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Regional Economic Vulnerability to Sea Level Rise in San Diego County

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Regional Economic Vulnerability to Sea Level Rise
In San Diego County

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Contents

List of Figures and Tables

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The San Diego Regional Climate Collaborative is a network for public agencies that serves the San Diego region to share expertise, leverage resources, and advance comprehensive solutions to facilitate climate change planning. By partnering with academia, non-profits, and businesses, we also work to raise the profile of regional leadership.

Executive Summary

One of the consequences of climate change and sea level rise that has not been extensively examined is the possible damages that can be done to regional economies. Even under scenarios of relatively small sea level rise, areas historically at risk from flooding will find flooding increasing as storms increase in frequency and severity. The result will likely be temporary disruptions of business activity lasting days to weeks. Climate change and accompanying higher sea levels will mean increasing severity of flood risk that will well to areas that have been historically immune to flooding. The cumulative effect of these flood threats poses a significant risk to the San Diego County economy.

To investigate these vulnerabilities, the San Diego Regional Climate Collaborative engaged the Center for the Blue Economy of the Middlebury Institute of International Studies at Monterey to investigate the potential effects from climate change and projected sea level rise, and coastal storms on the economy of San Diego County. The importance of assessing these vulnerabilities arises because San Diego County is the 17th largest metropolitan area in the country and the 5th largest in California. San Diego County has a GDP that is larger than 25 other states.

Much of this economy is located near the ocean and bays. In 2014, the 30 zip codes in the county that are adjacent to the shore were the location of over 34,000 employment establishments, with over 543,000 employees accounting for nearly $30 billion in wages and salaries. These zip codes accounted for 42% of county employment establishments, 46% of employment, and 50% of county wages & salaries.

This report consists of a regional economic vulnerability assessment using flooding projections developed by the United States Geological Survey (USGS) Coastal Storm Modeling System and economic activity and asset data available for San Diego County. The economic vulnerability assessment seeks to identify whether important parts of the economic base of the region (the industries which sell outside the region) are vulnerable and where adaptation strategies may be needed to sustain commercial and industrial activity. This type of vulnerability assessment does not forecast specific impacts, but points to possible effects of the conditions that define the scenario. It is designed to alert about possible future issues and highlight aspects that require priority attention in planning. It does not consider planned adaptation strategies, which many jurisdictions in the region are currently working on but seeks to help inform those planning efforts.

Vulnerability was identified by spatially analyzing the relationship between potential flooding projected by the USGS Coastal Storm Modeling System (CoSMoS) under assumptions of no sea level rise, 1 meter (39.7" or 3.3. feet) of sea level rise and 2 meters (78.7" or 6.6 feet). These assumptions are generally consistent with other sea level rise vulnerability assessments conducted by jurisdictions in the San Diego region that assume between 1.5 to 2 feet of sea level rise by 2050 and 3 to 6.6 feet by 2100. The CoSMoS data

combines sea level rise estimates with the effects of more frequent (less intense) storms and more intense (but less frequent) storms. The CoSMoS data includes the effects of both horizontal flooding and of waves; only the effects of flooding are considered in this report.

CoSMoS data combines sea level rise with estimates of storm intensity associated with coastal storms that occur every year (a "1-year storm") and those that have only a 1% chance of occurring every year (a "100-year storm"). An analysis comparing the flood vulnerability estimates generated by CoSMoS with those included in the flood zone of designated for the National Flood Insurance Program is also provided.

The flood effects projected by CoSMoS were linked to measures of economic activity and assets to determine vulnerability by using data on individual employment establishments from a commercial database and property tax data from San Diego County for commercial and industrial zone property. This provided alternate perspectives on the economic values at risk.

Major conclusions include:

- This analysis indicates that commercial and industrial properties in San Diego County, and particularly those in the cities of San Diego, Chula Vista, and Coronado, face significant risks to their economies from sea level rise-related flooding. The largest industries in terms of vulnerabilities include tourism & recreation, ship building, and professional & technical services, each of which is an important part of the economic base of the County.

- The vulnerability analysis reported here is for single events associated with a storm of specific frequency and magnitude combined with sea level rise of a specified amount. The single event results will recur with unknown but likely increasing rates into the future. It is the cumulative impacts of these possible effects that will create the greatest stress on the San Diego regional economy.

- The analysis uses six different scenarios combining sea level rise and storm intensity:

    o No sea level rise and an annual storm ("1 Year")
    o No sea level rise and a 1% Storm ("100 Year")
    o 1 meter sea level rise and an annual storm ("1 Year")
    o 1 meter sea level rise and a 1% Storm ("100 Year")
    o 2 meters sea level rise and an annual storm ("1 Year")
    o 2 meters sea level rise and a 1% Storm ("100 Year")

- Under the highest sea level scenario with the most severe storm (2 meters sea level rise and a 1% Storm) over 2,600 establishments with 49,000 jobs, $8.0 billion in sales, and $6.1 billion in contribution to the gross domestic product in San Diego County are vulnerable to flooding. Under this same scenario, $2.2 billion to $2.6 billion in buildings and equipment on property classified as commercial or industrial is at risk

of damage. **These estimates assume that maximum flood depth affects all establishments, which overstates the vulnerability.**

- The same storm intensity with 1 meter of sea level rise makes 830 establishments, 15,000 jobs, $2.0 billion sales and GDP vulnerable. Again, these estimates assume maximum flood effects at all establishments.

- Storms likely to occur every year (1-year storms) when coupled with 2 meters of sea level rise makes 1800 establishments, 32,000 jobs, $4.0 billion sales and $4.3 billion GDP vulnerable. These more frequent storms make 230 establishments vulnerable with 7,600 jobs, $0.95 billion in sales and $1.1 in GDP with 1 meter of sea level rise.

- These results do not take into account the variance in flood depths that may occur. The CoSMoS model estimates the flooding depth at each of the affected establishments and parcels. Mean flood depths range from 24 to 109 centimeters (9" to 43") from the lowest to the highest scenario. Maximum estimated flood depths range from 196 centimeters (77" or 6.4 feet) to 400 centimeters (158" or 13.1 feet) depending on storm intensity and sea level rise.

- To adjust for the varying effects of flood depth in the vulnerability assessment, each establishment's economic activity in the area potentially affected by flooding was weighted by a factor reflecting expected depth. These depth-adjusted estimates indicate that 900 to 1600 employees would be potentially in the sea level rise scenario 1-meter sea level rise scenario, and from 4,800 to 6,700 employees in the 2-meter sea level rise scenario. The range reflects storm intensity.

- The vulnerability of the buildings and equipment on commercial and industrial parcels can also be estimated with and without adjustments for possible flood depths. These vulnerabilities range from annual values of $2.4 to $2.8 billion in the 2-meter sea level rise scenarios without depth adjustment. The related depth-adjusted estimates range from annual values of $395 to $451 million.

- Flooding is generally a temporary problem. Floods disrupt business activity for temporary periods which can last from a few days to several months; much depends on the extent of the flood and the nature of the structure. The effects on sales and GDP are thus multiples of daily values. One month of lost sales would range from $5 to $20 million in the 1-meter sea level rise depending on storm. With two meters of sea level rise, one month of lost depth-adjusted sales would range from $62 million to $102 million.

- Commercial and industrial properties within the City of San Diego including the Unified Port District of San Diego (Port District) are the most economically vulnerable in the county. These account for at least 75% of the economic vulnerabilities in all of the scenarios. The other cities with high economic vulnerability to their commercial properties are Chula Vista and Coronado. These three cities account for 85-90% of

employment vulnerability under both the 1-year and 100-year storm intensity scenarios. Other cities' levels of vulnerability depend on the storm and sea level rise scenario but are generally relatively small in comparison with the four largest cities.

- The extent of damages to the regional economy depend on the extent and frequency of flooding, both of which are expected to increase, but also on the speed and extent of recovery from flooding. Having flood insurance is an important element in recovery. A comparison of CoSMoS projections with the flood zones and coverage by flood insurance suggests that flood insurance coverage for sea level rise-related flooding may be inadequate for commercial and industrial properties in San Diego City, Imperial Beach, Encinitas, and Coronado.

Estimates of sea level rise generally assume that the level projected will occur by a specific year (usually 2100), but the extent and pace of climate change and sea level rise are still basically unknown. The actual rate will depend primarily on the effectiveness of efforts to reduce the rate of climate change. Storms and flooding can occur every year, and even under the lower sea level rise scenarios, the potential damage increases each year. More detailed information about recent California-focused sea level rise research can be found in the *Rising Seas: An Update on Sea Level Science Report* (2017)[1].

In general, the risks to the San Diego economy should be thought of as the *cumulative* damage to the economy from the combination of randomly occurring severe storms with steadily increasing flood areas and severity. It is possible that the economy may encounter long periods with little damage. In individual events, flooding will affect a relatively small number of assets in the scope of the overall San Diego economy; recovery efforts will be sufficient to minimize long term damage for most assets.

However, the consequences of climate change in both the weather and the sea level are that flood damages will occur more and more frequently to the point that recovery efforts are inadequate or too expensive. Insurance providers will become extremely stressed transferring more and more of the risk to property owners. In the most severe circumstances, resources to reduce flood damages may only be large enough in the context of post-disaster funding.

Offsetting these increasing risks are the adaptation actions to be taken individually and collectively in the region to reduce the risk and extent of flood damages. The extent and pace of these changes are also unknown. In an ideal scenario, adaptation strategies will be needed to address smaller rates of sea level rise, while carbon reduction measures taken globally would slow climate change itself and resulting sea level rise. From an economic perspective, the challenge is to invest sufficiently in adaptation to avoid the levels of losses that would result in severe disruptions to key industries and areas of San Diego County. Finally, it should be stressed that the region is actually on the forefront of

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[1] Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea level Rise Science. California Ocean Science Trust, April 2017

climate adaptation planning in the United States.   Several jurisdictions, for example, collaborated on the development of a formal "Sea Level Rise Adaptation Strategy for San Diego Bay" in 2012. This initial planning effort has been further supported by public agencies' ongoing collective efforts and information sharing through the San Diego Regional Climate Collaborative (which commissioned this study) and individual agency's implementation of on-the-ground adaptation projects.

1. Introduction

The San Diego Regional Climate Collaborative engaged the Center for the Blue Economy at the Middlebury Institute of International Studies at Monterey to investigate the potential effects on the economy of San Diego County from climate change impacts, specifically projected sea level rise, and coastal storms. At this time, a number of San Diego jurisdictions have conducted vulnerability assessments to better understand their risks including exposed assets and populations[2]. These assessments contain some characterization of potential fiscal impacts but contain a limited view of the broader economic impacts because they are limited to a specific jurisdictional boundary.

One of the consequences of climate change and sea level rise that has not been extensively examined is the possible damages that can be done to regional economies. Even under scenarios of relatively small sea level rise, areas historically at risk from flooding will find flooding increasing as storms increase in frequency and severity. The result will likely be temporary disruptions of business activity lasting days to weeks. Under higher sea level rise scenarios with even more frequent and larger flooding events, areas that have been historically immune to flooding may find themselves subject to periodic and increasingly serious flooding.

San Diego County has a very large and interdependent economy to consider when evaluating climate change impacts. The county is the 17th largest metropolitan area in the country and the 5th largest in California based on the size of the economy in gross domestic product. San Diego County has a GDP that is larger than 25 other states. Much of this economy is located near the ocean and bays. In 2014, the 30 zip codes in the county that are adjacent to the shore were the location of over 34,000 employment establishments, with over 543,000 employees accounting for nearly $30 billion in wages and salaries. These zip codes accounted for 42% of county employment locations, 46% of employment, and 50% of county wages & salaries.[3]

The shoreline typography of San Diego County creates particularly vulnerable areas. Some areas, such as Mission Bay, San Diego Bay, and the coastal area in Imperial Beach near the Mexican border are primarily low lying and are known to be historically susceptible to flooding. Shoreline areas north of Mission Bay are characterized more by erodible bluffs and residential properties, but there are also several areas where increased flooding of commercial and industrial facilities is possible.   Sea level rise will fundamentally alter historical patterns of flood vulnerability.

For this reason, an analysis of the vulnerabilities of the San Diego regional and local economies to the possible effects of sea level rise is an important part of the planning process. Vulnerability analysis is not a forecast of specific consequences; sufficient information is not available to make forecasts. But it is a starting point which can highlight aspects that require priority attention in planning.

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[2] See www.resilientcoastlines.org for information and links to these vulnerability assessments.
[3] Source: U.S. Census, County Business Patterns.

Figure 1 Employment establishments relative to potential flood Areas based on 100-year Coastal Storm Intensity and 1 and 2-meter sea level rise
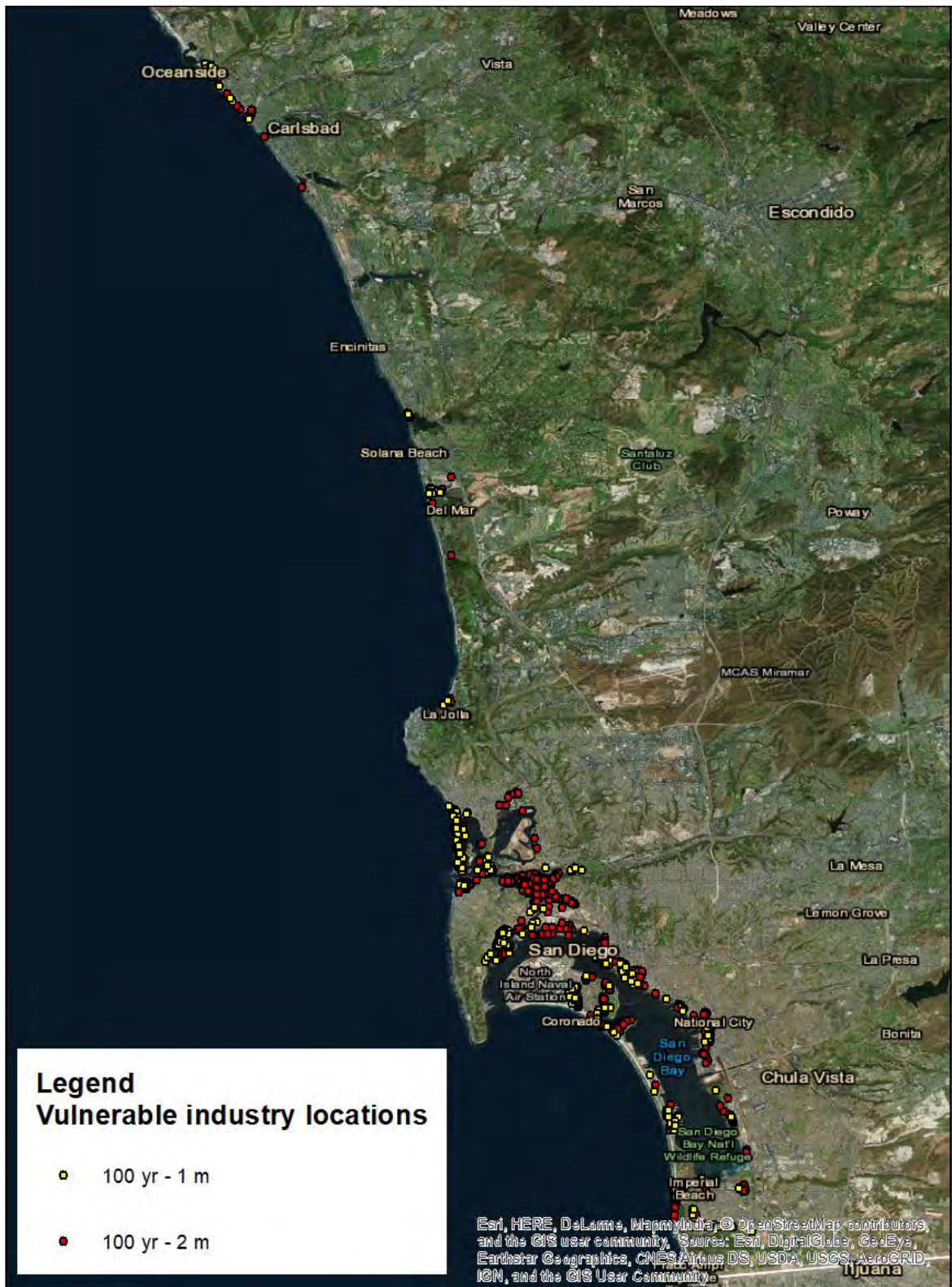
Methodology

To assess the extent of San Diego County's economic vulnerability to future coastal flooding, this report relies primarily on the Coastal Storm Modeling System (CoSMoS) 3.0 for Southern California developed by the United States Geological Survey (USGS).[4] The CoSMoS model was released in 2016 and provides enhanced sea level rise forecasting for the West Coast by combining possible extents of sea level rise with the effects of coastal storm events. For San Diego County, CoSMoS demonstrates that much of the damage from sea level rise will most likely be associated with coastal storms, in which both rising tides and storm surge intensify the extent and depth of flood possibilities.

The designation of areas vulnerable to flooding has been undertaken for some time by the Federal Emergency Management Agency (FEMA) for purposes of the National Flood Insurance Program. These flood vulnerability zones are currently used for planning but are derived from historical data that does not incorporate sea level rise using different analytic techniques than the USGS data. A comparison of possible vulnerabilities derived from analysis of the FEMA and CoSMoS data is also provided in Appendix B.

For this report, six CoSMoS scenarios were selected to evaluate regional economic impacts:

1.   1-year storm with no sea level rise
2.   100-year storm with no sea level rise
3.   1-year storm with 1 meter (3.3 feet) of sea level rise
4.   100-year storm with 1 meter (3.3 feet) of sea level rise
5.   1-year storm with 2 meters (6.6 feet) of sea level rise
6.   100-year storm with 2 meters (6.6 feet) of sea level rise

The report evaluates two aspects of San Diego County's regional economic vulnerability. The first identifies possible effects on employment, sales, and contribution to the regional economy as measured by gross domestic product. This analysis uses business records that are identified by precise geographic location by InfoUSA, a private sector vendor of economic data that provides business data to services such as Google maps. The second analysis looks at the potential impacts on property values in the commercial and industrial classifications of the San Diego County Property Tax Assessment Data. This analysis identifies the gross assessed value at risk from flooding under different scenarios.

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[4] Patrick Barnard, Li Erikson, Amy Foxgrover, Andrea O'Neill, and Liv Herdman, 2016, CoSMoS (Coastal Storm Modeling System) Southern California v3.0 Phase 2: U.S. Geological Survey Data Release, http://dx.doi.org/10.5066/F7T151Q4.

The sea level rise scenarios from the CoSMoS data are relatively consistent with the low, medium and high range of scenarios used by the region's jurisdictions in their local vulnerability assessments. Figure 3 provides a comparison of sea level rise projections currently being used for risk assessments and planning by entities across San Diego County. For the 2050 planning horizon, there is general consistency with all the entities planning for between 0.9 feet and 2 feet of rise. For those regions that chose to use a range of possible sea level rise scenarios during a specific time period, this is reflected with a vertical line connecting the minimum and maximum extent of the range. We have also included the sea level rise ranges that the Ocean Protection Council Sea Level Rise Guidance Document (2018) suggests for planning purposes but acknowledge that this guidance may change.

Figure 2 Sea Level Rise Projections Used for Planning.
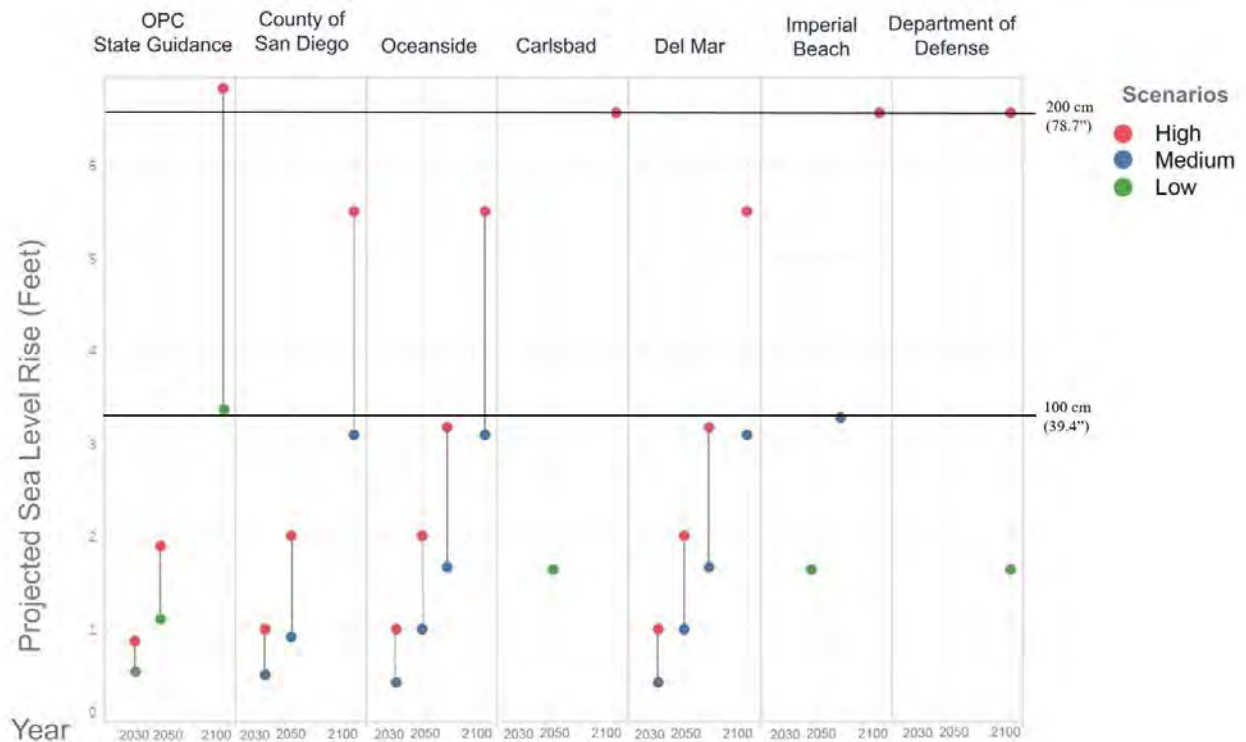
There is one notable difference between the vulnerability assessments using other sea level rise guidance. Most sea level rise models relate sea levels to time periods in the future. They attempt to answer the question: "how high will sea levels be in a specified year?" The California Coastal Commission guidance designates 2030, 2060, and 2100 as appropriate years for planning.[5]

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[5] California Coastal Commission. "Addressing Sea Level Rise in Local Coastal Programs." In California Coastal Commission Sea Level Rise Policy Guidance, 76. 2015. https://documents.coastal.ca.gov/assets/slr/guidance/August2015/5_Ch5_Adopted_Sea_Level_Rise_Policy_Guidance.pdf.

The CoSMoS data, however, is not dependent on time. The CoSMoS model addresses a different question: "if sea level has risen by X amount and a storm equal to the project storm that has a 1% chance of occurring each year occurs, what is the area that will be flooded?"[6]

This has important implications for interpretation of the analysis. We show levels of economic assets at risk from flooding given, but these are risks that can occur *every year* once a certain sea level rise is reached.

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[6] The terms "100 year" and "200 year" storm refers to a storm of an intensity that is, based on the historical record, has a 1% chance of occurring in each year or a 0.5% chance of occurring each year. It does not relate to the frequency of such storms, since these storms have the same probability of occurring every year. Thus, the terms "100 year" and "200 year" storms refer to *intensity*, not frequency.

2. Summary of Findings

Major Conclusions

- This analysis indicates that San Diego County, particularly in the tourism and recreation industries in the cities of San Diego, Chula Vista, and Coronado, faces significant risks to its economic assets and activities from enhanced flooding risks due to sea level rise.

- Under the high scenario of 2 meters (6.6 feet) of sea level rise combined with a 100-year storm, San Diego County has over 2,600 establishments with 49,000 jobs, $8.0 billion in sales, and $6.1 billion in contribution to the gross domestic product that would be vulnerable to flooding. Under this same scenario, $2.2 billion to $2.6 billion in buildings and other structures on property classified as commercial or industrial is at risk of damage. This scenario assumes that maximum projected flood depth affects all establishments; adjustments for flood depth lower these totals and are discussed below.

Figure 3 Comparison of impacts (without regard to flood depth) using the upper (100-year storm) and lower (1-year storm) bounds of the medium (1 meter) and high (2 meter) SLR scenarios.
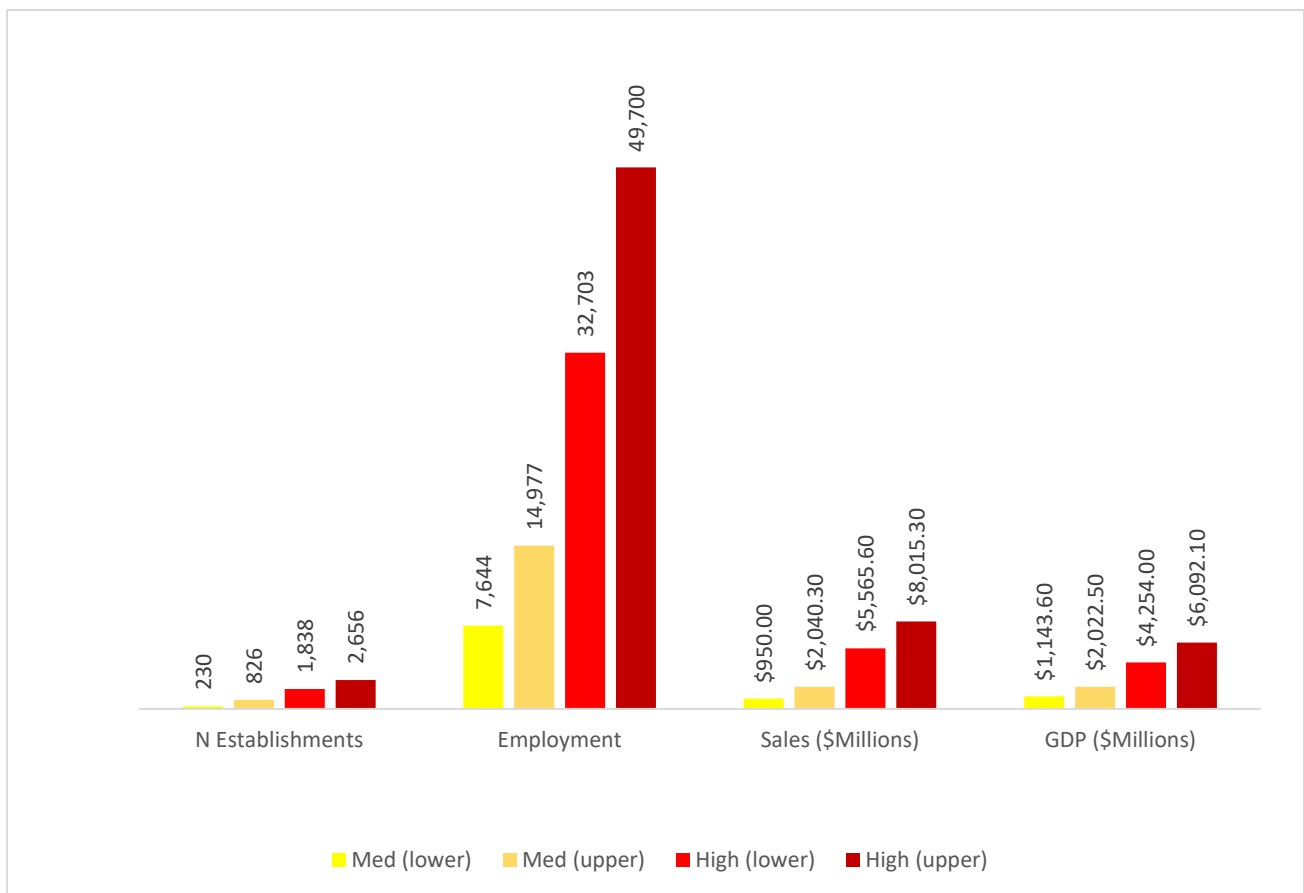
- Under the medium range[7] scenario of a 1-meter sea level rise, there are 230 to 830 establishments affected, with 7,600 and 15,000 jobs vulnerable to flooding depending on the intensity of storms hitting the region. This vulnerability includes establishments with $0.95 to over $2.0 billion in annual sales and $1.1 to $2.0 billion in annual GDP. The lower bound of these estimates is associated with the 1-year storm and the upper bound is associated with a 100-year storm. These estimates are subject to depth-adjustment discussed below.

- Analysis of the InfoUSA establishment data shows that the San Diego County's areas affected by sea level rise includes 82 industry groups. The number of industries affected depends on the scenario examined, ranging from 15 to 50 industries, with 16 industries affected in all scenarios (Figure 5).

Figure 4 Number of industries affected
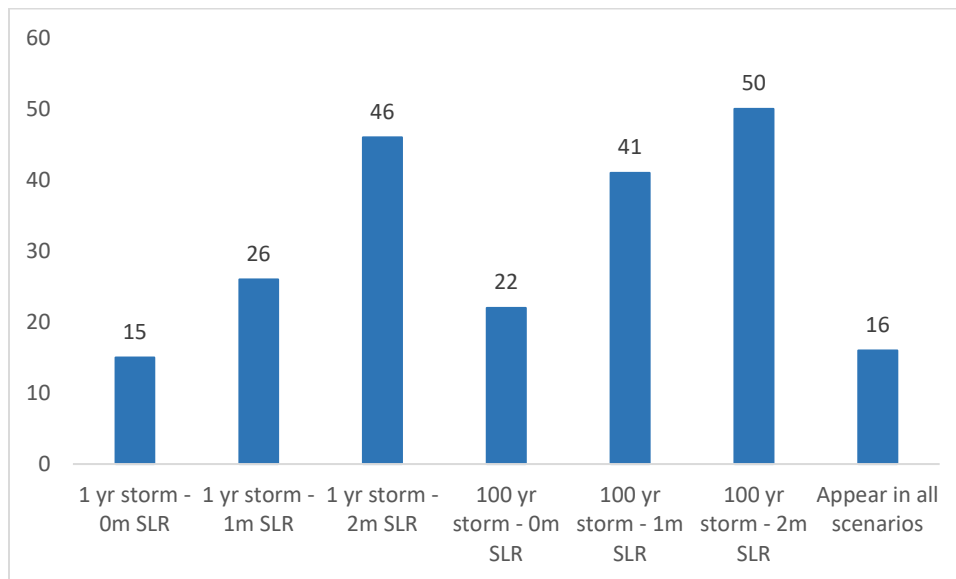
- The sixteen industries that appear in all scenarios, and thus may be considered the most vulnerable include:

  o Accommodation
  o Food services and drinking places
  o Administrative and support services
  o Retail trade
  o Amusements, gambling, and recreation industries
  o Real estate
  o Professional and Technical Services

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[7] The analysis here focuses on 0 centimeters of sea level rise, 1 meter (100 centimeters) and 2 meters (200 centimeters), making 100 centimeters case the medium scenario. CoSMoS provides data on 50 centimeters (19.7") sea level rise and on 150 centimeters (59") sea level rise. Those are not examined here to keep the number of scenarios to be reported on to a manageable level.

- o Other services, except government
- o Performing arts, spectator sports, museums, and related activities
- o Wholesale trade
- o Other transportation and support activities
- o Construction
- o Ambulatory health care services
- o Rental and leasing services and lessors of intangible assets
- o Securities, commodity contracts, and investments
- o Printing and related support activities.

- The industries with the greatest vulnerability are those associated with tourism and recreation. The Accommodations industry (hotels, motels, B&B's, etc.) has the highest vulnerability in all scenarios. When combined with Food & Drinking Places, and Amusements, & Performing Arts, these industries comprise 65% of vulnerable employment in the 2 meter (6.6 feet) 100-year storm scenario. If the retail trade vulnerabilities are also related to tourism and recreation, this sector would comprise 74% of the vulnerable employment (Figure 6). The vulnerability of the tourism industry is also indicated by the analysis of property values in flood risk areas; about one half of all of the commercial & industrial value at risk is classified as "hotel/motel". Ship building and professional & technical services are also key regional industries with high vulnerabilities.

Figure 5 Employment (unadjusted for flood depth) in 100-year storm and 1 meter of Sea Level Rise: industries in all CoSMoS scenarios
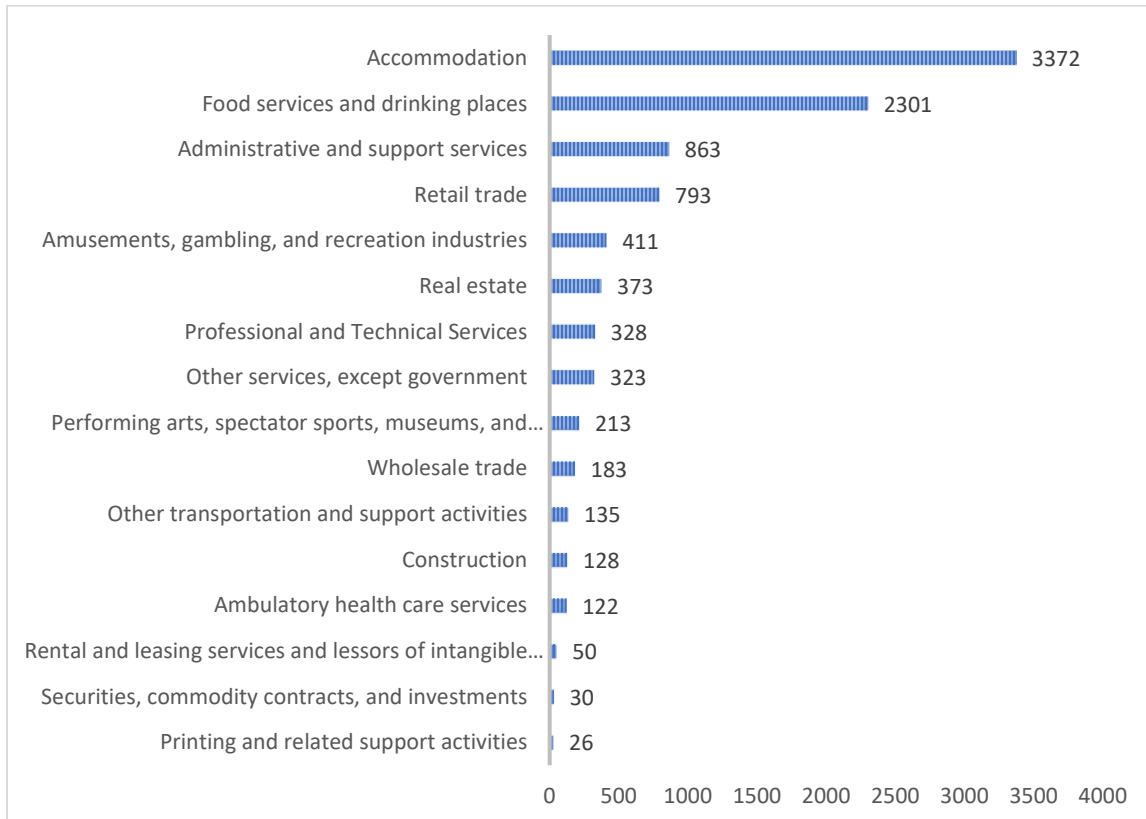
Figure 6 Daily sales vulnerabilities by scenarios
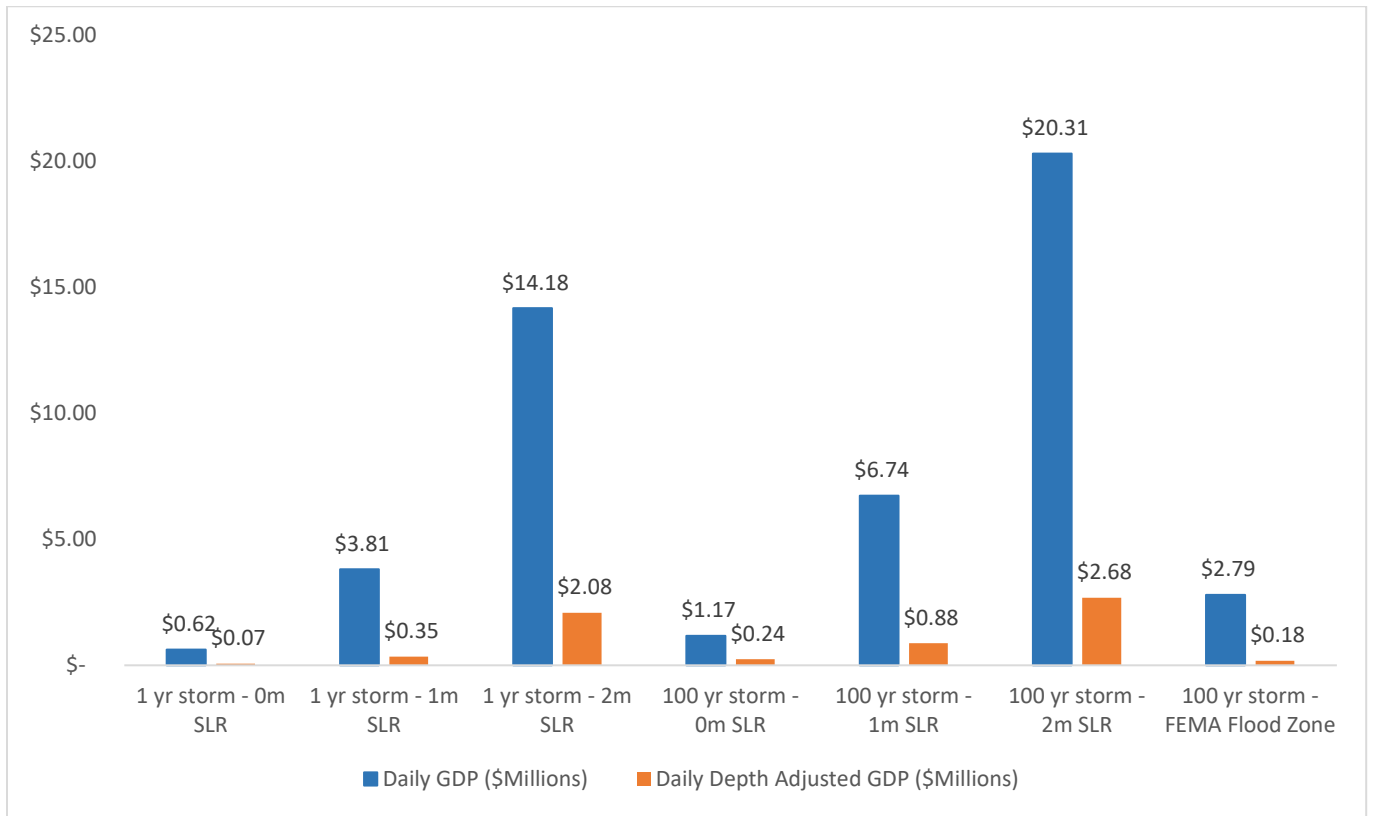
- Flood damages disrupt economic activity for periods of time that can range from days to months. The estimates for possible effects on sales and gross domestic product noted above are for the annual values associated with vulnerable assets. But the actual impacts depend on daily volumes of output.

- Figure 7 shows the daily values of sales from potentially affected firms (based on 300 days of output). Based on these estimates, one month of lost sales would range from $5 to $20 million in the 1-meter sea level rise depending on storm. With two meters of sea level rise, one month of lost depth-adjusted sales would range from $62 million to $102 million.

18
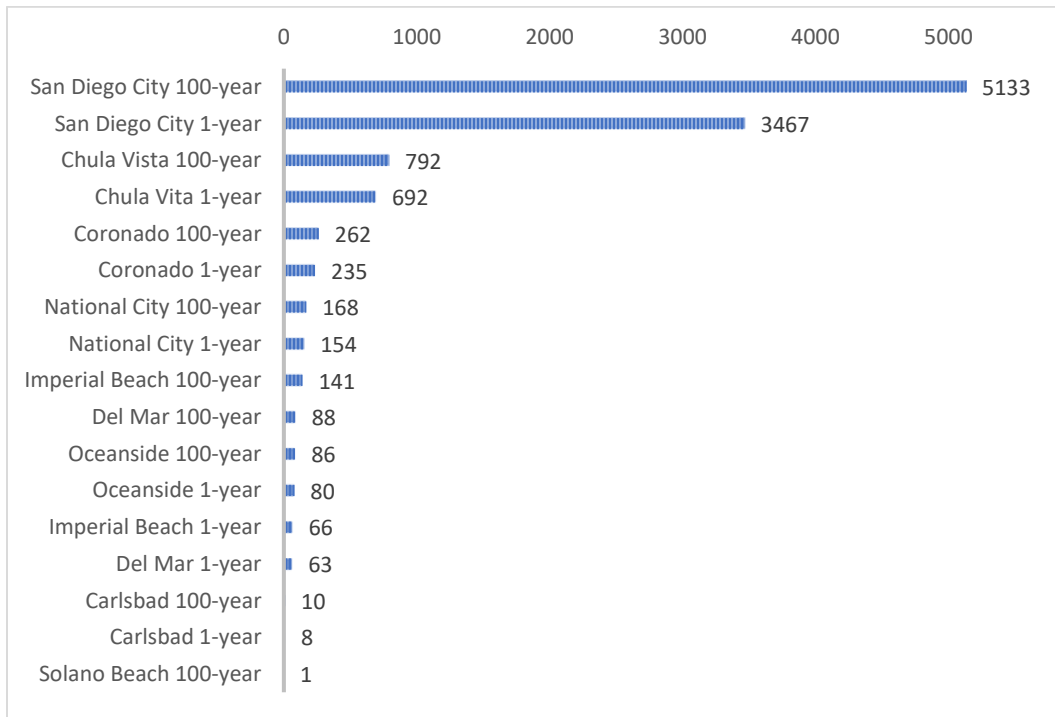
- Given both the physical and economic geography of San Diego County, it is not surprising that the City of San Diego is the most economically vulnerable city in the county (Figure 8). The City accounts for at least 75% of all the economic impacts in each of the scenarios, with higher percentages for the lower sea level rise scenarios. The other cities with high economic vulnerability are Chula Vista and Coronado. These three cities account for 85-90% of employment vulnerability under both the 1-year and 100-year storm scenarios. Other cities' levels of vulnerability depend on the storm and sea level rise scenario and are generally relatively small in comparison.

- These results do not take into account the variance in flood depths that may occur. The CoSMoS model estimates the flooding depth at each of the affected establishments. Flood depths ranged by scenario, as shown in Figure 9. Mean flood depths range from 24 to 109 centimeters (9" to 43"). Maximum estimated flood depths range from 196 centimeters (77" or 6.4 feet) to 400 centimeters (158" or 13.1 feet) depending on storm intensity and sea level rise.

Figure 8 Flooding summary by scenario
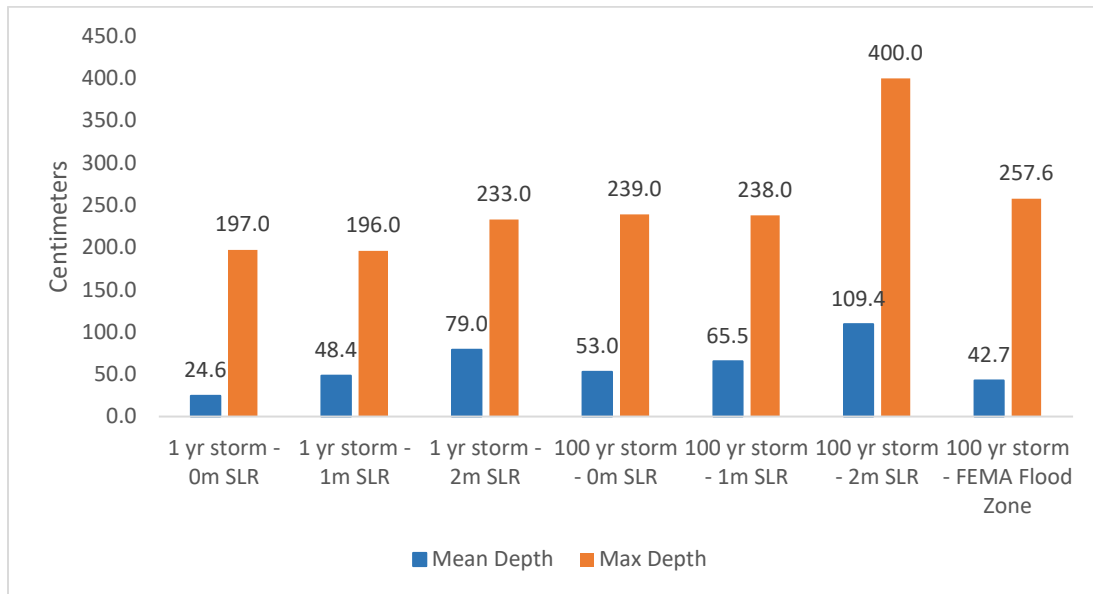
- To include flood depth in the vulnerability assessment, each establishment's economic activity in the area potentially affected by flooding was weighted by the range of expected depth associated with each scenario. The weighting allows the impacts of a specific establishment to be recorded at the maximum level if it is also affected by the maximum depth. The employment and related measures reported as vulnerability of establishments that are exposed to smaller depths within the scenario are reduced proportionately. (Weights are explained in detail in Appendix 1.) The result of flood depth adjustment is to reduce the estimated vulnerabilities compared with the "maximum vulnerabilities discussed above", as shown in Figure 10.

- These depth-adjusted estimates indicate that employment vulnerabilities range from 900 to 1,600 employees in the sea level rise scenario that is most widely expected, and from 4,800 to 6,700 employees in the highest sea level rise scenario. These figures are meant only to represent the variation in depth of possible.

- Analysis of property vulnerability was also undertaken using the San Diego County property tax assessments. For this purpose, the economic measure used is the assessed value of the buildings and equipment ("improvements") located on parcels designated for commercial and industrial uses can also be estimated. Figure 11 shows the assessed value of the improvements on commercial and industrial properties with and without adjustments for possible flood depths using the same method as with employment data. These vulnerabilities range from $2.4 to $2.8 billion in the 200-centimeter scenarios. The related depth-adjusted estimates range from $395 to $451 million.

Figure 9 Employment vulnerability unadjusted and adjusted by flood depth
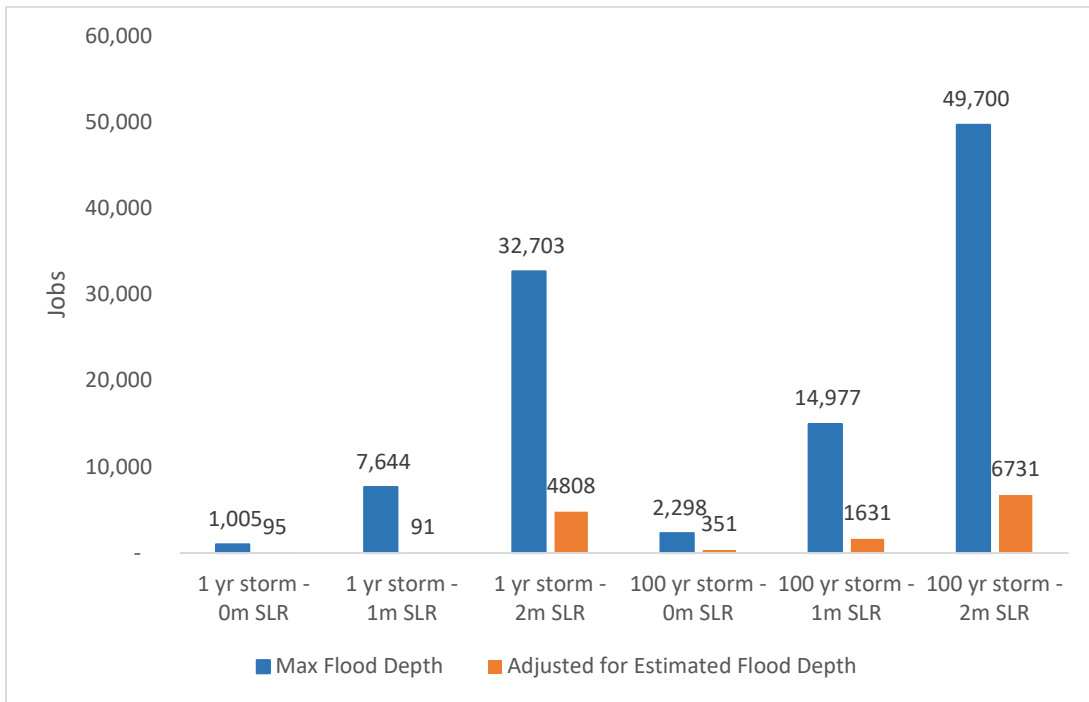
Figure 10 Commercial & Industrial structure assessed value vulnerable to flooding: unadjusted and adjusted for flood depth
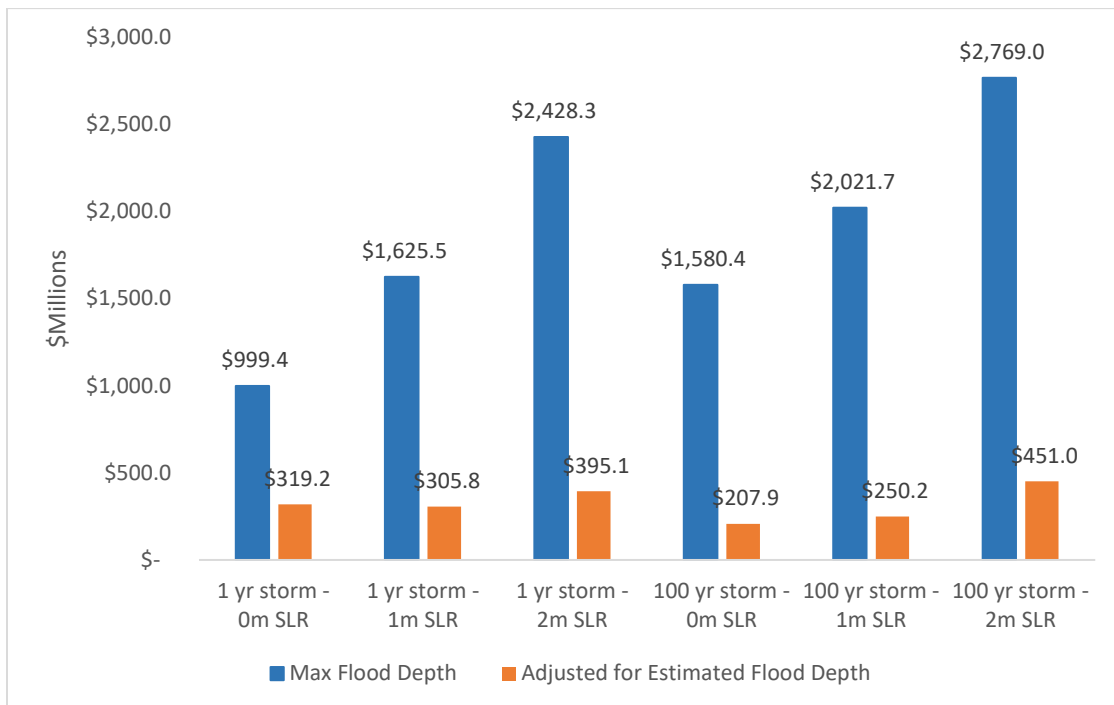
How the Risks of Sea Level Rise Shape Vulnerabilities

The analysis indicates substantial risks to the economy of San Diego County with higher risks for certain industries and places. The CoSMoS model also helps understand the nature of the risks that San Diego County faces, which is shaped by the interaction between sea level and storm. Sea level is already rising, and all evidence indicates that this will continue and accelerate. But the exact pace of that rise is unknown. Much will depend on the extent and effectiveness of climate change mitigation issues.

If these are extensive around the world and highly effective (essentially limiting global temperature rise to the Paris Climate Accord level of 2 degrees Celsius), then the most likely sea level rise will be towards the 1-meter level, and much of it will occur later in the century. If climate change mitigation is unsuccessful and temperatures exceeds 2 degrees Celsius or approaches the "business as usual case" of 4 degrees Celsius or more, then the 2-meter sea level rise becomes the more probable scenario. But these are not the only determinants of sea level risk. There could be extremely rapid rises in the near term if ice melt in Antarctica or Greenland exceeds current expectations. The State of California's guidance for sea level rise planning now takes this possibility into account[8].

Thus, the sea level rise component of the risks is steadily increasing. The most likely scenarios for the next several decades are for less than 1-meter increase, but the longer term (more than 20-30 years away) could shift towards the 2-meter level.[9] Moreover, large and unpredictable events easily move this entire risk pattern to occur within years, not decades.

The risks to the San Diego economy should therefore be thought of as the *cumulative* damage to the economy from the combination of randomly occurring severe storms with steadily increasing flood areas and severity. It is possible that the economy may encounter long periods with little damage. Flooding will affect a small number of assets; recovery efforts will be sufficient to minimize long term damage. But it is also possible that severe flood damages may occur so frequently that recovery efforts are inadequate or too expensive. Even a 1-meter or less sea level rise coupled with repeated severe storms could do the extent of damage to the economy envisioned here associated with the higher sea level rise.

For this reason, the estimates presented here should not be considered one time only events associated with the conditions specified, but risks that may occur infrequently in the near term but more and more frequently in the future. It is in the interaction between increasingly frequent flood damages and the ability of the region to minimize damages through adaptation and recovery that the effects of sea level rise will shape those parts of the San Diego economy and region that are most vulnerable.

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[8] Griggs, G, Árvai, J, Cayan, D, DeConto, R, Fox, J, Fricker, HA, Kopp, RE, Tebaldi, C, Whiteman, EA (California Ocean Protection Council Science Advisory Team Working Group). Rising Seas in California: An Update on Sea level Rise Science. California Ocean Science Trust, April 2017

[9] See Griggs et.al, Note 8 above.

3. Detailed Analysis

A vulnerability assessment is the first stage of planning for responses to climate change. Vulnerability assessments do not forecast specific impacts but point to possible effects of the conditions that define the scenario, which creates alerts about possible future issues and helps set priorities for future planning efforts. Those planning efforts should follow the vulnerability assessments with more detailed analyses of possible damages to structures along with engineering and other options for adaptation. For an economic vulnerability assessment, the issues include whether important parts of the economic base of the region (the industries which sell outside the region) are threatened and what may be needed to rearrange commercial and industrial space within the region in order to maintain levels of economic activity.

The range of possible changes examined in this study are taken from the estimations of sea level rise developed by the United States Geological Survey (USGS) in the Coastal Storm Modeling System 3.0 (CoSMoS). The CoSMoS modeling system integrates possible sea level rise, the projected frequency and characteristic of coastal storms, and changes in the shoreline which increase or decrease flood potential. The result is data that includes estimates of flood depth as well as extent, providing a three-dimensional picture of possible effects.

The CoSMoS estimates can thus be divided into two factors. The first is *storm intensity*, which is divided into 1-year storms (those with an intensity most likely to occur once a year) and 100-year storms (those with an intensity that are projected to have a 1% change to occur in any year). The second is *sea level rise*. For this study, we use scenarios of zero sea level rise, 1 meter (3.3 feet) and 2 meters (6.6 feet). The zero sea level rise scenario can be considered a baseline analysis reflecting only storm - related flood hazards. For a detailed discussion of the methodology used for identifying vulnerable establishments and parcels, see Appendix 1.

In addition, separate analyses were undertaken using the flood zone as defined by the Federal Emergency Management Agency (FEMA), which is based on the 100-year storm without sea level rise. A similar analysis on the economic and property values was undertaken using the FEMA-designated flood zone, from the 2016 Flood Risk Database[10], which defines the area eligible for flood insurance. Analyzing the FEMA flood zone permits a comparison between expectations of flood risks based on current policies and those projected by the CoSMoS system to determine whether the vulnerabilities are different. This analysis is included in Appendix 5.

Summary for San Diego County

Table 1 presents an overview comparison of the economic vulnerabilities for each of the scenarios examined as defined by the storm intensity (1 year or 100 year) and the

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[10] Federal Emergency Management Agency. *Flood Risk Database, Version 2.3.3.2, Sand Diego County, California USA, 13-09-0634S*. Washington, DC: Federal Emergency Management Agency, 2016. https://msc.fema.gov

extent of sea level rise (1-meter or 2-meter). The employment and sales figures in Table 1 are estimated by InfoUSA. Vulnerabilities are measured as the number of locations (establishments), the sum of the annual employment at those establishments, the estimated annual sales and the contribution to the San Diego County gross domestic product. [11] Table 1 also shows the estimated economic vulnerabilities without adjustments for flood depth and with adjustments for depth (weighted).

The depth adjustment process is needed because the distribution of exposure to floods varies significantly across the shoreline geography and with the scenario used. A depth adjustment weight is calculated for each scenario. Figure 12 shows the distribution of employment establishments across the depth categories (measured in centimeters) for the 100-year storm 200-centimeter (2 meters) sea level rise scenario. This distribution shows that most of the establishments are exposed to 150 centimeters (59 inches) or less of flood depth; relatively few are exposed to more than that.

Figure 11 Histogram of Depth Distribution of Employment Establishments- 100-year storm 2-meter SLR
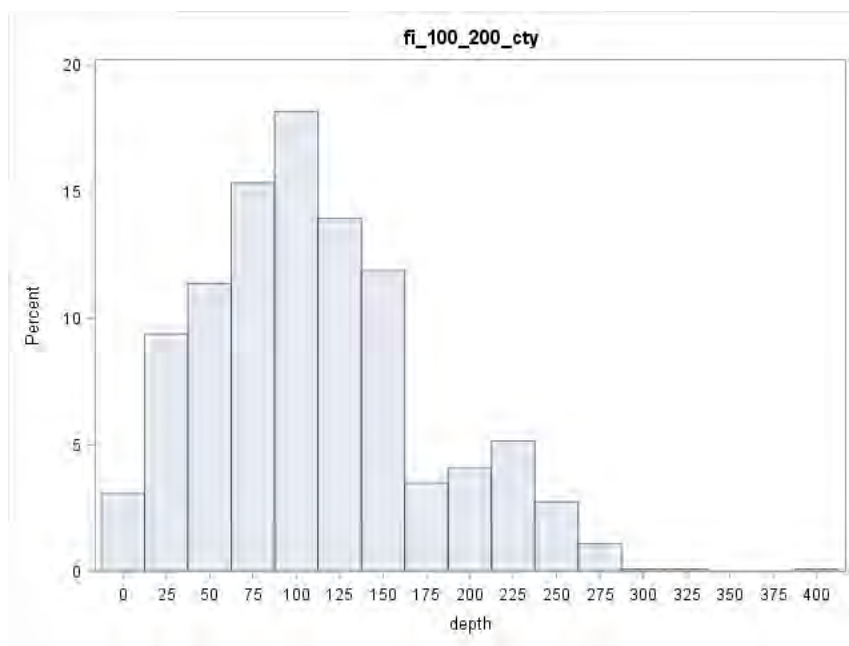
The adjustments for flood depth and estimation of contribution to regional GDP are estimated by the CBE and are described in Appendix 1. The employment and sales estimates are derived from the InfoUSA database; Appendix 2 describes the Info USA methodology.

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[11] GDP differs from sales in that sales represents gross revenues to a firm, while contribution to GDP is a measure of value added, that is, the difference between a firm's gross sales and the cost of inputs to the production of the good or service. GDP is primarily comprised of the value of labor, returns to the owners, and certain tax adjustments. GDP allows the unique contributions of each firm to be measured without double counting the sales of one firm that are the purchases of another.

	N Establishments	Employment	Sales ($Millions)	GDP ($Millions)	Depth Weighted Employment	Depth Weighted Sales ($Millions)	Depth Weighted GDP ($Millions)
1 yr storm – 0m SLR	82	1,005	$119.70	$186.20	95	$5.10	$22.40
1 yr storm – 1m SLR	230	7,644	$950.00	$1,143.60	919	$57.40	$105.10
1 yr storm – 2m SLR	1,838	32,703	$5,565.60	$4,254.00	4,808	$616.10	$622.60
100 yr storm – 0m SLR	215	2,298	$224.00	$351.00	310	$26.30	$70.70
100 yr storm – 1m SLR	826	14,977	$2,040.30	$2,022.50	1,631	$191.80	$263.10
100 yr storm – 2m SLR	2,656	49,700	$8,015.30	$6,092.10	6,731	$1,024.70	$805.20

As would be expected, sea level rise significantly increases the economic vulnerabilities in the region. With 1 meter (39.7") of sea level rise the level of vulnerable employment increases by more than 700% (1,000 to 7,600); an additional 1 meter of sea level more than quadruples the exposure to over 32,000 jobs. Storm intensity (1-year v. 100 year) doubles the employment vulnerability with 1 meter of sea level rise (15,000 v. 7,600). At 2 meters, the difference in storm intensity increases the employment vulnerability by 50% (49,000 v. 32,000). This indicates that the largest employment vulnerabilities are associated with the larger sea level rise, but the increase in vulnerability is more rapid due to changes in storm intensity.

The estimates of sales and gross domestic product in Table 1 show vulnerabilities that range from the tens of millions to the billions. Generally, GDP is smaller than total sales, but there are some scenarios where the total GDP exceeds the total sales vulnerability. These discrepancies are partly accounted for by differences in estimating methods, but also reflect the industries that are affected. Some scenarios touch establishments with very high productivity where a small number of employees produce significant value added. The industrial detail of the impacts is discussed in more detail below.

Table 1 also compares the impacts adjusted for depth and unadjusted for depth. The adjustment for depth is calculated as a weight applied to the economic measure. The weight discounts the economic measure by the depth estimated by the CoSMoS model at each specific location. Those establishments which are subject to the least depth in each scenario are discounted the most. Those establishments subject to maximum flooding estimate are not discounted. The weighted values are substantially smaller than the unadjusted estimates which reflects the fact that flood depth will vary across the region; relatively few establishments are subject to the greatest flood depths, as noted below.

Flooding Scenarios and Vulnerability

The flood-adjusted weighted estimates of vulnerability should not be interpreted as precise estimates as their values are determined by the weighting process, which is somewhat arbitrary. Other weighting approaches would produce other results. But the adjustment for depth is important because of the variability in depth across the region. Those depths for each scenario are shown in Table 2, which indicates the number of employment establishments identified as vulnerable, or within one of the flood zones of a modeled scenario.

Table 2 CoSMoS Flood Depth Estimates by Scenario

	N Establishments	Centimeters			Feet		
		Mean Depth	Max Depth	STD Depth	Mean Depth	Max Depth	STD Depth
1 yr storm – 0m SLR	82	24.6	197	27.7	0.8	6.5	0.9
1 yr storm – 1m SLR	230	48.4	196	31.4	1.6	6.4	1
1 yr storm – 2m SLR	1,838	79	233	57.4	2.6	7.6	1.9
100 yr storm – 0m SLR	215	53	239	39.5	1.7	7.8	1.3
100 yr storm – 1m SLR	826	65.5	238	47.7	2.1	7.8	1.6
100 yr storm – 2m SLR	2,656	109.4	400	62.8	3.6	13.1	2.1

The mean depths of the sea level rise scenarios vary from 1.6 feet in the 1-year storm/1-meter sea level rise to over 3.6 feet in the 100-year storm - 2-meter scenario. These mean depths suggest that flooding when it occurs will be significantly disruptive, but also lie within the range where modifications to structures and sites may reduce damages. Recovery from flooding should also be possible for many locations at levels that lie within insurance coverage. But the upper range of flood depths of between 7 and 13 feet in the 100-year storm/2-meter scenarios will present significant issues of adaptation and recovery.

Figure 13 compares the extent of projected flooding with the 1- and 2-meter CoSMoS model estimates with the variability in depth across the southern part of San Diego County,

the portion of the county that will experience the greatest impacts. The columns indicate the projected flood depths at each employment establishment; the height of the column is exaggerated to make the differences in flood depths visible in the illustration.

Figure 12 CoSMoS 100-year flood scenarios and flood depth (blue) – Southern San Diego County
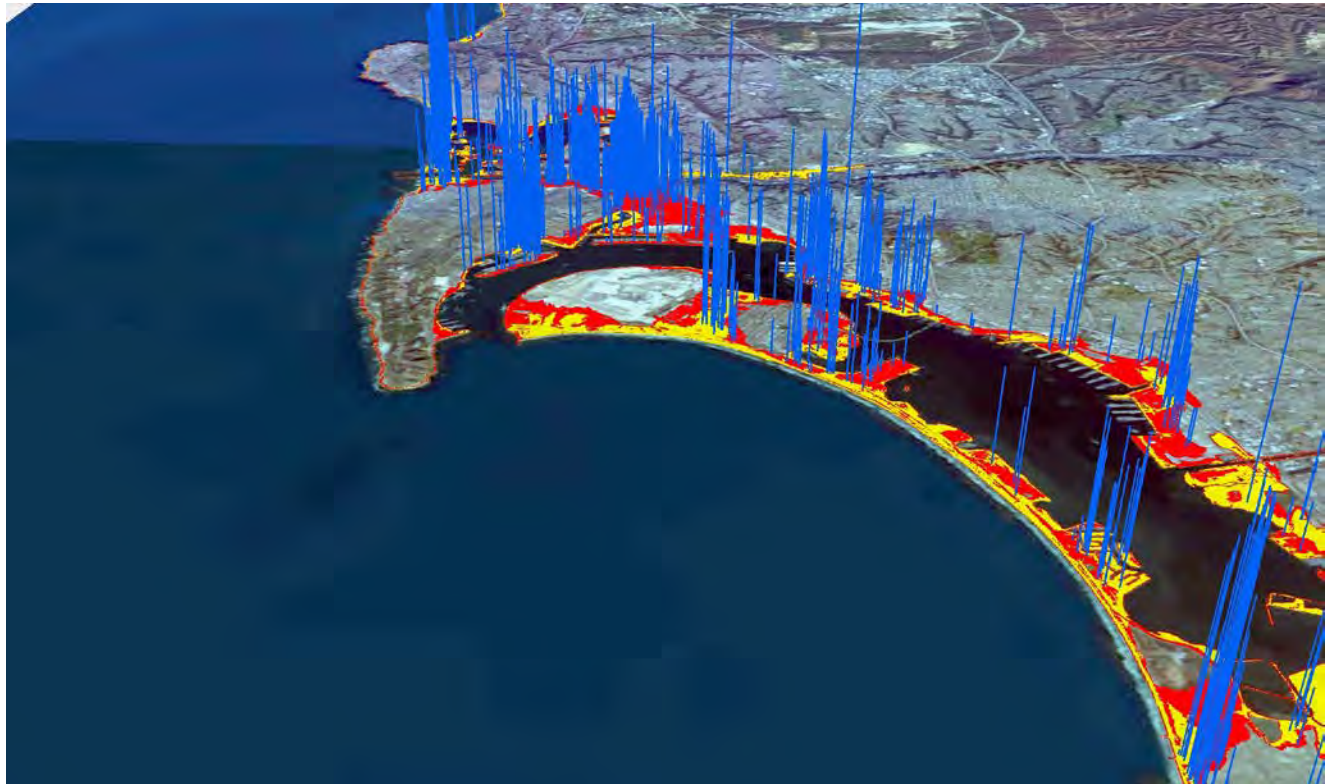
Extensive flooding is also projected on the northern tip of Coronado Island and in the area of southern San Diego near Naval Base San Diego. These two areas are predominantly used by the Navy and Marine Corps and impacts are likely to be significant. However, detailed analysis of the impacts on military property are outside the scope of this study as they require access to information that is not fully publicly available.

Employment Vulnerabilities

Employment in this study is estimated as full- and part-time employment. Figure 14 maps employment locations by size relative to the projected flood plains under both sea level rise scenarios. Larger employers tend to be concentrated around the periphery of San Diego Bay, while smaller employers are especially clustered around La Playa, and along the shoreline of Mission Bay and Pacific Beach.

Figure 13 Employment at industry location.
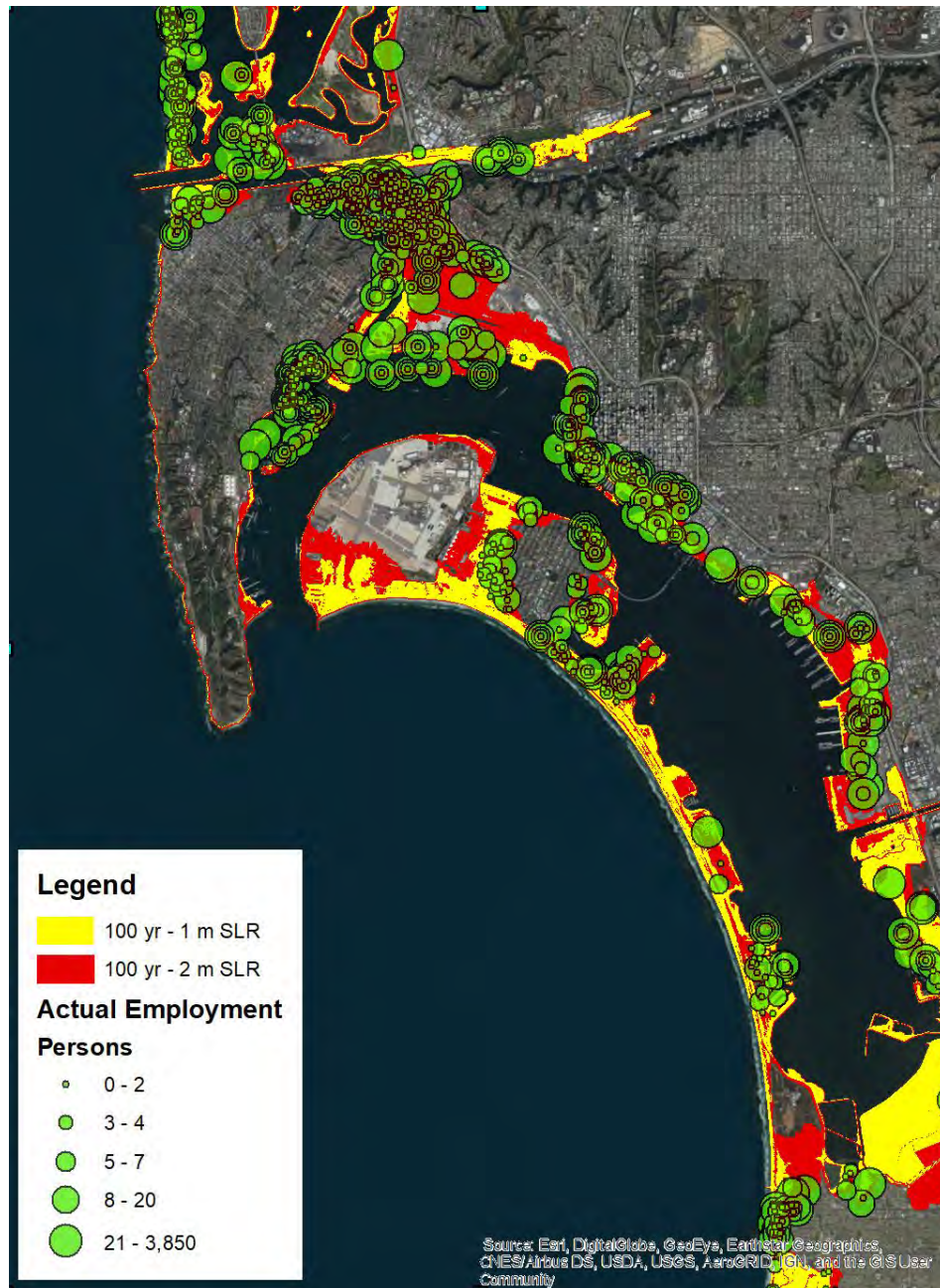
Table 3 Impacts to employment in each of the modeled scenario.

Scenario	Employment	Depth-Adjusted (Weighted) Employment	Depth Adjusted as Percent of Max Employment
1 yr storm – 0m SLR	1,005	95	9%
1 yr storm – 1m SLR	7,644	919	12%
1 yr storm – 2m SLR	32,703	4,808	15%
100 yr storm – 0m SLR	2,298	310	13%
100 yr storm – 1m SLR	14,977	1,631	11%
100 yr storm – 2m SLR	49,700	6,731	14%

Table 3 focuses on the employment estimates of vulnerability across the county. The maximum job vulnerabilities are quite significant in the 2 meter sea level rise scenario under both storm intensities, but these are over-statements. Adjusting for depth yields employment vulnerabilities that are between 10% and 15% of the maximum possible levels. As discussed earlier, these are highly approximate numbers. It is probable that actual vulnerabilities range between 10% and 25% of maximum depending on actual storm intensities. This would still leave vulnerabilities up to 10,000 jobs.

Sales Vulnerabilities

Sales are estimated for individual establishments by InfoUSA, using the methods described in Appendix 2. These are approximations based on industry-level data since sales for individual companies and establishments are confidential. Sales are annual estimates, and so the gross estimates overstate the actual vulnerability estimates, which are more likely to be temporary.

Table 4 Estimated Sales Vulnerabilities by Scenario

Scenario	Annual Sales Values ($Millions)	Depth-Adjusted Annual Sales Values ($Millions)	Daily Sales ($Millions)	Daily Depth-Adjusted Sales ($Millions)
1 yr storm - 0m SLR	$119.7	$5.1	$0.40	$0.02
1 yr storm - 1m SLR	$950.0	$57.4	$3.17	$0.19
1 yr storm - 2m SLR	$5,565.6	$616.1	$18.55	$2.05
100 yr storm - 0m SLR	$224.0	$26.3	$0.75	$0.09
100 yr storm - 1m SLR	$2,040.3	$191.8	$6.80	$0.64
100 yr storm - 2m SLR	$8,015.3	$1,024.7	$26.72	$3.42

To reflect the temporary nature of sales interruptions from storms and flooding, an average daily loss in sales is calculated by dividing the annual sales values in vulnerable properties by 300, as an approximation of the number of days open across all industries and all years (Table 4).   The losses are minor at zero sea level rise levels but increase with sea level rise. Unadjusted for depth, daily sales losses are $18 to $27 million in the 2-meter sea level rise scenario. Adjusted for depth, the losses range from about $200 thousand ($0.19 million) to $640,000 ($0.64 million) in the 1-meter scenario. In the 2-meter scenario the depth adjusted losses range from $2 million to $3.4 million.

It is important to remember that these estimated daily values are only the starting point for estimating vulnerabilities, since flood damages could last weeks or months. One month of lost sales would range from $5 to $20 million in the 1-meter sea level rise depending on storm. With two meters of sea level rise, one month of lost depth-adjusted sales would range from $62 million to $102 million.

Vulnerabilities to Gross Domestic Product

Table 5 Gross Domestic Product Vulnerabilities by Scenario

Scenario	Annual GDP ($ Millions)	Depth-Adjusted Annual GDP ($ Millions)	Daily GDP ($ Millions)	Daily Depth-Adjusted GDP ($ Millions)
1 yr storm - 0m SLR	$186.20	$22.40	$0.62	$0.07
1 yr storm - 1m SLR	$1,143.60	$105.10	$3.81	$0.35
1 yr storm - 2m SLR	$4,254.00	$622.60	$14.18	$2.08
100 yr storm - 0m SLR	$351.00	$70.70	$1.17	$0.24
100 yr storm - 1m SLR	$2,022.50	$263.10	$6.74	$0.88
100 yr storm - 2m SLR	$6,092.10	$805.20	$20.31	$2.68

Gross domestic product vulnerabilities range from about $1 to $2 billion in non-depth adjusted annual values for 1 meter in sea level rise to $4.2 to $6.1 billion with 2 meters. Depth-adjusted annual values range from $100 million to $260 million in the 1-meter scenario and from $622 million to $805 million in the 2-meter scenario. As with sales, these annual values are useful for comparing across scenarios, but do not reflect the actual effects from flooding. Table 5 thus also shows daily GDP values calculated in the same manner as the daily sales values above. As with sales, these daily values are multiplied by the number of days of a flood/recovery event.

At over $210 billion in 2016 ($701 million per day), the San Diego County GDP would be dented by the losses associated with flooding and sea level rise on an individual event basis, depending on the length and seriousness of the event but individual events will have small proportional effects on GDP. But it is not the individual events, but their cumulative effects over time that will matter.

Vulnerabilities by Industry

The economic impacts summarized above can be disaggregated by industry to examine which parts of the San Diego economy are most likely to be vulnerable. Using the North American Industrial Classification System (NAICS), each establishment is assigned to one of 82 industries.[12] Appendix 3 provides the industrial detail of possible economic impacts for the seven flood scenarios. The number of industries affected varies by scenario, as shown in Figure 15. The number of industries that are represented increases from 15 to 46 in the 1-year storm scenario and from 22 to 50 in the 100-year storm scenario depending on the sea level rise scenario.

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[12] The industries correspond with the industrial groupings used by the Bureau of Economic Analysis for Gross Domestic Product data.

Figure 14 Number of industries in flood scenarios
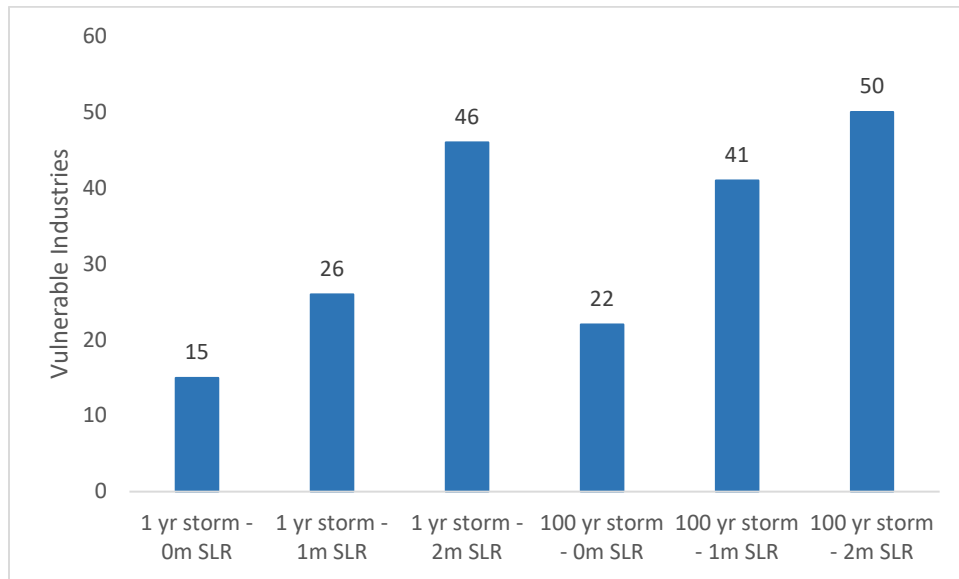
Table 6 shows the fifteen largest industries by depth-adjusted (weighted) employment vulnerability in the 100-year storm scenarios for 1-meter sea level rise scenario, and the estimated vulnerabilities measured by annual sales and contribution to GDP. (The annual figures for sales and GDP are meant to illustrate size only; actual vulnerabilities will depend on daily values and the length of damages and recovery.) These top 15 industries account for 93% of total depth-adjusted employment and sales vulnerabilities and 96% of GDP vulnerabilities. The most vulnerable industries vary by economic measure. Accommodation, retail trade, and food services rank high on all measures. When combined with other tourism and recreation-related industries like Amusements and Performing Arts, this sector comprises 57% of the top 15 employment vulnerabilities, 35% of sales vulnerabilities and 17% of total GDP vulnerability (36% of industries excluding Real Estate). Other key industries in terms of vulnerability:

- Real Estate, where the large GDP vulnerability reflects the high property values in the coastal areas of San Diego County.

- Other Transportation Equipment, which ranks 3rd in employment, 5th in sales, and 2nd in GDP, is the ship and boat building industry.

- Administrative Services and Professional & Technical Services, which are comprised of a variety of "office" industries rank in the middle to upper half of the ranges.

Employment		Sales ($Millions)		GDP ($Millions)	
Food services and drinking places	415	Accommodation	$30.13	Real estate	$139.44
Accommodation	257	Retail trade	$26.00	Other transportation equipment manufacturing	$27.33
Other transportation equipment manufacturing	186	Wholesale trade	$24.85	Accommodation	$19.21
Administrative and support services	135	Food services and drinking places	$23.64	Food services and drinking places	$14.93
Retail trade	107	Other transportation equipment manufacturing	$23.48	Administrative and support services	$9.68
Government	87	Real estate	$15.02	Retail trade	$8.04
Real estate	76	Amusements, gambling, and recreation industries	$7.16	Rental and leasing services and lessors of intangible assets	$6.96
Amusements, gambling, and recreation industries	48	Administrative and support services	$6.34	Professional and Technical Services	$6.55
Professional and Technical Services	39	Professional and Technical Services	$5.32	Performing arts, spectator sports, museums, and related activities	$4.86
Other services, except government	39	Construction	$4.68	Wholesale trade	$3.36
Performing arts, spectator sports, museums, and related activities	30	Ambulatory health care services	$2.98	Other services, except government	$3.31
Educational services	27	Other transportation and support activities	$2.90	Construction	$2.77
Construction	25	Transit and ground passenger transportation	$2.16	Amusements, gambling, and recreation industries	$2.35
Transit and ground passenger transportation	22	Publishing industries, except Internet (includes software)	$2.00	Transit and ground passenger transportation	$2.01
Other transportation and support activities	20	Rental and leasing services and lessors of intangible assets	$1.84	Educational services	$1.85

Vulnerability estimates for all industries and scenarios are provided in Appendix 3.

A key issue in assessing the regional economic vulnerabilities is understanding the role of most vulnerable industries in the San Diego County economy. A simple measure of the economic importance of industries is the location quotient, which is simply the ratio of an industry's proportion of employment in San Diego to the proportion of employment of that industry in the U.S. If this ratio is over 1, the industry plays a larger role in the San Diego County economy and is assumed to attract spending from outside the county. These industries have higher "multiplier" effects; changes in these industries have disproportionate effects on the regional economy. A ratio of less than 1 is assumed to be an industry that serves local markets primarily.   Table 7 takes the industries listed in

Table 6 and shows the location quotient for each.   These are calculated from Bureau of Labor Statistics data.

Table 7 Indicators of Economic Importance of Most Vulnerable Industries

Industry	Location Quotient
Construction	0.74
Other transportation equipment manufacturing	5.34
Wholesale trade	0.76
Retail trade	1.03
Other transportation and support activities	0.72
Transit and ground passenger transportation	0.77
Publishing industries, except Internet (includes software)	0.96
Real estate	1.34
Rental and leasing services and lessors of intangible assets	1.06
Professional and Technical Services	3.60
Administrative and support services	2.38
Educational services	1.01
Ambulatory health care services	1.80
Amusements, gambling, and recreation industries	3.06
Performing arts, spectator sports, museums, and related activities	1.29
Accommodation	3.70
Food services and drinking places	1.22
Other services, except government	0.45
Government	0.94

Industries with high vulnerabilities and high location quotients include other transportation equipment manufacturing (ship and boat building); professional and technical services; administrative and support services, and several tourism related industries, notably accommodation and amusements & recreation services.

Vulnerabilities by City

The analysis so far has focused at the county level as a whole, but the economic vulnerabilities within San Diego County vary greatly with geography. Table 8 shows the economic vulnerability estimates by city. In this table, the data are shown for each scenario that affects a particular city, which for most of the cities are only the scenarios that include sea level rise. Only three cities (Chula Vista, Oceanside, and San Diego) show vulnerability in all scenarios.

Industry located within the City of San Diego accounts for the greatest share of vulnerabilities, with commercial and industrial properties in the City (including the Port District) accounting for 75% or more of estimated vulnerability on each of the measures. Industry in the City has by far the largest potential vulnerabilities to storm impacts as evidenced by the no-sea level-rise and 100–meter scenarios combined with storms scenarios. This is certainly in part because San Diego is the largest city in the County and its jurisdiction for the purpose of this analysis includes the Port of San Diego and San Diego International Airport, which includes a significant part of the region's industrial economy which is located near the shoreline. Specific details on the Port District of San Diego can be found on page 40. The large presence of hotels and restaurants in the industrial distribution of vulnerabilities is consistent with the large role of these industries in the City of San Diego.

After San Diego, the largest vulnerabilities are in Chula Vista and Coronado by the size of economic vulnerabilities in the 2-meter scenarios. The vulnerabilities outside of the City of San Diego are relatively small even on an unweighted basis. As sea level rise approaches 2 meters, most of the cities see a significant increase in flooding vulnerability; though some cities such as Imperial Beach, Oceanside, and Carlsbad show relatively high vulnerabilities in both the 1 meter and 2-meter scenarios.

Table 8 Economic vulnerabilities by city and flood scenario.

CITY	Scenario	No. of Employ-ees	Annual Sales ($Millions)	Annual GDP ($Millions)	Depth-adjusted Employment	Depth-Adjusted Sales ($Millions)	Depth-Adjusted GDP ($Millions)	No. of Estabs.
Carlsbad	1 yr storm - 2m SLR	90	$68.30	$39.41	8	$7.69	$3.16	2
	100 yr storm - 2m SLR	90	$68.30	$39.41	10	$9.51	$3.69	2
Chula Vista	1 yr storm - 0mm SLR	50	$20.16	$9.27	2	$0.31	$0.41	2
	1 yr storm - 1m SLR	4919	$679.37	$735.60	547	$26.49	$28.63	7
	1 yr storm - 2m SLR	5092	$737.34	$759.51	692	$61.24	$57.87	36
	100 yr storm - 0m SLR	36	$0.80	$15.86	8	$0.05	$1.95	2
	100 yr storm - 1m SLR	68	$23.94	$21.19	23	$5.67	$4.50	6
	100 yr storm - 2m SLR	5219	$776.19	$774.96	792	$68.77	$64.34	48

CITY	Scenario	No. of Employ-ees	Annual Sales ($Millions)	Annual GDP ($Millions)	Depth-adjusted Employment	Depth-Adjusted Sales ($Millions)	Depth-Adjusted GDP ($Millions)	No. of Estabs.
	Flooding_100 yr storm - FEMA Flood Zone	30	$0.00	$4.87	5	$0.00	$0.80	1
Coronado	1 yr storm - 1m SLR	29	$8.00	$11.12	5	$1.82	$0.41	5
	1 yr storm - 2m SLR	1637	$147.43	$255.22	235	$20.29	$34.00	122
	100 yr storm - 1m SLR	629	$37.86	$134.08	67	$7.37	$16.07	60
	100 yr storm - 2m SLR	2328	$173.29	$372.41	262	$22.01	$39.56	167
	Flooding_100 yr storm - FEMA Flood Zone	52	$6.46	$84.48	12	$1.16	$11.59	6
Del Mar	1 yr storm - 1m SLR	27	$4.18	$2.22	1	$0.13	$0.07	5
	1 yr storm - 2m SLR	791	$60.91	$71.03	63	$7.13	$7.33	44
	100 yr storm - 0m SLR	243	$22.89	$14.44	23	$2.05	$1.78	15
	100 yr storm - 1m SLR	91	$18.32	$10.75	18	$2.48	$2.15	15
	100 yr storm - 2m SLR	1021	$82.45	$95.52	88	$9.33	$10.05	61
Imperial Beach	1 yr storm - 1m SLR	9	$2.09	$0.90	1	$0.21	$0.10	3
	1 yr storm - 2m SLR	440	$58.14	$73.73	66	$7.19	$9.36	45
	100 yr storm - 0m SLR	2	$0.37	$0.59	0	$0.03	$0.05	2
	100 yr storm - 1m SLR	438	$44.09	$69.86	44	$4.44	$5.50	35
	100 yr storm - 2m SLR	697	$75.43	$123.04	141	$16.53	$20.94	72
National City	1 yr storm - 2m SLR	857	$241.78	$98.57	154	$29.55	$17.04	38
	100 yr storm - 1m SLR	495	$151.26	$46.05	46	$9.80	$4.46	19

CITY	Scenario	No. of Employ-ees	Annual Sales ($Millions)	Annual GDP ($Millions)	Depth-adjusted Employment	Depth-Adjusted Sales ($Millions)	Depth-Adjusted GDP ($Millions)	No. of Estabs.
	100 yr storm - 2m SLR	1078	$309.50	$120.79	168	$32.75	$19.47	49
Oceanside	1 yr storm - 0m SLR	63	$3.75	$3.63	11	$0.66	$0.72	9
	1 yr storm - 1m SLR	181	$12.68	$8.13	43	$2.72	$2.12	15
	1 yr storm - 2m SLR	291	$16.96	$16.04	80	$4.33	$3.55	24
	100 yr storm - 0m SLR	120	$9.40	$6.15	26	$1.84	$1.31	14
	100 yr storm - 1m SLR	271	$13.78	$9.00	48	$2.19	$1.51	19
	100 yr storm - 2m SLR	313	$20.50	$25.17	86	$4.54	$5.01	34
	100 yr storm - FEMA Flood Zone	80	$0.00		13	$0.00		1
San Diego City	1 yr storm - 0m SLR	880	$91.99	$173.26	82	$4.06	$21.27	61
	1 yr storm - 1m SLR	2454	$237.25	$385.07	317	$24.57	$73.76	171
	1 yr storm - 2m SLR	23256	$4,159.34	$2,937.68	3467	$470.14	$489.50	1390
	100 yr storm - 0m SLR	1865	$183.77	$312.54	246	$21.13	$65.32	162
	100 yr storm - 1m SLR	12908	$1,736.69	$1,730.00	1367	$156.45	$228.53	610
	100 yr storm - 2m SLR	38611	$6,395.13	$4,532.15	5133	$846.83	$640.92	2008
	100 yr storm - FEMA Flood Zone	4590	$565.50	$747.63	221	$26.10	$42.26	73
Solana Beach	100 yr storm - 2m SLR	9	$1.64	$4.29	1	$0.13	$0.33	1

Special Note: The Port of San Diego

The San Diego Unified Port District (Port District) is a special jurisdiction within San Diego County. The Port District includes 5,480 acres (8.25 square miles or 22.2 square kilometers) spanning five cities: San Diego, National City, Chula Vista, Coronado, and Imperial Beach. The Port District's jurisdiction is comprised of tidelands, submerged lands, and uplands that were assigned to the Port District by state statute. (Figure 16)
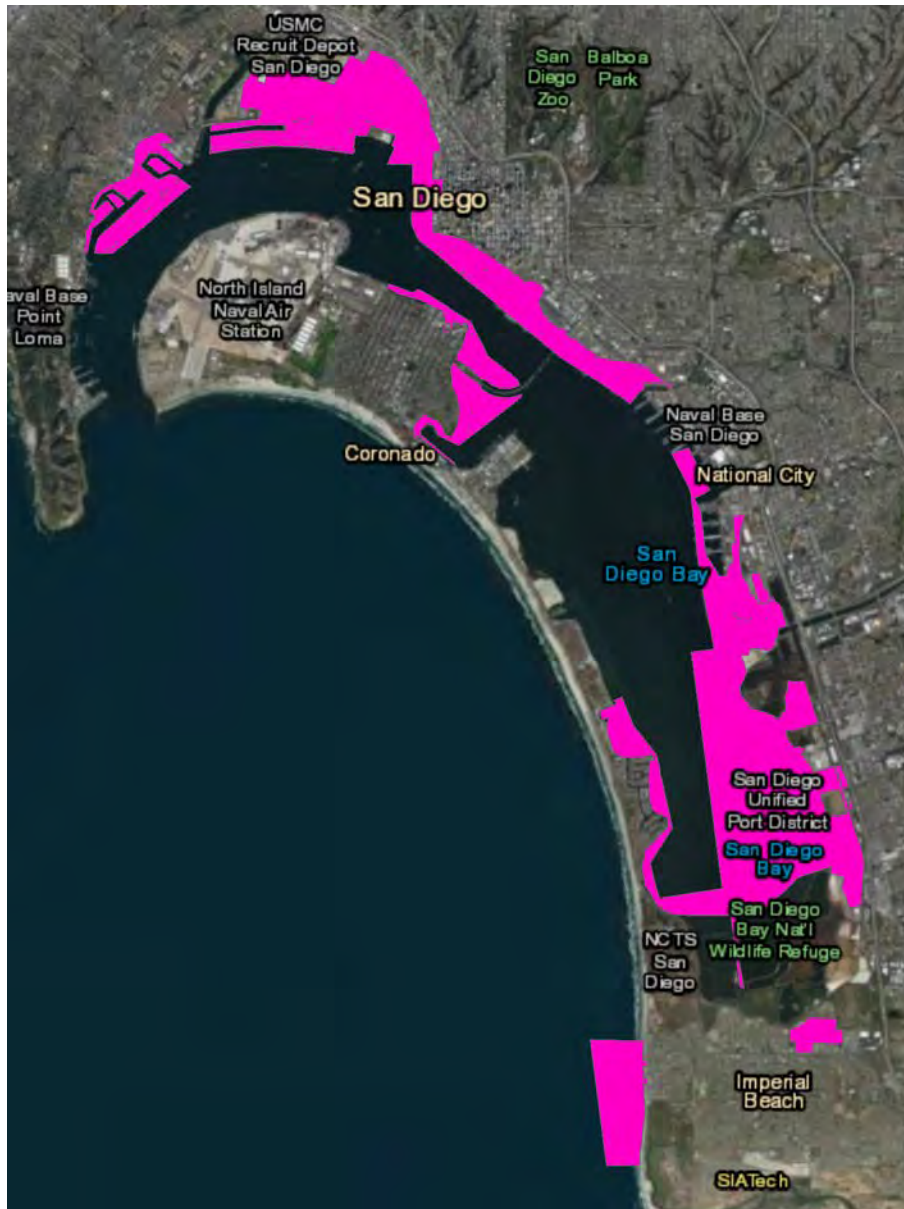
Figure 15 Lands of the Unified Port District of San Diego
Note: Port District Shown in Magenta

The large area encompassed by the Port District includes a diverse array of businesses in addition to the core operations of the port itself. The vulnerability analysis indicates that the 1 meter 100-year storm scenario leaves 165 establishments with 7,682 employees vulnerable. The 2-meter scenario and 100-year scenario leaves 405 establishments with 15,036 employees vulnerable.

Vulnerabilities Measured by Commercial Property Values

The analysis of employment, sales, and GDP vulnerabilities discussed in the previous section provides one perspective on the possible impacts of sea level rise. Another is to examine the effects on buildings and equipment in commercial and industrial properties in the property tax assessment database for San Diego County. This additional perspective addresses concerns about possible changes in property tax revenues for local governments and allows a cross check on the results of using the Info USA establishment-level data.

For this analysis, the same basic process was used to analyze the parcel data as was used in the establishment data. The CoSMoS scenarios were intersected with the parcel data. To provide a context within which the commercial & industrial parcels can be understood, the analysis includes all parcels and land uses is included, with a separate analysis of commercial and industrial-zoned parcels.

Table 9 shows the physical dimensions of the flood data for each of the CoSMoS scenarios and the FEMA flood plain. The general patterns of risks in terms of the number of parcels affected and the patterns of flooding relative to storm frequency and sea level rise similar to those in the establishment analysis, with significantly larger possible effects if sea level rises beyond 1 meter (3.3 feet) and 2 meters (6.6 feet).

Table 10 shows the assessed value of all parcels under each of the flooding scenarios. The results are divided into land, improvements and total value. Both depth-adjusted and unadjusted vulnerabilities are shown. The depth adjustments are calculated for the parcel data in each scenario in the same manner as the establishment data (See Appendix 1).

The vulnerabilities for all parcels are quite large, with $11.4 billion of non-depth adjusted real estate value in the 100-year storm/2-meter scenario at potential risk. Even when adjustments are applied, the resulting risk is still in excess of $2.4 billion in total valuation. The more appropriate measure of flooding vulnerability is the risk to structures, measured as "improvements" in the tax assessment data. The depth adjusted vulnerabilities for structures on all parcels range from $480 to $980 million.

Table 9 Property vulnerabilities by Scenario- San Diego County

Scenario	N All Parcels/ C&I Parcels	Centimeters			Feet		
		Mean Depth	Max Depth	Standard Deviation Depth	Mean Depth	Max Depth	Standard Deviation Depth
1 yr storm – 0m SLR	3,645/ 387	52	469	43	1.7	15.4	1.4
1 yr storm – 1m SLR	6,387/ 698	71	458	51	2.3	15	1.7
1 yr storm – 2m SLR	9,345/ 1,505	105	499	69	3.4	16.4	2.3
100 yr storm – 0m SLR	2,641/ 274	69	453	89	2.3	14.9	2.9
100 yr storm – 1m SLR	2,233/ 253	32	169	35	1.1	5.5	1.2
100 yr storm – 2m SLR	3,276/ 381	53	293	39	1.7	9.6	1.3

The commercial and industrial (C&I) parcel data in Table 10 follows the same basic patterns with respect to storms and sea levels, but the effects on C&I are disproportionately larger in all scenarios. Across all scenarios, the number of C&I parcels average about 12% of the parcels defined as vulnerable but comprise an average of 56% of the improvements valuation potentially affected.

The land is assumed to be unaffected in the long term as in many cases there will be rebuilding of previous uses so that the land retains its value. But this may not be true for some parcels subject to repeated flooding in the higher sea level rise scenarios. In this case the land may be permanently abandoned and kept in vacant status with little potential for development. This analysis is at too coarse a scale to identify these.

Table 10 Assessed value ($Millions) vulnerabilities by scenario for All Parcels and Commercial/Industrial Parcels: San Diego County

	Land	Improvements	Total	Depth-adjusted Land	Depth-adjusted Improvements	Depth-adjusted Totals	Parcels
All Vulnerable Parcels							
1 yr storm – 0m SLR	$2,361.7	$1,686.1	$4,047.8	$627.8	$485.8	$1,113.6	2,223
1 yr storm – 1m SLR	$3,250.0	$1,908.9	$5,158.9	$752.5	$551.5	$1,304.0	2,641
1 yr storm – 2m SLR	$3,692.8	$2,863.7	$6,556.5	$666.6	$480.7	$1,147.2	3,726
100 yr storm – 0m SLR	$3,681.8	$2,591.6	$6,273.4	$436.5	$323.7	$760.2	3,645
100 yr storm –	$5,737.1	$3,831.9	$9,568.9	$857.1	$523.4	$1,380.5	6,397

	Land	Improvements	Total	Depth-adjusted Land	Depth-adjusted Improvements	Depth-adjusted Totals	Parcels
1m SLR							
100 yr storm – 2m SLR	$7,692.1	$5,185.4	$12,877.4	$1,614.6	$979.2	$2,593.8	9,537
Total- Commercial & Industrial Parcels							
1 yr storm – 0m SLR	$594.6	$940.0	$1,534.6	$163.6	$298.9	$462.6	253
1 yr storm – 1m SLR	$618.1	$987.5	$1,605.6	$202.2	$353.7	$555.9	274
1 yr storm – 2m SLR	$947.4	$1,570.2	$2,517.5	$160.1	$283.0	$443.1	381
100 yr storm – 0m SLR	$926.3	$1,502.7	$2,429.0	$108.1	$197.8	$305.9	387
100 yr storm – 1m SLR	$1,209.9	$1,888.9	$3,098.8	$138.3	$240.0	$378.3	698
100 yr storm – 2m SLR	$2,027.7	$2,564.9	$4,592.6	$318.1	$421.8	$740.0	1,505

The commercial and industrial parcels can be further divided using the detailed land use zone in the San Diego County property database. There are 56 distinct C&I land use designations in this taxonomy. For simplicity of presentation, the ten largest categories by total assessed value designated as vulnerable in each of the scenarios are shown in

Table 11. Consistent with the establishment-based analysis, hotels and motels rank first in vulnerable assessed value in all scenarios. This includes both the category hotel/motel and resort hotel. Restaurants (Generic Restaurant/Nightclub/Tavern along with Restaurant-Independent) are also found in all the scenarios. The retail and office-related industries are represented in several categories in each of the scenarios, with regional shopping centers ranked second in all sea level rise scenarios.

One category that appears in the parcel analysis that does not appear in the establishment analysis is vacant commercial land, which ranks in the top five by value in each of the scenarios. This vacant land poses an important planning challenge. The normal expectation is that owners and economic developers will look at this land as an important opportunity for the region. But adding significant improvements to this land will increase the flood-vulnerable assets in the region. At the same time, development of these parcels may offer the opportunity to incorporate various floodproofing strategies into the developments. Figure 17 shows the vulnerable assessed values for commercial, industrial, and all properties for each of the coastal cities. As would be expected, the city of San Diego has the largest values at risk under all scenarios. Across all scenarios, San Diego City counts for an average of 54% of the depth adjusted C&I improvements valuation at risk (61% of unadjusted valuation) In commercially-zoned property, Coronado may be considered the most vulnerable city to sea level rise under both storm scenarios given the growth in vulnerable valuation as sea level rise increases in the 1-year storm and the high valuation in all 100-year storm scenarios.

Table 11 Top Ten Commercial & Industrial C&I Property Value Vulnerabilities by Scenario ($ Millions)

1 yr storm – 0m SLR		1 yr storm – 1m SLR		1 yr storm – 2m SLR	
Total C&I	**$1,534.60**	**Total C&I**	**$2,517.51**	**Total C&I**	**$3,967.73**
Hotel/Motel	$778.30	Hotel/Motel	$1,491.52	Hotel/Motel	$1,810.39
Regional Shopping Center	$452.22	Regional Shopping Center	$452.22	Regional Shopping Center	$452.22
Generic-Radio Station /Bank/Misc.	$52.22	Generic Commercial Office/Retail 1-3 Stories	$109.84	Generic Commercial Office/Retail 1-3 Stories	$319.93
Generic-Restaurant/Night Club/Tavern	$46.25	Factory/Heavy Manufacturing	$92.22	Vacant Land Commercial	$127.79
Commercial Office/Retail 1-3 Stories	$52.29	Vacant Land Commercial	$72.29	Community Shopping Center	$108.19
Vacant Land Commercial	$40.14	Resort Hotel	$71.44	Warehouse-Processing/ Storage/Distribution	$102.02
Generic-4 And More Story Office Building	$35.54	Generic-Radio Station /Bank/Misc.	$52.22	Generic-Restaurant/Night Club/Tavern	$98.53
Factory/Heavy Manufacturing	$31.06	Generic-Restaurant/Night Club/Tavern	$50.75	Factory/Heavy Manufacturing	$92.22
Misc. Industrial/ Special Land	$8.59	Generic-4 And More Story Office Building	$35.54	Generic-Radio Station /Bank/Misc.	$79.60
Restaurant-Independent	$7.64	Combination Commercial/Residential Building	$12.37	Neighborhood Shopping Center	$77.84

100 yr storm – 0m SLR		100 yr storm – 1m SLR		100 yr storm – 2m SLR	
Total C&I	**$2,428.96**	**Total C&I**	**$3,098.83**	**Total C&I**	**$4,592.56**
Hotel/Motel	$1,414.44	Hotel/Motel	$1,663.96	Hotel/Motel	$1,919.41
Regional Shopping Center	$484.49	Regional Shopping Center	$484.49	Regional Shopping Center	$484.49
Vacant Land Commercial	$118.57	Vacant Land Commercial	$209.00	Generic Commercial Office/Retail 1-3 Stories	$361.21
Generic-4 And More Story Office Building	$81.87	Generic Commercial Office/Retail 1-3 Stories	$197.16	Vacant Land Commercial	$209.00
Resort Hotel	$71.44	Vacant Land Commercial	$118.57	Community Shopping Center	$141.53
Vacant Land Commercial	$70.47	Warehouse-Processing/Storage/Distribution	$112.66	Combination Commercial/ Residential Bldg	$130.22
Generic Commercial Office/Retail 1-3 Stories	$59.76	Factory/Heavy Manufacturing	$92.22	Warehouse-Processing/Storage/Distribution	$112.66
Generic-Radio Station /Bank/Misc.	$52.22	Resort Hotel	$71.44	Generic-Restaurant/Night Club/Tavern	$108.40
Generic-Restaurant/Night Club/Tavern	$52.07	Generic-Restaurant/Night Club/Tavern	$66.56	Factory/Light Manufacturing	$97.91
Community Shopping Center	$38.55	Vacant Industrial	$66.17	Factory/Heavy Manufacturing	$92.22

Figure 16 Share of C&I Improvement Valuation by City for 100- year storm - 2-meter sea level rise scenario
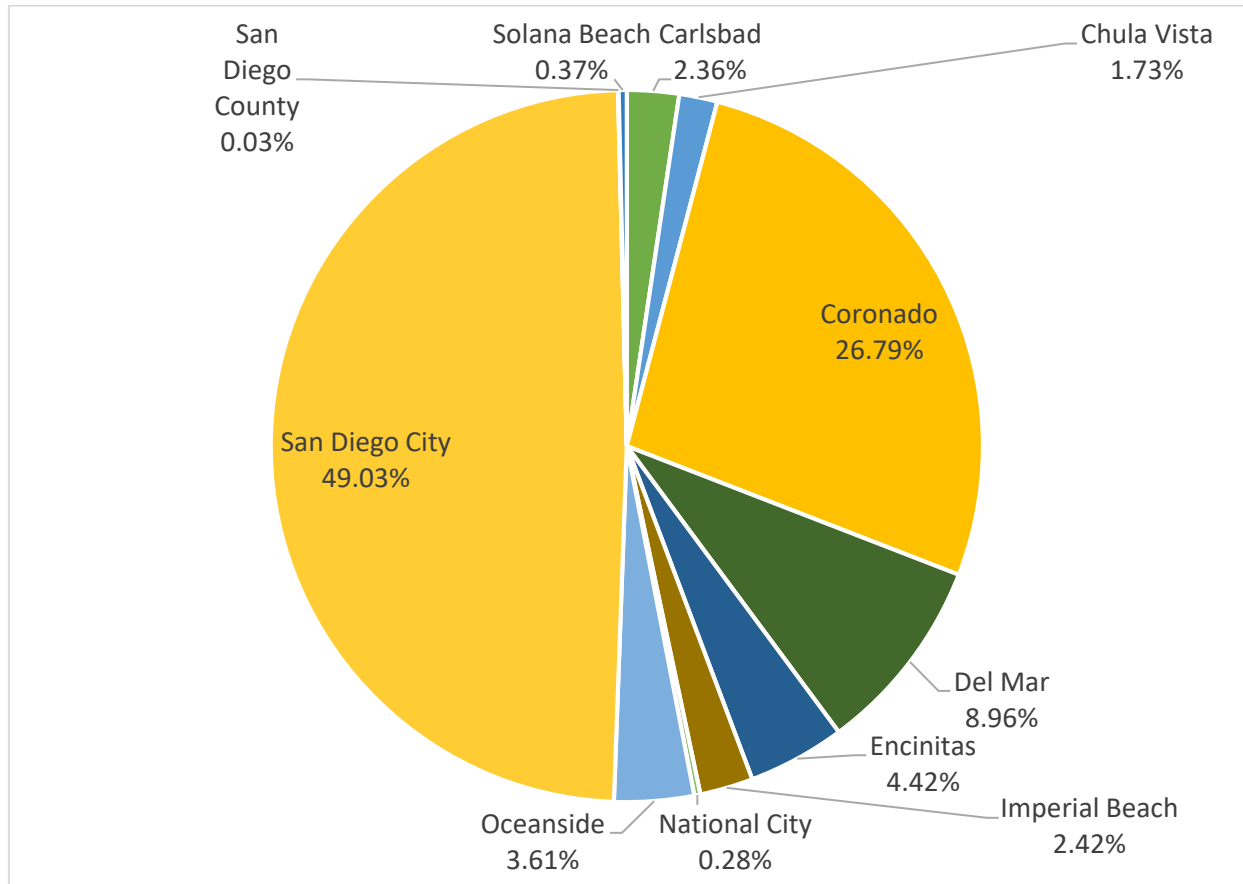
Table 12 Commercial and Industrial Property Vulnerabilities by City and Scenario

	1 yr storm – 0m SLR		1 yr storm – 1m SLR		1 yr storm – 2m SLR	
	Total Value	Depth-Adjusted Value	Total Value	Depth-Adjusted Value	Total Value	Depth-Adjusted Value
Carlsbad	$123.20	$12.83	$188.01	$35.65	$228.31	$51.68
Chula Vista	$38.15	$4.49	$167.09	$42.86	$207.36	$44.40
Coronado	$518.31	$43.69	$1,870.43	$158.59	$2,986.08	$540.54
Del Mar	$169.04	$5.05	$203.58	$52.99	$960.71	$201.05
Encinitas	$276.46	$19.28	$309.90	$81.04	$326.12	$102.64
Imperial Beach	$23.38	$0.84	$72.76	$5.99	$213.76	$30.01
National City	$0.00	$0.00	$0.00	$0.00	$44.21	$5.26
Oceanside	$216.59	$16.80	$296.58	$75.46	$371.30	$77.89
San Diego City	$2,663.66	$381.78	$3,412.75	$714.95	$5,995.24	$1,332.62
San Diego County	$5.05	$0.49	$5.05	$0.64	$5.05	$0.82
Solana Beach	$13.94	$1.27	$30.32	$7.57	$46.30	$13.77
	100 yr storm – 0m SLR		100 yr storm – 1m SLR		100 yr storm – 2m SLR	
	Total Value	Depth-Adjusted Value	Total Value	Depth-Adjusted Value	Total Value	Depth-Adjusted Value
Carlsbad	$153.84	$22.01	$255.79	$41.95	$64.55	$60.52
Chula Vista	$38.15	$3.62	$187.15	$21.47	$141.34	$44.44
Coronado	$1,324.37	$125.07	$2,612.75	$291.29	3,486.48	$686.39
Del Mar	$699.48	$76.63	$929.90	$141.93	$164.23	$229.64
Encinitas	$244.07	$40.74	$289.34	$69.06	$83.24	$113.22
Imperial Beach	$81.74	$7.32	$212.42	$23.75	$191.87	$61.98
National City	$0.00	$0.00	$28.68	$1.36	$24.31	$7.13
Oceanside	$213.13	$39.00	$365.15	$65.06	$104.39	$92.62
San Diego City	$3,489.50	$446.09	$4,684.21	$718.06	$6,688.47	$1,256.16
San Diego County	$5.05	$0.44	$5.05	$0.87	$2.62	$0.80
Solana Beach	$24.07	$5.19	$22.22	$5.29	$3.57	$9.35

Table 13 Property Tax Revenue Vulnerabilities from Depth-Adjusted C&I Property Values ($ Thousands)

	1 yr storm – 0m SLR	1 yr storm – 1m SLR	1 yr storm – 2m SLR	100 yr storm – 0m SLR	100 yr storm – 1m SLR	100 yr storm – 2m SLR
Carlsbad	$136.79	$380.00	$550.83	$234.56	$447.06	$645.03
Chula Vista	$50.80	$484.46	$501.87	$38.58	$242.68	$502.33
Coronado	$466.89	$1,694.84	$5,776.83	$1,332.99	$3,113.05	$7,335.57
Del Mar	$51.80	$543.77	$2,063.26	$816.71	$1,456.52	$2,356.68
Encinitas	$202.02	$849.07	$1,075.27	$434.17	$723.55	$1,186.21
Imperial Beach	$9.58	$68.77	$344.26	$78.01	$272.46	$711.01
National City	$0.00	$0.00	$59.72	$0.00	$15.41	$80.91
Oceanside	$181.68	$816.13	$842.42	$415.70	$703.60	$1,001.63
San Diego City	$4,345.01	$8,136.78	$15,166.40	$4,754.48	$8,172.18	$14,296.27
San Diego County	$7.44	$9.71	$12.35	$4.71	$13.06	$12.00
Solana Beach	$13.05	$77.67	$141.31	$55.29	$54.25	$95.97

Table 13 estimates the property revenues that are vulnerable from the loss of improvements on commercial and industrial properties in each city (including San Diego County). These were calculated by applying the 2017 property tax rate to the depth-adjusted vulnerable valuation. The depth-adjusted valuation was used to reflect, though imperfectly, the proportion of property value that could be lost. The implicit assumption of these estimates is that the property value is reduced in proportion to the depth of flooding. This is obviously inaccurate as it does not account for building structure characteristics, which could reduce or enhance potential damages. Moreover, the losses will in many cases be only temporary and might not affect assessed values if completed by the date of annual assessment. Thus, like other components of the vulnerability analysis, these property tax revenue estimates are not forecasts but indicators of possible magnitudes.

4. Factors Affecting Over- and Under- Estimates of Vulnerability

It is important to reiterate the point that all the figures presented in this report are not forecasts of specific impacts but are indicators of the scale of possible vulnerabilities in the future. In addition to the elements of risk associated with climate change and sea level rise projections, discussed in more detail below, the data and methods of the analysis do not account for factors that may lead to over- or under-estimates of vulnerability.

One key factor is the relationship between the spatial location of the flood hazard estimated by CoSMoS and the measure of economic vulnerability.   Info-USA data points were included in the analysis when a point representing the location of an employer intersected the flood zone defined by the relevant CoSMoS scenario. This is independent of parcel size and shape as well as building size and structural characteristics. This means that employment locations on upper floors were treated as equal to those on the first floor. This is a reasonable assumption in that building equipment is usually located in basements and lower floors and damages to the first floor will affect the whole building, but it may overstate vulnerability in some cases.

Parcels are included if the flood zone touches any part of a parcel. Again, this does not consider the site characteristics of a parcel, what portion of the parcel is developed (relevant to possible flooding) or building characteristics and can result in an overestimate of possible vulnerabilities.

Assessed values for properties may or may not reflect actual market values or replacement values. Assessed values usually lag behind the market to a greater or lesser extent, and market values reflect the property "as is", including depreciation. The actual costs of replacing structures will usually be higher than the market value except for the newest buildings. In this sense, the parcel analysis underestimates the values at risk.

This analysis does not take into account likely or possible future changes in the San Diego economy. The San Diego metro area GDP grew by 32% in real dollars over the past fifteen years, and employment by 18% or over 300,000 jobs. While much of this job growth occurred away from shoreline areas, continued employment and economic growth is likely, meaning that all estimates using present (or recent history) data are likely underestimates of actual risks to be encountered in the future.

This analysis does not factor in adaptation strategies which many of the jurisdictions are currently planning at this time. These strategies could reduce flooding hazards and therefore, the risk to the region's economy.

5. Responding to Climate Risks in the Coastal San Diego County Economy

This analysis presents evidence that there are significant risks to the San Diego regional economy from climate change and sea level rise, but the analysis presents only a partial picture of the nature of those risks. Some flooding hazards may be increases in tidal flooding associated with periodic higher tides ("king tides"), but the major threats will be associated with storms that cannot be predicted with any certainty in time frames longer than about two weeks. Trying to estimate storms and their effects years or decades in the future is not possible. All that can be done at this stage is to note the factors that may increase the frequency and intensity of storms and to couple those factors with expectations about factors determining sea level rise. This (and most similar analyses) use simplifications of the probabilities such as the differences in scenarios between the 1-year (very high probability of occurring each year) and the 100-year storm (very low probability of occurring in any year). Those factors include[13]:

- The rate and extent of climate change, which itself will largely be determined by the extent and effectiveness of global efforts to dramatically reduce the emissions of greenhouse gases into the atmosphere.

- The extent of sea level rise associated with climate change. The rate at which the oceans warm (and thus expand) as well as the rates of ice melt in major glacial systems such as Greenland and Antarctica as well as the extent of runoff of precipitation from rainfall over both oceans and land.

- Climate change will also change the intensity and, especially, the frequency of storm events. Larger storms will become more frequent; the 100-year storm will occur more frequently. These storms, which have historically had a 1% chance of occurring in one year, will increase the chance of occurring to as much as a 10% chance of occurring with higher levels of climate change. Storms that occur once a year may occur twice or even more per year.

This combination of factors suggests that the annual risks of flooding are likely to be higher than presented in this analysis, which is based on historical patterns that were shaped by a different climate than the one likely to exist in the future.

The risks of damages to the economy also depend on the factors that shape the damages to structures and the time and expense needed to repair those damages. Most buildings near the shore are not built to easily absorb frequent flooding; ground floors are fully occupied and building systems are usually placed in basements where they are the most vulnerable to being damaged. Natural features such as beaches and wetlands are

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[13] Walsh, J., D. Wuebbles, K. Hayhoe, J. Kossin, K. Kunkel, G. Stephens, P. Thorne, R. Vose, M. Wehner, J. Willis, D. Anderson, S. Doney, R. Feely, P. Hennon, V. Kharin, T. Knutson, F. Landerer, T. Lenton, J. Kennedy, and R. Somerville, 2014: Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT.

subject to erosion and degradation from development. These risk factors vary greatly across the structures in the vulnerable areas and require much more location-specific analysis.

In addition to implementing greenhouse gas reduction strategies, local jurisdictions are looking to take actions to adapt to sea level rise by reducing the risk of flooding damages. The extent to which these will be used as well as the timing with which they are deployed is another unknown factor.

A final factor affecting the risks to the economy is the speed and cost of recovery from damages. Adaptation measures should be directed and increasing the speed and reducing the cost of recovery to the maximum extent practicable. This will depend in part on the choices made and in part on the resources available to invest in flood risk reduction.

The first source of funding for recovery is from insurance. Many, but not all, of the properties likely to face flood risks, are eligible for coverage under the Federal Flood Insurance Program (FIP). There are three reasons why NFIP coverage is likely to be an inadequate source of funds:

- Flood insurance is voluntary in many cases; it is only mandatory for properties that use federally guaranteed mortgages, which is uncommon with commercial properties.

- The FIP-designated flood zone within which insurance is available (and sometimes mandatory) does not currently include any adjustments for sea level rise, so the adequacy of the program for the future is subject to serious question.

- The NFIP is under significant financial stress because its funding structure was never designed to cover current, let alone future levels of damages from flooding. The future of the program has been a source of significant controversy for many years now and no clear vision for reforming the program is yet apparent.

Nonetheless, understanding the current relationship between vulnerabilities defined by CoSMoS and FEMA by comparing the 100 Year Storm with zero sea level rise scenario results with similar analysis applied to flood insurance data. This is provided in Appendix 5. In general, the FEMA analysis and the CoSMoS analysis are roughly consistent, but there are significant differences in some communities to which attention should be directed.

This brief summary of risk factors in the natural, built, and financial environments suggest that San Diego County and its cities face significant challenge to be prepared for the flood and other risks associated with sea level rise and climate change. These challenges are to be found at the individual property level, but there are larger risks to the regional economy as key sectors such as tourism, manufacturing, and office services have very high vulnerabilities all have significant property and establishments in the potential flood zones. The challenge also takes the form of repeated and increasingly severe damages that will steadily grow at hopefully modest rates but may possibly very serious much more quickly than currently foreseen.

Preparing for the Future

Together, the climate, structural, and recovery factors mean that *individual event risks* analyzed here will be less important than the *cumulative risks over time.* The question for businesses at risk, particularly in the tourism and recreation sectors and in the cities of San Diego, Coronado, and Chula Vista, will be how they can sustain economic success in the face of repeated and increasingly severe disruptions in their business.

Parts of San Diego County are already planning for precautionary measures to mitigate structural damage related to sea level rise and flooding. Several jurisdictions surrounding San Diego Bay, for example, collaborated on the development of a formal "Sea Level Rise Adaptation Strategy for San Diego Bay" in 2012. The planning effort, which involved extensive engagement with NGOs, academia, and utility providers, included a vulnerability assessment for the natural and built environment and recommended adaptation strategies to help address any impacts.

The Chula Vista Bayfront Master Plan, approved in 2012 and led by the Port of San Diego and the City of Chula Vista, assessed the shore front for sea level rise vulnerability and recommended measures such as "buffer areas, raised-height building pads, and situating future construction slightly inland." The plan also guides developers in the region to plan for first-floor flooding in their construction designs. The San Diego County Regional Airport Authority has recently installed one of the largest storm water collection systems in the region that will treat and reuse storm water (instead of conveying it to the Bay) to make the Airport site more resilient to sea level rise-related flooding issues. Other projects, such as the expansion of the San Diego Convention Center, are planning for their lowest point to exceed the projected sea level rise scenarios. Finally, the San Diego Regional Climate Collaborative creates an ongoing forum for public agencies and community partners to share best practices and to partner on initiatives to further the region's resilience to sea level rise and associated flooding impacts.

The challenge for San Diego is both to implement such strategies in the near future in places where change is already occurring. It is also to be prepared to choose the appropriate strategies when the next flood comes. This means detailed assessments of the risks at each location as well as an economic assessment of available options. The need to make major decisions affecting large areas of the County may still lie in the future, but when the need arises it will do so suddenly rather than gradually.

Developing and maintaining a plan for dealing with flood risks is critical because such plans can be essential for the most effective use of recovery funding when disasters occur. There are options for dealing with flood risks at times of new or re-construction, but the critical opportunities will likely come in the wake of flooding during the recovery period. If the aim of recovery is simply to restore what was lost in structures, the evidence suggests this will simply result in repeated disasters and losses to the economy. But recovery that incorporates actions that reduce future flood risks also significantly reduce the risks to

businesses and to the regional economy. Every period of recovery must be an opportunity to reduce future risks, not to maintain or increase risks. But relying on rapid and full recovery is a weak strategy under any circumstance because current and future resources for recovery will diminish as climate change affects all of California and the rest of the U.S. The long-term costs to the economy are almost certainly greater than taking action to reduce the likelihood or extent of possible damages.

Appendix 1: Vulnerability Assessment Methodology

Estimating the potential economic effects in this report requires a three-step process:

1. GIS data was secured from USGS, San Diego Association of Governments (SANDAG) (property tax parcels), and InfoUSA establishment data. All data was converted to a common projection, then the economic data was intersected with the CoSMoS data. The CoSMoS data is organized as raster-based data. A parcel or a point to be included as vulnerable to CoSMoS-estimated flooding requires at least one point of intersection between the raster-based CoSMoS data and either the vector-based parcel data or the point-based InfoUSA data. In addition, the depth of flooding in the CoSMoS data must be equal to or greater than 1 centimeter (cm).

2. The resulting intersected data files were then summarized. For parcel data, the assessed values of land, improvements, and total values were summarized by the detailed land use codes (NUCLEUS_US) in the SANDAG parcel. For this analysis, only parcels classified as commercial or industrial were included.

   The InfoUSA data contained information on employment and sales for each establishment. Sales data is not a measure that is published by any other source, so it is not possible to compare the value of economic activity in affected areas with other parts of the economy. For this reason, the contribution of affected areas to the GDP of San Diego County is calculated. This is done using the estimates of GDP for the county prepared by the Bureau of Economic Analysis.

   InfoUSA records contain the 6-digit industrial classification of the North American Industrial Classification System (NAICS). These NAICS codes are used to assign each record the appropriate code from the 80 sector GDP data. A GDP per employee ratio was calculated for each of the 80 sectors by dividing San Diego County GDP by the total number of wage & salary employees in the county taken from the Bureau of Labor Statistics' Quarterly Census of Employment and Wages. This GDP per employee was assigned to each InfoUSA record and then aggregated across each sector.

3. The effects of flooding on any given location depend on many different factors, most of which are not measured in any data sets. But the CoSMoS data includes the estimated depth of flooding at any given point for the assumed storm frequency and sea level rise. It is obvious that the depth of flooding and the extent of impacts are related to one another. A 1-cm (0.4 inch) flood will have a very different impact than a 4-meter (13.1 foot) flood.

   To reflect this difference, a weighted impact is calculated in addition to the summaries described above. To calculate the weights, flood depths were divided into deciles or ten equal categories based on the specific distribution in each scenario. Employment, sales, GDP, and assessed values were then weighted by the ratio of the starting value for each decile to the maximum depth in each scenario. Table 14 provides an example.

Table 14 Decile weights for adjusting for flood depths in economic analysis.

	Flood depth (cm)	Weight
Decile 1	1	0.004
Decile 2	1	0.004
Decile 3	7	0.029
Decile 4	19.5	0.082
Decile 5	27	0.113
Decile 6	32.5	0.136
Decile 7	49	0.205
Decile 8	62	0.259
Decile 9	80	0.335
Decile 10	239	1.000

The effect of this weighting system is that the largest floods (in the example, those where flood depths are estimated at 239 cm (2.39 meters or 7.84 feet) will have their full employment, sales, etc. included in the impact estimates. Those with flood depths below 239 cm will have their employment, sales, etc. multiplied by the weight indicated and then totals will be calculated by summing across all weighted records.

Appendix 2: InfoUSA Methodology

As the name implies, location employment size represents the number of employees of the business at that location. Volunteers are included, but only when there are no paid employees. The Infogroup Database carries two separate employment number fields: Location and Corporate. Location employment is available on 96% of the businesses and is largely obtained through the telephone verification process.

Reported versus Modeled Values

Approximately 49% of the businesses have their location employment size verified through telephone interviews. When an employment number cannot be verified through the telephone interview process, a model is applied to estimate the employment size. About 51% of businesses have their location employment size modeled. The model uses a multi-step approach, with over seven million telephone verified employment figures as the cornerstone, to create the most accurate estimated employment information possible.

The model considers records that are part of a chain or corporate family, comparing their values to actual data for similar locations in similar geographies. For records that are not part of a chain or corporate family, the model profiles actual data for records with the same 6-digit, then 4-digit NAICS assignment within similar geographies, state, and county. The model also takes into account the number of NAICS codes assigned per business, as businesses serving multiple industries tend to have more employees than businesses with just one line of business. Professional records, such as doctors, dentists, and lawyers, have their own modeling rules because of their unique structure.

All modeled employment numbers on the Infogroup Database are distinguishable from the actual number of employees by using the modeled employment derivation code on the record layout.

Accuracy
Infogroup's Employment Size Model is 95% accurate within two bin ranges when compared to the reported data collected through our telephone interviews.

Employment Size Distribution

Infogroup maintains a true employee count, even when the value is applied through a model. Additionally, an employee size code is assigned. The following are the Infogroup standardized employment size ranges:

Table 15 Info group standardized employment size range.

Code	Description	Percent of Database
A	1 to 4	58.3%
B	5 to 9	18.7%
C	10 to 19	9.2%
D	20 to 49	5.8%
E	50 to 99	2.1%
F	100 to 249	1.1%
G	250 to 499	0.3%
H	500 to 999	0.1%
I	1,000 to 4,999	0.1%
J	5,000 to 9,999	Less than 0.1%
K	10,000 or More	Less than 0.1%
" "	Blank*	4.5%

* Certain industries are not eligible to possess a location employee size count. These include Automated Teller Machines, Video Rental Kiosks, Coin Counting/Sorting Kiosks, Propane Tank Kiosks, Electric Charging Stations, E-Waste Recycling Kiosks, Mailing & Shipping Kiosks, Commercial Fuel Stations and Non-Classified Establishments.

Corporate Employee Size
Corporate employee size is only available for records in the Info group Database that are coded as corporate parents or subsidiary headquarters. The corporate employment number represents the company-wide number of employees for that parent or subsidiary headquarters family. Such locations are also eligible to have a location employee size assigned reflecting the number of employees specific to that location.

All corporate employment figures are actual numbers from telephone interviews, annual reports, newspapers, and periodicals. Infogroup does not model or sum corporate employment.

Sales Data
Because verifiable sales volume figures are virtually impossible to obtain from private businesses, Infogroup has developed, and continually improves, a model that estimates the sales volume for the company. An estimate of annual location sales volume is available on the majority of the records that have a location employment figure.

The Annual Sales Volume Estimate model is built upon data from the U.S. Department of Commerce where sales per employee is provided for each 6-digit NAICS code at the county level, where available, and indexed to this level where current data at that specificity is not available. Infogroup then leverages data from its own Business Database including the number of employees at the location, industry codes (4-digit SIC and 6-digit NAICS), and the county and state in which the business resides to calculate the estimated annual sales volume. Bureau of Economic Analysis data is used to account for price changes within the

industry since the Census survey date, bringing our estimates into current dollar values. Finally, extreme values are normalized within chains and franchise to ensure all individual location estimates have reasonable values. The Economic Census is performed every five years and the estimating model is refreshed after each release.

Some lines of business (e.g., educational institutions, government offices, associations, and organizations) are not assigned a sales volume modeled because companies within these industries generally do not generate sales

Code	Location Sales Volume	%*
A	Less Than $500,000	38.7%
B	$500,000 to $1 MM	19.7%
C	$1 to $2.5 MM	12.5%
D	$2.5 to $5 MM	4.9%
E	$5 to $10 MM	2.8%
F	$10 to $20 MM	1.3%
G	$20 to $50 MM	0.86%
H	$50 to $100 MM	0.29%
I	$100 to $500 MM	0.17%
J	$500 MM to $1 B	0.01%
K	OVER $1 B	0.01%
	Blank	18.77%

*Distribution (based on February 2016 Verified file)

Corporate sales volume is available on records that are coded as parent or subsidiary headquarters locations. Thus, only 20,000 records carry this data. The corporate sales volume values are compiled from annual reports, newspapers, and periodicals. Infogroup does not model or sum the corporate sales volume figures.

Code	Corporate Sales Volume	%*
A	Less Than $500,000	0.00%
B	$500,000 to $1 MM	0.00%
C	$1 to $2.5 MM	0.00%
D	$2.5 to $5 MM	0.00%
E	$5 to $10 MM	0.00%
F	$10 to $20 MM	0.01%
G	$20 to $50 MM	0.01%
H	$50 to $100 MM	0.02%
I	$100 to $500 MM	0.04%
J	$500 MM to $1 B	0.01%
K	OVER $1 B	0.02%
	Blank	99.87%

*Distribution (based on February 2016 Verified file)

Within the Infogroup Database financial institutions, mostly within SIC 60, listed as headquarters or sub headquarters are not assigned an actual or estimated Sales Volume. Rather, these types of companies are assigned an "Asset Flag" to more accurately represent the business entity. This number is based upon reported data only.

Appendix 3 Detailed Economic Impact Tables by Industry

Table 16 1 Year Storm, 0m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	**Total**	**1005**	**$119.66**	**$186.16**	**95**	**$5.06**	**$22.40**	**82**
11	Construction	7	$1.77	$0.79	1	$0.24	$0.11	3
30	Printing and related support activities	2	$0.39	$0.15	0	$0.06	$0.02	1
34	Wholesale trade	25	$20.16	$5.50	2	$0.31	$0.35	2
35	Retail trade	59	$12.23	$4.45	5	$0.88	$0.35	19
43	Other transportation and support activities	8	$0.60	$0.71	2	$0.11	$0.13	1
53	Securities, commodity contracts, and investments	1	$0.33	$0.22	0	$0.02	$0.02	1
57	Real estate	59	$7.85	$108.07	9	$1.17	$16.10	6
58	Rental and leasing services and lessors of intangible assets	24	$3.13	$11.45	1	$0.07	$0.30	5
60	Professional and Technical Services	5	$0.84	$0.83	0	$0.02	$0.03	2
66	Administrative and support services	45	$-	$3.22	45	$0.00	$3.22	1
71	Ambulatory health care services	7	$1.51	$0.73	0	$0.02	$0.01	2
76	Performing arts, spectator sports, museums, and related activities	35	$0.37	$5.68	2	$0.00	$0.35	2
77	Amusements, gambling, and recreation industries	114	$6.76	$5.62	2	$0.13	$0.10	4
79	Accommodation	405	$50.05	$30.23	7	$0.91	$0.55	2
80	Food services and drinking places	168	$9.45	$6.04	18	$1.03	$0.66	14
81	Other services, except government	29	$0.46	$2.47	1	$0.06	$0.12	7

Table 17 1 Year Storm, 1m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	Total	7644	$950.04	$1,143.58	919	$57.39	$105.11	230
11	Construction	42	$7.83	$4.75	4	$0.93	$0.50	13
17	Fabricated metal products	8	$0.96	$0.75	2	$0.24	$0.19	1
19	Computer and electronic products mfg.	2840	$651.27	$714.00	101	$23.26	$25.50	1
22	Other transportation equipment mfg.	31	$1.50	$4.55	0	$0.01	$0.01	2
28	Apparel and leather and allied products mfg.	2	$0.20	$0.13	0	$0.04	$0.03	1
30	Printing and related support activities	17	$3.32	$1.26	1	$0.25	$0.09	2
34	Wholesale trade	29	$27.51	$6.38	5	$3.25	$1.15	4
35	Retail trade	226	$54.54	$17.03	27	$6.37	$2.03	47
43	Other transportation and support activities	60	$8.89	$5.32	14	$2.24	$1.26	6
46	Publishing industries, except Internet (includes software)	20	$8.23	$6.18	1	$0.24	$0.18	2
5	Forestry, fishing, and related activities	3	$0.34	$0.32	0	$0.01	$0.01	1
52	Federal Reserve banks, credit intermediation, and related	15	$6.23		1	$0.22		1
53	Securities, commodity contracts, and investments	1	$0.33	$0.22	0	$0.14	$0.10	1
54	Insurance carriers and related activities	2	$0.33	$0.35	0	$0.01	$0.01	1
57	Real estate	141	$18.99	$258.28	31	$4.17	$56.02	16
58	Rental and leasing services and lessors of intangible assets	26	$3.49	$12.40	5	$0.43	$2.60	6
60	Professional and Technical Services	49	$7.78	$8.14	5	$0.88	$0.90	16
66	Administrative and support services	70	$2.09	$5.00	47	$0.14	$3.34	4
69	Educational services	1	$0.00	$0.07	0	$0.00	$0.00	1
71	Ambulatory health care services	27	$4.17	$2.82	3	$0.41	$0.30	7
76	Performing arts, spectator sports, museums, and related activities	35	$0.37	$5.68	13	$0.03	$2.15	2
77	Amusements, gambling, and recreation industries	171	$17.07	$8.43	8	$0.93	$0.40	12
79	Accommodation	563	$69.58	$42.02	23	$2.83	$1.71	5
80	Food services and drinking places	835	$46.92	$30.04	156	$8.80	$5.63	34

		Unweighted by Depth			Weighted by Depth			
Sector ID	Industry	Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	Establishments
81	Other services, except government	111	$2.25	$9.45	12	$0.13	$1.00	19
82	Government	2300	$0.00	N/A	453	$0.00	N/A	2

Table 18 1 Year Storm, 2m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	Total	32,703	$5,565.57	$4,254.00	4,808	$616.11	$622.56	1838
10	Utilities	70	$39.21	$35.01	5	$2.69	$2.40	1
11	Construction	610	$127.39	$68.95	120	$22.06	$13.58	75
17	Fabricated metal products	118	$13.36	$11.04	42	$4.78	$3.95	11
18	Machinery mfg.	71	$18.09	$11.19	11	$2.30	$1.74	4
19	Computer and electronic products mfg.	2,856	$654.54	$718.03	197	$45.14	$49.54	4
20	Electrical equipment, appliance, and components mfg.	6	$1.69	$0.64	2	$0.69	$0.26	1
21	Motor vehicles, bodies and trailers, and parts mfg.	5	$1.46	$0.63	1	$0.33	$0.14	1
22	Other transportation equipment mfg.	3,890	$505.08	$571.11	281	$35.23	$41.20	5
23	Furniture and related products mfg.	4	$0.78	$0.28	0	$0.05	$0.02	1
24	Miscellaneous mfg.	41	$8.65	$7.46	3	$0.58	$0.50	8
26	Food and beverage and tobacco products mfg.	61	$25.10	$6.46	9	$1.61	$0.92	8
27	Textile mills and textile product mills	20	$2.12	$1.24	3	$0.32	$0.18	4
28	Apparel and leather and allied products mfg.	6	$0.37	$0.40	1	$0.12	$0.09	2
29	Paper products mfg.	6	$1.36	$0.80	0	$0.09	$0.05	1
30	Printing and related support activities	88	$17.17	$6.54	12	$2.43	$0.92	9
32	Chemical products mfg.	6	$3.98	$4.50	0	$0.27	$0.31	2
33	Plastics and rubber products mfg.	3	$0.57	$0.40	0	$0.04	$0.03	1
34	Wholesale trade	550	$1,556.11	$121.05	78	$109.96	$17.16	46
35	Retail trade	2,362	$575.96	$178.02	345	$85.26	$25.98	340
37	Air transportation	81	$46.37	$14.14	10	$5.96	$1.75	6
38	Rail transportation	20	$1.25		2	$0.15		2

		Unweighted by Depth			Weighted by Depth			
Sector ID	Industry	Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	Establishments
39	Water transportation	22	$4.00		4	$0.71		2
4	Farms	25	$7.30	$1.73	7	$2.10	$0.50	1
40	Truck transportation	66	$14.74	$6.68	5	$1.01	$0.46	3
41	Transit and ground passenger transportation	426	$62.29	$38.53	70	$8.30	$6.34	15
43	Other transportation and support activities	555	$68.00	$49.22	70	$9.98	$6.21	39
44	Warehousing and storage	250	$46.74	$20.37	20	$2.20	$1.66	2
46	Publishing industries, except Internet (includes software)	83	$34.16	$25.63	13	$5.43	$4.07	5
47	Motion picture and sound recording industries	34	$11.59	$7.15	6	$1.91	$1.23	8
5	Forestry, fishing, and related activities	3	$0.34	$0.32	0	$0.02	$0.02	1
52	Federal Reserve banks, credit intermediation, and related	145	$53.89	N/A	17	$6.03	N/A	11
53	Securities, commodity contracts, and investments	43	$17.12	$9.57	8	$2.97	$1.69	13
54	Insurance carriers and related activities	71	$14.15	$12.41	7	$1.90	$1.26	28
57	Real estate	559	$105.77	$1,023.95	131	$25.05	$240.52	89
58	Rental and leasing services and lessors of intangible assets	350	$48.68	$166.92	46	$6.88	$21.79	25
60	Professional and Technical Services	1,133	$142.54	$188.16	139	$16.20	$23.13	166
66	Administrative and support services	1,217	$94.29	$86.99	306	$19.46	$21.86	59
67	Waste management and remediation services	9	$2.50	$1.05	3	$0.72	$0.30	1
69	Educational services	637	$16.71	$43.57	136	$5.88	$9.29	27

		Unweighted by Depth			Weighted by Depth			
Sector ID	Industry	Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	Establishments
71	Ambulatory health care services	287	$47.15	$29.93	35	$5.82	$3.68	100
72	Hospitals and nursing and residential care facilities	137	$19.33	$9.62	10	$0.21	$0.74	5
73	Social assistance	241	$13.93	$7.45	32	$1.74	$0.98	16
76	Performing arts, spectator sports, museums, and related activities	724	$48.12	$117.57	99	$4.33	$16.01	23
77	Amusements, gambling, and recreation industries	769	$125.87	$37.90	143	$24.25	$7.05	72
79	Accommodation	4,963	$574.00	$370.44	661	$78.82	$49.31	51
80	Food services and drinking places	4,574	$263.79	$164.54	865	$49.10	$31.12	215
81	Other services, except government	898	$57.01	$76.45	148	$7.82	$12.60	171
82	Government	3,382	$0.31	N/A	666	$0.02	N/A	27

Table 19 100 Year Storm, FEMA Flood Zone

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	Total	4,764	$575.73	$836.98	252	$27.44	$54.65	91
11	Construction	8	$2.10	$0.90	1	$0.27	$0.11	4
22	Other transportation equipment mfg	3,850	$500.00	$565.23	151	$19.56	$22.12	1
30	Printing and related support activities	2	$0.39	$0.15	1	$0.06	$0.02	1
35	Retail trade	69	$15.18	$5.20	6	$1.52	$0.44	22
43	Other transportation and support activities	22	$3.26	$1.95	6	$0.61	$0.50	3
53	Securities, commodity contracts, and investments	1	$0.33	$0.22	1	$0.04	$0.02	1
57	Real estate	123	$16.37	$225.31	15	$2.03	$27.90	15
58	Rental and leasing services and lessors of intangible assets	20	$2.26	$9.54	1	$0.09	$0.58	4
60	Professional and Technical Services	6	$0.95	$1.00	1	$0.05	$0.05	3
71	Ambulatory health care services	3	$0.65	$0.31	1	$0.03	$0.01	1
76	Performing arts, spectator sports, museums, and related activities	35	$0.37	$5.68	5	$0.03	$0.87	2
77	Amusements, gambling, and recreation industries	114	$6.76	$5.62	5	$0.29	$0.23	4
79	Accommodation	4	$0.50	$0.30	1	$0.04	$0.03	2
80	Food services and drinking places	402	$22.56	$14.46	47	$2.62	$1.68	13
81	Other services, except government	13	$0.29	$1.11	1	$0.03	$0.09	4
82	Government	80	$0.00	N/A	13	$0.00	N/A	1

Table 20 100 Year Storm, 0m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	Total	2,298	$223.96	$351.01	310	$26.33	$70.71	215
11	Construction	20	$3.12	$2.26	6	$0.53	$0.66	7
26	Food and beverage and tobacco products mfg	4	$0.24	$0.42	0	$0.02	$0.04	1
28	Apparel and leather and allied products mfg	2	$0.20	$0.13	0	$0.02	$0.01	1
30	Printing and related support activities	21	$4.10	$1.56	2	$0.38	$0.15	3
34	Wholesale trade	11	$6.80	$2.42	2	$0.43	$0.35	3
35	Retail trade	189	$39.52	$14.24	25	$5.21	$1.85	46
41	Transit and ground passenger transportation	6	$0.29	$0.54	0	$0.02	$0.03	1
43	Other transportation and support activities	24	$2.32	$2.13	4	$0.36	$0.39	4
46	Publishing industries, except Internet (includes software)	2	$0.82	$0.62	1	$0.21	$0.16	1
53	Securities, commodity contracts, and investments	5	$2.66	$1.11	1	$0.75	$0.30	2
54	Insurance carriers and related activities	2	$0.33	$0.35	0	$0.02	$0.02	1
57	Real estate	109	$15.42	$199.66	28	$3.86	$51.17	20
58	Rental and leasing services and lessors of intangible assets	30	$4.77	$14.31	4	$0.48	$1.82	8
60	Professional and Technical Services	37	$5.86	$6.14	5	$0.72	$0.85	9
66	Administrative and support services	53	$0.65	$3.79	46	$0.14	$3.32	5
69	Educational services	1	$0.00	$0.07	0	$0.00	$0.00	1
71	Ambulatory health care services	41	$6.88	$4.28	6	$0.98	$0.61	13
76	Performing arts, spectator sports, museums, and related activities	35	$0.37	$5.68	8	$0.05	$1.37	2
77	Amusements, gambling, and recreation industries	128	$8.07	$6.31	9	$0.71	$0.46	7

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
79	Accommodation	675	$69.79	$50.38	33	$4.14	$2.50	10
80	Food services and drinking places	822	$46.25	$29.57	117	$6.59	$4.19	37
81	Other services, except government	59	$1.74	$5.02	5	$0.24	$0.46	15

Table 21 100 Year Storm, 1m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	Establishments
00	Total	14,977	$2,040.28	$2,022.47	1,631	$191.80	$263.09	826
11	Construction	128	$25.28	$14.47	25	$4.68	$2.77	31
17	Fabricated metal products	98	$11.15	$9.17	15	$1.68	$1.40	5
18	Machinery mfg	11	$4.16	$1.73	1	$0.19	$0.08	2
19	Computer and electronic products mfg	4	$0.92	$1.01	0	$0.09	$0.10	1
20	Electrical equipment, appliance, and components mfg	6	$1.69	$0.64	2	$0.46	$0.17	1
22	Other transportation equipment mfg	3,881	$501.50	$569.79	186	$23.48	$27.33	3
24	Miscellaneous mfg	5	$1.50	$0.91	0	$0.07	$0.04	1
26	Food and beverage and tobacco products mfg	16	$1.80	$1.69	3	$0.38	$0.35	3
27	Textile mills and textile product mills	6	$0.71	$0.37	1	$0.07	$0.04	1
28	Apparel and leather and allied products mfg	2	$0.20	$0.13	1	$0.08	$0.05	1
30	Printing and related support activities	26	$5.08	$1.93	4	$0.86	$0.33	5
32	Chemical products mfg	4	$3.25	$3.00	0	$0.15	$0.14	1
33	Plastics and rubber products mfg	3	$0.57	$0.40	0	$0.03	$0.02	1
34	Wholesale trade	183	$408.48	$40.28	15	$24.85	$3.36	17
35	Retail trade	793	$197.25	$59.77	107	$26.00	$8.04	157
37	Air transportation	17	$6.55	$2.97	1	$0.30	$0.14	2
39	Water transportation	11	$2.00					1

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	Establishments
4	Farms	25	$7.30	$1.73	2	$0.71	$0.17	1
40	Truck transportation	8	$1.10	$0.81	0	$0.05	$0.04	1
41	Transit and ground passenger transportation	127	$12.56	$11.49	22	$2.16	$2.01	3
43	Other transportation and support activities	135	$18.44	$11.97	20	$2.90	$1.81	21
44	Warehousing and storage	50	$5.41	$4.07	11	$1.16	$0.87	1
46	Publishing industries, except Internet (includes software)	20	$8.23	$6.18	5	$2.00	$1.50	2
47	Motion picture and sound recording industries	4	$0.34	$0.84	1	$0.07	$0.16	2
5	Forestry, fishing, and related activities	3	$0.34	$0.32	0	$0.02	$0.01	1
52	Federal Reserve banks, credit intermediation, and related	4	$2.51	N/A	0	$0.12	N/A	1
53	Securities, commodity contracts, and investments	30	$12.37	$6.68	4	$1.66	$0.81	8
54	Insurance carriers and related activities	20	$3.29	$3.50	2	$0.30	$0.32	9
57	Real estate	373	$72.30	$683.24	76	$15.02	$139.44	54
58	Rental and leasing services and lessors of intangible assets	50	$8.67	$23.85	15	$1.84	$6.96	14
60	Professional and Technical Services	328	$45.29	$54.47	39	$5.32	$6.55	85
66	Administrative and support services	863	$60.61	$61.69	135	$6.34	$9.68	25

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
67	Waste management and remediation services	9	$2.50	$1.05	1	$0.24	$0.10	1
69	Educational services	183	$1.31	$12.52	27	$0.50	$1.85	12
71	Ambulatory health care services	122	$20.06	$12.72	17	$2.98	$1.79	42
73	Social assistance	10	$0.63	$0.31	0	$0.03	$0.01	5
76	Performing arts, spectator sports, museums, and related activities	213	$6.68	$34.59	30	$0.68	$4.86	12
77	Amusements, gambling, and recreation industries	411	$53.02	$20.26	48	$7.16	$2.35	45
79	Accommodation	3,372	$366.72	$251.69	257	$30.13	$19.21	25
80	Food services and drinking places	2,301	$137.09	$82.77	415	$23.64	$14.93	100
81	Other services, except government	323	$10.15	$27.50	39	$0.98	$3.31	52
82	Government	733	N/A	N/A	87	N/A	N/A	12

Table 22 100 Year Storm, 2m Sea Level Rise

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
00	Total	49,700	$8,015.29	$6,092.08	6731	$1,024.74	$805.22	2,656
10	Utilities	70	$39.21	$35.01	5	$3.04	$2.71	1
11	Construction	958	$207.38	$108.28	153	$31.50	$17.28	107
16	Primary metals mfg	10	$5.44	$0.96				1
17	Fabricated metal products	144	$16.83	$13.47	39	$4.46	$3.65	13
18	Machinery mfg	92	$21.35	$14.49	18	$3.58	$2.90	6
19	Computer and electronic products mfg	2,915	$667.80	$732.86	229	$52.31	$57.49	7
20	Electrical equipment, appliance, and components mfg	6	$1.69	$0.64	2	$0.57	$0.21	1
21	Motor vehicles, bodies and trailers, and parts mfg	6	$1.63	$0.76	2	$0.51	$0.22	2
22	Other transportation equipment mfg	4,910	$930.52	$720.86	389	$72.38	$57.08	10
23	Furniture and related products mfg	14	$3.25	$0.99	1	$0.25	$0.08	3
24	Miscellaneous mfg	53	$10.97	$9.64	5	$0.97	$0.91	10
26	Food and beverage and tobacco products mfg	65	$25.34	$6.88	12	$3.70	$1.25	9
27	Textile mills and textile product mills	23	$2.48	$1.43	4	$0.39	$0.22	5
28	Apparel and leather and allied products mfg	8	$0.73	$0.53	1	$0.12	$0.08	3
29	Paper products mfg	13	$2.95	$1.73	1	$0.23	$0.13	2
30	Printing and related support activities	103	$19.60	$7.66	13	$2.56	$0.99	11
32	Chemical products mfg	6	$3.98	$4.50	0	$0.31	$0.35	2
33	Plastics and rubber products mfg	3	$0.57	$0.40	0	$0.04	$0.03	1
34	Wholesale trade	672	$1,874.29	$147.90	118	$275.21	$26.07	55
35	Retail trade	4,955	$989.93	$373.46	491	$125.56	$36.99	459
37	Air transportation	85	$48.86	$14.84	10	$5.93	$1.75	7
38	Rail transportation	20	$1.25		3	$0.32		2
39	Water transportation	22	$4.00		4	$0.74		2
4	Farms	25	$7.30	$1.73	7	$2.13	$0.50	1
40	Truck transportation	77	$16.70	$7.79	6	$1.23	$0.56	5
41	Transit and ground passenger transportation	519	$64.39	$46.94	81	$8.94	$7.34	23
43	Other transportation and support activities	761	$108.30	$67.49	97	$15.03	$8.57	54
44	Warehousing and storage	272	$49.12	$22.16	63	$11.21	$5.14	3
46	Publishing industries, except Internet (includes software)	183	$75.32	$56.51	20	$8.13	$6.10	6
47	Motion picture and sound recording industries	34	$11.59	$7.15	5	$1.49	$1.13	8

Sector ID	Industry	Unweighted by Depth			Weighted by Depth			Establishments
		Employment	Sales ($ Millions)	GDP ($ Millions)	Employment	Sales ($ Millions)	GDP ($ Millions)	
5	Forestry, fishing, and related activities	3	$0.34	$0.32	0	$0.03	$0.03	1
52	Federal Reserve banks, credit intermediation, and related	231	$92.76		30	$11.30		24
53	Securities, commodity contracts, and investments	64	$24.77	$14.25	9	$3.71	$2.06	19
54	Insurance carriers and related activities	91	$19.92	$15.91	11	$2.90	$1.99	35
57	Real estate	733	$134.63	$1,342.67	131	$23.80	$240.74	130
58	Rental and leasing services and lessors of intangible assets	656	$111.25	$312.86	89	$14.54	$42.50	35
60	Professional and Technical Services	2,666	$352.62	$442.75	297	$37.45	$49.37	235
64	Management of companies and enterprises	300	$0.00	$51.46	23	$0.00	$3.99	1
66	Administrative and support services	1,625	$140.22	$116.15	333	$24.82	$23.82	88
67	Waste management and remediation services	11	$5.00	$1.28	3	$0.92	$0.32	2
69	Educational services	797	$19.02	$54.51	152	$4.55	$10.42	45
7	Oil and gas extraction	7	$8.66	$37.86	1	$0.67	$2.93	1
71	Ambulatory health care services	590	$88.49	$61.53	63	$9.89	$6.62	188
72	Hospitals and nursing and residential care facilities	981	$98.29	$68.86	72	$11.83	$5.06	10
73	Social assistance	365	$21.26	$11.29	76	$4.43	$2.35	30
76	Performing arts, spectator sports, museums, and related activities	812	$49.57	$131.86	177	$5.60	$28.68	33
77	Amusements, gambling, and recreation industries	965	$144.92	$47.56	163	$26.89	$8.04	89
79	Accommodation	7,708	$889.31	$575.32	1040	$123.42	$77.66	71
80	Food services and drinking places	7,450	$425.29	$267.99	1087	$61.57	$39.11	309
81	Other services, except government	1,534	$71.15	$130.59	232	$10.92	$19.79	235
82	Government	4,790	$0.31		915	$0.06		51

Appendix 4: Detailed Property Value Tables

Table 23 Assessed value vulnerabilities by city.

City	Class	1 yr storm – 0m SLR			1 yr storm – 1m SLR			1 yr storm – 2m SLR		
		Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels
Carlsbad	COMMERCIAL	$1.08	$0.05	2	$22.76	$3.01	4	$23.72	$4.97	5
	INDUSTRIAL	$0.00	$0.00	1	$0.00	$0.00	1	$0.00	$0.00	1
	TOTAL	$123.20	$12.83	119	$188.01	$35.65	160	$228.31	$51.68	204
Chula Vista	COMMERCIAL	$14.65	$0.00	3	$14.65	$2.76	3	$14.65	$3.75	3
	INDUSTRIAL	$23.50	$4.49	3	$152.45	$40.09	11	$185.24	$39.71	33
	TOTAL	$38.15	$4.49	26	$167.09	$42.86	43	$207.36	$44.40	71
Coronado	COMMERCIAL	$76.78	$11.66	3	$664.96	$73.35	5	$673.93	$100.64	8
	INDUSTRIAL	$0.04	$0.00	1	$90.29	$6.02	2	$90.29	$20.38	2
	TOTAL	$518.31	$43.69	257	$1,870.43	$158.59	725	$2,986.08	$540.54	1807
Del Mar	COMMERCIAL	$4.29	$0.31	3	$5.43	$1.44	4	$18.64	$3.04	7
	INDUSTRIAL	$0.11	$0.00	4	$0.17	$0.02	5	$1.91	$0.20	8
	TOTAL	$169.04	$5.05	70	$203.58	$52.99	84	$960.71	$201.05	458
Encinitas	COMMERCIAL	$16.82	$0.68	7	$31.36	$4.90	17	$34.54	$5.49	22
	TOTAL	$276.46	$19.28	194	$309.90	$81.04	254	$326.12	$102.64	275
Imperial Beach	COMMERCIAL	$0.00	$0.00	1	$1.35	$0.11	5	$75.32	$10.23	74
	INDUSTRIAL	$2.60	$0.15	1	$7.22	$0.90	12	$8.00	$2.30	15
	TOTAL	$23.38	$0.84	82	$72.76	$5.99	241	$213.76	$30.01	571
National City	INDUSTRIAL	$0.00	$0.00	0				$44.21	$5.26	81
	TOTAL	$0.00	$0.00	15	$0.00	$0.00	18	$44.21	$5.26	141
Oceanside	COMMERCIAL	$0.61	$0.04	3	$4.14	$0.95	3	$21.77	$2.27	12
	INDUSTRIAL	$0.01	$0.00	1	$0.01	$0.00	1	$4.38	$0.39	5
	TOTAL	$216.59	$16.80	182	$296.58	$75.46	262	$371.30	$77.89	337
San Diego City	COMMERCIAL	$1,126.75	$226.36	190	$1,258.29	$281.47	272	$2,348.72	$369.45	667
	INDUSTRIAL	$381.88	$76.30	27	$382.57	$88.46	31	$803.23	$126.71	246
	TOTAL	$2,663.66	$381.78	1057	$3,412.75	$714.95	1684	$5,995.24	$1,332.62	3648

San Diego County	COMMERCIAL	$1.83	$0.15	1	$1.83	$0.18	1	$1.83	$0.41	2
	INDUSTRIAL	$0.01	$0.00	1	$0.01	$0.00	1	$0.01	$0.00	2
	TOTAL	$5.05	$0.49	10	$5.05	$0.64	12	$5.05	$0.82	16
Solana Beach	COMMERCIAL	$0.00	$0.00	0				$3.98	$1.18	1
	TOTAL	$13.94	$1.27	22	$30.32	$7.57	30	$46.30	$13.77	38

		100 yr storm – 0m SLR			100 yr storm – 1m SLR			100 yr storm – 2m SLR		
City	Class	Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels
Carlsbad	COMMERCIAL	$21.08	$1.01	3	$23.72	$2.31	5	$2.37	$3.94	5
	INDUSTRIAL	$0.00	$0.00	0	$232.08	$39.63	174	$0.00	$0.00	1
	TOTAL	$153.84	$22.01	124				$64.55	$60.52	224
Chula Vista	COMMERCIAL	$14.65	$0.94	3	$14.65	$2.07	3	$0.00	$3.49	3
	INDUSTRIAL	$23.50	$2.68	3	$165.02	$19.03	14	$137.38	$39.73	36
	TOTAL	$38.15	$3.62	26	$187.15	$21.47	49	$141.34	$44.44	77
Coronado	COMMERCIAL	$664.96	$64.84	5	$664.96	$79.55	5	680.75	$143.61	11
	INDUSTRIAL	$0.04	$0.01	1	$90.29	$6.43	2	90.29	$17.67	3
	TOTAL	$1,324.37	$125.07	443	$2,612.75	$291.29	1429	3,486.48	$686.39	2371
Del Mar	COMMERCIAL	$18.64	$0.98	7	$18.64	$1.81	7	$7.15	$4.57	11
	INDUSTRIAL	$1.25	$0.06	7	$1.91	$0.09	8	$0.70	$0.20	8
	TOTAL	$699.48	$76.63	328	$929.90	$141.93	424	$164.23	$229.64	467
Encinitas	COMMERCIAL	$27.19	$1.51	9	$34.19	$3.55	21	$8.74	$8.18	23
	TOTAL	$244.07	$40.74	180	$289.34	$69.06	244	$83.24	$113.22	277
Imperial Beach	COMMERCIAL	$6.44	$0.64	5	$76.31	$9.14	64	$58.23	$20.16	141
	INDUSTRIAL	$6.34	$0.44	8	$8.00	$1.06	15	$4.21	$2.16	16
	TOTAL	$81.74	$7.32	240	$212.42	$23.75	513	$191.87	$61.98	1000
National City	INDUSTRIAL	$0.00	$0.00	0	$28.68	$1.36	42	$24.31	$7.13	123
	TOTAL	$0.00	$0.00	17	$28.68	$1.36	94	$24.31	$7.13	188
Oceanside	COMMERCIAL	$0.00	$0.00	0	$0.01	$0.00	1	$2.28	$0.97	11
	INDUSTRIAL	$0.01	$0.00	1	$365.14	$65.06	310	$2.25	$0.42	5
	TOTAL	$213.13	$39.00	179				$104.39	$92.62	425
	COMMERCIAL	$1,436.60	$194.75	301	$1,779.82	$221.97	451	2,910.86	$410.82	791

75

City	Type	Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels	Total Value	Weighted Value	Parcels
San Diego City	INDUSTRIAL	$382.57	$60.40	30	$491.46	$54.15	53	889.39	$136.02	300
	TOTAL	$3,489.50	$446.09	1872	$4,684.21	$718.06	2856	6,688.47	$1,256.16	4139
San Diego County	COMMERCIAL	$1.83	$0.15	1	$1.83	$0.55	1	$1.10	$0.79	2
	INDUSTRIAL	$0.01	$0.00	1	$0.01	$0.00	2	$0.00	$0.00	2
	TOTAL	$5.05	$0.44	10	$5.05	$0.87	15	$2.62	$0.80	16
Solana Beach	COMMERCIAL	$0.00	$0.00	0				$0.00	$1.04	1
	TOTAL	$24.07	$5.19	25	$22.22	$5.29	27	$3.57	$9.35	31

City		100 yr storm – FEMA Flood Zone		
		Total Value	Weighted Value	Parcels
Carlsbad	COMMERCIAL	$22.63	$1.06	3
	TOTAL	$191.30	$22.15	109
Chula Vista	COMMERCIAL	$14.65	$1.04	3
	INDUSTRIAL	$19.14	$5.46	4
	TOTAL	$33.79	$6.50	26
Coronado	COMMERCIAL	$666.03	$272.36	5
	INDUSTRIAL	$11.78	$0.66	2
	TOTAL	$1,124.30	$331.17	293
Del Mar	COMMERCIAL	$4.29	$1.18	2
	TOTAL	$522.93	$103.97	108
Encinitas	COMMERCIAL	$33.54	$6.29	21
	TOTAL	$296.06	$97.79	230
Imperial Beach	COMMERCIAL	$18.66	$2.93	19
	INDUSTRIAL	$2.97	$0.19	2
	TOTAL	$64.85	$9.83	131
National City	INDUSTRIAL	$0.57	$0.04	1
	TOTAL	$0.57	$0.04	14
Oceanside	INDUSTRIAL	$0.00	$0.00	1
	TOTAL	$350.06	$82.46	257
San Diego City	COMMERCIAL	$574.48	$149.65	182
	INDUSTRIAL	$347.68	$165.89	27
	TOTAL	$2,563.41	$648.71	1226

San Diego County	INDUSTRIAL	$0.01	$0.00	1
	TOTAL	$0.01	$0.00	8
Solana Beach	INDUSTRIAL	$0.00	$0.00	1
	TOTAL	$11.65	$2.52	24

Appendix 5: Comparison of CoSMoS and NFIP

Analyzing the National Flood Insurance Program flood zone permits a comparison between expectations of flood risks based on current policies and those projected by the CoSMoS system to determine whether the vulnerabilities are different. The comparison between the CoSMoS scenario of a 100-year storm and zero sea level rise is consistent with the assumptions in the designation of the flood hazard zones used by the NFIP as designated by the Federal Emergency Management Agency (FEMA). The two are estimated differently; CoSMoS is a modeled result, while the FEMA flood zone represents historical experience and topography.

Figure 18 compares the number of commercial and industrial parcels and the InfoUSA establishments covered by the CoSMoS scenario and the NFIP flood zone across the county. The CoSMoS data touches a larger number of parcels (though a slightly smaller number of establishments), as well as shows higher mean and maximum depths for parcels. Mean depth for establishments is slightly smaller. But overall, the NFIP data somewhat under-estimates the extent flooding relative to businesses compared with CoSMoS.

Figure 17 Comparison of CoSMoS 100-year storm and 0m sea level rise with FEMA Estimates. (Depths in centimeter)
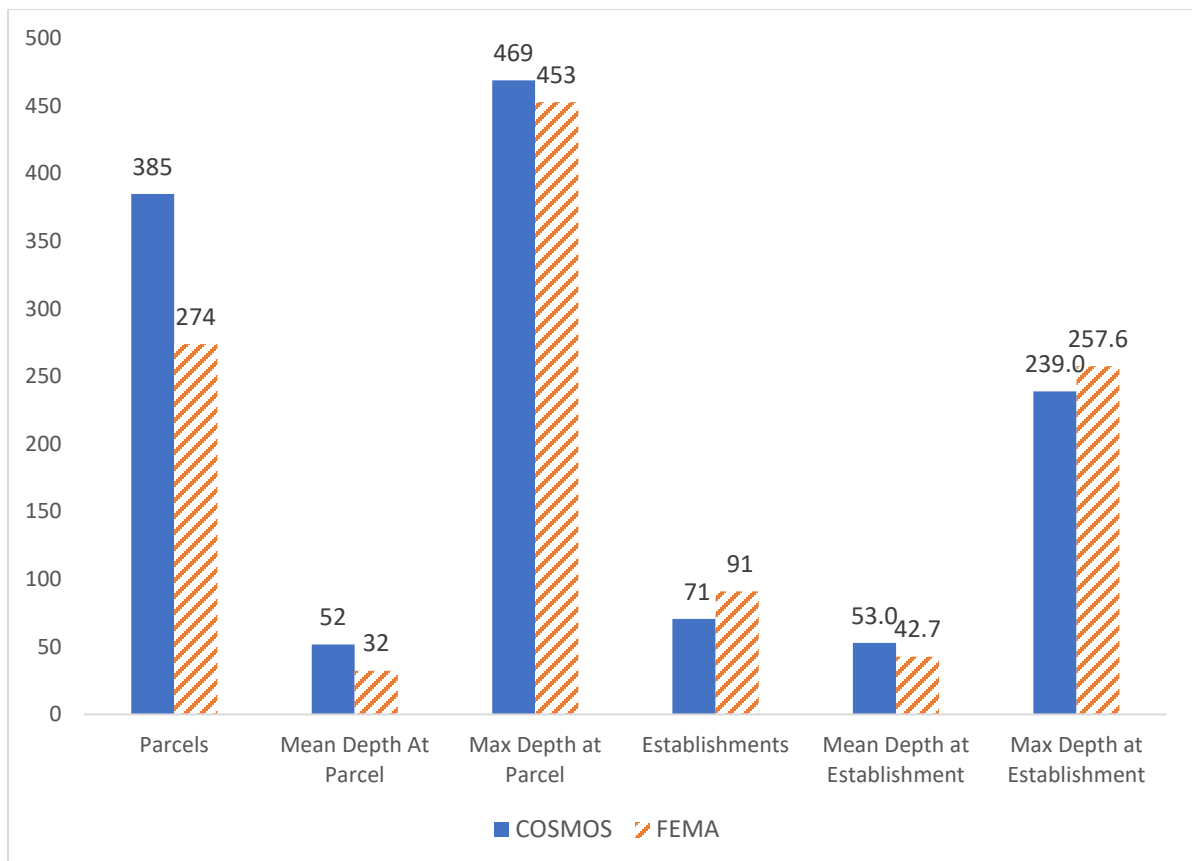
Comparison of NFIP and CoSMoS related vulnerability among commercial and the estimated vulnerabilities at the city level is provided in Figure 19 San Diego has the greatest excess of Federal Flood Insurance policies in force over the number of parcels affected by either the FEMA or CoSMoS 100 year-storm scenarios. Flood insurance policies as reported by FEMA are not only in coastal areas but include policies along inland rivers and streams, so the comparison based on parcel exposure may be imprecise in that case. Of the ten cities examined, seven had more policies than vulnerable policies, but three (Imperial Beach, Encinitas, and Coronado) have more vulnerable parcels than policies in effect. This analysis indicates that there are or may be mismatches between the flood vulnerabilities in the region and the resources available for recovery in the event of a flood.

Figure 18 Comparison of C&I parcels in CoSMoS and NFIP flood zones and parcels covered by NFIP.
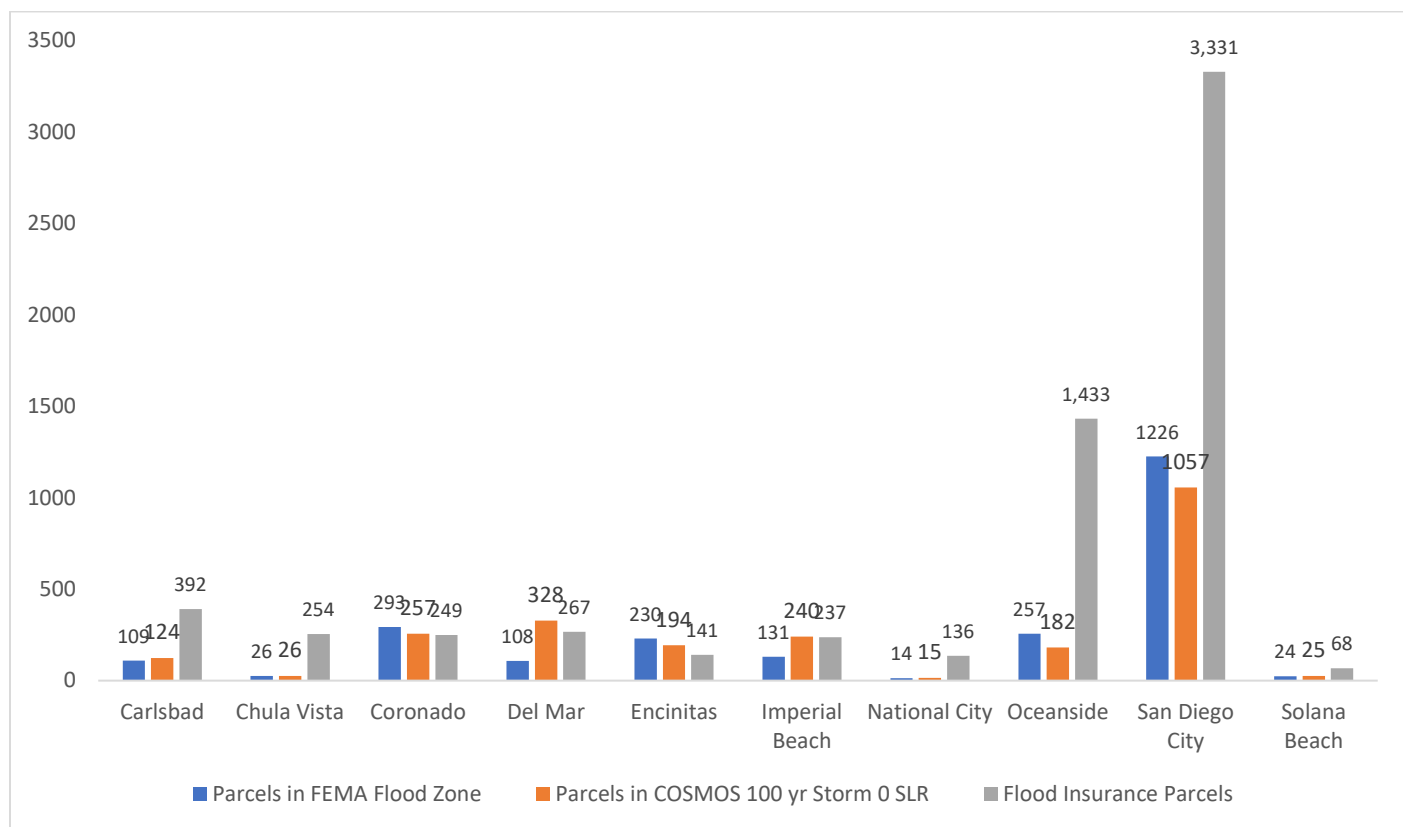
Figure 20 provides additional city-level comparison. Bars above zero mean that the FEMA flood zone is *underestimating* vulnerable valuation relative to CoSMoS; bars above zero mean that the FEMA flood zone is estimating more valuation than the CoSMoS model. The city of San Diego is indicated as having the greatest *underestimates* of risk as there are underestimates in all three categories. As this analysis focuses on the shoreline areas, it reinforces the need to closely examine the relationship between NFIP coverage and vulnerabilities related to sea level rise

.*Figure 19 Comparison of vulnerability in FEMA flood zone and CoSMoS model.*
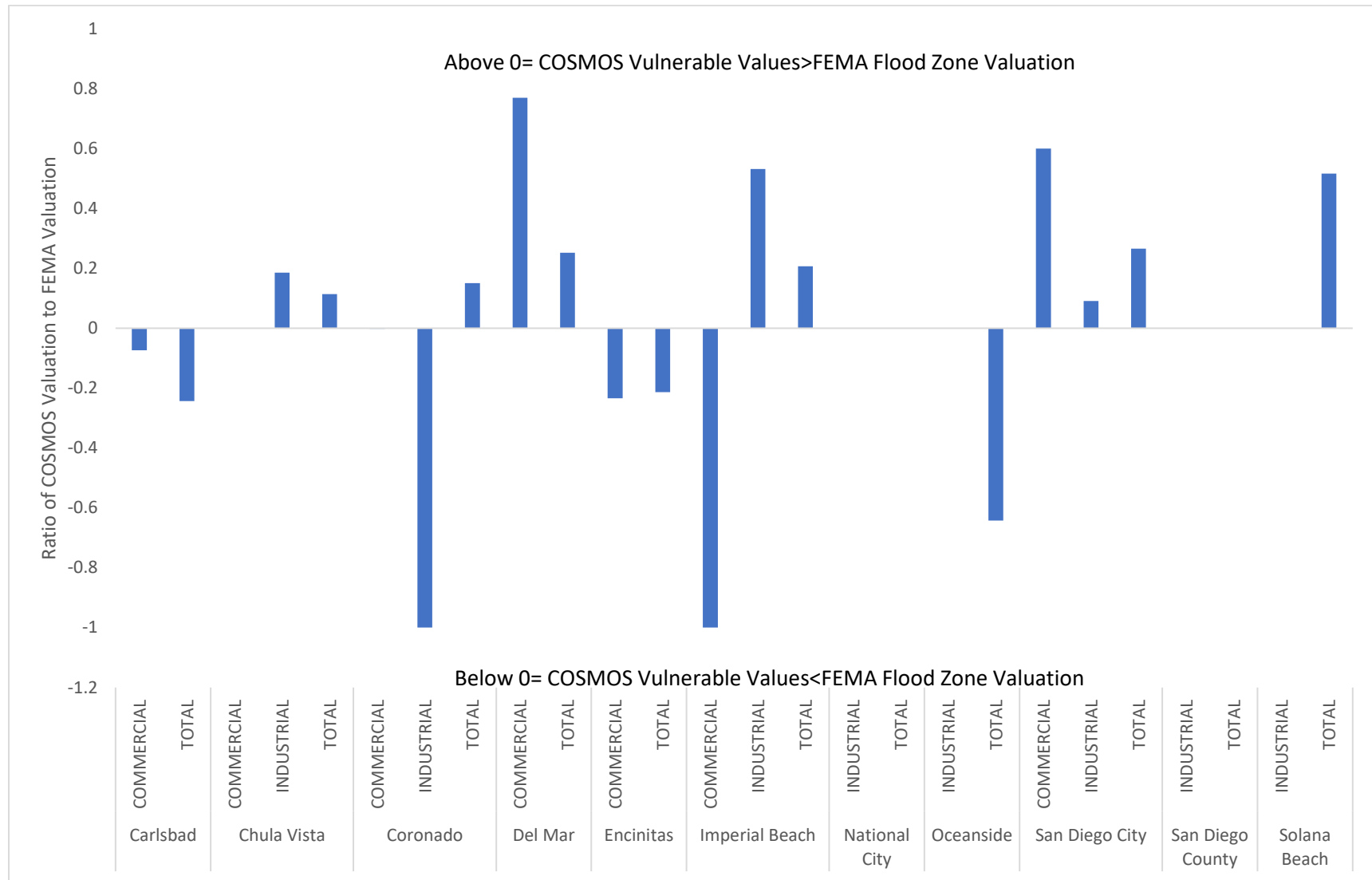
	N Establishments	Employment	Sales ($Millions)	GDP ($Millions)	Depth Weighted Employment	Depth Weighted Sales ($Millions)	Depth Weighted GDP ($Millions)
100 yr storm - 0m SLR	215	2,298	$224.00	$351.00	310	$26.30	$70.70
100 yr storm - FEMA Flood yr Zone	91	4,764	$575.70	$837.00	252	$27.40	$54.70

	N Establishments	Centimeters			Feet		
		Mean Depth	Max Depth	STD Depth	Mean Depth	Max Depth	STD Depth
100 yr storm - 0m SLR	215	53	239	39.5	1.7	7.8	1.3
Flooding_100 yr storm - FEMA Flood Zone	91	42.7	257.6	53.9	1.4	8.5	1.8

Scenario	Employment	Depth-Adjusted (Weighted) Employment	Depth Adjusted as Percent of Max Employment
100 yr storm - 0m SLR	2,298	310	13%
100 yr storm - FEMA Flood Zone	4,764	252	5%

Scenario	Annual Sales Values ($Millions)	Depth-Adjusted Annual Sales Values ($ Millions)	Daily Sales	Daily Depth-Adjusted Sales ($ Millions)
100 yr storm - 0m SLR	$224.00	$26.30	$0.75	$0.09
Flooding_100 yr storm - FEMA Flood Zone	$575.70	$27.40	$1.92	$0.09

Scenario	Annual GDP ($ Millions)	Depth-Adjusted Annual GDP ($ Millions)	Daily GDP ($ Millions)	Daily Depth-Adjusted GDP ($ Millions)
100 yr storm - 0m SLR	$351.00	$70.70	$1.17	$0.24
Flooding_100 yr storm - FEMA Flood Zone	$837.00	$54.70	$2.79	$0.18

		Centimeters			Feet		
Scenario	N All Parcels/ C&I Parcels	Mean Depth	Max Depth	Standard Deviation Depth	Mean Depth	Max Depth	Standard Deviation Depth
100 yr storm - 0m SLR	2,641/274	69	453	89	2.3	14.9	2.9
Flooding_100 yr storm - FEMA Flood Zone	7,871/1204	77	333	64	2.5	10.9	2.1

		Land	Improvements	Total	Depth-adjusted Land	Depth-adjusted Improvements	Depth-adjusted Totals	Parcels
All Parcels	100 yr storm - 0m SLR	$3,681.80	$2,591.60	$6,273.40	$436.50	$323.70	$760.20	3,645
	Flooding_100 yr storm - FEMA Flood Zone	$6,854.90	$4,529.60	$11,384.50	$1,521.20	$889.40	$2,410.60	7,871
C&I Parcels	100 yr storm - 0m SLR	$926.30	$1,502.70	$2,429.00	$108.10	$197.80	$305.90	387
	Flooding_100 yr storm - FEMA Flood Zone	$1,706.40	$2,261.30	$3,967.70	$272.90	$373.20	$646.00	1,204