. LADWP has a vast workforce that provides service to the City of L.A. Work crews are also located in areas outside of the City. Should emergency situations necessitate the use of additional staff, crews can be called in to assist. LADWP is also member to several Mutual Assistance Agreements that can be activated for additional support of resources.

Energy facilities also have a high long-term adaptive capacity, because DWP maintains a robust asset replacement schedule of 30-35 years. As such, new infrastructure will likely be designed with sea level rise and other environmental risks in mind. Furthermore, redundancies in the electric power system mean that the consequences of impaired coastal assets would likely not be widely felt.

Asset Vulnerabilities

Harbor Generation Station

The Harbor Generation Station is a natural gas fired steam electric generating facility located in the Wilmington area. The facility's total capacity is 472 megawatts and it occupies approximately 20 acres.

Sensitivities: DWP analysis concludes that the Harbor Generation Station is not sensitive to the impacts of sea level rise, because, as a coastal asset, it was designed to be able to cope with these impacts.

Adaptive Capacity: This asset can continue to function if partially disabled and its functionality can be restored quickly if impaired. Outdoor components are designed for water resistance and exposure. Indoor components are designed for water to drain into sumps and are also equipped with pumps to quickly remove the water from the sumps. Consequences: Impacts would be equally distributed to the immediate area.

Haynes Generation Station

Haynes Generation Station is a natural gas fired power plant located in the Long Beach area with a capacity of 1556 megawatts.

Sensitivities: DWP analysis concludes that this asset is not sensitive to the impacts of sea level rise, because, as a coastal asset, it was designed to be able to cope with these impacts.

Adaptive Capacity: This asset can continue to function if partially disabled and its functionality can be restored quickly, because outdoor assets are designed for water resistance and exposure. Indoor assets are designed for water to drain into sumps and are also equipped with pumps to quickly remove the water from the sumps.

Consequences: Impairment of Haynes would have moderate economic consequences, because clean up could take time, potentially affecting the power supply to other parts of Los Angeles. The disruption in power supply could also have environmental consequences, because it could impact power supply to waste water treatment plants, potentially resulting in sewage spills.

Receiving Station Q

Receiving Station (RS) Q is located in the Wilmington area and is comprised of equipment that receives power from generation, transforms the voltage, and distributes the power out again into the distribution network. Specifically, it has underground transmission connections to RS-C and Harbor Generation stations and connection to distribution stations that serve the San Pedro and Wilmington areas.

Sensitivities: DWP analysis concludes that this asset is not sensitive to the impacts of sea level rise, because as a costal asset, it was designed to be able to cope with these impacts.

Adaptive Capacity: This asset can continue to function if partially disabled and its functionality can be restored quickly, because outdoor assets are designed for water resistance and exposure. Indoor assets are designed for water to drain into sumps and are also equipped with pumps to quickly evacuate the water from the sumps.

Consequences: The DWP reports minor economic consequences from the potential impairment of RS-Q, because impacts would be distributed equally in the immediate area. A vulnerability assessment conducted by USC reported that the loss of RS-Q would disrupt power supply in the Los Angeles harbor area, but not the rest of the city.[2] Impairment of RS-Q could have moderate environmental consequences, however, because it could impact power supply to wastewater treatment plants, potentially resulting in a sewage spill.

[2] http://create.usc.edu/2005/05/vulnerability_assessment_and_s.html

Local Electricity Distribution Assets

Local electricity distribution assets include three distribution stations, poles, transformers, wires, vaults, and cables. These assets help deliver electricity at relatively low voltages to customers.

Sensitivities: DWP analysis concludes that these assets are not sensitive to the impacts of sea level rise, because, as coastal assets, they were designed to be able to cope with these impacts.

Adaptive Capacity: These assets can continue to function if partially disabled. Outdoor assets are designed for water resistance and exterior exposure. Indoor assets are designed for water to drain into sumps and are also equipped with pump to quickly evacuate the water from the sumps. In addition, assets are laid out in a manner that is easily reparable and their function can also be restored quickly. Lastly, if needed, power can be re-routed to other parts of the network.

Consequences: The DWP reports minor consequences from the potential impairment of these assets, because impacts would be distributed equally in the immediate area.

230KV Scattergood-Olympic Cable

This is an underground cable in the Dockweiler Beach/ Venice area that connects to a high voltage interstate line.

Sensitivities: This asset is potentially sensitive to coastal flooding that would make maintenance and repair difficult.

Adaptive Capacity: This asset can continue to function if partially disabled. Outdoor assets are designed for water resistance and exterior exposure. Their function can also be restored quickly.

Consequences: The DWP reports minor consequences from the potential impairment of this asset, because impacts would be distributed equally in the immediate area.

Electrode Vault

This is an underground vault. It is currently being redesigned and moved for reasons unrelated to sea level rise.

Sensitivities: DWP analysis concludes that this asset is not sensitive to the impacts of sea level rise, because, as a coastal asset, it was designed to deal with these impacts.

Adaptive Capacity: This asset can continue to function if partially disabled. Outdoor assets are designed for water resistance and exterior exposure. Their function can also be restored quickly.

Consequences: The DWP reports minor consequences from the potential impairment of this asset, because impacts would be distributed equally in the immediate area.

Recreation and Parks

Overview

The Recreation and Parks Department manages parks and recreational facilities in the City of Los Angeles. There are three assets located in the flood exposure zone in the San Pedro/Harbor area and five assets located in the flood exposure zone in the Venice area. This sector has relatively limited adaptive capacity because the department is already operating under budget constraints that make it difficult to meet current demand and cope with current challenges at these locations.

Despite these constraints, parks and other open spaces are generally fairly resilient assets, because they can be restored relatively quickly or they can change to cope with new environmental conditions. For example, different landscaping can be introduced that can deal with periodic flooding without significantly changing the function of the park. However, these parks and greenspaces may be reduced in size or access due to sea level rise. Built structures, such as recreational buildings and museums, are much less resilient, because damage takes longer to repair and they cannot function if partially impaired.

The consequences of impairment of these facilities are highly dependent on the location. Some facilities, like the Venice Beach Boardwalk, are iconic destinations and their impairment could have significant economic consequences. Some parks are unique because provide habitat for rare plants and animals. Other parks and recreation centers are highly valued and used by the local communities, especially in the San Pedro/Harbor area, because few other parks exist in the area.

Asset Vulnerabilities in the San Pedro Harbor Area

Cabrillo Beach

Cabrillo Beach includes a public beach, a marine aquarium, a recreation center, and a fishing pier. The beach area is divided into an outer beach and an inner beach.

Sensitivities: The public beach is sensitive to flooding, erosion, and interaction with groundwater. The public beach could potentially be lost to erosion. In fact, five years ago, a large storm washed away the sand and the outer beach was exposed down to rocks with much of the sand being deposited on the inside of the breakwater. The sand on the outer beach was replaced naturally over time, but with higher sea level, it is uncertain if the sand would return naturally following a storm event. Flooding could also damage the inner beach, recreation center and aquarium.

Adaptive Capacity: The public beach could potentially continue to function if partially impaired. For example, if the beach is inundated only during high tides, visitors could potentially use the beach during low tides. Also, it could potentially continue to function if impaired by storm-related flooded. After previous storm events, some of the beach sand

still remained, but with a two to three foot berm that visitors had to navigate to access the water.

On the other hand, partial impairment of the aquarium and recreation center could render them non-functional. Also, these facilities could not be quickly or easily restored if impaired. Flooding in the parking lot or road would result in a temporary loss of access for visitors. There are no current efforts in place to make the facilities at Cabrillo Beach more resilient to the impacts of sea level rise.

Consequences: Impairment of this asset would have high economic and social consequences, because the beach and aquarium attract visitors from all over Southern California. The local communities of Wilmington, San Pedro, and Harbor City also use the beach and the recreation center, and the impairment of these assets would be a loss of open space and recreation opportunities for these park-poor communities.

The Los Angeles Maritime Museum

One cultural facility affected by sea level rise in the San Pedro Harbor Area is the Los Angeles Maritime Museum. The Maritime Museum is located in the 1941 Municipal Ferry Terminal and is on the National Register of Historic Places.

Sensitivities: The museum site is sensitive to coastal flooding and undermining erosion. These impacts would cause damage to the structure and/or contents of the building and would cause the facility to close to the public.

Adaptive Capacity: This facility cannot function if it is partially impaired and cannot be quickly or easily restored if impaired. There are no current efforts in place to make the museum more resilient to the impacts of sea level rise.

Consequences: The greatest consequence would be the economic impact of a storm-related flood, because this could cause damage to the valuable artifacts within the museum. In addition, closure of the Maritime Museum would be a cultural loss for the local community and greater City of Los Angeles, as this site attracts visitors from around the region.

Asset Vulnerabilities in Venice Area

Venice Beach Recreation Center

The Venice Beach Recreation Center consists of a boardwalk, fishing pier, picnic areas, and athletic courts.

Sensitivities: This asset is sensitive to coastal flooding, which could damage the various elements of the recreation center and render them unusable by the public. The pier already has some structural weakness and it could be further damaged by these impacts. Erosion could also weaken the structural stability of the pier and the boardwalk.

Adaptive Capacity: This asset cannot function if partially impaired. The boardwalk and athletic courts could be quickly restored if impaired, but the pier would take considerably longer to restore if damaged. Recreation and Parks is currently working on a plan to reinforce the pier to better withstand current impacts, but the plan does not explicitly take the impacts of sea level rise into consideration.
Consequences: Impairment of these iconic facilities, particularly the boardwalk, would have high economic consequences, because of their cultural, recreational, and tourist value. They draw visitors from around the region and even from around the world. The boardwalk also includes spaces for about 200 vendors, who would have to seek other locations to sell their goods.

Neighborhood Parks

Neighborhood Parks include Del Rey Lagoon Park, Canal Park, and Titmouse Park. Del Rey Lagoon features a tidal basin, children's play area, a ball field, and restroom facility. Canal Park is pocket park located along the Venice canals and it includes grass and a children's play area. Titmouse Park is a small park located near Ballona Creek consisting of native plants that provide habitat for birds.

Sensitivities: These parks are sensitive to flooding and erosion that could damage the park facilities and make the park unusable an inaccessible.

Adaptive Capacity: The parks could potentially function if they were partially impaired. For example, if only a small part of the park experiences tidal flooding, other parts of the park could in use. The park could also potentially be quickly restored depending on how fast flood water recedes. The landscape and vegetation of the parks could potentially change given these impacts and still be useful as habitat for plants and animals.

Consequences: The consequences of impairment of these parks would be relatively minor given their small size. There would be a loss of recreational opportunities for residents and habitat for plants and animals.

Land Use Planning

Overview

The Planning Department carries out land use planning in the City. While there has not yet been monies identified for the development of climate adaptation plans, the department recognizes the importance of such plans and will be looking to obtain funds for adaptation plans in the forthcoming years. In the meanwhile, several neighborhood groups have become organized and engaged around the topic of risks related to climate change and are helping to raise the profile of this important topic.

Asset Vulnerabilities

Building Stock and Roads in Venice Area

Venice is particularly vulnerable to sea level rise because of its exposure not only via the beach, but also the channels.

Sensitivities: The building stock and roads in the Venice area are sensitive to flooding and undermining from erosion. The impacts of sea level rise could lead to damaged and/or uninhabitable homes, businesses, schools, and public buildings. Many structures are built at, or very-near, sea level. In addition, many of the structures were built before the 1970s, which means they are more sensitive to flooding. In fact, some residents already experience flooded basements during storm events. Damage to roads from the impacts of sea level rise could also result in a lack of access for residents and emergency services.

Adaptive Capacity: The ability of the roads and building stock in Venice to continue to function if partially disabled depends on the extent of damage. The functionality of these assets could not be restored very quickly or easily. The City Planning department does not have any plans in place to make the roads and buildings in Venice more resilient to the impacts of sea level rise.

Consequences: The economic and social consequences of the impairment of these assets would be high due to the displacement of residents and businesses. In particular, the displacement of low-income residents in the Venice Beach area would have significant social consequences. In addition, flooding in this area could cause damage to the Ballona wetlands, which provides habitat for plants and animals and helps filter groundwater.

Building Stock and Roads in the San Pedro/HarborArea

Sensitivities: The building stock and roads in the San Pedro/Harbor Area are sensitive to flooding and undermining from erosion. Not many residential buildings will be exposed to sea level rise because they are terraced up on the hillside, but there are some people that live in boats in the marina. Roads could be damaged by these impacts.

Adaptive Capacity: The City Planning department is uncertain if this asset could continue to function if partially disabled, because it depends upon the extent of the damage. The City Planning Department does not have any efforts in place to make these assets more resilient.

Consequences: Impairment of roads would have significant economic consequences because they are important for regional goods movement due to their proximity to the Port of Los Angeles. Damage to roads could also limit access to the neighborhoods. Damage to the building stock could displace businesses and low-income residents.

Pacific Coast Highway (PCH) in Pacific Palisades Area

This asset consists of approximately 2.5 miles of PCH from Sunset Boulevard to Entrada Drive. The highway in this stretch generally has six lanes and it runs near the ocean, separated from the sea by sandy beaches and some coastal armoring. CalTrans has jurisdiction over PCH, but it provides a critical connection to coastal communities.

Sensitivities: This asset is sensitive to flooding and undermining from erosion. These impacts could result in damage to the highway, potentially causing frequent closures and even structural failure.

Adaptive Capacity: It is uncertain if PCH could continue to function if partially disabled, because it would depend on decision-making by CalTrans regarding keeping the highway open with a reduced number of lanes.

Consequences: Impairment of PCH would have significant economic consequences, because it's an important transportation connection in the region. In addition, it would have adverse consequences for communities living in Pacific Palisades who could have difficulty accessing their homes or be less accessible by emergency services.